NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency:	US Fish and Wildlife Service, Region 5
Activity Considered:	Funding of Passamaquoddy Tribal Research on Alewife Migration Behavior and Food Web Interactions in the St. Croix River and Estuary. NER-2014-11886
Conducted by:	National Marine Fisheries Service Greater Atlantic Region Fisheries Office
Date Issued:	March 13, 2015
Approved by:	

TABLE OF CONTENTS

1.0 INTRODUCTION AND BACKGROUND

This is the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543). This Opinion analyzes the effects to listed Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon from proposed alewife research to be carried out by the Passamaquoddy Tribe and funded by the U.S. Fish and Wildlife Service (USFWS). Work will be carried out in the St. Croix River estuary in Passamaquoddy Bay, Maine and Canada. The proposed project will provide information to better understand the ecological issues and interactions that may affect large river management and alewife restoration. The term of the proposed survey is from mid-March through mid-November in 2015 - 2017.

This Opinion is based on information provided in the USFWS' Biological Assessment (BA) (December 9, 2014). A complete administrative record of this consultation will be maintained at our Maine Field Office in Orono, Maine. Formal consultation was initiated with USFWS on December 9, 2014.

1.1 Consultation History

- November 18, 2014 – We received a BA and request for formal section 7 consultation from USFWS.

- December 9, 2014 – USFWS provided an updated BA to us.

- January 22, 2015 – We submitted a letter to USFWS acknowledging all information required to initiate formal Section 7 consultation was included in the December 9, 2014 letter and BA.

1.2 Relevant Documents

The analysis in this Opinion is based on a review of the best available scientific and commercial information. Specific sources are listed in Section 13 of this Opinion and are cited directly throughout the body of the document. Primary sources of information include: 1) information provided in the BA from USFWS in their request for consultation letter dated December 9, 2014; 2) Determination of Endangered Status for the Gulf of Maine Distinct Population Segment of Atlantic salmon; Final Rule (74 FR 29345; June 19, 2009); 3) Status Review for Anadromous Atlantic Salmon (*Salmo salar*) in the United States (Fay *et al.* 2006); 4) Designation of Critical Habitat for Atlantic salmon Gulf of Maine Distinct Population Segment (74 FR 29300; June 19, 2009); 5) Final Recovery Plan for Shortnose Sturgeon (December, 1998); and 6) Final listing determinations for the five distinct population segments of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) (77 FR 5880 and 77 FR 5914; Feb. 6, 2012).

1.3 Application of ESA Section 7(a)(2) Standards – Analytical Approach

This section reviews the approach used in this Opinion in order to apply the standards for determining jeopardy and destruction or adverse modification of critical habitat as set forth in section 7(a)(2) of the ESA and as defined by 50 CFR §402.02 (the consultation regulations). Additional guidance for this analysis is provided by the Endangered Species Consultation Handbook, March 1998, issued jointly by NMFS and the USFWS. In conducting analyses of actions under section 7 of the ESA, we take the following steps:

- Identify the action area based on the extent of the effects of the proposed action (Section 2);
- Evaluate the current status of the species with respect to biological requirements indicative of survival and recovery and the essential features of any designated critical habitat (Section 4);
- Evaluate the environmental baseline in the action area to biological requirements and the species' current status, as well as the status of any designated critical habitat (Section 5);
- Evaluate the relevance of climate change on environmental baseline and status of the species (Section 5);
- Determine whether the proposed action affects the abundance, reproduction, or distribution of the species, or alters any physical or biological features of designated critical habitat (Section 6);
- Determine and evaluate any cumulative effects within the action area (Section 7); and,
- Evaluate whether the effects of the proposed action and the status of the species, taken together with any cumulative effects and the environmental baseline, can be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the affected species, or is likely to destroy or adversely modify their designated critical habitat (Section 8).

In completing the last step, we determine whether the action under consultation is likely to jeopardize the ESA-listed species or result in the destruction or adverse modification of designated critical habitat. If so, we must identify a reasonable and prudent alternative(s) (RPA) to the action as proposed that avoids jeopardy or adverse modification of critical habitat and meets the other regulatory requirements for an RPA (see 50 CFR §402.02). In making these determinations, we must rely on the best available scientific and commercial data.

2.0 PROJECT DESCRIPTION AND PROPOSED ACTION

The USFWS proposes to issue funds to the Passamaquoddy Tribe through the 2013 Tribal Wildlife Grant (W-5-14-003) to conduct alewife research in the St. Croix River estuary in Passamaquoddy Bay, Maine and Canada. The Passamaquoddy Tribe will sample alewives in Passamaquoddy Bay using a weir and fyke net to document any spawning events by monitoring the abundance of juveniles. Large juvenile catches should provide indications of when major spawning events occurred off of Nova Scotia, George’s Bank, in the Bay of Fundy and in local rivers. The research will also provide data concerning the importance of alewives in the food web of the St. Croix River estuary.

Section 9 of the ESA states that it is unlawful for any person subject to the jurisdiction of the United States to take any endangered species within the United States or its territorial sea. As the fyke will be set in Canadian waters, any incidental take of endangered species in the Canadian side of the St. Croix river is not prohibited under the ESA. Nevertheless, as those activities are part of the proposed action, we analyze the potential effects of the fyke net sampling on listed species in the action area.

2.1 Field Sampling Methods

The Passamaquoddy Tribe proposes to sample fish in the St. Croix River using a herring weir and fyke net (Figures 1 and 2). The herring weir will be installed off Pleasant Point in the St. Croix River, Washington County, Maine (Figure 3). The weir will be heart shaped, measuring 170 feet (52 m) across at its widest point. The weir lead will start at the mid-tide line (19T 654641.73 m E and 4980018.82 m N) and extend ~400’ (121 m) to the East x Northeast, at a progressively increasing height of 3 m to 10 m with depth. The opening at the top of the weir, in between the right and left lobes of the heart, will be 10 feet (3 m). The lead will terminate in-between the lobes but not extend into the weir. The lead mesh will be 2 in. (5 cm) stretch; the lower 23’ (~7 m) of the weir mesh will be 1 3/8 in. (3.5 cm), the upper 10 ft (3 m) will be 1 in. stretch mesh (2.5 cm) .

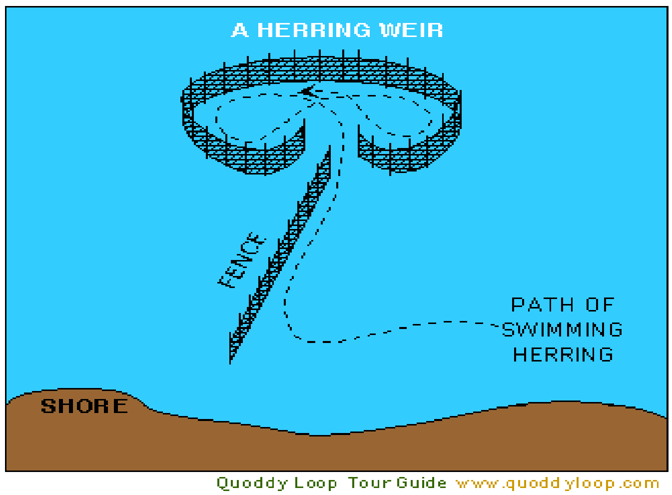


Figure 1. Diagram of proposed herring weir.

Figure 2. Photograph of proposed fyke net.

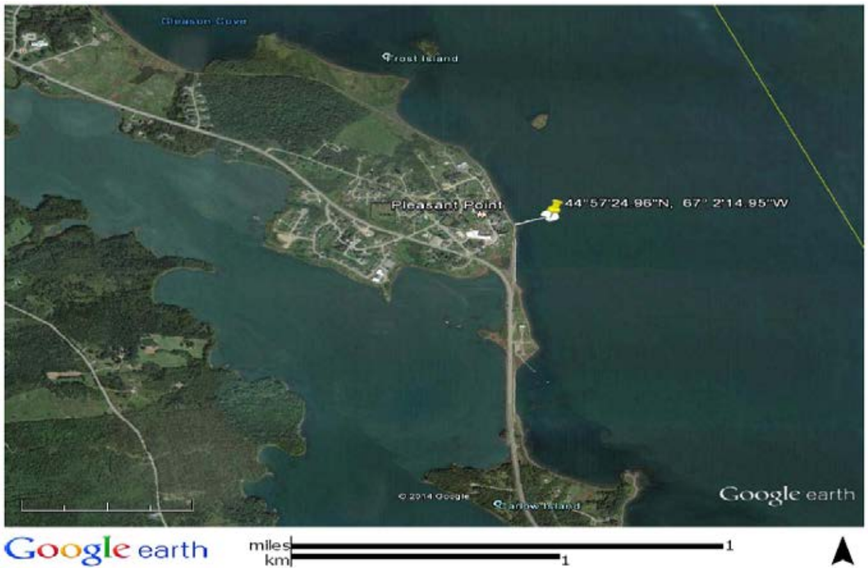


Figure 3. Photograph of proposed herring weir location off Pleasant Point.

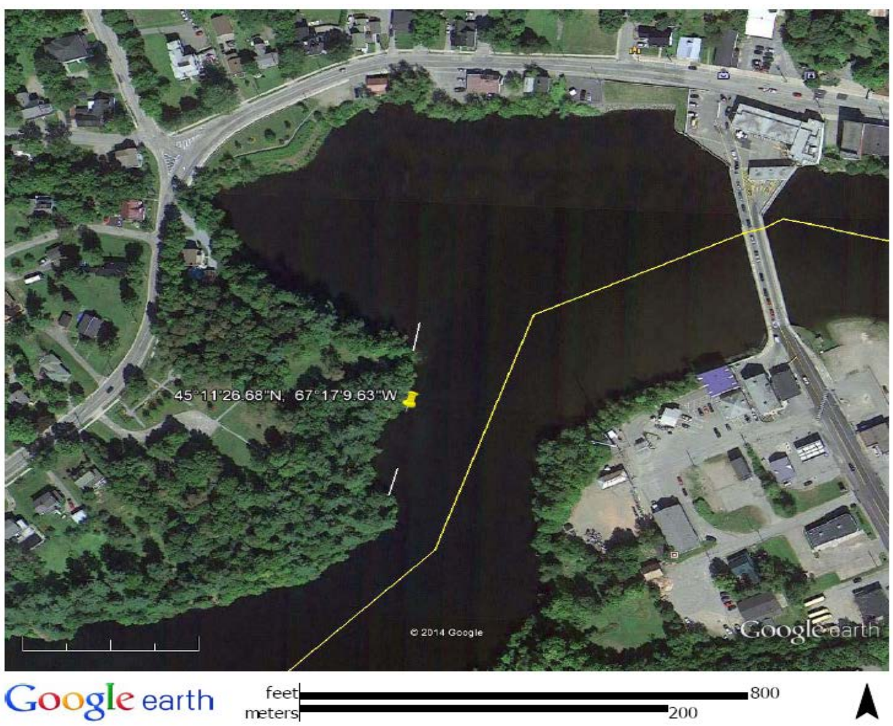


Figure 4. Photograph of proposed fyke net sampling location.

The weir will be operated from mid-March to mid-November in 2015, 2016 and 2017 on a constant schedule. The weir will be checked daily for fish and swept at least once a week. Depending upon frequency of catches in 2015, the Passamaquoddy Tribe may check the weir less frequently (3x per week) in 2016 and 2017. Checking the weir will consist of visual inspection at low tide to determine if sweeping the weir with the purse seine is warranted. During sweeping, a 1 inch stretch mesh purse seine (200 ft. (60 m) length, 33 ft. (10 m) depth) will be attached to the south wall of the weir. The center of the seine will be attached to a pole in the center of the weir and the free side will be worked from the North lobe near the opening to within 6 feet (2 m) of the attached net side on the weir's south wall. The seine will be pursed at that point and fish removed as the pocket size is decreased.

Activity to install the weir will take up to four weeks and will involve pounding stakes into the sub-tidal zone to hold the twine. A stake is required every six feet; approximately 100 stakes will be driven to hold the weir and another 67 stakes for the lead. Stringing the weir will involve using boats and divers to stretch the twine out between posts and secure the twine to the posts at the water-sediment interface. These activities may discourage fish from occupying the weir site for as long as the installation is in progress. No heavy equipment or pile driving will occur during installation of the weir.

The Passamaquoddy Tribe also proposes to sample alewives using a fyke net installed in Canadian waters of the St. Croix River in St. Stephen, New Brunswick (Figure 4). The fyke net will have a 4 foot by 5 foot front hoop and three 3-foot diameter throats with a 40 foot lead. All sections of net will consist of ½ inch mesh. The throat of the net will be 6 – 8 inches. The fyke net will be fished during the last week of May and the first week of June to capture adult alewives. The fyke net will be tended at least once every three hours and all fish will be removed.

2.2 Field Sampling Processing Procedures

Herring Weir

Small fish captured in the herring weir will be bulk weighed using a dip net (24 in x 24 in x 12 in deep). Larger fish will be counted and weighed individually. Most fish will be released outside the weir. Subsamples for scientific processing will be taken by the basket such that every 6th dip net (e.g., the 1st, 6th, 12th, 18th, 24th, etc.) are held for species identification, enumeration and other biological measures.

Any ESA-listed species captured in the weir, including Atlantic salmon or sturgeon, will be searched for during the emptying process. If one is found it will be safely removed from the weir; length and weight data will be collected using best management practices. Any salmon or sturgeon captured in the weir will be moved into a water-filled stretcher; length measurements will be taken with a tape measure and weights by weighing the entire sling from a hanging balance. No anesthetic will be used, consistent with protocols for sturgeon handling noted in Moser et al. (2000) for short term handling. A ¼ inch x ¼ inch piece of fin tissue will be collected from sturgeon for genetic analysis. ESA listed fish will be released on the outside of the weir.

Fyke Net

Alewife will be moved into a net pen for biological measurement and implant of acoustic or PIT tags. A total of 80 alewife will be held, 40 for tagging. Fishing will continue until all tags are implanted and successfully released. Bycatch will be enumerated and released as quickly as possible after alewife and other species are removed.

Any salmon or sturgeon will be identified before the net is pulled from the water. If one is found while emptying the contents of the net, that fish will be worked up first using best management practices. Any salmon or sturgeon captured in the fyke will be moved into a net pen and then into a stretcher; length measurements will be taken with a tape measure and weights by weighing the entire sling from a hanging balance. No anesthetic will be used, as recommended by Moser et al. (2000; regarding protocols for short term handling). A 1/4in x 1/4in piece of fin tissue will be collected from sturgeon for genetic analysis. Fish will be released upstream from the net.

2.3 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 must encompass all areas where the direct or indirect effects of the proposed action would affect listed species or critical habitat. The action area is as all areas where sampling will occur. As explained above, the action will involve installing a herring weir and fyke net in the lower St. Croix River. Thus, the action area consists of the two proposed sampling sites in the river. The proposed action is not expected to have any direct or indirect effects to listed species outside of the areas where sampling will occur. We did not identify any interrelated or interdependent actions.

3.0 SPECIES THAT ARE NOT LIKELY TO BE ADVERSELY AFFECTED BY THE PROPOSED ACTION

Fish

Shortnose sturgeon (*Acipenser brevirostrum*)	Endangered
Gulf of Maine DPS of Atlantic salmon (*Salmo salar*)	Endangered

According to the Joint NMFS-FWS Section 7 Consultation Handbook, a conclusion that an action "is not likely to adversely affect" a listed species is appropriate when effects are expected to be discountable, insignificant, or completely beneficial: "Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur" (pp. xv-xvi). We have determined that all effects of the proposed action on shortnose sturgeon and the GOM DPS of Atlantic salmon will be insignificant and discountable. We do not anticipate any incidental take of shortnose sturgeon or Atlantic salmon from any of the activities considered in this Opinion. Our supporting analysis is presented below.

3.1 Shortnose sturgeon in the Action Area

Shortnose sturgeon are listed as endangered as a single species throughout their range. To date, critical habitat has not been designated for shortnose sturgeon. Below, we present information on the use of the action area by shortnose sturgeon.

This project is located within the range of listed shortnose sturgeon (i.e., St. John River, Canada to St. Johns River, Florida, USA). There have been no shortnose sturgeon documented in the St. Croix River, including no documented interactions between fishing gear and shortnose sturgeon. In order to complete their life cycle, shortnose sturgeon require access to freshwater. Because the salt wedge intrudes all the way to the first impassable barrier at river km 16, the St. Croix River could not support a population of shortnose sturgeon. We have considered the possibility that coastal migrant shortnose sturgeon (as described in Dionne *et al*. 2013 and Zydlewski *et al*. 2011) could be present in the action area.

Tagging and telemetry studies indicate that shortnose sturgeon are present in the Penobscot, Kennebec, Androscoggin, Sheepscot and Saco Rivers in Maine. Shortnose sturgeon are known to move between the Kennebec and Penobscot Rivers as well as between the Kennebec, Saco and Merrimack Rivers. Tagged individuals have also been detected at telemetry receivers in smaller coastal rivers (Damariscotta, Medomak, St. George) located between the Kennebec and Penobscot Rivers (Zydlewski *et al.* 2011; Dionne *et al.* 2013). Movement east of the Penobscot is thought to be rare, with only one tagged sturgeon detected in the Narraguagus River; however, the limited number of tagged fish and telemetry receivers make determinations regarding presence of shortnose sturgeon in waters east of the Penobscot difficult to predict (Dionne *et al.* 2013). Nearly all visits to these smaller coastal rivers were short in duration (1-48 hours and typically less than 24 hours, with the exception of one shortnose that spent three months in the Damariscotta River) (Zydlewski *et al.* 2011). Once in the rivers, shortnose sturgeon were most often detected at least 10km from the coast. The significance of these coastal rivers is unknown. Researchers speculate that these detections may be an inadvertent consequence of a near-coast navigational strategy or may serve as stopover sites, for refuge (from ocean salinities) or foraging (Zydlewski *et al.* 2011).

The lack of telemetry receivers in other coastal rivers east of the Penobscot makes determining the likely presence of shortnose sturgeon outside of the rivers noted above difficult. However, no shortnose sturgeon have been documented at any existing telemetry receivers in Passamaquoddy Bay. It is possible that shortnose sturgeon occur in other estuaries in Passamaquoddy Bay and they have gone undetected because of limited sampling or because of misidentifications of shortnose sturgeon as Atlantic sturgeon (Dadswell 1984). In 2013, the first verified shortnose sturgeon was captured in the Minas Basin of the Bay of Fundy (Dadswell and Stokesbury 2013). However, at this time there is no information to indicate that shortnose sturgeon are present in the St. Croix river. In all coastal rivers that shortnose sturgeon have been documented in, there is access to low salinity waters. The only accessible habitats for shortnose sturgeon in the St. Croix river are completely saline. Based on the available information, it is extremely unlikely any shortnose sturgeon would be present in St. Croix River. Since shortnose sturgeon are extremely unlikely to occur in the action area, any effects to shortnose sturgeon are extremely unlikely to occur and are, therefore, discountable. As shortnose sturgeon are not likely to be adversely affected by the proposed action, the species will not be considered further in this consultation.

3.2 Atlantic salmon in the Action Area

The action area for this consultation is not within the geographic range of the Gulf of Maine DPS of Atlantic salmon. In addition, the action area does not occur within designated critical habitat for the species. Atlantic salmon in the St. Croix River are within Canada's St. John River managed unit (USASC 2013). St. John origin Atlantic salmon have not been stocked into the St. Croix watershed since 2003 (USASC 2013). St. John origin Atlantic salmon are not listed under the ESA.

We do not expect any GOM DPS origin Atlantic salmon to occur in the St. Croix River. Therefore, the proposed project will have no effect on listed GOM DPS Atlantic salmon. As there is no critical habitat in the action area, none will be affected by the proposed action.

4.0 RANGEWIDE STATUS OF LISTED SPECIES THAT MAY BE AFFECTED BY THE PROPOSED ACTION

We have considered the best available information on the distribution of Atlantic sturgeon and have determined that Atlantic sturgeon may be present in the action area. Five Distinct Population Segments (DPSs) of Atlantic sturgeon *(Acipenser oxyrinchus oxyrinchus)* are listed as threatened or endangered under the ESA; 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). The marine range for all 5 DPSs extends from Labrador Inlet, Labrador, Canada to Cape Canaveral, Florida (Figure 5) and includes the action area.

Gulf of Maine DPS

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 the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning occurs in the Kennebec River and it is possible that it still occurs in the Androscoggin and Penobscot Rivers. Currently, evidence of spawning in the Androscoggin River is limited to the capture of one larval Atlantic sturgeon by the Maine Department of Marine Resources during the 2011 spawning season below the Brunswick Dam. There is no evidence of recent spawning in other Gulf of Maine rivers; studies are on-going to determine whether Atlantic sturgeon are spawning in these rivers. As Atlantic sturgeon are unable to access freshwater in the St. Croix, the river cannot currently support a spawning population of Atlantic sturgeon.

Atlantic sturgeons that are spawned elsewhere continue to use habitats within rivers and estuaries of the Gulf of Maine as part of their overall 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). Information specific to use of the action area by Atlantic sturgeon is presented in Section 5.0, below.

New York Bight DPS

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco, 1977; Secor, 2002; ASSRT, 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (ASSRT, 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT, 2007; Savoy, 2007; Wirgin and King, 2011).

Chesapeake Bay DPS of Atlantic sturgeon
The Chesapeake Bay DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT, 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT, 2007). Spawning still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (Musick *et al.*, 1994; ASSRT, 2007; Greene, 2009). However, conclusive evidence of current spawning is only available for the James River. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (Vladykov and Greeley, 1963; ASSRT, 2007; Wirgin *et al.*, 2007; Grunwald *et al.*, 2008).

Carolina DPS
The Carolina DPS includes all Atlantic sturgeon that spawn in the watersheds from the Roanoke River, Virginia, southward along the southern Virginia, North Carolina and South Carolina coastal areas to the Cooper River. There are six known spawning rivers (Roanaoke, Tar-Pamlico, Cape Fear, Waccamaw, Pee Dee and Santee-Cooper) and possibly others (e.g. Neuse River). The abundance and trends of the Carolina DPS are not known.

South Atlantic DPS
The South Atlantic DPS includes all Atlantic sturgeon that spawn in the watersheds of the ACE Basin in South Carolina to the St. Johns River, Florida. The abundance and trends of the South Atlantic DPS are not known. There are seven spawning rivers (Ashepoo, Combahee, and Edisto (ACE Basin), Savannah, Ogeechee, Altamaha, and Satilla Rivers). In addition, the St. Marys and St. Johns Rivers are used as nursery habitat by young Atlantic sturgeon originating in other rivers. An estimate of 343 spawning adults/year is available for the Altamaha River (Schueller and Peterson 2006).

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon, and provides information specific for each DPS of Atlantic sturgeon.

4.1 Atlantic Sturgeon Life History

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, FL (Scott and Scott 1988; ASSRT 2007;). Atlantic sturgeon are long-lived (approximately 60 years), late maturing, estuarine dependent, anadromous[1] fish (Bigelow and Schroeder 1953; Vladykov and Greeley 1963; Mangin 1964; Pikitch *et al.* 2005; Dadswell 2006; ASSRT 2007).

1 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 FAQs, available at http://www.nefsc.noaa.gov/faq/fishfaq1a.html, modified June 16, 2011)

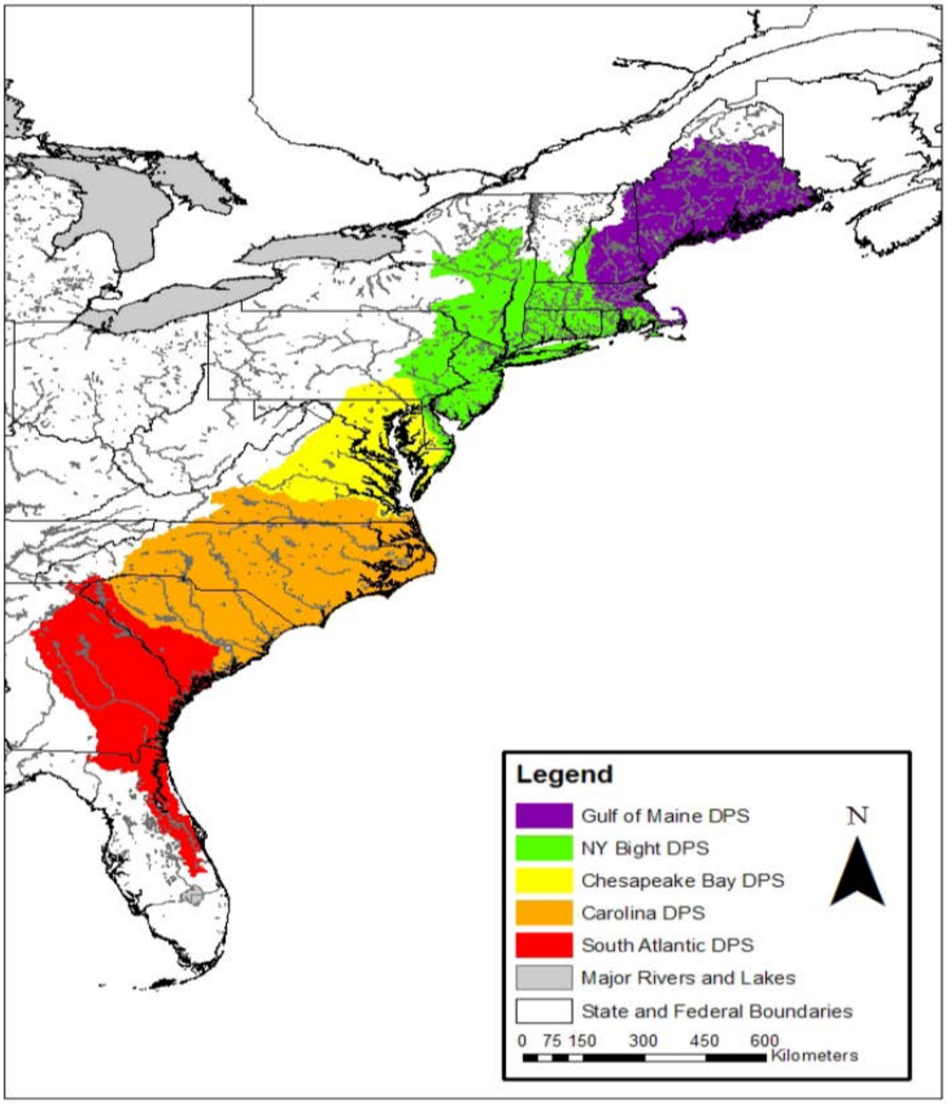


Figure 5. Map Depicting the Boundaries of the five Atlantic sturgeon DPSs

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

Age Class	**Size**	**Description**
Egg		Fertilized or unfertilized
Larvae		Negative photo-taxic, nourished by yolk sac
Young of Year (YOY)	**0.3 grams <41 cm TL**	Fish that are > 3 months and < one year; capable of capturing and consuming live food
Non-migrant subadults or juveniles	**>41 cm and <76 cm TL**	Fish that are at least age 1 and are not sexually mature and do not make coastal migrations.
Subadults	**>76cm and <150cm TL**	Fish that are not sexually mature but make coastal migrations
Adults	**>150 cm TL**	Sexually mature fish

Table 1. Descriptions of Atlantic sturgeon life stages

Atlantic sturgeon can grow to over 14 feet, weighing 800 pounds (Pikitch *et al.* 2005). Atlantic sturgeon are bottom feeders that suck food into a ventral 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. The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 meters (Vladykov and Greeley 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. While females are prolific, with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of two to five 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% of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman 1997). Males exhibit spawning periodicity of one to five years (Smith 1985; Collins *et al.* 2000; Caron *et al.* 2002).

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). Recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning in Maine occurs in June-July (Squiers *et al.*, 1981; ASMFC, 1998; NMFS and USFWS, 1998). 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°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).

The spawning areas in most U.S. rivers have not been well defined. However, 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 centimeters per second and depths are 3-27 meters (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 1984; 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 four weeks old, with total lengths (TL) less than 30 millimeters; Van Eenennaam *et al.* 1996) are assumed to mostly live on or near the bottom 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 both high salinity and 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 Berggen 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 meters 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.* 2004a; Laney *et al.* 2007; Dunton *et al.* 2010; Erickson *et al.* 2011; Wirgin and King 2011). 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.

4.2 Distribution and Abundance

Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing in the mid to late 19^{th} century when a caviar market was established (Scott and Crossman 1973; Taub 1990; Kennebec River Resource Management Plan 1993; 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 is approximately half of what it was 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). Thus, there are substantial gaps between Atlantic sturgeon spawning rivers among northern and Mid-Atlantic states which could make recolonization of extirpated populations more difficult.

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), and 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 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, NOAA's Northeast Fishery Science Center (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 (Table 2). 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, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. NEFSC's ASPI predicted a mean population size of 417,934 for Atlantic sturgeon in US waters.

In additional to the ASPI, a population estimate was derived for Atlantic sturgeon from the Northeast Area Monitoring and Assessment Program (NEAMAP)(Table 2). 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 since 2007 and spring since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations. Using NEAMAP survey-based swept area estimates of abundance and assumed estimates of gear efficiency, Atlantic sturgeon population estimates ranged from 8,921 to 338,882 individuals. These estimates are based on average of ten surveys from fall 2007 to spring 2012. 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 8).

Table 2. 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

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. True efficiencies less than 100% are common for most species and we expect that the NEAMAP surveys did not capture all Atlantic sturgeon within the path of the trawl and all size classes of sturgeon. Therefore, the NEAMAP estimates are minimum estimates of the ocean population of Atlantic sturgeon but are 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.

The ASPI model uses 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, 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 3) 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 3. 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

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

4.3 Threats Faced by Atlantic Sturgeon Throughout Their Range

Atlantic sturgeon are susceptible to over-exploitation given their life history characteristics (e.g., late maturity and 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 affects 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 loss of a population will negatively impact the persistence and viability of the DPS as a whole, as fewer than two individuals per generation spawn outside their natal rivers (Secor and Waldman 1999). 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, NMFS has concluded that bycatch in fisheries, vessel strikes, poor water quality, fresh 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 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 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, because Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

Atlantic sturgeon are particularly sensitive to bycatch mortality because they are a long-lived species, have an older age at maturity, have lower maximum fecundity values, and a large percentage of egg production occurs later in life. Based on these life history traits, Boreman (1997) calculated that Atlantic sturgeon can only withstand the annual loss of up to 5% of their population to bycatch mortality without suffering population declines. Mortality rates of Atlantic sturgeon taken as bycatch in various types of fishing gear range are variable with the greatest mortality occurring in sturgeon caught by sink gillnets. Atlantic sturgeon are particularly vulnerable to being caught in sink gillnets; therefore, fisheries using this type of gear account for a high percentage of Atlantic sturgeon bycatch. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or may result in delayed post-capture mortality.

As a wide-ranging anadromous species, Atlantic sturgeon are subject to numerous federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency activities. While these mechanisms, including the prohibition on possession, have addressed impacts to Atlantic sturgeon through directed fisheries, the listing determination concluded that the mechanisms in place to address the risk posed to Atlantic sturgeon from commercial bycatch were insufficient.

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 their parts in or from the EEZ 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, 2010; 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 captured 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.

Bycatch in U.S. waters is one of the threats faced by all five DPSs. 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 (NMFS NEFSC 2011b) 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 DPSs. This is because of (1) the small number of data points and, (2) the lack of information on the percent of incidents 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 (NMFS NEFSC 2011b). The analysis estimates that from 2006 through 2010, there were averages of 1,548 and 1,569 encounters per year in observed gillnet and trawl fisheries, respectively, with an average of 3,118 encounters combined annually. Mortality rates in gillnet gear were approximately 20%. Mortality rates in otter trawl gear are generally lower, at approximately 5%.

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 biological opinion includes the effects of several activities that occur in the St. Croix River that may affect the survival and recovery of the endangered species in the action area. Therefore, it is important to consider these activities when assessing the impacts of the survey on individual Atlantic sturgeon. The activities that shape the environmental baseline in the action area of this consultation generally include: water quality impacts, scientific research, commercial and recreational fisheries, and recovery activities associated with reducing those impacts.

5.1 Atlantic Sturgeon in the Action Area

There is very little information regarding the occurrence of Atlantic sturgeon in the St. Croix River. An Atlantic sturgeon that was tagged in the Penobscot River was detected at a stationary hydro-acoustic receiver in Passamaquoddy Bay at Head Harbor in November, 2010 (Gayle Zydlewski, personal communication March 5, 2014). Head Harbor is located approximately 15 miles from the proposed sampling area off Pleasant Point. Additionally, one juvenile Atlantic sturgeon was found dead on Friar Beach on Campobello Island, Canada in February, 2014. Friar Beach is located approximately 5 miles from Pleasant Point. Although the 2007 status review of Atlantic sturgeon mentions sturgeon possibly spawning in the St. Croix River, the reference is actually for the St. Croix in Nova Scotia, not New Brunswick (Dadswell 2006). Therefore, the statement in the 2007 status review is not relevant to the action area.

The best available information indicates that a spawning population of Atlantic sturgeon does not occur in the St. Croix River in Maine or New Brunswick, Canada. Spawning occurs exclusively in freshwater and early life stages need at least several kilometers of freshwater in order to develop due to an intolerance to salinity. In the St. Croix River, the salt wedge intrudes all the way to the first impassable falls at river km 16 (ASSRT 2007), indicating that there is no accessible freshwater habitat for spawning or rearing.

The lack of spawning habitat does not preclude Atlantic sturgeon from using the St. Croix River. Subadult Atlantic sturgeon leave their natal river and are present in marine, estuarine and riverine areas along the Atlantic coast. Adult Atlantic sturgeon are also well distributed in marine waters and have been documented in non-natal rivers. Given the migratory nature of the species and the confirmed presence of Gulf of Maine and New York Bight DPS Atlantic sturgeon in the Bay of Fundy, it is reasonable to anticipate that at least occasional transient Atlantic sturgeon will be present in the action area.

Data concerning Atlantic sturgeon presence and behavior has been collected in the Penobscot River, Maine. This information likely represents the best available information to describe the distribution of any Atlantic sturgeon present in the St. Croix River. Subadult Atlantic sturgeon were concentrated in a small area of the Penobscot River estuary near the freshwater/saltwater interface in late May until the end of October (Fernandes et al., 2010). Fernandes *et al.* 2010 documented three movement patterns for Atlantic sturgeon in the Penobscot River including: 1) concentration into a small area of the estuary during the late spring and summer; 2) summer immigration; and 3) fall emigration. These movement patterns in and out of the Penobscot River estuary are consistent with the paradigm that subadult Atlantic sturgeon primarily inhabit estuarine regions during summer and move into higher-salinity waters during late fall and winter when temperatures decrease (Collins and Smith 1997). We assume similar movement patterns for Atlantic sturgeon in the St. Croix River. Therefore, we expect transient subadult and adult Atlantic sturgeon in the vicinity of the proposed herring weir off Pleasant Point from July - November.

The fyke net will be used to sample alewives in the upper reaches of the St. Croix River estuary during the last week of May to the first week of June. During this period, transient sub-adult Atlantic sturgeon that are not sexually mature, but make coastal migrations, could occur in the action area. At this time of year, we expect adult Atlantic sturgeon to be in the ocean or in their natal river for spawning. We would not expect any adult Atlantic sturgeon in this area of the St. Croix at this time of year since suitable spawning habitat is not accessible in the river. Because no spawning occurs in the St. Croix River, there would be no spawning adults, eggs, larvae or juveniles in the action area.

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. Sub-adult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, sub-adult and adult Atlantic sturgeon in the action area would not be limited to just individuals originating from the GOM DPS. Based upon mixed stock analysis, we have determined that Atlantic sturgeon in the action area likely originate from two of the five ESA listed DPSs as well as from the St. John River in Canada. Fish originating from the St. John River are not listed under the ESA. The only way to tell the river (or DPS) of origin for a particular individual is by genetic sampling. 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 you are. Areas that are geographically close are expected to have a similar composition of individuals. The nearest areas to the action area for which mixed stock analysis is available is the Bay of Fundy, Canada. In this area, 63% of individuals are Canadian (St. John River) origin, 36% are GOM DPS origin and 1% are NYB origin. We do not currently have a mixed stocked analysis for the action area. In the St. Croix River, we expect the composition to be similar to the St. John River. Therefore, in the action area we expect Atlantic sturgeon to occur at the following frequencies: St. John River (Canada) 63%; Gulf of Maine 36% and, NYB 1%. 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 in Damon-Randall *et al*. (2012).

5.2 Factors Affecting Atlantic Sturgeon in Action Area

5.2.1 Contaminants and Water Quality

Atlantic sturgeon are vulnerable to effects from contaminants and water quality over their entire life history. In addition, their long life span increases the potential for environmental contaminants to build up in the tissue which may affect the development of the individual or its gametes. Point source discharges (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality that may also impact the health of individual sturgeon. The compounds associated with discharges can alter the chemistry and temperature of receiving waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival. Contaminants including heavy metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs), can have serious, deleterious effects on aquatic life and are associated with the production of acute lesions, growth retardation, and reproductive impairment (Ruelle and Keenlyne, 1993). Contaminants introduced into the water column or through the food chain eventually become associated with the benthos where bottom dwelling species like Atlantic sturgeon are particularly vulnerable. The St. Croix River downstream of Calais, Maine is designated as impair by the Maine Department of Environmental Protection due to Combined Sewer Overflows (MDEP 2012). Areas of the St. Croix River upstream of Calais may also be impaired but there is insufficient data at this time to conclusively make this determination (MDEP 2012).

5.2.2 Conservation and Recovery Actions

We are not aware of any Atlantic sturgeon conservation or recovery actions occurring in the St. Croix River at this time.

5.2.3 Formal or Early Section 7 Consultation

NMFS has not completed any formal or early section 7 consultations for actions taking place in the action area e.g., St. Croix River and estuary.

5.2.4 Other Federal Actions in the Action Area

In 2000, the US Environmental Protection Agency (EPA) delegated authority for the National Pollutant Discharge Elimination System (NPDES) permit program to the State of Maine. Currently, NMFS reviews and comments on all NPDES issued for discharges in the Gulf of Maine. In general, water quality has improved in the Gulf of Maine over the past decades (Lichter *et al*., 2006; EPA, 2008). However, water quality issues that derive from wastewater treatment plants and power plants are still a concern for all life stages of Atlantic sturgeon as effects may be long-lasting.

5.2.5 Non-Federally Regulated Actions

Atlantic sturgeon are taken incidentally in anadromous fisheries along the East Coast and may be targeted by poachers (NMFS 1998, ASSRT 2007). The St. Croix River is an important corridor for migratory movements of various species including alewife (*Alosa pseudohernegus*), American eel (*Anguilla rostrata*), and blueback herring (*Alosa aestivalis*). Unauthorized take of Atlantic sturgeon is prohibited by the ESA. Atlantic sturgeon may be taken incidentally in fisheries by recreational anglers on the St. Croix River, but due to a lack of reporting, no information on the number of Atlantic sturgeon caught and released or killed in recreational fisheries in the St. Croix River is available.

5.3 Global Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities - frequently referred to in layman's terms as "global warming." Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The EPA's climate change webpage provides basic background information on these and other measured or anticipated effects (see www. epa.gov/climatechange/index.html). Activities in the action area that may have contributed to global warming include the combustion of fossil fuels by vessels. The impact of climate change on Atlantic sturgeon in the action area is likely to be related to changes in water temperatures, potential changes to pH and salinity in rivers and oceans, and the potential decline of forage species abundance and distribution. These changes may affect the fitness of individuals and populations of Atlantic sturgeon due to the potential loss of foraging opportunities, displacement from ideal habitats and potential increase in susceptibility to disease (Elliot and Simmonds, 2007). Further, a decline in reproductive fitness as a result of global climate change could have profound effects on the abundance and distribution of Atlantic sturgeon in the action area, and throughout their range.

Climate change and other forces are predicted to cause a pole-ward shift in the distribution of species and to disrupt the evolved phenology of community organization. This may lead to a change in the species richness, their distribution among watersheds and migration timing in Maine's rivers and estuaries. This will have repercussions for the ecology of the area, including all of the diadromous species utilizing this river system for survival. For example, median capture date for adult Atlantic salmon in the Penobscot and Connecticut rivers has advanced by more than one day per two years from early 1980s to 2000s (Juanes *et al*., 2004). New England streams have warmed to 13°C about 12 days earlier compared to the 1970s and evidence suggests alewife runs also occur earlier based on historic run data (Ellis and Vokoun, 2009). Rainbow smelt were extirpated from the Hudson River in the 1990s and are becoming scarce south of Maine (Murawski and Cole, 1978; Waldman 2006). There is also a high economic interest in Maine, as many commercially harvested marine and diadromous species have life stages which exploit estuaries at some point in their life cycle.

As described above, over the long term, global climate change may affect Atlantic sturgeon by affecting the distribution of prey, water temperature and water quality. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect Atlantic sturgeon in the action area. However, given the short-term duration of the proposed action (i.e., 2015-2017), Atlantic sturgeon in the action area are unlikely to experience new climate change related effects not already captured in the "Status of the Species" section above concurrent with the proposed action.

6.0 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). We have not identified any interrelated or interdependent actions. There is no designated critical habitat in the action area.

In the analysis below, we consider the effects of the proposed fish sampling using a herring weir and fyke nets on GOM DPS and NYB DPS Atlantic sturgeon.

In order to determine whether the proposed action affects the abundance, reproduction, or distribution of the species, we first estimate the number of individuals that would likely interact with each gear type (exposure), then we describe the level of effects (response) to each individual. The effects analysis is broken into several components where impacts are likely to occur: 1) physiological stress associated with handling, capture and entanglement; and 2) migration delays. While all individuals will be released alive, actively capturing and handling fish will result in non-lethal physiological stress. Appropriate precautions and handling protocols will be utilized to minimize effects from sampling, which should also decrease the likelihood of long term physiological effects or mortalities.

6.1 Effects of Herring Weir Activities

The Passamaquoddy Tribe proposes to continuously fish the herring weir off Pleasant Point from mid-March through mid-November to sample alewives in the St. Croix River. During this time of year, sub-adult and adult Atlantic sturgeon are likely to occur in the action area. Given the likely presence of Atlantic sturgeon in the action area, we expect that Atlantic sturgeon will interact with and become captured in the herring weir. This conclusion is supported by the documented capture of Atlantic sturgeon by weirs in Minas Basin, Nova Scotia (Dyer *et al*. 2005).

Anticipated capture rate

Data for estimating the efficiency of weirs to capture sturgeon is limited. In Nova Scotia, Atlantic sturgeon are routinely captured in weirs (personal communication, Trevor Avery, Acadia University, January 6, 2014). From 1998 to 2000, Fisheries and Oceans Canada (DFO) reported a three-year average of 155 Atlantic sturgeon captured in ten weirs in the Bay of Fundy (9 in Minas Basin and 1 in Margaretsville). An estimated 400 Atlantic sturgeon were captured in Avon Estuary in the Minas Basin (personal communication, Trevor Avery, Acadia University, January 6, 2014). The inner bays of the Bay of Fundy are known to support large populations of foraging Atlantic sturgeon in the summer (Dyer *et al.* 2005). Atlantic sturgeon are the fifth most common species captured in trawls in Minas Basin in summer months (Dadswell, 2010). Approximately 10,000 Atlantic sturgeon consisting mostly of juveniles in believed to congregate in Minas Basin in the summer months (Dadswell 2010).

The weirs used in Canada are considerably larger (800 meter wings) than the one proposed for use in Passamaquoddy Bay (less than 100 meter wings). In addition, we do not expect any large congregations of Atlantic sturgeon in the St. Croix River estuary. Therefore, it would not be appropriate to use data from weir fisheries in Canada to estimate capture efficiency of the proposed weir in the St. Croix River.

Catch per unit effort (CPUE) data for Atlantic sturgeon and gill nets deployed in the Penobscot River was collected by the University of Maine (UM). In 2006, UM began a study to document the presence of shortnose sturgeon in the Penobscot River. During the first summer of sampling, 35 subadult Atlantic sturgeon were captured in gill nets set throughout the Penobscot River estuary. Based on the number of fish caught per hour of fishing with 6 inch and 12 inch mesh gill nets in the Penobscot River in 2006, UM calculated a capture rate of 0.009 fish/net hour using a standardized net length. UM's CPUEs are a reasonable estimate of interactions with a herring net set in the St. Croix River because: (1) fishing occurred in a similar temporal and spatial scope as expected in the proposed study; (2) both gill nets and herring weirs were set at the bottom of the river, where sturgeon reside; (3) Atlantic sturgeon are known to be vulnerable to capture in both gear types (e.g., gill nets and herring weirs); and (4) the wings of UM's gill nets (300 feet) are similar in length to the proposed herring weir wing (400 feet). Therefore, UM's 2006 study represents the best available information to predict encounter rates for Atlantic sturgeon in the action area. It is important to note that the capture estimates for 2006 reflect an upper limit or "worst case scenario", as gill nets were fished in areas of known sturgeon congregations in the Penobscot River and we do not expect as many Atlantic sturgeon in the action area as in the areas fished in the Penobscot River.

The Passamaquoddy Tribe proposes to fish the herring weir in the St. Croix River continuously from mid-March through mid-November. Transient sub-adult and adult Atlantic sturgeon could occur in the vicinity of the proposed herring weir off Pleasant Point in summer through late fall as alewives move into and out of the St. Croix River. Fernandes *et al.* 2010 documented three movement patterns for Atlantic sturgeon in the Penobscot River including: 1) concentration into a small area of the estuary during the late spring and summer; 2) summer immigration; and 3) fall emigration. These movement patterns in and out of the Penobscot River estuary are consistent with the paradigm that sub-adult Atlantic sturgeon primarily inhabit estuarine regions during summer and move into higher-salinity waters during late fall and winter when temperatures decrease (Collins and Smith 1997). Since the weir will be located in full salinity salt water, we anticipate that Atlantic sturgeon would only overlap with this portion of the action area between July and November, the time period when we expect subadults and adults to be moving into and out of the river. Because no spawning occurs in the St. Croix river, we do not anticipate adults moving into the river in the spring. Therefore, the time period when weir operations will overlap with Atlantic sturgeon presence is July – November. The Atlantic sturgeon detected off at a stationary hydro-acoustic receiver off Head Harbor in November, 2010 (Gayle Zydlewski personal communication March 5, 2014) supports this conclusion.

To determine the total amount of fishing effort that should be applied to the incidental capture rate, an estimation of the exposure time individuals would likely encounter the herring weir is considered below. To do this, we considered how the gear will be fished through each of the tide cycles which accounts for the orientation of the gear to the flow of the river and the height of each tide cycle. This allows us to determine the appropriate amount of time the gear will be effectively fishing during these times. At low tide, most of the herring weir will be exposed. Therefore, the effective fishing time of the herring weir can be reduced over a 24 hour tide cycle, mainly during periods of low tide. We anticipate that low tides will reduce the effective fishing time of the herring weir for 4 hours each tide (8 hours over a 24 hour period). Over the course of one month, the herring weir will effectively fish for a total of 480 hours. As indicated above, we anticipate that Atlantic sturgeon would only occur in the action area from July – November. Using the capture rate of 0.009 fish/net hour, four[2] Atlantic sturgeon are likely to encounter the herring weir on a monthly basis. Therefore, we expect no more than twenty Atlantic sturgeon would be captured on an annual basis (five months, July through November). Based on the mixed stock analysis discussed above, the annual composition of these Atlantic sturgeon would likely be: 12 Canadian; 7 GOM DPS; and 1 NYB. Over the course of the three year study, we expect a total of up to 60 Atlantic sturgeon captured in the weir. We anticipate 36 will be Canadian origin, 21 GOM DPS and 3 NYB DPS.

Entrapment and Handling

Herring nets are considered a non-lethal sampling method. However, there is always the potential for a fish to become entangled in the sampling gear; entanglement in nets can result in injury and mortality, reduced fecundity, and delayed or aborted spawning migrations of sturgeon (Moser and Ross, 1995; Collins *et al*., 2000; Moser *et al.*, 2000 and Kahn and Mohead, 2010). In some cases, if pre-spawning adults are captured and handled, it is possible that they could interrupt or abandon their spawning migrations after being handled (Moser and Ross, 1995). However, we do not anticipate any sturgeon in the action area to be on a pre-spawning migration. Generally, most of the reported mortalities from similar gear types are due to other extraneous circumstances including environmental conditions (e.g., water temperature and dissolved oxygen), net configuration, soak times and experience handling captured fish. Reported mortality rates for shortnose sturgeon captured in gill nets fishing in northern river systems range from less than 1% to approximately 4% (Zydlewski *et al*., 2010 in Maine DMR 2010; Hastings, 1983; Kieffer and Kynard, 1993; Kynard *et al*., 1999). In the Penobscot River, mortality rates have been less than 1% (4 mortalities/662 captures; UM unpublished data). Since fish enter the herring weir are trapped, not hooked or gilled, we believe captured sturgeon are less likely to be injured or stressed in weirs, compared to gill nets. Captured Atlantic sturgeon may experience minor abrasions due to chafing on the net. These injuries are expected to be minor and recovery is expected to be rapid and complete. No other injuries are anticipated.

Migration Delays

Transient sub-adult and adult Atlantic sturgeon could occur in the vicinity of the proposed herring weir off Pleasant Point from July - November as they move into and out of the St. Croix River. Indirect effects of capture in the net may include post-capture stress and delayed access to foraging or overwintering grounds. The herring weir will be inspected daily throughout the study. During the daily inspection, any Atlantic sturgeon observed in the weir will be immediately removed (Pers. Comm. Theodore Willis, Principle Investigator, University of Southern Maine, February 27, 2015). At low tide, any trapped Atlantic sturgeon should be observable such that their capture should not be more than 24 hours (Pers. Comm. Theodore Willis, Principle Investigator, University of Southern Maine, February 27, 2015). Because

[2] Calculated by multiplying the catch rate (0.009 fish/net hour) by the number of hours the net will effectively fish each day (16) by the average number of days in a month (30).

Atlantic sturgeon could be passively trapped in the herring weir, the capture of Atlantic sturgeon would inhibit their movements for short periods (not more than 24 hours). We understand that the Passamaquoddy Tribe may request to check the weir less frequently in 2016 and 2017. Presently, the proposed action for the consultation requires the Passamaquoddy Tribe to inspect the weir daily.

Based on results of gill net studies in other river systems where the same fish have been repeatedly captured, the stress related to short capture (24 hours or less) is likely to be temporary and Atlantic sturgeon are expected to be able to rapidly recover and resume their normal behaviors. As such, long term disruptions to normal migratory behaviors are not likely.

Sedimentation
Some sediments could be released to the water during installation of the herring weir. To install the weir, approximately 170 stakes will be hand-driven into the substrate. Boats and divers will be used to string the weir to the stakes. The Passamaquoddy Tribe estimates that installation of the weir will take four weeks to complete.

Driving stakes in the substrate will release only minor amounts of sediments. In addition, the tidal action of the St. Croix estuary will rapid dissipate any sediments released to the water. Therefore, any effects of the suspension of sediments will be undetectable. Therefore, effects of sediments will be insignificant.

6.2 Effects of Fyke Net Activities

The fyke net will be used to sample alewives in the upper reaches of the St. Croix River estuary during the last week of May to the first week of June in 2015, 2016 and 2017. During this period, transient sub-adult Atlantic sturgeon that are not sexually mature, but make coastal migrations, could occur in the action area. Any sub-adult Atlantic sturgeon in this area of the St. Croix River would likely be between 76 cm and 150 cm in length. At this time of year, we expect adult Atlantic sturgeon to be in the ocean or in their natal river for spawning. We would not expect any adult Atlantic sturgeon in this area of the St. Croix at this time of year since suitable spawning habitat is not accessible in the river.

The fyke net will be fished in shallow near shore waters. In the Penobscot River, the mean depth of acoustically tagged Atlantic sturgeon was 10.3 ± 0.1 m (Fernandes *et al.* 2010) indicating that Atlantic sturgeon are not likely to spend significant amounts of time in shallow waters. In addition, the proposed fyke net has a relatively small 6-8 inch throat and no wings; we expect any Atlantic sturgeon present in the area where the fyke net will be fished will be able to avoid capture. This conclusion is supported by the absence of Atlantic sturgeon encounters in fyke nets fished by NMFS Northeast Fishery Science Center in the Penobscot River in areas where sub-adult Atlantic sturgeon are known to occur. Based upon this information, it is extremely unlikely that any Atlantic sturgeon will interact with the proposed fyke net. Therefore, we do not anticipate the capture or collection of any Atlantic sturgeon in the fyke nets. Effects of the fyke net study on Atlantic sturgeon are discountable

7.0 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.

Several features of a sturgeon's life history, including delayed maturation, non-annual spawning (Dadswell *et al*., 1984; Boreman, 1997), and long life-span, affect the rate at which recovery can proceed. Future state and private activities in the action area that are reasonably certain to occur during project operations are recreational and commercial fisheries, pollutants, and development and/or construction activities resulting in excessive water turbidity and habitat degradation.

Impacts to individual Atlantic sturgeon from non-Federal activities are largely unknown in this large river system. It is possible that recreational and commercial fishing for anadromous fish species may result in incidental takes of Atlantic sturgeon.

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, power plants and other industrial facilities. Contaminants introduced into the water column or through the food chain eventually become associated with the benthos where bottom dwelling species like Atlantic sturgeon are particularly vulnerable.

Industrialized waterfront development such as the paper mill in Baileyville, Maine will continue to impact the water quality in and around the action area. Sewage treatment, industrial, and electric generating facilities present in the action area are likely to continue to operate. Excessive water turbidity, water temperature variations and increased shipping traffic are likely with continued future operation of these facilities. However, any adverse effects to Atlantic sturgeon from waterfront development is not known at this time.

This Opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the status of the species/environmental baseline section.

8.0 INTEGRATION AND SYNTHESIS OF EFFECTS

In the discussion below, we consider whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of New York Bight and Gulf of Maine DPSs of Atlantic sturgeon. 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 the New York Bight or Gulf of Maine DPS of Atlantic sturgeon.

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 New York Bight and Gulf of Maine DPSs of Atlantic sturgeon, the listed species likely to be affected by the proposed action, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of that species and then consider whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of that species, as those terms are defined for purposes of the ESA.

We estimate the proposed St. Croix alewife study, to be carried out between 2015-2017, will result in the capture of up to 60 Atlantic sturgeon in the herring weir. Any interactions between the sampling gear and Atlantic sturgeon are expected to have minor behavioral, physiological and physical effects. The proposed study may capture/collect St. John River (n= 36), GOM DPSs (n=21), and New York Bight DPS (n=3) Atlantic sturgeon. No interactions resulting in any mortality of any Atlantic sturgeon are likely to result from any of the activities associated with the study.

8.1 Gulf of Maine DPS of Atlantic sturgeon

The GOM DPS is listed as threatened. While Atlantic sturgeon occur in several rivers in the GOM DPS, recent spawning has only been documented in the Kennebec; spawning is suspected to also occur in the Androscoggin river. No estimate of the number of Atlantic sturgeon in any river or for any life stage or the total population is available. The NEAMAP based estimates discussed in Section 4.2 estimate a total of 7,455 subadult and adult GOM DPS Atlantic sturgeon in the ocean.

We estimate the proposed alewife study will result in non-lethal physiological and behavioral impacts to no more than 21 GOM DPS Atlantic sturgeon over the three year study period; no mortality is anticipated. These impacts will result from the capture/collection of these individuals. No interactions with Atlantic sturgeon are likely to result from any other activities in the proposed study. Effects are anticipated when fish encounter or are trapped by the sampling gear. These effects consist of: an alteration of normal behavior, such as a temporary startle or avoidance of the sampling area; minor physiological stress; and minor physical injury from abrasion associated with physically interacting with the trap, main lead or wings. Non-lethal behavioral responses are expected to be temporary and spatially limited to the area and time fish interact with or are restricted by sampling gear. Due to the minor nature of anticipated effects, as well as the lack of non-recoverable injuries and mortalities, there will be no reduction in the numbers of GOM DPS Atlantic sturgeon and no change in the status of this species or its trend due to the proposed action.

Reproductive potential of the GOM DPS is not expected to be affected in any way. As all sturgeon are anticipated to fully recover from collection, and the short duration of any capture and handling will not delay or disrupt any essential behaviors, including spawning, there will be no reduction in individual fitness or any future reduction in numbers.

The proposed action is not likely to reduce distribution, because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the action area or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporary capture and handling of the individual sturgeon.

Based on the information provided above, the non-lethal collection of 21 GOM DPS Atlantic sturgeon between 2015 and 2017, will not appreciably reduce the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) there will be no mortalities; (2) because there will be no mortalities, there will be no change the status or trends of the species as a whole; (3) there will be no effect on the levels of genetic heterogeneity in the population; (4) there will not be any loss of any age class; (5) there will be no effect on reproductive output; (6) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area (limited to only the temporary holding of a small number of individuals) and no effect on the distribution of the species throughout its range; and, (7) the action will have no effect on the ability of GOM DPS Atlantic sturgeon to shelter and no effect on individual foraging GOM DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon will survive in the wild, which includes some consideration of recovery potential. Here, we consider whether the actions will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood the population can rebuild to a point where the GOM DPS of Atlantic sturgeon is no longer in danger of extinction through all or a significant part of its range.

No Recovery Plan for the GOM DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained, would allow the species to be delisted. 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. 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. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by sub-adults and adults will occur and in the ocean where sub-adults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect any GOM DPS river population of Atlantic sturgeon in a way that would affect the GOM DPS likelihood of recovery.

This action will not change the status or trend of any population of Atlantic sturgeon or the status and trend of the GOM DPS as a whole. The proposed action will not result in any mortality and no reduction in future reproductive output. Because there will be no effect on numbers or reproductive output, the actions will not affect the trend of the population. The proposed action will have only insignificant effects on habitat and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. Therefore, the proposed action will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

8.2 New York Bight DPS of Atlantic sturgeon

Individuals originating from the New York Bight (NYB) DPS are reasonably likely to occur in the action area. The NYB DPS is listed as endangered. While Atlantic sturgeon occur in several rivers in the NYB DPS, recent spawning has only been documented in the Delaware and Hudson Rivers. The capture of age 0 Atlantic sturgeon in the Connecticut River in 2014 indicates that spawning may also occur in this river. However, as these young sturgeon represent the only evidence of spawning since the population began being studied in the 1980s, and we do not have any information on the genetic identity of these individuals, we do not know if these represent a unique Connecticut River population or were spawned by migrants from the Hudson River. Based on existing data, we expect any NYB DPS Atlantic sturgeon in the action area to originate from the Delaware or Hudson river. There is limited information on the demographics of the Hudson River population of Atlantic sturgeon. Spawning still occurs in the Delaware, however, this are no abundance estimates for the Delaware River population of Atlantic sturgeon (ASSRT, 2007).An annual mean estimate of 863 mature adults (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007). As discussed in Section 4.2, the NEAMAP based methodology estimates a total of 34,566 sub-adult and adult NYB DPS Atlantic sturgeon in the ocean.

We estimate the proposed study will result in the capture of three NYB DPS Atlantic sturgeon with no mortality. Effects are anticipated when fish encounter or are trapped by the sampling gear. These effects consist of alterations in normal behavior, such as a temporary startle or avoidance of the sampling area; minor physiological stress; and minor physical injury from abrasion associated with physically interacting with the trap, main lead or wings. Non-lethal behavioral responses are expected to be temporary and spatially limited to the area and time fish interact with or are restricted by sampling gear.

No significant injury and no mortality is anticipated. The survival of any NYB DPS Atlantic sturgeon will not be affected by the action. As such, there will be no reduction in the numbers of NYB DPS Atlantic sturgeon and no change in the status of this species or its trend. Reproductive potential of the NYB DPS is not expected to be affected in any way. As all sturgeon are anticipated to fully recover from collection, and the short duration of any capture and handling will not disrupt any essential behavior, including spawning, there will be no reduction in individual fitness nor any future reduction in numbers.

The proposed action is not likely to reduce distribution because the action will not impede NYB DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the action area or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporary capture and handling of the individual sturgeon.

Based on the information provided above, the non-lethal collection of three NYB DPS Atlantic sturgeon between 2015 and 2017, will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) there will be no mortalities; (2) because there will be no mortalities, there will be no change the status or trends of the species as a whole; (3) there will be no effect on the levels of genetic heterogeneity in the population; (4) there will not be any loss of any age class; (5) there will be no effect on reproductive output; (6) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area (limited to only the temporary holding of three individuals) and no effect on the distribution of the species throughout its range; and, (7) the action will have no effect on the ability of NYB DPS Atlantic sturgeon to shelter and no effect on individual foraging NYB DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon will survive in the wild, which includes some consideration of recovery potential. Here, we consider whether the actions will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood the population can rebuild to a point where the NYB DPS of Atlantic sturgeon is no longer in danger of extinction through all or a significant part of its range.

No Recovery Plan for the NYB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained, would allow the species to be delisted. 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. 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. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by sub-adults and adults will occur and in the ocean where sub-adults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the Hudson or Delaware river population of Atlantic sturgeon in a way that would affect the NYB DPS likelihood of recovery.

This action will not change the status or trend of the Hudson or Delaware River population of Atlantic sturgeon or the status and trend of the NYB DPS as a whole. The proposed action will not result in any mortality and no reduction in future reproductive output. Because there will be no effect on numbers or reproductive output, the action will not affect the trend of the population. The proposed action will have only insignificant effects on habitat and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. Because it will not reduce the likelihood that the Hudson or Delaware river population can recover, it will not reduce the likelihood that the NYB DPS as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

9.0 CONCLUSION

After reviewing the current status of the species discussed herein, the environmental baseline for the action area, the effects of the proposed action, the funding and carrying out of the Passamaquoddy Tribe Alewife Study in the St. Croix River from 2015-2017, it is our biological opinion that the proposed action is likely to adversely affect, but is not likely to jeopardize the continued existence of the New York Bight or Gulf of Maine DPSs of Atlantic sturgeon. Because no critical habitat is designated for any DPS of Atlantic sturgeon, none will be affected.

10.0 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. 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"). A "person" is defined in part as any entity subject to the jurisdiction of the United States, including an individual, corporation, officer, employee, department or instrument of the Federal government (see 16 U.S.C. 1532(13)). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of carrying out an otherwise lawful activity is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement. In issuing this ITS, we take no position on whether this action is an "otherwise lawful activity."

The measures described below are non-discretionary, and must be undertaken by USFWS so that they become binding conditions of the grant issued to the Passamaquoddy Tribe for the exemption in section 7(o)(2) to apply. The USFWS has a continuing duty to regulate the activity covered by this Incidental Take Statement. If USFWS and the Passamaquoddy Tribe fail to assume and implement the terms and conditions, or the USFWS fails to require the Passamaquoddy Tribe to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, USFWS and the Passamaquoddy Tribe must report the progress of the action and its impact on the species to the NMFS as specified in the Incidental Take Statement [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-469).

10.1 Amount or Extent of Take

The proposed action, the funding of the proposed St. Croix alewife study in 2015-2017, is expected to result in the capture/collection of up to 60 Atlantic sturgeon juveniles and/or sub-adults (36 St. John River (Canada), 21 GOM DPS and 3 NYB DPS). The anticipated capture of GOM DPS and NYB Atlantic sturgeon with sampling gear is considered take under Section 9 of the ESA. All take will be non-lethal capture/collection and injury as a result of the interaction of Atlantic sturgeon with the herring weir sampling gear. All effects from being captured and handled are anticipated to be minor and individuals are expected to make a full recovery with no impact to future survival or fitness. We anticipate all Atlantic sturgeon captured in the sampling gear will be released alive with only minor, recoverable injury.

10.2 Reasonable and Prudent Measures

Reasonable and prudent measures (RPMs) are those measures necessary and appropriate to minimize incidental take of a listed species. In order to effectively monitor the effects of this action, it is necessary to document the amount and type of incidental take that occurs (i.e., the number of Atlantic sturgeon captured, collected, injured or killed) and to examine any Atlantic sturgeon that are captured during the study. Monitoring provides information on the characteristics of the Atlantic sturgeon encountered and may provide data which will help develop more effective measures to avoid future interactions with listed species. We do not anticipate any additional injury or mortality to be caused by removing the fish from the water and examining them as required in the RPMs. Any live Atlantic sturgeon or other listed species (although not anticipated) are to be released alive back into the river, away from the research activities. In addition to adhering to the conditions relevant to Atlantic sturgeon outlined in this Opinion, sampling protocols and the BA, the following reasonable and prudent measures are necessary and appropriate to monitor incidental captures of listed Atlantic sturgeon:

1. USFWS and the Passamaquoddy Tribe must promptly report all captures of any listed species to the Protected Resources Division.
2. USFWS and the Passamaquoddy Tribe must promptly report any injuries or mortalities of listed species to the Protected Resources Division and follow proper handling procedures.
3. USFWS and the Passamaquoddy Tribe must sample any sturgeon captured; sampling must be limited to visually inspecting the animal for any external tags, scanned for PIT tags, photographed and measured.

10.3 Terms and conditions

In order to be exempt from prohibitions of section 9 of the ESA, USFWS and the Passamaquoddy Tribe must comply with the following terms and conditions of the Incidental Take Statement, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Any taking that is in compliance with the terms and conditions specified in this Incidental Take Statement shall not be considered a prohibited taking of the species concerned (ESA Section 7(o)(2)).

1. To implement RPM #1, USFWS and the Passamaquoddy Tribe must visually inspect the herring weir daily throughout the study for any captured Atlantic sturgeon.

2. To implement RPM #1 and #2, USFWS and the Passamaquoddy Tribe must contact the Northeast Region Protected Resources Division by e-mail (incidental.take@noaa.gov) within 24 hours of any captures of listed species including non-lethal and lethal takes.

3. To implement RPM # 3 any sturgeon captured during sampling must be visually assessed for any external tags, scanned for PIT tags, photographed and measured following proper protocols. The corresponding incident report form (Appendix A) must be completed and submitted to NMFS **within 24 hours** by e-mail (incidental.take@noaa.gov) of any captures of sturgeon.

4. To implement RPM #2, USFWS and the Passamaquoddy Tribe in the event of any lethal takes, any dead specimens or body parts of sturgeon must be photographed, measured, and preserved (held in cold storage) until disposal procedures are discussed with NMFS's GARFO. The form included as Appendix A must be completed and submitted to NMFS's GARFO as noted above.

5. To implement RPM #3, USFWS and the Passamaquoddy Tribe must take fin clips if any sturgeon captures occur (according to the procedure outlined in Appendix B).

6. To implement RPM #1 through #3, USFWS and the Passamaquoddy Tribe must submit a final report at the end of each calendar year summarizing the results of sampling activities and any takes of listed species to NMFS by mail (to the attention of the Section 7 Coordinator, NMFS Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930).

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that might otherwise result from the proposed action. Specifically, these RPMs and Terms and Conditions will keep NMFS informed of when sampling activities are taking place and will require the USFWS and Passamaquoddy Tribe to report any non-lethal and lethal take in a reasonable amount of time, as well as avoid additional sources of injury and mortality to Atlantic sturgeon that may result from handling associated with sampling.

Term and Conditions #1 through #6 are specifically designed to reduce the amount of take and to monitor the amount of take. In order to effectively monitor and report the effects of this action, Term and Condition #3 requires collecting data from captured sturgeon. Collecting the specified data on captured Atlantic sturgeon will enable NMFS to monitor the number of captures, their condition, and life stage. This information will serve as a check on the assumptions and estimates in our analysis. It will also help ensure proper identification of sturgeon to species. People sometimes confuse Atlantic sturgeon and shortnose sturgeon based on visual inspection. The data to be collected will help us ensure that a shortnose sturgeon is not counted against the take limit for Atlantic sturgeon and that an Atlantic sturgeon will not be mistakenly identified as a shortnose sturgeon and not counted against the take limit. In addition, individuals from different Atlantic sturgeon DPSs cannot be identified to DPS without genetic tests. The data collected will help us do that and, therefore, monitor the incidental take limit for each of the DPSs. The implementation of Term and Condition #4 is necessary and appropriate to preserve any dead Atlantic or shortnose sturgeon so that they are retained and examined to determine the cause of death. Genetic information is important to document which population the fish comes from. Additionally, tissue samples will provide information on contaminants found in the specimen, which may serve as a check on our environmental baseline assessment.

If, during the course of the action, the level of incidental take is exceeded, reinitiation of consultation is required. As explained above, the best available information supports the determination that no lethal take associated with this action is likely to occur from sampling with the herring weir. We do not anticipate the capture of any Atlantic sturgeon in the fyke net.

11.0 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 proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. As such, NMFS recommends that the USFWS and the Passamaquoddy Tribe consider the following Conservation Recommendation:

1. If any sturgeon mortalities occur, USFWS and the Passamaquoddy Tribe should arrange for genetic and contaminant analysis of the specimen. If this recommendation is to be implemented, the fish should be immediately frozen and NMFS's NER should be contacted within 24 hours to provide instructions on shipping and preparation

12.0 REINITIATION NOTICE

This concludes formal consultation on the proposed action. 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. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately. If there is any incidental take of listed shortnose sturgeon or Atlantic salmon, reinitiation would be required.

13.0 LITERATURE CITED

Alden Research Laboratory, Inc. 2012. Atlantic Salmon Survival Estimates At Mainstem Hydroelectric Projects on the Penobscot River. Prepared by S. Amaral, C. Fay, G. Hecker and N. Perkins. 556 pps.

Allen, K.R. 1940. Studies on the biology of the early stages of the salmon (*Salmo salar*): growth in the river Eden. J. Animal Ecol. 9(1):1-23.

Arkoosh, M.R., E. Casillas, E. Clemons, A.N. Kagley, R. Olson, P. Reno, and J.E. Stein. 1998a. Effect of pollution on fish diseases: potential impacts on salmonid populations. Journal of Aquatic Animal Health 10:182-190.

Arkoosh, M.R., E. Casillas, P. Huffman, E. Clemons, J. Evered, J.E. Stein, and U. Varanasi. 1998b. Increased susceptibility of juvenile Chinook salmon from a contaminated estuary to *Vibrio anguillarum*. Transactions of the American Fisheries Society 127: 360-374.

ASA (Analysis and Communication). 2008. 2006 year class report for the Hudson River Estuary

Program prepared for Dynegy Roseton LLC, on behalf of Dynegy Roseton LLC Entergy Nuclear Indian Point 2 LLC, Entergy Nuclear Indian Point 3 LLC, and Mirant Bowline LLC. Washingtonville NY.

Bakshtansky, E.L.,V.D. Nesterov and M.N. Nekludov. 1982. Change in the behaviour of Atlantic salmon (*Salmo salar*) smolts in the process of downstream migration. ICES, 16 pages.

Bain, Mark B., N. Haley, D. L. Peterson, K. K. Arend, K. E. Mills, P. J. Sullivan. 2000. Annual meeting of American fisheries Society. EPRI-AFS Symposium: Biology, Management and Protection of Sturgeon. St. Louis, MO. 23-24 August 2000.

Barr, L.M. 1962. A life history of the chain pickerel, *Esox niger Lesueur*, in Beddington Lake, Maine. M.S. Thesis University of Maine, Orono, ME: 88 pp.

Bates, B.C., Z.W. Kundzewicz, S. Wu, and J.P. Palutikof (Eds.). 2008. Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change (IPCC), IPCC Secretariat, Geneva 1-210.

Battin, J., M. Wiley, M. Ruckelshaus, R. Palmer, E. Korb, K. Bartz, and H. Imaki. 2007. Project impacts of climate change on habitat restoration. Proceedings of the National Academy of Sciences 104, no. 16: 6720-6725.

Baum, E.T. 1997. Maine Atlantic salmon - a national treasure. Atlantic Salmon Unlimited, Hermon, Maine.

Baum, E.T. and A.L. Meister. 1971. Fecundity of Atlantic salmon (*Salmo salar*) from two Maine rivers. J. Fish. Res. Bd. Can. 28(5):7640767.

Beland, K.F., R.M. Jordan and A.L. Meister. 1982. Water depth and velocity preferences of spawning Atlantic salmon in Maine Rivers. North American Journal of Fisheries Management 2:11-13.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers. North Pacific Division.

Berg, L. and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (Oncorhynuchus kisutch) following short-term pulses of suspended sediment. Can. J. Aquat. Sci. 42(8): 1410-1417.

Beaugrand, G. and P. Reid. 2003. Long-term changes in phytoplankton, zooplankton, and salmon related to climate. Global Change Biology 9: 801-817.

Birtwell, I.K, G. Hartman, B. Anderson, D.J. McLeay and J.G. Malik. 1984. A brief investigation of Arctic grayling (Thymallus arcticus) and aquatic invertebrates in the Minto Creek drainage, Mayo, Yukon Territory Can. Tech. Rept. Fish. Aquat. Sci. 1287.

Bjornn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in Meehan, W.R (ed.). 1991. Influences of forest and rangeland management of salmonid fishes and their habitats. Am. Fish. Soc. Special Publication 19. Bethesda, MD.

Blackwell, B.F., W.B. Krohn, N.R. Dube, and A.J. Godin. 1997. Spring prey use by doublecrested cormorants on the Penobscot River, Maine, USA. Colonial Waterbirds 20(1): 77-

Blackwell, B.F. and F. Juanes. 1998. Predation on Atlantic salmon smolts by striped bass after dam passage. North American Journal of Fisheries Management 18: 936-939.

Bley, P.W. 1987. Age, growth, and mortality of juvenile Atlantic salmon in streams: a review. Biological Report 87(4). U.S. Fish and Wildlife Service, Washington, D.C.

Bley, P.W. and J.R. Moring. 1988. Freshwater and ocean survival of Atlantic salmon and steelhead: a synopsis. Biological Report 88(9). Maine Cooperative Fish and Wildlife Research Unit, Orono.

Breau, C., L. Weir and J. Grant. 2007. Individual variability in activity patterns of juvenile Atlantic salmon (Salmo salar) in Catamaran Brook, New Brunswick. Canadian Journal of Fisheries and Aquatic Science 64: 486-494.

Buckley, J. and B. Kynard. 1985. Habitat use and behavior of pre-spawing and spawning shortnose sturgeon, *Acipenser brevirostrum*, in the Connecticut River. North American Sturgeons: 111-117.

Budy, P., G. P. Thiede, N. Bouwes, C.E. Petrosky, and H. Schaller. 2002. Evidence linking delayed mortality of Snake River salmon to their earlier hydrosystem experience. North American Journal of Fisheries Management 22: 35-51.

Burton, W. 1993. Effects of bucket dredging on water quality in the Delaware River and the potential for effects on fisheries resources. Prepared by Versar, Inc. for the Delaware Basin Fish and Wildlife Management Cooperative, unpublished report. 30 pp.

Chaput, G., Legault, C.M., Reddin, D.G., Caron, F., and Amiro, P.G. 2005. Provision of catch advice taking account of non-stationarity in productivity of Atlantic salmon (Salmo salar L.) in the Northwest Atlantic. ICES Journal of Marine Science, 62: 131-143.

Clews, E., I. Durance, I.P. Vaughan and S.J. Ormerod. Juvenile salmonid populations in a temperate river system track synoptic trends in climate. Global Change Biology 16 (2010): 3271-3283.

Collins, M., K. Lucey, B. Lambert, J. Kachmar, J. Turek, E. Hutchins, T. Purinton, D. Neils. 2007. Stream barrier removal monitoring guide. [Internet]. Gulf of Maine Council on the Marine Environment. [cited 9 February 2011]. Available from: www.gulfofmain.org/streambarrierremoval.

Cunjak, R.A. 1988. Behavior and microhabitat of young Atlantic salmon (*Salmo sala*r) during winter. Can. J. Fish. Aquat. Sci. 45(12): 2156-2160.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* Lesueur 1818. NOAA Technical Report, NMFS 14, National Marine Fisheries Service. October 1984 45 pp.

Dadswell, M.J. 2010. Occurrence and migration of fishes in minas passage and their potential for tidal turbine interaction.

Dadswel, M.J. and M.J. Stokesbury. 2013. First verified record for Shortnose sturgeon, Acipenser brevirostrum LeSueur, 1818, IN MINAS BASIN, BAY OF FUNDY, NOVA SCOTIA, CANADA Department of Biology, Acadia University Wolfville, NS Canada B4P 2R6. Proceedings of the Nova Scotian Institute of Science (2013) Volume 47, Part 2, pp. 273-279.

Danie, D.S., J.G. Trial, and J.G. Stanley. 1984. Species profiles: life histories and environmental requirements of coastal fish and invertebrates (North Atlantic) – Atlantic salmon. U.S. Fish Wildl. Serv. FW/OBS-82/11.22. U.S. Army Corps of Engineers, TR EL-82-4. 19 pp.

Dempson, J.B., M.F. O'Connell, and M. Shears. 1996. Relative production of Atlantic salmon from fluvial and lacustrine habitats estimated from analyses of scale characteristics. J. Fish Biol. 48: 329-341

deGaudemar B., Beall E. 1998. Effects of overripening on spawning behaviour and reproductive success of Atlantic salmon females spawning in a controlled flow channel. J Fish Biol 53:434-446.

DeVore, P.W., L.T. Brooke, and W.A. Swenson. 1980. The effects of red clay turbidity and sedimentation on aquatic life in the Nemadji River System. Impact of nonpoint pollution control on western Lake Superior. EPA Report 905/9-79-002-B. U.S. Environmental Protection Agency, Washington, D.C.

Dolat, S.W. 1997. Acoustic measurements during the Baldwin Bridge Demolition. Sonalysts, Inc. Waterford, CT.

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

Drinkwater, K., A. Belgrano, A. Borja, A. Conversi, M. Edwards, C. Greene, G. Ottersen, A. Pershing and H. Walker. 2003. The Response of Marine Ecosystems to Climate Variability Associated with the North Atlantic Oscillation. Geophysical Monograph 134: 211-234.

Dube, N.R. 1988. Penobscot River 1987 radio telemetry investigations. Maine Atlantic Sea-Run

Salmon Commission. Bangor, ME. 22 pp. and appendices.

Dutil, J.D. and J.M. Coutu. 1988. Early marine life of Atlantic salmon, *Salmo salar*, postsmolts in the northern Gulf of St. Lawrence. Fish. Bull. 86(2):197-211.

Dyer, C., Wehrell, S. and G. Dearborn. 2005. Fisheries Management Issues in the Upper Bay of Fundy. Acadia Centre for Estuarine Research, Acadia University.

Elliott, J.M. 1991. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*. Fresh. Biol. 25:61-70.

Elliot, S., T. Coe, J. Helfield and R. Naiman. 1998. Spatial variation in environmental characteristics of Atlantic salmon (Salmo salar) rivers. Canadian Journal of Fisheries and Aquatic Sciences 55, suppl. 1: 267-280.

Erkinaro, J., Y. Shustov, and E. Niemelä. 1995. Enhanced growth and feeding rate in Atlantic salmon parr occupying a lacustrine habitat in the river Utsjoki, northern Scandinavia. J. Fish Bio. 47(6): 1096-1098.

Erkinaro, J., E. Niemelä, A. Saari, Y. Shustov, and L. Jøgensen. 1998. Timing of habitat shift by Atlantic salmon parr from fluvial to lacustrine habitat: analysis of age distribution, growth, and scale characteristics. Can. J. Fish. Aquat. Sci. 55: 2266-2273.

Fay, C., M. Bartron, S. Craig, A. Hecht, J. Pruden, R. Saunders, T. Sheehan, and J. Trial. 2006. Status review for anadromous Atlantic salmon (*Salmo salar*) in the United States. Report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. 294 pages.

Fisheries Hydroacoustic Working Group (FHWG). 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities. Memorandum signed June 12, 2008.

Food and Agriculture Organization of the United Nations (FAO). 2012. Species Fact Sheets, Salmo salar. FAO Fisheries and Aquaculture Department. http://www.fao.org/fishery/species/2929/en (Accessed June 18, 2012).

Foster, N.W. and C.G. Atkins. 1869. Second report of the Commissioners of Fisheries of the state of Maine 1868. Owen and Nash, Printers to the State, Augusta, ME.

Friedland, K.D., D.G. Redding, and J.F. Kocik. 1993. Marine survival of N. American and European Atlantic salmon: effects of growth and environment. ICES J. of Marine Sci. 50**:** 481-492.

Friedland, K. 1998. Ocean climate influences on critical Atlantic salmon (Salmo salar) life history events. Canadian Journal of Fisheries and Aquatic Sciences 55, suppl. 1: 119-130.

Friedland, K.D., J.-D. Dutil, and T. Sadusky. 1999. Growth patterns in postsmolts and the nature of the marine juvenile nursery for Atlantic salmon, *Salmo salar*. Fish. Bull. 97**:** 472-481.

Friedland, K.D., D.G. Reddin, and M. Castonguay. 2003. Ocean thermal conditions in the post-smolt nursery of North American Atlantic salmon. ICES Journal of Marine Scienc. 60: 343-355.

Gibson, R.J. 1993. The Atlantic salmon in freshwater: spawning, rearing, and production. Reviews in Fish Biology and Fisheries. 3(1):39-73.

Gorsky, D. 2005. Site fidelity and the influence of environmental variables on migratory movements of adult Atlantic salmon (Salmo salar) in the Penobscot River basin, Maine. Master's thesis. University of Maine, Orono.

Greene CH, Pershing AJ, Cronin TM and Ceci N. 2008. Arctic climate change and its impacts on the ecology of the North Atlantic. Ecology 89:S24-S38

Gulf of Maine Council on the Marine Environment (GMCME). 2010. Gulf of Maine. 2005-2010. [Internet]. [Cited 7 December 2010]. Available from: http://www.gulfofmaine.org/.

Gustafson-Greenwood, K. I., and J. R. Moring. 1991. Gravel compaction and permeabilities in redds of Atlantic salmon, *Salmo salar* L. Aquaculture and Fisheries Management 22:537-540.

Gustafson-Marjanan, K. I., and H. B. Dowse. 1983. Seasonal and diel patterns of emergence from the redd of Atlantic salmon (*Salmo salar*) fry. Can. J. Fish.Aquat. Sci. 40**:** 813-817.

Haeseker, S. L., J. A. McCann, J. Tuomikoski, B. Chockley. 2012. Assessing Freshwater and Marine Environmental Influences on Life-Stage-Specific Survival Rates of Snake river Spring-Summer Chinook Salmon and Steelhead. Transactions of the American Fisheries Society 141:121-138.

Haines, T. A. 1992. New England's rivers and Atlantic salmon. Pages 131-139 in R. H. Stroud (ed.) Stemming the tide of coastal fish habitat loss. National Coalition for Marine Conservation, Savannah, Georgia.

Halvorsen, M. & Svenning, M.-A. 2000. Growth of Atlantic salmon parr in fluvial and lacustrine habitats. J. Fish Biol. 57**:** 145–160.

Heggenes, J. 1990. Habitat utilization and preferences in juvenile Atlantic salmon (*Salmo salar*) in streams. Regulated Rivers: Research and Management 5(4): 341-354.

Hendry, K., D. Cragg-Hine, M. O'Grady, H. Sambrook, and A. Stephen. 2003. Management of habitat for rehabilitation and enhancement of salmonid stocks. Fisheries Research 62: 171-192.

Herbert, D. W., and J. C. Merkens. 1961. The effect of suspended mineral solids on the survival of trout. International Journal of Air and Water Pollution 5: 46-55.

Hiscock, M. J., D. A. Scruton, J. A. Brown, and C. J. Pennell. 2002. Diel activity pattern of juvenile Atlantic salmon (*Salmo salar*) in early and late winter. Hydrobiologia 483: 161-165.

Hoar W.S. 1988. The physiology of smolting salmon. Pages 275–343 in W.S. Hoar and D.J. Randall (eds.), *Fish Physiology XIB*, Academic Press, New York.

Hulme, P.E. 2005. Adapting to climate change: is there scope for ecological management in the face of global threat? Journal of Applied Ecology 43: 617-627.

Hutchings, J.A. 1986. Lakeward migrations by juvenile Atlantic salmon, *Salmo salar*. Can. J. Fish. Aquat. Sci. 43(4**):** 732-741.

Hyvarinen, P., P. Suuronen and T. Laaksonen. 2006. Short-term movement of wild and reared Atlantic salmon smolts in brackish water estuary – preliminary study. Fish. Mgmt. Eco. 13(6): 399 –401.

Independent Scientific Advisory Board for the Northwest Power and Conservation Council (ISAB). 2007. Latent Mortality Report: Review of hypotheses and causative factors contributing to latent mortality and their likely relevance to the "Below Bonneville" component of the COMPASS model. *Independent Scientific Advisory Board,* April 6, 2007 (revised June 11, 2007) ISAB 2007-1.

Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report. Valencia, Spain.

Jackson, D. A. 2002. Ecological Effects of Micropterus Introductions: The Dark Side of Black Bass. In Black Bass: Ecology, Conservation, and Management. American Fisheries Society Symposium No. 31:221-232.

Jordan, R.M. and K.F. Beland. 1981. Atlantic salmon spawning and evaluation of natural spawning success. Atlantic Sea Run Salmon Commission. Augusta, ME. 26 pp.

Juanes, F., S. Gephard and K. Beland. 2004. Long-term changes in migration timing of adult Atlantic salmon (Salmo salar) at the southern edge of the species distribution. Canadian Journal of Fisheries and Aquatic Sciences 61: 2392-2400.

Kalleberg, H. 1958. Observations in a stream tank of territoriality and competition in juvenile salmon and trout (*Salmo salar* L. and *S. trutta* L.). Report/Institute of Fresh-Water Research, Drottningholm 39:55-98.

Karl, T., J. Melillo and T. Peterson (Eds.) Global Climate Change Impacts in the United States. 2009. U.S. Global Change Research Program (USGCRP), Cambridge University Press.

Kieffer, M.C. and B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 1221: 1088-1103.Klemetsen, A., P.A. Amundsen, J.B. Dempson, B. Jonsson, N. Jonsson, M.F. O'Connell, and E.

Mortensen. 2003. Atlantic salmon *Salmon salar* (L.), brown trout *Salmo trutta* (L.) and Arctic charr *Salvelinus alpinus* (L.): a review of aspects of their life histories. Ecology of Freshwater Fish 12(1):1-59.

Kleinschmidt Associates. 2010. 2010 Dam survey of the Penobscot and Merrymeeting Bay SHRU. Unpublished data.

Lacroix, G.L. and McCurdy, P. 1996. Migratory behavior of post-smolt Atlantic salmon during initial stages of seaward migration. J. Fish Biol. 49, 1086-1101.

Lacroix, G. L, McCurdy, P., Knox, D. 2004. Migration of Atlantic salmon post smolts in relation tohabitat use in a coastal system. Trans. Am. Fish. Soc. 133(6**):** pp. 1455-1471.

Lacroix, G. L. and D. Knox. 2005. Distribution of Atlantic salmon (*Salmo salar*) postsmolts of different origins in the Bay of Fundy and Gulf of Maine and evaluation of factors affecting migration, growth and survival. Can. J. Fish. Aquat. Sci. 62(6): 1363- 1376.

Legault, C.M. 2004. Population viability analysis of Atlantic salmon in Maine, USA. Transactions of the American Fisheries Society, 134: 549-562.

Lehodey, P., J. Alheit, M. Barange, T. Baumgartner, G. Beaugrand, K. Drinkwater, J.M. Fromentin, S.R. Hare, G. Ottersen, R.I. Perry. 2006. Climate Variability, Fish, and Fisheries. American Meteorological Society. 19: 5009-5030.

Lloyd, D. S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7:34-45.

Lloyd, D. S., J. P. Koenings, and J. D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

Lundqvist, H. 1980. Influence of photoperiod on growth of Baltic salmon parr (*Salmo salar* L.) with specific reference to the effect of precocious sexual maturation. Can. J. Zool. 58(5):940-944.

Maine Department of Environmental Protection. 2012. 2010 Integrated Water Quality Monitoring and Assessment Report. 204 pp.

Maine Department of Inland Fisheries and Wildlife (MDIFW). 2002. Fishes of Maine. Augusta, ME. 38 pp.

Marschall, E.A., T.P. Quinn, D.A. Roff, J. A. Hutchings, N.B. Metcalfe, T.A. Bakke, R.L.Saunders and N.LeRoy Poff. 1998. A Framework for understanding Atlantic salmon (*Salmo salar*) life history. Can. J. Fish. Aquat. Sci**.** 55(Suppl. 1**):** 48-58.

McLeay, D.J., G.L. Ennis, I.K. Birtwell, and G.F. Hartman. 1984. Effects on Arctic grayling (Thymallus arcticus) of prolonged exposure to Yukon placer mining sediment: a laboratory study. Yukon River Basin Study. Canadian Technical Report of Fisheries and Aquatic Sciences 1241.

McLeay, D.J., I.K. Birtwell, G.F. Hartman, and G.L. Ennis. 1987. Responses of Arctic grayling, Thymallus arcticus, to acute and prolonged exposure to Yukon placer mining sediment. Can. J. Fish. Aquat. Sci. 44: 658–673.

McCormick, S.F. and R.L. Saunders. 1987. Preparatory physiological adaptation for marine life of salmonids: osmoregulation, growth, and metabolism. Common strategies of anadromous and catadromous fishes. Proceedings of an International Symposium held in Boston, MA, USA, March 9-13, 1986. American Fisheries Society. 1:211-229.

McCormick S.D., L.P. Hansen, T. Quinn, and R. Saunders. 1998. Movement, migration, and smolting of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. **55**(Suppl. 1): 77-92.

McCormick, S. D., R. A. Cunjak, B. Dempson, M. F. O'Dea, and J. B. Carey. 1999. Temperature-related loss of smolt characteristics in Atlantic salmon (*Salmo salar*) in the wild. Canadian Journal of Fisheries and Aquatic Sciences 56(9): 1649-1658.

McLaughlin, E. and A. Knight. 1987. Habitat criteria for Atlantic salmon. Special Report, U.S. Fish and Wildlife Service, Laconia, New Hampshire. 18 pp.

Meister, A.L. 1958. The Atlantic salmon (*Salmo salar*) of Cove Brook, Winterport, Maine. M.S. Thesis. University of Maine. Orono, ME. 151 pp.

Murdoch, P. S., J. S. Baron, and T. L. Miller. 2000. Potential effects of climate change on surface-water quality in North America. JAWRA Journal of the American Water Resources Association, 36: 347–366

Murphy, B.R. and D.W. Willis, editors. 1996. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

National Assessment Synthesis Team (NAST). 2008. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, US Global Change Research Program, Washington DC, http://www.usgcrp.gov/usgcrp/Library/nationalassessment/1IntroA.pdf

National Marine Fisheries Service (NMFS). 2005. Salmon at the River’s End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon. NOAA Technical Memorandum NMFS-NWFSC-68. 279pp.

National Marine Fisheries Service (NMFS). 2009. Endangered and threatened species; designation of critical habitat for Atlantic salmon Gulf of Maine distinct population segment. Federal Register 74 (117): 29300-29341.

National Marine Fisheries Service (NMFS). Atlantic Salmon Recovery Team. 2010. Atlantic

salmon recovery framework. Draft.2010.
http://www.nero.noaa.gov/prot_res/altsalmon/FrameworkWorkingDraft081110-1.pdf

National Marine Fisheries Service (NMFS). 2011. Atlantic Salmon Fate and Straying at Upstream Fish Passage Facilities on the Penobscot River. Summary of an expert panel convened on December 8, 2010 at the Maine Field Station of the Northeast Regional Office.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2005. Recovery plan for the Gulf of Maine distinct population segment of the Atlantic salmon (*Salmo salar*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2009. Endangered and threatened species; Determination of endangered status for the Gulf of Maine distinct population segment of Atlantic salmon. Federal Register 74 (117):29344-29387.

National Oceanic and Atmospheric Administration (NOAA). 2010. Internal non-federal database of dams. Unpublished data.

National Science and Technology Council (NSTC). 2008. Scientific Assessment of the Effects of Global Change on the United States. A report of the Committee on Environment and Natural Resources, Washington, DC.

Newcombe, C.P. and T.O.T. Jensen. 1996. Channel Suspended Sediment and Fisheries: A synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16(4): 693-716

Newcombe, C.P., and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. N. Am. J. Fish. Manage. 11:72–82.

Normandeau Associates, Inc. 2011. A review of the Weston Project on the Kennebec River, Maine on Atlantic salmon (*Salmo salar*) smolts and kelt downstream passage and adult upstream passage. Prepared for FPL Energy Maine Hydro, Hallowell, ME. April 2011.

National Research Council (NRC). 2004. Atlantic Salmon in Maine. National Academy Press. Washington, D.C. 304 pp.

O'Connell, M.F. and E.G.M. Ash. 1993. Smolt size in relation to age at first maturity of Atlantic salmon (*Salmo salar*): the role of lacustrine habitat. J. Fish Biol. 42(4):551-569.

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

Pepper, V.A. 1976. Lacustrine nursery areas for Atlantic salmon in Insular Newfoundland. Fishereis and Marine Service Technical Report 671. 61 pp.

Pepper, V.A., N.P. Oliver, and R. Blunden. 1984. Lake surveys and biological potential for natural lacustrine rearing of juvenile Atlantic salmon (*Salmo salar*) in Newfoundland. Canadian Technical Report of Fisheries and Aquatic Sciences 1295. 72 pp.

Pizzuto, J. 2002. Effects of dam removal on river form and process. Bioscience 52(8):683-691.

Popper AN, Fay RR, Platt C, Sand O. 2003. Sound detection mechanisms and capabilities of teleost fishes. In: Collin SP, Marshall NJ (eds) Sensory Processing in Aquatic Environments. New York: Springer-Verlag, pp. 3–38.

Randall, R.G. 1982. Emergence, population densities, and growth of salmon and trout fry in two New Brunswick streams. Can. J. Zool. 60(10):2239-2244.

Reddin, D.G. 1985. Atlantic salmon (*Salmo salar*) on and east of the Grand Bank. J. Northwest Atl. Fish. Soc. 6(2):157-164.

Reddin, D.G. 1988. *Ocean* life of Atlantic salmon *(Salmo salar L*.) in the Northwest Atlantic. pp. 483 – 511. in D. Mills and D. Piggins [eds.] *Atlantic Salmon: Planning for the Future.* Proceedings of the 3rd International Atlantic Salmon symposium.

Reddin, D.G and K.D. Friedland. 1993. Marine environmental factors influencing the movement and survival of Atlantic salmon. 4th Int. Atlantic Salmon Symposium. St. Andrews, N.B. Canada.

Reddin, D.G. and W.M. Shearer. 1987. Sea-surface temperature and distribution of Atlantic salmon in the Northwest Atlantic Ocean. Am. Fish. Soc. Symp.

Reddin, D.G and P.B. Short. 1991. Postsmolt Atlantic salmon (*Salmo salar*) in the Labrador Sea. Can. J. Fish Aquat. Sci.. 48: 2-6.

Reddin, D.J., D.E. Stansbury, and P.B. Short. 1988. Continent of origin of Atlantic salmon (*Salmo salar* L.) caught at West Greenland. Journal du Conseil International pour l'Eploration de la Mer, 44**:** 180-8.

Redding, J.M., C.B. Shreck, and F.H. Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Transactions of the. American Fisheries Society 116: 737–744.

Riley, W.D., D.L. Maxwell, M.G. Pawson, and M.J. Ives. 2009. The effects of low summer flow on wild salmon (Salmo salar), trout (Salmo trutta), and grayling (Thymallus thymallus) in a small stream. Freshwater Biology 54: 2581-2599.

Ritter, J.A. 1989. Marine migration and natural mortality of North American Atlantic salmon *(Salmo salarL*.). Can. MS Rep. Fish. Aquat. Sci.. No. 2041. 136 p.

Ruggles, C.P. 1980. A review of downstream migration of Atlantic salmon. Canadian Technical Report of Fisheries and Aquatic Sciences. Freshwater and Anadromous Division.

Scannell, P. O. 1988. Effects of elevated sediment levels from placer mining on survival and Behavior of immature arctic grayling. Alaska Cooperative Fishery Unit, University of Alaska. Unit Contribution 27.

Schaffer, W.M. and P.F. Elson. 1975. The adaptive significance of variations in life history among local populations of Atlantic salmon in North America. Ecology 56:577-590.

Schaller, H. A. and C. E. Petrosky. 2007. Assessing hydrosystem influence on delayed mortality of Snake River Stream-Type Chinook salmon. North American Journal of Fisheries Management 27:810–824.

Scott, W.B. and E.J. Crossman. 1973. Atlantic salmon. Pages 192-197 in Freshwater Fishes of Canada (Bulletin 184). Department of Fisheries and Oceans, Scientific Information and Publications Branch, Ottawa.

Servizi, J.A., and D.W. Martens. 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon, Oncorhynchus kisutch. Canadian Journal of Fisheries and Aquatic. Sciences. 48: 493–497.

Shelton, R.G.J., J.C. Holst, W.R. Turrell, J.C. MacLean, I.S. McLaren. 1997. Young Salmon at Sea. In Managing Wild Atlantic Salmon: New Challenges – New Techniques. Whoriskey, F.G and K.E.Whelan. (eds.). Proceedings of the Fifth Int. Atlantic Salmon Symposium, Galway, Ireland.

Shortnose Sturgeon Status Review Team. 2010. A Biological Assessment of shortnose sturgeon (Acipenser brevirostrum). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and Coho salmon. Transactions of the American Fisheries Society. 113: 142-150.

Snyder, D.E. 2003. Electrofishing and its harmful effects on fish. Information and Technology Report USGS/BRD/ITR-2003-0002. U.S. Government Printing Office, Denver, CO. 149 pp.

Spence, B.. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis OR. (Available from the National Marine Fisheries Service, Portland, Oregon.)

Spidle, A.P., S.T. Kalinowski, B., A. Lubinski, D.L. Perkins, K.F. Beland, J.F. Kocik, and T.L. King. 2003. Population structure of Atlantic salmon in Maine with references to populations from Atlantic Canada. Trans. Am. Fish. Soc. 132:196-209.

Stadler, J and D.P Woodbury. 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. Internoise 2009: Innovations in practical noise control. Ottawa, Canada. August 23-26 2009.

Swansburg, E., G. Chaput, D. Moore, D. Caissie, and N. El-Jabi. 2002. Size variability of juvenile Atlantic salmon: links to environment conditions. J. Fish Biol. 61**:** 661-683.

Taubert, B.D., and M.J. Dadswell. 1980. Description of some larval shortnose sturgeon (Acipenser brevirostrum) from the Holyoke Pool, Connecticut River, Massachusetts, USA, and the Saint John River, New Brunswick, Canada. Canadian Journal of Zoology 58:1125-1128.

Trial, J.G. 2012. February 3, 2012 letter to Laury Zicari (Service) documenting Maine Department of Marine Resources (MDMR) activities authorized under Regional Endangered Species blanket permit #697823 for the take of Atlantic salmon under the Endangered Species Act during 2011 activities.

Turnpenny, A W. H., K. P Thatcher, and J. R Nedwell. 1994. The effects on fish and other marine animals of high-level underwater sound." Report FRR 127/94, Fawley Aquatic Research Laboratories, Ltd., Southampton, UK.

U.S. Army Corps of Engineers (USACE). 2005. National inventory of dams. [Internet]. [cited 19 January 2011]. Available from: http://www.usace.army.mil/Library/Maps/Pages/National InventoryofDams.aspx.

U.S. Atlantic Salmon Assessment Committee (USASAC). Annual reports between 2001 and 2012. Annual Report of the U.S. Atlantic Salmon Assessment Committee.

U.S. Fish and Wildlife Service (USFWS). 2012a. Draft Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon (*Salmo salar*). April 2012. 142 pgs.

U.S. Fish and Wildlife Service (USFWS). 2012b. Technical Memorandum: Assumptions Used and Verification Process for the Development of the Black Bear Hydro Species Projection Plan. Maine Field Office, Orono, Maine. 66 pgs.

Van den Ende, O. 1993. Predation on Atlantic salmon smolts (*Salmo salar*) by smallmouth bass (*Micropterus dolomeiu*) and chain pickerel (*Esox niger*) in the Penobscot River, Maine. M.S. Thesis. University of Maine. Orono, ME. 95 pp.

Whalen, K. G., D. L. Parish, and M. E. Mather. 1999. Effect of ice formation on selection habitats and winter distribution of post-young-of-the-year Atlantic salmon parr. Can. J. Fish. Aquat. Sci. 56(1): 87-96.

Wheaton, J. M., G. B. Pasternack, and J. E. Merz. 2004. Spawning habitat rehabilitation-I. Conceptual approach and methods. International Journal of River Basin

Management 2(1): 3-20.

White, H.C. 1942. Atlantic salmon redds and artificial spawning beds. J. Fish. Res. Bd. Can. 6:37-44.

Windsor, M. L., P. Hutchinson, L.P. Hansen and D. G. Reddin. 2012. Atlantic salmon at sea: Findings from recent research and their implications for management. NASCO document CNL(12)60. Edinburgh, UK. 20pp.

Wood, H., J. Spicer and S. Widdicombe. 2008. Ocean acidification may increase calcification rates, but at a cost. Proceedings of the Royal Society: Biological Sciences 275, no. 1644: 1767-1773.

Wright, J., J. Sweka, A. Abbott, and T. Trinko. 2008. GIS-Based Atlantic Salmon Habitat Model. *Appendix C in*: NMFS (National Marine Fisheries Service). 2008. Biological valuation of Atlantic salmon habitat within the Gulf of Maine Distinct Population Segment. NOAA National Marine Fisheries Service, Northeast Regional Office, Gloucester, MA.

Wysocki, L.E., J.W. Davidson III, M.E. Smith, A.S. Frankel, W.T. Ellison, P.M. Mazik, A.N. Popper, J. Bebak. 2007. Effects of aquaculture production noise on hearing, growth, and disease resistance of rainbow trout Oncorhynchus mykiss. Aquaculture 272:687–697

APPENDIX A

STURGEON DATA COLLECTION FORM

For use in documenting sturgeon injury or mortality incidental to a federal action

OBSERVER'S CONTACT INFORMATION

Name: First ________________ Last ________________________

Agency Affiliation ________________ Email________________________

Address ____

____

Area code/Phone number ______________________________________

SEC 7 UNIQUE IDENTIFIER (PCTS No. Assigned by NMFS)

DATE REPORTED:

Month ☐☐ Day☐☐ Year 20☐☐

DATE EXAMINED:

Month ☐☐ Day☐☐ Year 20☐☐

SPECIES: (check one)

☐ shortnose sturgeon
☐ Atlantic sturgeon
☐ Unidentified *Acipenser* species

Check "Unidentified" if uncertain . See reverse side of this form for aid in identification.

LOCATION FOUND: ☐Offshore (Atlantic) ☐Inshore (bay, river, sound, inlet, etc)

River/Body of Water________________ City________________________ State ____

Descriptive location (be specific)____

____

____

Latitude _______________N (Dec. Degrees) Longitude _______________ W (Dec. Degrees)

CARCASS CONDITION at time examined: (check one)

☐ 1 = Fresh dead
☐ 2 = Moderately decomposed
☐ 3 = Severely decomposed
☐ 4 = Dried carcass
☐ 5 = Skeletal, scutes & cartilage

SEX:

☐ Undetermined
☐ Female ☐ Male

How was sex determined?

☐ Necropsy
☐ Eggs/milt present when pressed
☐ Borescope

MEASUREMENTS: Circle unit

Fork length	_________	cm / in
Total length	_________	cm / in
Length ☐ actual ☐ estimate		
Mouth width (inside lips, see reverse side)	_________	cm / in
Interorbital width (see reverse side)	_________	cm / in
Weight ☐ actual ☐ estimate	_________	kg / lb

TAGS PRESENT? Examined for external tags including fin clips? ☐ Yes ☐ No Scanned for PIT tags? ☐ Yes ☐ No

Tag #	Tag Type	Location of tag on carcass
____________	____________	____________
____________	____________	____________

CARCASS DISPOSITION: (check one or more)

☐1 = Left where found
☐2 = Buried
☐3 = Collected for necropsy/salvage
☐4 = Frozen for later examination
☐5 = Other (describe) ________________________

Carcass Necropsied?

☐Yes ☐No

Date Necropsied:____________

Necropsy Lead:

____

PHOTODOCUMENTATION:

Photos/vide taken? ☐ Yes ☐ No

Disposition of Photos/Video:__________

____

____

SAMPLES COLLECTED? ☐ Yes ☐ No

Sample	How preserved	Disposition (person, affiliation, use)
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

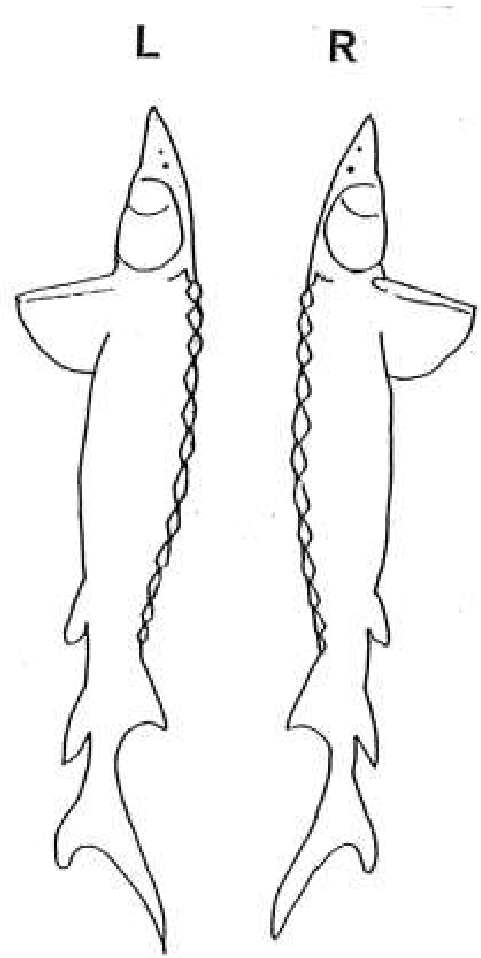
Comments:

____

____

____

Draw wounds, abnormalities, tag locations on diagram and briefly describe below



Describe any wounds / abnormalities (note tar or oil, gear or debris entanglement, propeller damage, etc.). **Please note if no wounds / abnormalities are found.**

____

____

____

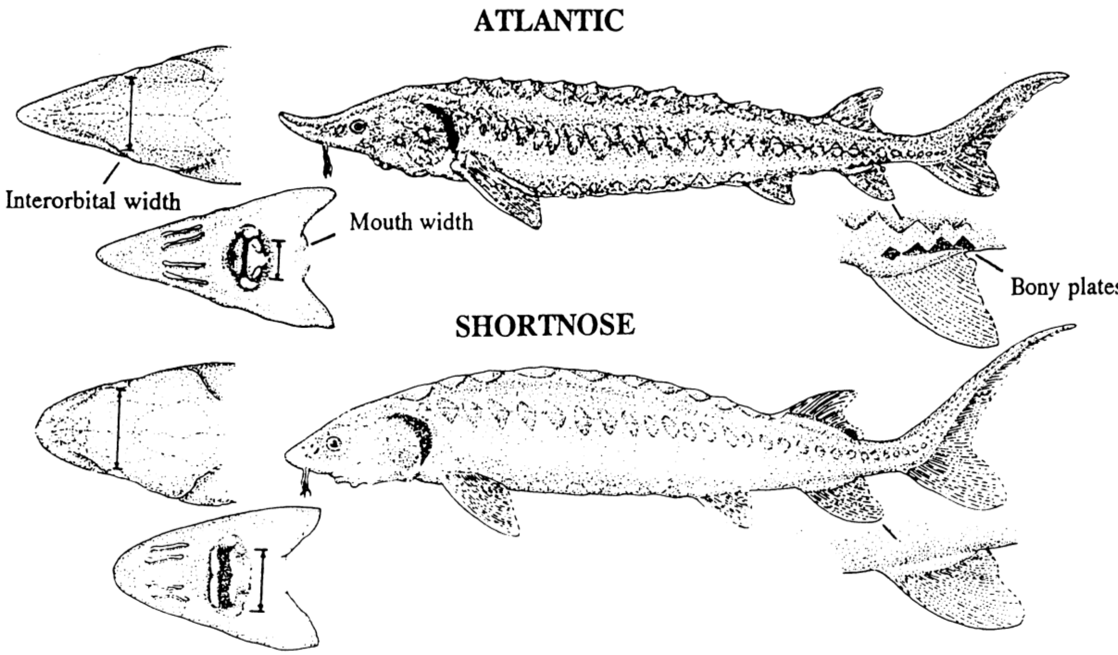
____

____

Submit completed forms (within 24 hours of observation of fish): by email to Incidental.Take@noaa.gov or by fax (978-281-9394). Questions can be directed to NMFS Protected Resources Division at 978-281-9328.

Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service (NOAA Fisheries) on this form will be released to the requestor provided that the requestor credit the collector of the information and NOAA Fisheries. NOAA Fisheries will notify the collector that these data have been requested and the intent of their use.

Appendix A continued
Sturgeon Identification



Distinguishing Characteristics of Atlantic and Shortnose Sturgeon

Characteristic	Atlantic Sturgeon, *Acipenser oxyrinchus*	Shortnose Sturgeon, *Acipenser brevirostrum*
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth	Football shaped and small. Width inside lips < 55% of bony interorbital width	Wide and oval in shape. Width inside lips > 62% of bony interorbital width
*Pre-anal plates	Paired plates posterior to the rectum & anterior to the anal fin.	1-3 pre-anal plates almost always occurring as median structures (occurring singly)
Plates along the anal fin	Rhombic, bony plates found along the lateral base of the anal fin (see diagram below)	No plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004

APPENDIX B

Procedure for obtaining fin clips from sturgeon for genetic analysis

Obtaining Sample

1. Wash hands and use disposable gloves. Ensure that any knife, scalpel or scissors used for sampling has been thoroughly cleaned and wiped with alcohol to minimize the risk of contamination.

2. For any sturgeon, after the specimen has been measured and photographed, take a one-cm square clip from the pelvic fin.

3. Each fin clip should be placed into a vial of 95% non-denatured ethanol and the vial should be labeled with the species name, date, name of project and the fork length and total length of the fish along with a note identifying the fish to the appropriate observer report. All vials should be sealed with a lid and further secured with tape Please use permanent marker and cover any markings with tape to minimize the chance of smearing or erasure.

Storage of Sample

1. If possible, place the vial on ice for the first 24 hours. If ice is not available, please refrigerate the vial. Send to the NMFS-approved lab for processing to determine DPS or river of origin per the agreement you have with that facility.