NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agency: Endangered Species Conservation Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Activity Considered: Biological Opinion on the Office of Protected Resources' proposal to issue an Incidental Take Permit for Atlantic sturgeon affected by North Carolina's inshore anchored gill net fishery pursuant to section 10(a)(1)(B) of the Endangered Species Act of 1973.

Consultation Conducted by: Endangered Species Act Interagency Cooperation Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Approved by: Donna S Wieting

Date: JUL 09 2014

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. 1531 *et seq.*) requires that each federal agency ensure any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or its designated critical habitat, that action agency is required to consult with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the listed species that may be affected.

This document represents NMFS' biological opinion (Opinion) on the issuance of an incidental take permit, and has been prepared in accordance with section 7(b) of the ESA. The permit authorizes the take of threatened and endangered Atlantic sturgeon incidental to otherwise lawful commercial fishing in the State of North Carolina as those fisheries are managed by the State under commercial fishing regulations. This Opinion is based on our review of the North Carolina Division of Marine Fisheries (NCDMF) Conservation Plan contained in the Application for an Individual Incidental Take Permit (ITP) for Atlantic sturgeon under the Endangered Species Act of 1973 (herein Conservation Plan) (NCDMF 2014), draft Implementing Agreement, the most current Atlantic sturgeon status review, Atlantic sturgeon listing documents, scientific and technical reports from government agencies and the peer-reviewed literature, biological opinions addressing similar forms of sturgeon take, and other sources of information which together represent the best available scientific information on effects to these species.

A complete administrative record for this consultation is on file at NMFS' Office of Protected Resources (OPR) in Silver Spring, Maryland.

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1. DESCRIPTION OF THE PROPOSED ACTION

The proposed action in this Opinion is OPR's issuance of an individual incidental take permit and approval of a Conservation Plan with an accompanying Implementing Agreement to monitor, minimize, and mitigate, to the maximum extent practicable, impacts of incidental take of Atlantic sturgeon as a result of inshore anchored gill net commercial fisheries bycatch in North Carolina. Fishermen participating in the commercial anchored gill net fisheries deploy gill nets which occasionally result in the unintended bycatch or capture of threatened and endangered Atlantic sturgeon. The State's operation of the commercial fisheries is an otherwise lawful activity. NMFS OPR is authorized to issue incidental take permits under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq*.), and its implementing regulations 50 CFR §203.307, provided, among other things, an applicant submits and commits to implement a Conservation Plan that NMFS determines will monitor, minimize, and mitigate the impacts of the take to the maximum extent practicable. The proposed activities involve incidental take[1] of threatened and endangered Atlantic sturgeon (*Acipenser oxyrinchus*) from the South Atlantic, Carolina, Chesapeake, New York Bight, and Gulf of Maine distinct population segments (DPSs).

NCDMF's conservation plan describes measures to minimize, monitor, and mitigate the incidental take of ESA listed Atlantic sturgeon. The conservation plan includes an adaptive management and monitoring program, fisheries reduction, extensive outreach, additional Atlantic sturgeon research, and timely response to ''hotspots'' where Atlantic sturgeon interactions are unusually high. The adaptive management and monitoring program is intended to change through time and the responsibilities of NMFS and NCDMF are identified in detail in the Implementing Agreement between the two agencies. NCDMF's monitoring program largely is funded through state appropriations and is supplemented through other sources such as the Atlantic Coastal Cooperative Statistics Program and the National Fish and Wildlife Foundation.

1.1 Background

North Carolina's inshore estuarine system is created by a chain of barrier islands that run along nearly the entire coast. These waters are described as the inshore coastal waters of North Carolina. Inlets within these barrier islands allow saline ocean water to mix with fresh water which is provided by a network of river systems to the west. This estuary provides prime habitat for numerous finfish species that are harvested by residents and visitors to North Carolina in both the commercial and recreational fisheries. Commercial and recreational fishermen deploy gill nets in North Carolina's estuarine and ocean waters. Gill net fishing in North Carolina is regulated by NCDMF through proclamations issued by the Director of NCDMF. Existing NCDMF proclamation requirements include mandatory attendance of gill nets in some areas and gear, yardage limits, soak-time restrictions, net shot limits, tie down requirements, closed areas, mesh size restrictions, minimum distance between fishing operations, marking requirements,

[1] The ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." The term "harm" is further defined by regulations (50 CFR §222.102) as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat amendment or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering."

reporting requirement, and monitoring requirements, which are discussed in greater detail below. Gill net fisheries and related restrictions differ throughout the state depending on the season, target species, location, and physical characteristics of water body being fished.

During the fall of 1999, increased sea turtle strandings were noted by the North Carolina Sea Turtle Stranding and Salvage Network in the southeastern portion of Pamlico Sound. As a result, initial monitoring of the gill net fisheries in 1999 identified the large mesh gill net fishery as the probable source of sea turtle interactions in Pamlico Sound during the fall months. With this information, NMFS issued an emergency 30-day rule closing Pamlico Sound to large mesh gill net fishing (≥5 inch stretch mesh) for the end of the 1999 fall season (64 FR 70196, December 16, 1999).

In the fall of 2000, NMFS issued ITP 1259 to NCDMF to manage the deep and shallow water gill net fishery in Pamlico Sound, establishing the Pamlico Sound gill net restricted area (GNRA). The goal of the Conservation Plan for ITP 1259 was for NCDMF to monitor sea turtle interactions in the fall gill net fishery in the Pamlico Sound GNRA and to implement management measures to reduce sea turtle mortality by 50% between September 15 and December 15, 2000, as compared to the levels of take seen in the strandings of 1999. The ITP also set corresponding limits on the allowed levels of observed takes of sea turtles, both lethal and non-lethal takes, and documented strandings.

The NCDMF was forced to close the fishery to gill nets larger than five inch stretch mesh on October 27, 2000 when sea turtle takes exceeded the levels authorized in ITP 1259. However, from October 28 to December 15, 2000, 59 sea turtles stranded within the Pamlico Sound GNRA. It was found that some fisherman reequipped their nets with 4-7/8 inch stretch mesh, to circumvent the closure and continued fishing and targeting flounder. Fisherman using small-mesh gear to target sea trout or mackerel were also unaffected by the closure and continue to fish within the Pamlico Sound GNRA. Due to demonstrated capture and mortality of sea turtles in large-mesh gill nets before the closure, NMFS believed that the continued, unmonitored gill net fishing in and around the Pamlico Sound GNRA after the closure contributed to much of the subsequent sea turtle strandings.

In the fall of 2001, NMFS issued ITP 1348 to NCDMF which authorized the incidental taking of sea turtle in the fall gill net fisheries in Pamlico Sound and mandated further restrictions for the 2001 fishing season. The Conservation Plan for ITP 1348 included the creation of three specified shallow water GNRAs around the inside of the Outer Banks in Pamlico Sound and two inlet corridors at Hatteras and Ocracoke Inlets. Large and small mesh gill net fishing operations in the SGNRAs were required to have a special permit from NCDMF, were required to accept observers, and were required to file weekly reports of fishing catch and effort to NCDMF. On August 22, 2001, NCDMF Director issued a state fisheries proclamation that implemented these management measures, effective September 15, 2001. NMFS published an interim final rule (66 FR 50350, October 3, 2001) restricting fishing with gill nets greater than 4 ¼ inch stretch mesh in Pamlico Sound from September 28 through December 15, 2001. NCDMF permit holders were exempted from the closure if they complied with the ITP conditions required in the NCDMF proclamation.

The ITP 1348 application and Conservation Plan only addressed the gill net fisheries that occur in the shallow water GNRAs and inlet areas. They did not include a requested take authorization or management measures for the large-mesh, deep-water component of the gill net fishery in Pamlico Sound. This component of the fishery used more net per vessel, soaked the nets longer and had higher sea turtle catch and mortality rates in 2000 than the shallow-water components. This deep-water component of the fishery remained closed for the 2001 season.

NMFS then published a final rule the following year on September 6, 2002 (67 FR 56931, September 6, 2002) closing all waters of Pamlico Sound to fishing with gill nets greater than 4 ¼ inch stretch mesh on a seasonal basis from September 1 through December 15 each year. The closed area included all inshore waters of Pamlico Sound, and remains in place.

In the summer of 2002, NMFS issued ITP 1398 to NCDMF which authorized the incidental take of sea turtles in shallow-water, large mesh gill nets in Pamlico Sound for a period of 3 years, including the fall seasons of 2002, 2003 and 2004. ITP 1398 expanded the management area to include waters within 200 yards of the mainland shore of Pamlico and Hyde Counties. The associated Conservation Plan required intensive sea turtle monitoring and a characterization program throughout the Pamlico Sound GNRA from September through December.

In 2005, NMFS issued ITP 1528 to NCDMF which authorized the incidental take of sea turtles in shallow-water, large mesh gill nets in Pamlico Sound for a period of 6 years, including the fall seasons between 2005 and 2010. The conservation plan for ITP 1528 included management measures, restricted and prohibited areas, and monitoring requirements similar to past management actions, as well as several changes from past permits. The changes made to the Pamlico Sound GNRA in 2005 included: establishment of a state closure in addition to the federal closure to provide state jurisdiction and enforcement authority, modification of observer program procedures to better direct resources to times and areas of higher potential for sea turtle interactions, and elimination of the permit requirements along the mainland side of Pamlico Sound due to the small number of interactions in this area NCDMF has monitored the shallow water gill net fishery in Pamlico Sound since 2001.

On February 23, 2010, the Duke Environmental Law and Policy Clinic filed suit against NCDMF and the North Carolina Marine Fisheries Commission on behalf of the Karen Beasley Sea Turtle Rescue and Rehabilitation Center (Beasley Center) for the illegal taking of sea turtles in state regulated inshore gill net fisheries. Negotiations between the parties occurred in the spring of 2010 resulting in a final settlement agreement (Settlement Agreement) between the Beasley Center and NCDMF and the North Carolina Marine Fisheries Commission. As a result of the Settlement Agreement, NCDMF issued proclamation M-8-2010 effective May 15, 2010, implementing the provisions discussed in the Settlement Agreement. Gill net restrictions implemented by the proclamation included: a stretch mesh size range of 4 inch stretch mesh to, and including, 6 ½ inch stretch mesh for large mesh gill nets; soak times limited to overnight soaks an hour before sunset to an hour after sunrise, Monday evenings through Friday mornings; large mesh gill nets were restricted to a height of no more than 15 meshes, constructed with a lead core or leaded bottom line and without corks or floats other than needed for identification; a maximum of 2,000 yards of large mesh gill nets allowed to be used per vessel; and maximum individual net (shot) length of 100 yards with a 25-yard break between shots. Fishermen in the

southern portion of the state were allowed to use floats on nets but were restricted to the use of a maximum of 1,000 yards of large mesh gill net per fishing operation.

The NCDMF submitted an application for an ITP to address sea turtle interactions with set gill nets in North Carolina internal coastal waters on June 14, 2010, with revisions submitted in August 2011 based on comments provided by NMFS.

Five DPSs (Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic) of the Atlantic sturgeon were listed under the ESA on February 6, 2012 (77 FR 5714, 77 FR 5880). As a result on April 5, 2012, NCDMF submitted to NMFS a draft permit application to exempt the take of Atlantic sturgeon incidentally captured in inshore gill net fisheries. The Conservation Plan proposed to protect Atlantic sturgeon is identical to the NCDMF Conservation Plan contained in the Application for an Individual ITP for Sea Turtles but it also contains specific criteria to protect Atlantic sturgeon where necessary.

1.2 Consultation History

This consultation conducted under section 7 of the Endangered Species Act examines NMFS OPR's issuance of an incidental take permit pursuant the section 10(a)(1)(B) of the ESA for take of Atlantic sturgeon incidental to the otherwise lawful inshore anchored gill net fishing activities regulated by NCDMF. North Carolina regulations and the ESA section 10 permit are issued in accordance with the monitoring, minimization, and mitigation measures in North Carolina's proposed Conservation Plan which results in unintended bycatch (i.e., capture) of Atlantic sturgeon in all estuaries and coastal rivers along the North Carolina Coast. NMFS OPR is the Federal action agency for this consultation.

Pre-consultation

When Atlantic sturgeon were listed, NCDMF notified NMFS that Atlantic sturgeon were also taken as bycatch in their inshore gillnet fisheries. The coordination between NMFS and NCDMF proceeded as follows:

- On April 5, 2012, NCDMF provided a draft application for a general ITP under section 10 of the ESA.
- On May 29, 2012, NMFS OPR Endangered Species Conservation Division (ESCD) and NMFS OPR Endangered Species Interagency Cooperation Division (ESA-CD) hosted a conference call to discuss the draft application and share comments with NCDMF.
- On July 23, 2012, OPR provided formal comments to NCDMF.
- On December 19, 2012, NCDMF provided a revised draft application for an individual ITP under section 10 of the ESA.
- On January 15, 2013 OPR provided comments to NCDMF addressing the December 19, 2012 draft application.

- On February 4, 2013, ESCD, ESA-CD, and NCDMF had a conference call to discuss OPR's comments on the December 19, 2012 draft ITP application.

- On April 1, 2013, ESCD, ESA-CD, and NCDMF had a conference call to discuss the draft ITP and introduced the concept of an implementing agreement that would detail how the Conservation Plan will be carried out.

- On April 30, 2013, NCDMF provided an amended application for an individual ITP that addressed OPR's comments.

- On May 15, 2013, ESCD provided NCDMF with an example of how an implementing agreement would be structured.

- On June 5, 2013, NCDMF provided comments and requested more information on the example implementing agreement.

- On June 13, 2013, NCDMF provided a draft implementing agreement to accompany their draft conservation plan.

- On June 28, 2013, NCDMF provided a draft application for an individual ITP along with an implementing agreement. OPR agreed to initiate consultation on this application.

Consultation

After the application was accepted, OPR ESA-CD began working on the Opinion with the following noteworthy actions helping to reach a determination:

- July 9, 2013 NMFS made the NCDMF application and Conservation Plan available for public review and comment. Upon receiving these comments, NMFS requested for NCDMF to make minor modifications to the application.

- On July 11, 2013, ESCD published an environmental assessment on the application from North Carolina for a section 10(a)(1)(B) ITP for Atlantic sturgeon as a result of their inshore anchored gill net fisheries. At the same time, ESCD requested consultation with ESA-CD and ESA-CD agreed to initiate consultation at that time.

- On August 14, 2013, ESA-CD requested the raw data used to estimate Atlantic sturgeon bycatch. The same day, NCDMF provided all of the fisheries monitoring data to ESA-CD.

- On August 28, 2013, ESA-CD requested more information on the 'effort' identified in the raw data and the 'actual effort' presented in Table 6 of the Conservation Plan application.

- On October 1, 2013, the US government shut down and work on this project was suspended.

- On October 17, 2013, the US government re-opened and consultation resumed. A conference call originally scheduled for October 1, was rescheduled for October 23.

- On October 23, 2013, ESA-CD and NCDMF had a conference call to discuss the modeling approach and the estimated take that resulted from the models. This also allowed ESA-CD to clarify the question about the two different 'effort' amounts provided by NCDMF.

- On November 6, 2013, NCDMF provided ESA-CD with a spreadsheet of the actual fisheries effort since 2004, allowing for an independent analysis of the bycatch.

- On December 18, 2013, ESA-CD requested mortality data in addition to bycatch data.

- On January 2, 2014, NCDMF provided the final application for an individual ITP along with an implementing agreement. The final application contained minor modifications as a result of public comment. These modifications were minor because they did not change the conservation plan or projected take request numbers.

- On January 6, 2014, NCDMF provided mortality data to ESA-CD.

1.3 Description of North Carolina's Inshore Gill Net Fisheries

Fisheries within the state of North Carolina are regulated by the NCDMF. Commercial fishermen deploy gill nets in much of North Carolina's estuarine waters. Gill net fisheries and related restrictions differ throughout the state depending on season, target species, location, mesh size and physical characteristics of the water body being fished. The NCDMF can alter the regulations for all inshore gill net fisheries through proclamation (proclamations available at http://portal.ncdenr.org/web/mf/proclamations). All of the fisheries considered in this opinion use anchored gill nets that are deployed with an anchor or stake at one or both ends of the nets and fish from the bottom upward into the water column. Anchored gill nets are considered passive sets meaning they are left in the water to "passively fish" for a period of hours or days before being pulled from the water. For the purpose of this Opinion, the term "gill net" refers to the anchored gill net.

Gill nets may be used to target specific size ranges of fish due to the selectivity of different mesh sizes. Consequently, fishermen use gill nets of different mesh sizes to target different species. Commonly used mesh sizes in North Carolina estuarine waters range from 2.5 inch stretch mesh (ISM) to 6.5 ISM and covers the range of allowable mesh sizes in North Carolina's estuarine waters. Mesh size limitations are established by fisheries rules or NCDMF proclamation. For the purpose of this Opinion, the term "large mesh" refers to fisheries that use greater than five inch stretch mesh nets and the term "small mesh" refers to fisheries that use less than five inch stretch mesh nets.

Large mesh fisheries consist primarily of five target species including southern flounder, striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), and catfishes (*Ictalurus sp*). The most common mesh size for all large mesh gill net fisheries is 5

½ inch stretch mesh. Small mesh gill net operations target a more diverse array of species relative to large mesh gill net fisheries. Mesh sizes generally fall between 3 and 3 ¾ inch stretch mesh. Small mesh gill net fisheries primarily target spot (*Leiostomus xanthurus*), striped mullet (*Mugil cephalus*), bluefish (*Pomatomus saltatrix*), spotted seatrout (*Cynoscion nebulosus*), weakfish (*Cynoscion regalis*), Atlantic menhaden (*Brevoortia tyrannus*), Spanish mackerel (*Scomberomorus maculatus*), white perch (*Morone americana*), and kingfishes (*Menticirrhus sp*). Each of these fisheries occur seasonally in North Carolina, often overlapping to some degree, and affecting Atlantic sturgeon to varying degrees.

Total annual estuarine gill net trips averaged 35,716 from 2001 through 2011. A declining trend in total estuarine commercial fishing trips is reflected in the number of estuarine gill net trips. Estuarine gill net trips declined from a high of 51,000 in 1997 to 25,431 trips in 2011. Gill net landings are responsible for greater than 50% of the total 2011 North Carolina estuarine landings for all of the top ten species except spot. In addition, for six of the top ten species landed from gill nets in estuarine waters in 2011, gill nets were responsible for more than 80% of the total North Carolina estuarine landings for each species.

1.4 Inshore Gill Net Fisheries Management

Commercial gill net fishing is regulated through rules adopted by the North Carolina Marine Fisheries Commission and proclamations issued by the NCDMF director. Regulations on mandatory net attendance, yardage limits, soak-time restrictions, net shot limits, net height tie down requirements, closed areas, mesh size restrictions, minimum distance between fishing operations, marking requirements, and observer requirements vary by location, season, mesh size and target species. Proclamations by NCDMF are binding documents that officially change state fisheries regulations and are issued frequently throughout the year. These management measures are aimed either at reducing discards of undersized finfish or at avoiding incidental capture of protected species.

Large mesh gill net rules

Restrictions on large mesh gill net fishing operations vary spatially and temporally (see Figure 1). Several restrictions were implemented as a result of the Settlement Agreement and NMFS ITP number 16230 that exempted the take of sea turtles in state gill net fisheries. These rules include the following:

- Soak times are restricted to between one hour before sunset on Monday through Thursday and one hour after sunrise from Tuesday through Friday (i.e., fishing is prohibited from one hour after sunrise on Friday through one hour before sunset on Monday) for management units B and D1. Management unit D2 and E are allowed an extra night of fishing (one hour before sunset on Sunday to one hour after sunrise on Monday).
- In management units B and E the maximum yardage is restricted to 2,000 yards per operation. In areas south of the Highway 58 bridge and management units D1 and D2 1,000 yards is maximum. Management unit D1 is also closed to large mesh gill nets each year from May 8 until one hour before sunset on October 14. The state-wide limit is 3,000 yards maximum per operation.
- Net-shot lengths are restricted to 100 yards with a 25 yard separation between each net-shot in Management units B, D1, D2 and E.

- Low profile requirements in management units B, D1, D2 and E include a maximum of 15 meshes in depth, tie-downs prohibited, floats or corks prohibited along float lines north of the Highway 58 bridge.

Small mesh gill net rules

Restrictions on small mesh gill net fishing operations also vary spatially and temporally. Generally there are no permanent restrictions on vertical net height, maximum yardage limits, or tie-down use in small mesh gill net fisheries. The NCDMF has implemented requirements for small mesh net attendance in an effort to avoid bycatch of undersize finfish (such as striped bass and red drum) that vary by location and season. Mandatory net attendance will protect sea turtles but also be expected to reduce mortality among incidentally captured Atlantic sturgeon. Small mesh gill nets in unit A (Figure 1) must be attended at all times if they exceed 800 yards to reduce the bycatch of striped bass, and the allowable mesh sizes less than 4.0 inch stretch mesh are limited. Net attendance for small mesh gill nets of any length is required in the management unit A from May 15th through November 18 and from May 1 through November 30 in primary and secondary nursery areas and in the attended gill net areas along the Outer Banks. Small mesh net attendance is also required for small mesh gill nets from May 1 through October 31 in all areas within 200 yards of any shoreline, the area of the lower Neuse out to the mouth of the river, the shallow grass flats located on the inshore side of the Outer Banks and all primary and secondary nursery areas for red drum (this rule is exempted from Core Sound to the South Carolina state line in October to allow for the fall spot fishery). Year-round attendance is required in the upper reaches of the Pamlico, Pungo, Neuse, and Trent rivers and within 200 yards of shore in the area of the lower Neuse out to the mouth of the river. Additional small mesh gill net rules designed to minimize discards of undersized finfish (such as yardage limits, vertical net height limits and mesh size restrictions) are promulgated by NCDMF in the form of proclamations throughout the year in response to changing environmental conditions.

1.5 Anticipated Take

The NCDMF estimated incidental take of Atlantic sturgeon for their permit application based on large and small mesh inshore fisheries effort observed in 2010 (Tables 1 and 2). The NCDMF amended their fisheries regulations in 2010, which restricted fishing practices in response to the above mentioned law suit by the Duke Environmental Law and Policy Clinic filed against NCDMF and the North Carolina Marine Fisheries Commission. Thus, the effort and level of bycatch before 2010 was higher and is most representative of the maximum fisheries effort likely to occur for the duration of the permit.

The majority of Atlantic sturgeon caught in inshore gill net fisheries in North Carolina are under 750mm (NCDMF 2014). Until future genetic analyses can be completed, NMFS assumes fish in this size range represent juveniles that have originated from rivers within the geographic area and have not migrated. Therefore, we assume juvenile Atlantic sturgeon that are caught in the North Carolina inshore gill net fishery are from the Carolina DPS. A breakdown of fish collected through NCDMF gill net surveys and the Observer Program identifies what proportion could have originated from outside the Carolina DPS based on the 750 mm TL cutoff (NCDMF 2014). Thus, the majority of the take is expected to come from the Carolina DPS, with a smaller fraction from the other DPSs. At this time, data are insufficient to apportion the non-Carolina DPS take

across the Gulf of Maine, New York Bight, Chesapeake, and South Atlantic DPSs (Tables 1 and 2). The Conservation Plan includes tagging of bycaught Atlantic sturgeon and collecting fin clips for genetic testing to identify which DPS the fish came from.

Table 1. Estimated annual incidental take of Atlantic sturgeon in North Carolina's large mesh (≥5.0 ISM) inshore gill net fishery.

Management Unit	Season	Carolina DPS Total Interactions (Mortality)	Other DPS Total Interactions (Mortality)
A	Winter	149 (6)	50 (2)
	Spring	460 (19)	154 (6)
	Summer	157 (6)	52 (2)
	Fall	838 (34)	279 (11)
B	Winter	*2 (1)	--
	Spring	*1 (1)	1 (0)
	Summer	*4 (2)	2 (0)
	Fall	*17 (2)	6 (0)
C	Winter	*2 (1)	--
	Spring	*3 (1)	1 (0)
	Summer	*2 (1)	1 (0)
	Fall	*4 (2)	2 (0)
D	Annual	*8 (2)	--
E	Annual	*8 (2)	--
Total		**1,655 (80)**	**548 (21)**

*Total interaction number represents actual observed and not estimated based on observer coverage. Mortality estimates could not be completed for Management Units B-E due to low take; thus, if observed interactions were ≤ 5 mortality was estimated to be one; if observed interactions were >5 mortality was estimated to be two.

Table 2. Estimated annual incidental take of Atlantic sturgeon in North Carolina's small mesh (≤5.0 ISM) inshore gill net fishery.

Management Unit	Season	Carolina DPS Total Interactions (Mortality)	Other DPS Total Interactions (Mortality)
A	Winter	175 (14)	35 (3)
	Spring	219 (17)	44 (4)
	Summer	72 (6)	14 (1)
	Fall	103 (8)	21 (2)
B	Winter	*2 (1)	--
	Spring	*6 (2)	1 (0)
	Summer	*3 (1)	1 (0)
	Fall	*3 (1)	1 (0)
C	Winter	*2 (1)	--
	Spring	*2 (1)	--
	Summer	*2 (1)	--
	Fall	*2 (1)	--
D	Annual	*8 (2)	--
E	Annual	*8 (2)	--

Management Unit	Season	Carolina DPS Total Interactions (Mortality)	Other DPS Total Interactions (Mortality)
Total		**607 (58)**	**117 (10)**

*Total interaction number represents actual observed and not estimated based on observer coverage. Mortality estimates could not be completed for Management Units B-E due to low take; thus, if observed interactions were ≤ 5 mortality was estimated to be one; if observed interactions were >5 mortality was estimated to be two.

The requested take in the application is based on Atlantic sturgeon interactions and extrapolated depending on fishing effort. Where no interactions occurred in the past, North Carolina estimated that some were likely to occur but had not yet to avoid closing a management area if one sturgeon were caught. The NCDMF anticipates approximately 2,927 Atlantic sturgeon to be captured each year and of those, approximately 169 may die as a result of capture (Table 3). Also, NCDMF plans to adaptively manage the impacts to Atlantic sturgeon via their Conservation Plan, which means there is a chance fisheries effort and sturgeon take will be reduced in the future, if necessary. As a result, NCDMF and NMFS agreed to enter an Implementing Agreement that allows setting reduction targets and changing management, if necessary, based on an analysis of the monitoring data collected over the first three years of the permit.

Table 3. Requested number of incidental takes of Atlantic sturgeon in the inshore gill net fishery for large and small mesh gill net per year for the duration of the permit.

Year	Annual Large Mesh(≥5.0 ISM)		Annual Small Mesh (≤5.0 ISM)		
	Carolina DPS Total Interactions (Mortality)	Other DPS Total Interactions (Mortality)	Carolina DPS Total Interactions (Mortality)	Other DPS Total Interactions (Mortality)	Annual Total Interactions (Mortality)
2013	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2014	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2015	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2016	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2017	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2018	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2019	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2020	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2021	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
2022	1,655 (80)	548 (21)	607 (58)	117 (10)	2,927 (169)
Total	**16,550 (800)**	**5,480 (210)**	**6,070 (580)**	**1,170 (100)**	**29,270 (1,690)**

1.6 Monitoring, Minimization and Mitigation Measures

The NCDMF has proposed monitoring, minimization, and mitigation measures in their Conservation Plan to reduce the impact of commercial fisheries on Atlantic sturgeon throughout the state. The primary component of these measures are establishing maximum bycatch limits seasonally in management areas, funding the observer program to ensure these bycatch limits aren't exceeded, establishing an implementing agreement to cooperatively adaptively manage bycatch, temporary and permanent hotspot closures, and outreach to the fishing community.

Monitoring

Monitoring of the inshore gill net fisheries will be done through onboard and alternative platform observers. NCDMF will observe 7–10% of fisheries effort when gill nets are larger than 5.0 inch stretch mesh and 1–2% of fisheries effort when gill nets are less than 5.0 inch stretch mesh statewide while gill net fishing occurs. Observer coverage will be based on the types and levels of fishing, Atlantic sturgeon activity, and NCDMF's ability to monitor fishing effort in primary fisheries within five primary management units (Figure 1. *note:* management unit A is subdivided into three subunits because quantifiable evidence of differences in Atlantic sturgeon distribution and fishing effort exist within the management unit). Each of the units will be monitored seasonally (defined as: (1) Winter December–February; (2) Spring March–May; (3) Summer June–August; and (4) Fall September–November) and by fishery with weighted coverage derived from estimated Atlantic sturgeon takes. Data on sturgeon incidental take will include gear type, soak time, gear parameters (e.g., mesh size), location, condition of individual caught, length, weight, disposition, and whether a tag was applied or fin clip collected. Information on fishing effort, catch, and discards will also be collected. Observers will be debriefed daily and submit reports weekly. The reports will include the following information: the fisherman's name, area fished, all protected species interactions, quantity and species of fish caught, fishing effort in the area, and other vessels in the area, as well as any other information which will assist in the determination of ongoing observer effort required at that location. In addition to enforcing state regulations, Marine Patrol officers will inspect fish houses, conduct aerial surveys, check fishing gear and licenses, interview fishermen, and monitor fishing activities. NCDMF will use data collected through the Trip Ticket Program, which requires fisheries to report on their catch and discards. The data collected through onboard and alternative platform observers, Marine Patrol officer reports, and the Trip Ticket Program will be used to estimate fishing effort, Atlantic sturgeon bycatch, and level of compliance. All data will be housed in a statewide biological database and reported to NMFS annually.

Measures to Minimize and Mitigate

Seasonal Closures

A seasonal closure is a management measure designed to limit effort and to reduce protected species interactions. If estimated takes are approached for any species and disposition (alive/dead) in a management unit for any given season, the management unit will be closed for the duration of the season (e.g., for large mesh gill nets in the summer—June through August—in management unit B, if the estimated allowable bycatch for Atlantic sturgeon is approached, then management unit B will close to all large mesh gill nets for the remainder of the summer season and not reopen until the fall—September through November). Adaptive seasonal closures will allow NCDMF to reduce interactions in areas with high Atlantic sturgeon abundance for a partial season and prevent approaching allowable takes for the entire management unit and season.

Area Closures

Area closures are a way to address hotspots or locations with high incidences of protected species interactions as compared with other locations confirmed by observations or fishery-independent surveys.

Hotspots for Atlantic sturgeon may exist in estuarine waters, but they have not been detected under previous observer effort levels. Identifying these hotspots and managing them proactively provides the best chance to minimize interactions and to avoid early season closures in the management units where these hotspots occur.

These management measures can be implemented individually or in conjunction with one another and can be applied statewide or to specific areas. A combination of management measures may be an effective way to minimize Atlantic sturgeon interactions. The potential management options provide the necessary flexibility to implement management measures that are most effective in terms of minimizing protected species interactions and still providing fishing opportunities for the commercial estuarine gill net fishery for a particular area.

Adaptive Management

The NCDMF has proposed using adaptive management as information on Atlantic sturgeon bycatch is gathered to effectively protect various DPSs of Atlantic sturgeon from particular managmenet units or during particular seasons. They have the ability to close areas on short notice, which allows them to make management decisions based on real time bycatch estimates. During the year, total fishing effort by all fishermen, fishing effort monitored by NOAA observers, and the number of Atlantic sturgeon captured is recorded and analyzed to determine when bycatch rates are higher than expected or to know when the proposed sturgeon take level is met to ensure take levels are never exceeded.

Another way adaptive management is useful is if research reveals some gear types or fishing conditions pose more risk to Atlantic sturgeon, it is possible to correct the fisheries and avoid higher risk bycatch conditions. There is currently research on going about gear alterations that will identify potential gear changes that will maintain target species catch but reduce Atlantic sturgeon bycatch.

A key component of an adaptive management program is the identification of areas of high potential for bycatch of protected species in fisheries through observed interactions of Atlantic sturgeon by the NCDMF observers, biological staff, and Marine Patrol in addition to reports from commercial and recreational fishermen and the general public. These areas will be referred to as “hotspots” and will provide managers the opportunity to address bycatch concerns through timely implementation of conservation measures such as increased observer and Marine Patrol coverage, additional gear restrictions, and temporary and/or seasonal closures.

For this permit's duration, a hotspot will be defined as any area, determined by geographically enforceable boundaries, where Atlantic sturgeon observations are unusually high within a management unit or subunit, such that the director determines that closure and evaluation is necessary to (1) avoid violation of a take limit, or (2) provide adequate protection for Atlantic sturgeon, or (3) to allow Atlantic sturgeon to complete a seasonal migration and minimize interactions. Temporary hotspot closures may be implemented while confirmatory data is gathered, or to allow real time data to be analyzed. Hotspot areas will be identified and handled proactively and reactively. For any given management unit or subunit during a season that shows high Atlantic sturgeon abundance (as defined in the Implementing Agreement), NCDMF may close the management unit or subunit for the duration of the defined season. If an area is

closed as a hotspot multiple times throughout the year or over a two-year period, NCDMF will take proactive measures to close the area for longer than a defined season. If a particular area within a management unit or subunit can be defined within the unit as the hotspot that area can be defined geographically and closed within the unit temporarily or permanently.

In order to proactively manage for hotspots certain steps can be taken for the adaptive management strategy which NCDMF utilizes:

- Observer data will be examined daily/weekly to determine the amount of interactions occurring in a given management unit or subunit.
- Observer coverage will be increased immediately in areas of concern.
- Interaction data will be compared to allowable takes and if the threshold of allowable takes is being approached the management unit will close for the remainder of the season.
- Once the management unit re-opens the following season NCDMF will continue increased levels of observer coverage to ensure interactions are minimal.
- If the management unit or subunit closes for multiple seasons throughout a year or closes for similar seasons over a two-year period it will be considered a hotspot and will be closed temporarily.
- If a management unit or subunit is determined to be a hotspot and closed temporarily, NCDMF will examine the interaction data and available fishery-independent gill-net survey data from the management unit to determine if the entire management unit shows high interaction levels or if certain areas within the management unit or subunit are the areas of concern.
- For management units or subunits that are entirely defined as a hotspot, NCDMF will close the management unit seasonally or annually according to the interaction data.
- For management units or subunits that have certain areas that are defined as a hotspot, NCDMF will close the area within the management unit or subunit seasonally or annually according to the interaction data.

Data Collection

The NCDMF will take biological samples of all Atlantic sturgeon that are observed incidentally caught in the gill net fisheries covered by this permit. Live Atlantic sturgeon encountered during fishing observations will be tagged by a trained observer. Passive Integrated Transponder (PIT) tagging and T-bar tagging of collected individuals will occur, as well as collection of fin clips for genetic testing. Tags will be provided by USFWS or NMFS when possible, to expand their tagging dataset and all the fin clips will be sent to the National Ocean Service repository in South Carolina and could be made available for researchers to assist with the validation of DPSs taken to ensure compliance with the incidental take permit and to assist in adaptive management actions in the future.

Outreach

Although NCDMF currently reaches out to the fishing community on fisheries and protected species management, outreach is an integral component of the Conservation Plan. Informing and educating the industry about the ESA, the protection of species listed as either threatened or endangered, and how this applies to the commercial fishing industry has been a major focus of the NCDMF outreach. Outreach efforts include public meetings, workshops, presentations, mail

outs of summary information, public involvement (through advisory committees), and direct communications.

2. APPROACH TO THE ASSESSMENT

NMFS approaches its section 7 analyses of research permits through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The results of this step define the action area for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our exposure analyses). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our response analyses).

The final steps of our analyses – establishing the risks those responses pose to listed resources – are different for listed species and designated critical habitat (these represent our risk analyses). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of species depends on the fate of the populations that comprise them, the continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population level risks to the Atlantic sturgeon DPSs they comprise.

We measure risks to listed individuals using the individuals' "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our response analyses) are likely to have consequences for the individual's fitness.

When listed species are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a necessary condition for reductions in a population's viability, which is itself a necessary condition for reductions in a species' viability. As a result, when listed species exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Brandon 1978, Mills and Beatty 1979, Stearns 1992, Anderson 2000). As a result, if we conclude that individual listed species are not likely to experience reductions in their fitness, we would conclude our assessment. These individuals are identified in the Status of the Species section and discounted before a further analysis of those species that may experience a reduction in their fitness.

Although reductions in fitness of individuals are a necessary condition for reductions in a population's viability, reducing the fitness of individuals is not always sufficient to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed species are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of the Species* sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always sufficient to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses (the risk assessment), we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of the Species* section of this Opinion) as our point of reference. With the action area being composed of a genetically mixed population, we also evaluate the change in numbers of Atlantic sturgeon encountered in the fishery year after year in the *Exposure Analysis* to evaluate any changes in habitat use or species density through time. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on the best scientific information available. During this consultation, we initially sought NOAA Observer data that had monitored bycatch between 2004 and 2011, fisheries dependent monitoring data from NCDMF, and information on the total amount of fishing effort conducted in North Carolina's inshore gill net fisheries. We also relied on the papers and reports identified in the administrative record.

3. DESCRIPTION OF THE ACTION AREA

The action area is defined in 50 CFR 402.2 as "all areas to be affected directly or indirectly by the Federal Action and not merely the immediate area involved in the action." The North Carolina inshore waters include the following five management areas (Figure 1):

Management Unit A is divided into three subunits:A-1, A-2, and A-3 to allow NCDMF to effectively address subunits where proactive management actions may be taken at a finer scale.

- **Management Subunit A-1** will encompass Albemarle Sound as well as contributing river systems in the unit not crossing a line 36° 4.30'N -75° 47.64'W east to a point 36° 2.50'N -75° 44.27'W in Currituck Sound or 35° 57.22'N -75° 48.26'W east to a point 35° 56.11'N -75°43.60'W in Croatan Sound and 36° 58.36'N -75° 40.07'W west to a point 35° 56.11'N -75°43.60'W in Roanoke Sound.
- **Management Subunit A-2** will encompass Currituck Sound north of a line beginning at 36° 4.30'N -75° 47.64' east to a point at 36° 2.50'N -75° 44.27'W as well as the contributing river systems in this unit.
- **Management Subunit A-3** will encompass Croatan Sound waters south from a point at 35° 57.22'N -75° 48.26'W east to a point 35° 56.11'N -75°43.60'W and Roanoke Sound waters south from a point 36° 58.36'N -75° 40.07'W west to a point 35° 56.11'N -75°43.60'W south to

Management Unit B includes all inshore waters south of 35°46.30'N, east of 76°30.00'W and north of 34°48.2'N. This management unit will include all of Pamlico Sound and the northern portion of Core Sound.

Management Unit C includes the Pamlico, Pungo, Bay, and Neuse river drainages west of 76° 30.00'W.

Management Unit D includes all inshore waters south of 34°48.27'N and west o a line running from 34°40.70'N - 76°22.50'W to 34°42.48'N - 76°36.70'W to the Highway 58 bridge. Management in unit D includes the southern Core Sound, Back Sound, Bogue Sound, North River, and Newport River.

Management Unit E includes all inshore waters south and west of the Highway 58 bridge to the North Carolina/South Carolina state line. This includes the Atlantic Intracoastal Waterway and adjacent sounds and the New, Cape Fear, Lockwood Folly, White Oak, and Shallotte rivers.

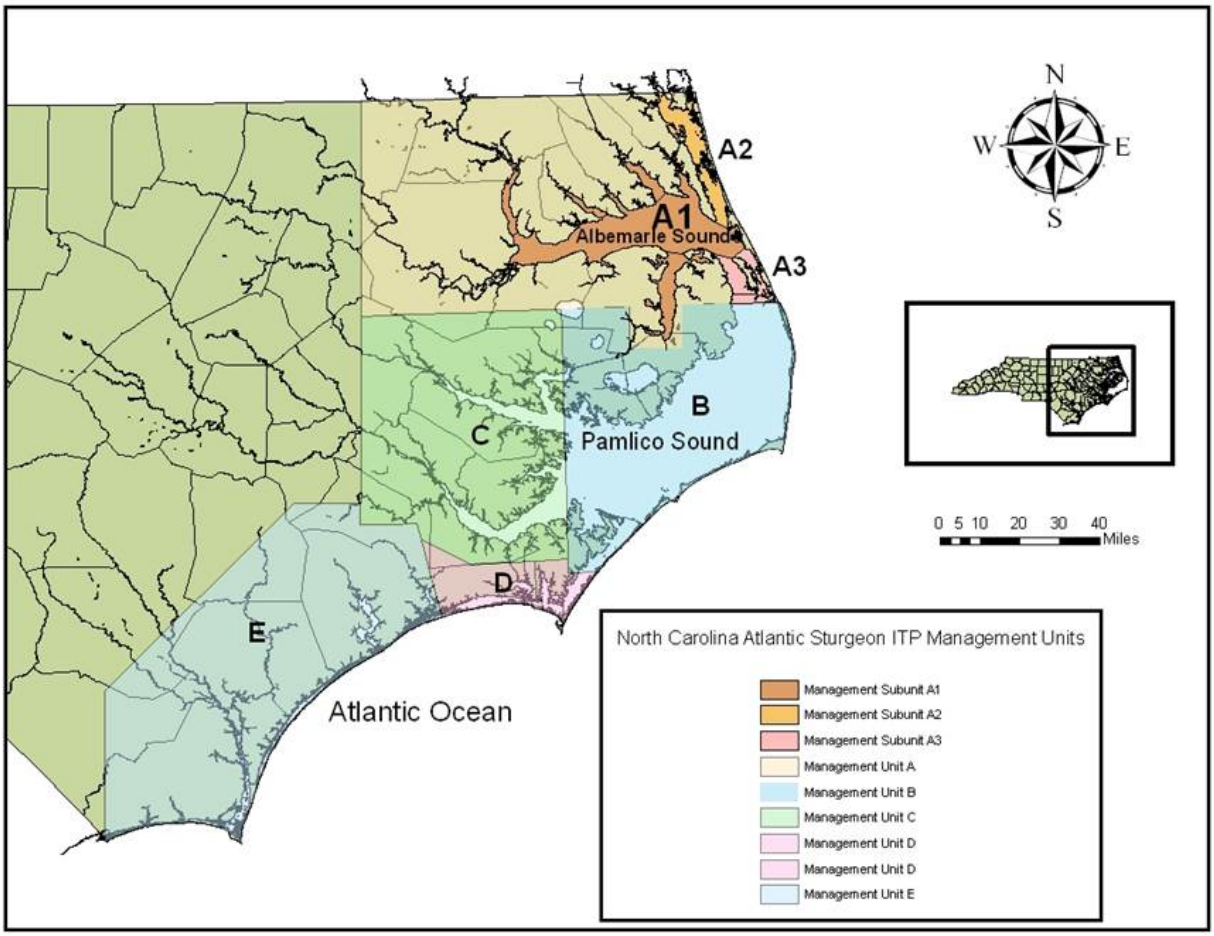


Figure 1. Management units for the North Carolina Atlantic sturgeon ESA section 10(a)(1)(B) incidental take permit (*source:* NCDMF Figure 4 in the application and Conservation Plan).

4. STATUS OF THE SPECIES/CRITICAL HABITAT

We determined that the species identified in Table 4 will occur in the action area during the time this Conservation Plan will be in place.

Table 4: Species present in the Action Area.

Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Atlantic sturgeon	*A. oxyrinchus oxyrinchus*	
South Atlantic Distinct Population Segment (DPS)		Endangered
Carolina DPS		Endangered
Chesapeake Bay DPS		Endangered
New York Bight DPS		Endangered
Gulf of Maine DPS		Threatened
Green sea turtles	*Chelonia mydas*	Endangered
Hawksbill sea turtles	*Eretmochelys imbricate*	Endangered
Leatherback sea turtles	*Dermochelys coriacea*	Endangered
Kemp's ridley sea turtles	*Lepidochelys kempii*	Endangered

Western Atlantic Loggerhead sea turtle DPS	*Caretta caretta*	Threatened

4.1 Species No Longer Considered in this Opinion

Sea turtles were the subject of legal action challenging the implementation of North Carolina's gill net fisheries, which prompted this Conservation Plan. A biological opinion considering the threats to sea turtles under ITP 16230 has been completed (NMFS 2013a). Because of this, NMFS OPR and NCDMF agreed to create two identical Conservation Plans with separate biological opinions. Because sea turtle bycatch associated with this Conservation Plan has already been allocated (NMFS 2013a), green, hawksbill, leatherback, Kemp's ridley, and loggerhead sea turtles will not be addressed further in this Opinion.

Shortnose sturgeon have been extirpated from most North Carolina rivers and likely only remain extant in the Cape Fear River (Kynard 1997, Oakley 2003). Fisheries that will occur in Management Units A-D are in areas that our outside the shortnose sturgeons current occupied range. Shortnose sturgeon are amphidromous and spend most of their lives in freshwater portions of rivers, with the highest observed salinity in an area with shortnose sturgeon being 31 parts per thousand (Gilbert 1989). The Cape Fear River is in management unit E. NCDMF has successfully captured shortnose sturgeon during research surveys; however, there are no records of shortnose sturgeon interactions from commercial fisheries based on monitoring efforts, despite monitoring approximately 100,000 net hours since 2004 in management unit E. Because of monitoring results of the previous 10 years and not observing any shortnose sturgeon as bycatch, there is a negligible probability of incidentally capturing a shortnose sturgeon in the next 10 years. Therefore, it is our determination that the proposed Conservation Plan is not likely to adversely affect shortnose sturgeon and will not be considered further in this Opinion.

4.2 Species Likely Adversely Affected by this Action

The following summarizes the biology and ecology of the Atlantic sturgeon in the action area that are relevant to the effects analysis in this Opinion. For more information on Atlantic sturgeon, refer to NMFS (2007).

4.2.1 ATLANTIC STURGEON, *ACIPENSER OXYRINCHUS*

Species' Description, Distribution, and Population Structure

Atlantic sturgeon are distinctive fish lacking scales, instead having armor-like plates along the dorsal, lateral, and ventral sides. Sturgeon also have a long protruding snout that is ventrally located, with four inferior barbels posterior to the mouth. The mouth is toothless. Sturgeon also have a distinctive heterocercal (upper lobe larger than lower lobe) tail. Atlantic sturgeon are large fish that may reach lengths up to 14 feet (ft; 4.27 meters (m)), and weigh over 800 pounds (lbs; 363 kg).

The Atlantic sturgeon's historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador, Canada, to the Saint Johns River in Florida (Smith and Clugston 1997, NMFS 2007). Atlantic sturgeon have been documented as far south as Bermuda and Venezuela (Lee *et al.* 1980). Historically, Atlantic sturgeon were present

in approximately 38 rivers in the United States from St. Croix, Maine to the Saint Johns River, Florida, of which 35 rivers have been confirmed to have had historic spawning populations. Atlantic sturgeon are currently present in 36 rivers, and spawning occurs in at least 20 of these. Other estuaries along the U.S. Atlantic Coast formed by rivers that do not support Atlantic sturgeon spawning populations may still be important rearing habitats.

Atlantic sturgeon throughout their range exhibit ecological separation during spawning that has resulted in multiple, genetically distinct, interbreeding population segments. Studies have consistently found populations to be genetically diverse and indicate that there are between 7 and 10 populations that can be statistically differentiated (King *et al.* 2001, Waldman *et al.* 2002, Wirgin *et al.* 2002, Wirgin *et al.* 2005, Grunwald *et al.* 2008). However, there is some disagreement among studies, and results do not include samples from all rivers inhabited by Atlantic sturgeon. We identified five DPSs in the United States (77 FR 5880, 77 FR 5914): the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic. Overall, the genetic markers used for mixed stock classification resulted in an average accuracy of 85% for determining a sturgeon's natal river origin, but an average accuracy of 96% for correctly classifying it to one of five DPSs (Tim King, USGS, unpublished data, 2014).

Life History Information

While intensely studied since the 1970s, many important aspects of Atlantic sturgeon life history are still unknown. The general life history pattern of Atlantic sturgeon is that of a long lived, late maturing, iteroparous, anadromous species. Atlantic sturgeon spawn in freshwater, but spend most of their sub-adult and adult life in the marine environment. While few specific spawning locations have been identified in the United States, through genetic analysis, many rivers are known to support reproducing populations. Early life stage Atlantic sturgeon coupled with upstream movements of adults suggest spawning adults generally migrate upriver in the spring/early summer; February-March in southern systems, April-May in mid-Atlantic systems, and May-July in Canadian systems (Smith 1985, Bain 1997, Smith and Clugston 1997, Kahnle *et al.* 1998). Atlantic sturgeon spawn in freshwater, but spend most of their adult life in the marine environment. Some rivers may also support a fall spawning migration.

Sub-adult and adult Atlantic sturgeon undertake long marine migrations and utilize habitat up and down the East Coast for rearing, feeding, and migrating (Dovel and Berggren 1983, Bain 1997, Stevenson 1997). These migratory sub-adults, as well as adults, are normally located in shallow (10-50m) near shore areas dominated by gravel and sand substrate (Stein *et al.* 2004). Tagging and genetic data indicate that sub-adult and adult Atlantic sturgeon may travel widely once they emigrate from rivers. Once in marine waters, sub-adults undergo rapid growth (Dovel and Berggren 1983, Stevenson 1997). Despite extensive mixing in coastal waters, Atlantic sturgeon display high site fidelity to their natal streams. Straying between rivers within a DPS would sometimes exceed five migrants per generation, but between DPSs was usually less than one migrant per generation, with the exception of fish from the Delaware River straying more frequently to southern rivers (Grundwald *et al.* 2008).

Atlantic sturgeon have been aged to 60 years (Mangin 1964). However, this should be taken as an approximation because the age validation studies conducted to date show ages cannot be reliably estimated after 15-20 years (Stevenson and Secor 1999). Vital parameters of sturgeon

populations generally show clinal variation with faster growth, earlier age at maturation, and shorter life span in more southern systems. Spawning intervals range from one to five years for male Atlantic sturgeon (Smith 1985, Collins *et al.* 2000, Schueller and Peterson 2010) and three to five years for females (Vladykov and Greely 1963, Stevenson and Secor 1999, Schueller and Peterson 2010). Fecundity of Atlantic sturgeon is correlated with age and body size (ranging from 400,000 – 8 million eggs) (Smith *et al.* 1982, Van Eenennaam and Doroshov 1998, Dadswell 2006). The average age at which 50% of maximum lifetime egg production is achieved estimated to be 29 years, approximately 3-10 times longer than for other bony fish species examined (Boreman 1997).

Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (e.g., cobble) (Gilbert 1989, Smith and Clugston 1997). Hatching occurs approximately 94-140 hours after egg deposition, and larvae assume a demersal existence (Smith *et al.* 1980). The yolksac larval stage is completed in about 8 to 12 days, during which time the larvae move downstream to rearing grounds over a 6 to 12-day period (Kynard and Horgan 2002). During the first half of their migration downstream, movement is limited to night. During the day, larvae use benthic structure (e.g., gravel matrix) as refugia (Kynard and Horgan 2002). During the latter half of migration when larvae are more fully developed, movement to rearing grounds occurs both day and night. Juvenile sturgeon continue to move further downstream into brackish waters, and eventually become residents in estuarine waters for months or years.

Most Atlantic sturgeon experts consider water quality as a moderate risk to every DPS in the United States (NMFS 2007). During all stages of development, Atlantic sturgeon are sensitive to temperatures above 28°C (Niklitschek and Secor 2005, Kahn and Mohead 2010, Niklitschek and Secor 2010) and dissolved oxygen levels below 4.3 to 4.7 parts per million (Secor and Niklitschek 2002, Niklitschek and Secor 2009). Juvenile sturgeon are also stressed by high salinities, which means they remain in freshwater environments until they are old enough to outmigrate. Additionally, sturgeons generally and Atlantic sturgeon specifically are sensitive to pesticides, heavy metals, and other toxins in the aquatic environment, as is discussed in the Baseline section below.

Listing Status

Five DPSs of Atlantic sturgeon have been listed under the ESA. The Gulf of Maine DPS was listed as threatened while the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs were listed as endangered (77 FR 5880, 77 FR 5914). Critical habitat has not been designated.

Status and Trends of Atlantic Sturgeon Populations

Prior to 1890, Atlantic sturgeon populations were at or near carrying capacity. Between 1890 and 1905, Atlantic sturgeon populations were drastically reduced as a result of overfishing for sale of meat and caviar. Between 1920 and 1998, the harvest level remained very low due to small remnant populations. Prompted by research on juvenile production between 1985 and 1995 (Peterson *et al.* 2000), the Atlantic sturgeon fishery was closed by the Atlantic States Marine Fisheries Commission in 1998, when a coastwide fishing moratorium was imposed for 20-40 years, or at least until 20 year classes of mature female Atlantic sturgeon were present (ASMFC 1998).

Since the closure of the Atlantic sturgeon fishery, the only assessments of adult spawning populations have been made in the Hudson (New York) and Altamaha (Georgia) Rivers, of the New York Bight and South Atlantic DPSs, respectively. While Atlantic sturgeon have been captured, tagged, and tracked through estuaries and rivers along the East Coast, no other estimates of spawning run size or juvenile population sizes have been made. Estimating the number of spawning adults relies on the assumptions that (1) all adults that migrate into the freshwater portion of a river are native to that river and (2) all adults are making that upstream migration with the intention of spawning. Kahnle *et al. (*2007) reported that at the end of the commercial sturgeon fishery, approximately 870 adults remained in the Hudson River between 1985 and 1995. Peterson *et al.* (2008) reported that approximately 324 and 386 adults per year returned to the Altamaha River in 2004 and 2005, respectively. No estimates are available for North Carolina river systems, however recent tagging efforts have captured and tagged six adults and also recovered two fertilized eggs in the Roanoke River and 18 Atlantic sturgeon in the Cape Fear River.

Juvenile Atlantic sturgeon abundance may be a more precise way to measure the status of Atlantic sturgeon populations because it is believed that all age-1 and age-2 juveniles are restricted to their natal rivers (Dovel and Berggren 1983, Bain *et al.* 1999), avoiding the assumptions noted above. Peterson *et al.* (2000) reported that there were approximately 4,300 age-1 and -2 Atlantic sturgeon in the Hudson River between 1985 and 1995. Schueller and Peterson (2010) reported that age-1 and -2 Atlantic sturgeon population densities ranged from 1,000 to 2,000 individuals over a 4-year period from 2004 to 2007 in the Altamaha River.

5. ENVIRONMENTAL BASELINE

By regulation, 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 which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that affect the survival and recovery of the listed species in the action area. The following information summarizes the primary human and natural phenomena in the action area that are believed to affect the status and trends of Atlantic sturgeon and the probable responses of the sturgeon to these phenomena.

Bycatch

Directed harvest of Atlantic sturgeon is prohibited by the ESA. However, sturgeon are taken incidentally in other fisheries in rivers, estuaries, and marine waters along the east coast, and are probably targeted by poachers throughout their range (Dadswell 1979, Dovel *et al.* 1992, Collins *et al.* 1996, NMFS 2007).

In inshore and riverine fisheries most Atlantic sturgeon are returned to the water, presumably unharmed; however, Collins *et al.* (1996) and Bahn *et al.* (2012) reported mortality rates ranging

from 8 to 20%. Moser and Ross (1993) found that captures of shortnose sturgeon in commercial shad nets disrupted spawning migrations in the Cape Fear River, and Weber (1996) reported that these incidental captures caused abandonment of spawning migrations in the Ogeechee River, Georgia Poaching is another fishing threat, but its impact to individual populations is unknown. Poaching may be more prevalent where legal markets for sturgeon exist from importations, commercial harvest, or commercial culture.

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. The incidental take of Atlantic sturgeon in estuarine and coastal waters of North Carolina is not well documented and often not reported, but Atlantic sturgeon originating from the five DPSs considered in this consultation are at risk of bycatch-related mortality in fisheries operating in the action area and beyond.

Atlantic sturgeon are particularly vulnerable to being caught in gill nets and sink gill nets in particular, therefore fisheries using this type of gear account for a high percentage of Atlantic sturgeon bycatch and bycatch mortality. They are also taken in trawl fisheries, though recorded captures and mortality rates are low.

Federally Regulated Fisheries

Federally regulated fisheries that may encounter Atlantic sturgeon have fishery management plans and those plans have undergone consultation with NMFS as is detailed below. Those fisheries have also been the subject of continuous research to best understand the causes and impacts of bycatch as well as potential ways to reduce adverse effects.

Stein *et al.* (2004) provided Atlantic sturgeon bycatch and mortality estimates for offshore fisheries operating in the Northeast and Mid-Atlantic regions, based on fisheries observer data from 1989-2000. The analysis focused on three gear types: otter trawl gear, sink gill nets, and drift gill nets. Atlantic sturgeon bycatch rates were calculated as ratios of sturgeon weight to catch weight of all landed species, per trip. Atlantic sturgeon were observed caught from Maine to North Carolina, with a total of 25,035 lbs of sturgeon caught from 1989-2000. Target species and gear type influenced Atlantic sturgeon bycatch and bycatch rates. Gears targeting monkfish and spiny dogfish accounted for over 60 percent of observed Atlantic sturgeon bycatch. Bycatch rates were highest for gill nets (overall drift gill net bycatch rate was 0.0059 lbs of Atlantic sturgeon per pound of landings) and sink gill nets (0.00144 lbs of Atlantic sturgeon per lb of landings). Bycatch rates for otter trawls were lower (mean bycatch rate of 0.00085 pounds of sturgeon per monitored pound landings). The baseline mortality rates of bycaught Atlantic sturgeon for sink and drift gill nets were estimated at 22 and 10 percent, respectively. Based on the bycatch and mortality rates estimated for sink gill nets, the authors reported that from 1989-2000 this gear killed an estimated 1,000 individual Atlantic sturgeon (236,292 lbs) annually, based on the mean weight from the individual fish records. During the same period, drift gill nets were estimated to have killed approximately 385 individual Atlantic sturgeon (70,604 lbs) (Stein *et al.* 2004).

In 2007, the ASMFC and NMFS sponsored a workshop to provide an updated assessment on the impacts of commercial otter trawl, sink gill net, and anchored gill net fishing on Atlantic

sturgeon from 2001-2006. The workshop participants opted to model bycatch, as opposed to estimating it via interpolation and a ratio method as done by Stein *et al.* (2004). The bycatch models indicated that between 2,752 and 7,906 (mean of 5,143) Atlantic sturgeon were incidentally caught in coastal gill net and otter trawl from 2001-2006, with mortalities ranging from 352 to 1,286 (mean of 649) animals during the same period. The estimated mortality rate of bycaught animals was 13.8%. Observed Atlantic sturgeon bycatch from 2001-2006 showed a temporal trend with most animals being caught in April and May and the fewest being caught in August and September. These trends are similar to those noted in Stein *et al.* (2004). Atlantic sturgeon bycatch in sink gill net gear occurred almost entirely in waters shallower than 40 m (ASMFC 2007).

An update to the ASMFC bycatch analysis by the NMFS Northeast Fisheries Science Center in 2011 indicates that bycatch in fisheries is still occurring in the Northeast at a rate that is unsustainable for Atlantic sturgeon survival and recovery (Miller and Shepherd 2011). The Northeast Fisheries Science Center estimated that based on data from 2006 to 2010, annually, an average of 3,118 Atlantic sturgeon are captured in Northeast fisheries with 1,569 in sink gill net and 1,548 in otter trawls. The mortality rate in sink gill nets is estimated at approximately 20% and the mortality rate in otter trawls is estimated at 5%.

While Stein *et al.* (2004) assessed all Federal fisheries in the Northeast and Mid-Atlantic, at the time of this writing the following Federal fisheries had undergone formal section 7 consultations that estimate and exempt take of the fishery on Atlantic sturgeon: Northeast multispecies, monkfish, spiny dogfish, Atlantic bluefish, Northeast skate complex, mackerel/squid/butterfish, summer flounder /scup/black sea bass, Atlantic sea scallop, highly migratory species shark and smoothhound, and the South Atlantic Federal shrimp fishery. No take of Atlantic sturgeon was anticipated or exempted in the American lobster fishery.

Seven Batched Federal Fisheries

On December 16, 2013, NMFS issued a "batched" section 7 biological opinion (NMFS 2013c) on the following fisheries: Northeast multispecies; monkfish; spiny dogfish; Atlantic bluefish; Northeast skate complex; mackerel/squid/butterfish; and summer flounder /scup/black sea bass. The Northeast multispecies fishery includes American plaice, Atlantic cod, Atlantic halibut, Atlantic wolffish, haddock, ocean pout, offshore hake, pollock, redfish, red hake, silver hake, white hake, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder. Gill net gear is used by five of the seven fisheries, and bottom trawl gear is used by six of the seven fisheries. It is also possible that bottom longline gear, which is used in the Northeast multispecies, monkfish, and spiny dogfish fisheries, could hook Atlantic sturgeon while foraging, but there have been no reported interactions.

The majority (73%) of all Atlantic sturgeon bycatch mortality in New England and Mid-Atlantic waters is attributed to the monkfish sink gill net fishery (ASMFC 2007). Observer data from 2001 to 2006 shows 224 recorded interactions between the monkfish fishery and Atlantic sturgeon, with 99 interactions resulting in death, a 44 percent mortality rate. Earlier data from Stein *et al.* (2004) showed a bycatch rate of 0.004984 pounds of Atlantic sturgeon per pound of monkfish landed.

Stein *et al.* (2004) reported a bycatch rate of 0.000947 pounds of Atlantic sturgeon per pound of landed spiny dogfish and a bycatch rate of 0.001595 pounds of Atlantic sturgeon per pound of unidentified dogfish. More recent observer data from 2001 to 2006 shows 32 recorded interactions between the dogfish fishery and Atlantic sturgeon, with 5 interactions resulting in death, a 16 percent mortality rate for Atlantic sturgeon that are taken as bycatch (ASMFC 2007).

Estimates of bycatch resulting from the other fisheries are provided below. These estimates do not account for all actual Atlantic sturgeon bycatch in federal fisheries, but if these take levels are exceeded, consultation must be reinitiated.

Fishing activity under the authority of many of the fishery management plans considered in the batched biological opinion often occurs simultaneously and on the same vessel, making the link between fishery management plans and sturgeon interactions difficult to quantify. Therefore interactions with Atlantic sturgeon were analyzed based on gear type. For all seven fisheries, the following take of Atlantic sturgeon was authorized annually: 1331 trawl interactions of which 42 may be lethal and 1229 gill net interactions of which 155 may be lethal, for a total of 2560 interactions of which 197 are expected to be lethal (Table 5).

The South Atlantic Federal Shrimp Fishery. The 2012 NMFS biological opinion (NMFS 2012a) on the Southeast shrimp trawl fishery concluded the fishery is unlikely to jeopardize Atlantic sturgeon. This biological opinion exempted the take of Atlantic sturgeon as follows: 1731 total interactions, including 243 captures of which 27 are expected to be lethal every three years (Table 5).

Atlantic Shark Fisheries. In 2012, NMFS provided an updated biological opinion (NMFS 2012b) on the Federal shark fisheries, including the smoothhound (dogfish) fishery on ESA-listed species. Observer reports through 2011 indicated that Atlantic sturgeon captures in shark directed gill net sets are uncommon but they do occur and have occurred in similar gears. Atlantic sturgeon bycatch in the smoothhound fishery are known to be significantly higher than in the shark fisheries. For the federal smoothhound fishery and shark fisheries combined, NMFS exempted the take of 321 Atlantic sturgeon over a three year span, with 66 of those takes expected to be lethal (Table 5).

Scallop fishery. In 2012, NMFS issued a biological opinion (NMFS 2012c) on the Federal scallop fishery, stating that despite the expectation that there will be some level of interaction between Atlantic sturgeon and trawl gear fishing for scallops, the incidence rate is expected to be very low. The capture of one Atlantic sturgeon per year in trawl gear fishing for scallops was exempted, with no more than one mortality of an Atlantic sturgeon expected every 20 years.

Table 5. Atlantic sturgeon captures and mortalities exempted by NMFS in federal fisheries. Total captures are inclusive of mortalities.

Federal fishery	**Exempted average annual total captures (lethal and non-lethal)**	**Exempted average annual mortalities**
Seven batched federal fisheries (Dec.16, 2013)	2,560	197

Southeast shrimp trawl (May 8, 2012)	274	34
Shark and smoothhound under consolidated HMS FMP (Dec. 12, 2012)	107	22
Atlantic sea scallop* (July 12, 2012)	1	.05 (1 every 20 years)
DPS		
Gulf of Maine	313	27
New York Bight	1414	116
Chesapeake Bay	384	34
Carolina	108	13
South Atlantic	722	63
Total *	**2942**	**253.05**

** The NMFS biological opinion on the federal sea scallop fishery concluded that Atlantic sturgeon takes could occur from any of the five DPSs.*

Additionally, there are several Federally regulated fisheries that likely take Atlantic sturgeon, that have not been reinitiated since Atlantic sturgeon were listed. Information on Atlantic sturgeon bycatch in these fisheries is detailed below. NMFS is in the process of reinitiating formal consultations to evaluate the impacts of these fisheries on Atlantic sturgeon.

Coastal Migratory Pelagic Resources Fisheries. Commercial fishermen target king and Spanish mackerel with hook-and-line (i.e., handline, rod-and-reel, and bandit), gill net, and cast net gears. Recreational fishermen use only rod-and-reel. Trolling is the most common hook-and-line fishing technique used by both commercial and recreational fishermen. No bycatch estimate for this fishery is available as of this writing, but bycatch levels are likely to be very low since gill nets are no longer the predominant gear used on the Atlantic Coast.

Atlantic Herring
Purse seines, midwater trawls (single), and pair trawls are the three primary gears involved in the Atlantic herring fishery (NEFMC 2006). These types of gears are unlikely to interact with Atlantic sturgeon because they occur above the benthos.

Atlantic Pelagic Fisheries for Swordfish, Tuna, Sharks, and Billfish
These fisheries use gears including pelagic longline, pelagic driftnet, bottom longline, and/or purse seine gear. The most recent formal section 7 consultation on the continued authorization of the Atlantic shark fisheries via the Consolidated highly migratory species fishery management plan is described above. A permanent prohibition on the use of driftnet gear in the swordfish

fishery was published by NMFS in 1999 (64 FR 4055). HMS fisheries for tuna, swordfish and billfish use mostly longline gears that are unlikely to interact with Atlantic sturgeon.

State fisheries

Data on Atlantic sturgeon captured or killed in state fisheries is extremely limited. Given that gill nets and otter trawls are used most frequently in state waters, state fisheries may have a greater impact on Atlantic sturgeon than Federal fisheries using these same gear types.

In 2013, after amending their commercial fishing regulations to minimize incidental capture, the Georgia Department of Natural Resources received a ESA Section 10 permit for incidental take of Atlantic sturgeon in the commercial shad fishery in state waters. The ITP allows the capture and live release of up to 180 Atlantic sturgeon annually, with a maximum of 5 incidental mortalities per year. A mortality rate of approximately 2.3 percent is anticipated based on recent research.

The NCDMF has employed NOAA observers to monitor sea turtle and Atlantic sturgeon bycatch since 2004. While the coverage allowed NCDMF to estimate bycatch levels at several thousand fish per year, mortality estimates as a result of inshore fisheries in North Carolina are approximately 200 per year of all life stages. These numbers were even higher prior to 2010 when fishing effort was substantially greater.

For 2001 to 2009, the NCDMF reported that no Atlantic sturgeon were observed in 958 observed tows conducted by commercial shrimp trawlers working in North Carolina waters (NCDMF 2014). Yet Collins *et al.* (1996) reported that of 1,534 juvenile Atlantic sturgeon tagged in the Altamaha River, Georgia, 97 were recaptured in trawl and gill net fisheries, while 38 (or 39 percent of the total recaptures) were taken in shrimp trawls. Seven Atlantic sturgeon were captured by a single shrimp trawler off Winyah Bay, South Carolina, from October 27-29, 2008 (Damon-Randall *et al.* 2010). Six of these were caught in otter trawl nets and one was captured in a try net. All of them were approximately 900 to 1000 mm total length and were caught in 18-30 feet of water. Six of the incidentally caught Atlantic sturgeon were released alive, one (captured by the otter trawl) was released dead. There were also a few observed captures in 2011. One Atlantic sturgeon was captured by a shrimp trawler off South Carolina near Kiawah Island, South Carolina, on December 13, 2011 (Damon-Randall *et al.* 2010) and was released alive. Two Atlantic sturgeon were captured by a shrimp trawler near Sapelo Island, Georgia, from December 27-29, 2011 (Damon-Randall *et al.* 2010). Both were approximately 2 feet long and both were released alive.

Based on gear type (i.e., gill nets), it is likely that Atlantic sturgeon would be vulnerable to capture in Virginia's black drum and sandbar shark fisheries. A "reward program" in Virginia in the late 1990s found that the majority of Atlantic sturgeon captures were in drift gill nets and pound nets. No quantitative information on the number of Atlantic sturgeon captured or killed in Virginia fisheries is currently available.

Atlantic sturgeon takes have been observed in the Atlantic croaker fishery, which uses trawl and gill net gear, but a quantitative assessment of the number of sturgeon captured in the croaker fishery is not available. A review of the northeast fisheries observer program database indicates that from 2006 to 2010, 60 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the target was Atlantic croaker. It should be noted that this

total is only for trips that had observer coverage and very few Atlantic croaker trips carry NEFOP observers.

The majority of commercially caught weakfish are caught in state waters (ASMFC 2002). The dominant commercial gears include gill nets, pound nets, haul seines, and trawls, with the majority of landings occurring in the fall and winter months (ASMFC 2002). North Carolina has accounted for the majority of annual landings since 1972 (ASMFC 2002). A quantitative assessment of the number of Atlantic sturgeon captured in the weakfish fishery is not available. A review of the northeast fisheries observer program database indicates that from 2006 to 2010, 36 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as weakfish. This represents a minimum number of Atlantic sturgeon captured in the weakfish fishery during this time period, as it only considers observed trips, and most inshore fisheries are not observed. An earlier review of bycatch rates and landings for the weakfish fishery reported that the weakfish-striped bass fishery had an Atlantic sturgeon bycatch rate of 16% from 1989 to 2000; the weakfish-Atlantic croaker fishery had an Atlantic sturgeon bycatch rate of .02%, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0% (ASSRT 2007).

Vessel Strike

The Atlantic Sturgeon Status Review Team (2007) determined Atlantic sturgeon in the Delaware River are at a moderately high risk of extinction because of ship strikes, and sturgeon in the James River are at a moderate risk from ship strikes. Since that time, managers in the Hudson River are concerned that ship strikes may also be threatening Atlantic sturgeon populations there. In these systems, large ships move upstream from the mouths of the river to ports upstream through narrow shipping channels. The channels are dredged to the approximate depth of the ships, usually leaving less than 6 feet of clearance between the bottom of ships and the benthos of the river. Because of the size of the propellers used on large ships, anything along the bottom is sucked through the propellers. Large sturgeon are most often killed by ship strikes because their size means they are unable to pass through ship propellers without making contact.

Water Quality and Contaminants

The quality of water in river/estuary systems is affected by human activities conducted in the riparian zone and those conducted more remotely in the upland portion of the watershed. Industrial activities can result in discharge of pollutants, changes in water temperature and levels of dissolved oxygen, and the addition of nutrients. In addition, forestry and agricultural practices can result in erosion, run-off of fertilizers, herbicides, insecticides or other chemicals, nutrient enrichment and alteration of water flow (Folmar *et al.* 1996, Culp *et al.* 2000, Wildhaber *et al.* 2000, Wallin *et al.* 2002). Coastal and riparian areas are also heavily impacted by real estate development and urbanization resulting in storm water discharges, non-point source pollution, and erosion. The Clean Water Act regulates water quality in the United States establishing standards under section 303(d) to identify polluted water bodies that require the establishment of a total maximum daily load to improve water quality.

The water quality over the range of Atlantic sturgeon varies by watershed. The U.S. Environmental Protection Agency (EPA) published its fourth edition of the National Coastal Condition Report (NCCR IV) in 2012, a “report card” summarizing the status of coastal

environments along the coast of the United States (EPA 2012; See Table 6 below). The report analyzes water quality, sediment, coastal habitat, benthos, and fish contaminant indices to determine status on a range from good to fair to poor. The results are notably poorer in the north than in the south. The northeast region of the U.S. (Virginia to Maine) was rated fair-poor. The southeast region of the U.S. (Florida to North Carolina) was rated good-fair, the best rating in the nation.

Table 6. Summary of the EPA NCCR IV for the U.S. east coast published by the EPA (2012) grading coastal environments. (Northeast region=VA to ME; southeast region=FL to NC; and Gulf of Mexico=TX to FL).

	Region		
Status Index	**Northeast**	**Gulf of Mexico**	**Southeast**
Water quality	Fair	Fair	Fair
Sediment	Fair	Poor	Fair-poor
Coastal Habitat	Good-fair	Poor	Fair
Benthos	Poor	Fair-poor	Good
Fish Tissue	Fair-poor	Good	Good
Overall	**Fair-poor**	**Fair-poor**	**Good-fair**

Chemicals such as chlordane, DDE, DDT, dieldrin, PCBs, cadmium, mercury, and selenium settle to the river bottom and are later consumed by benthic feeders, such as macroinvertebrates, and then work their way higher into the food web (e.g., to sturgeon). Some of these compounds may affect physiological processes and impede a fish's ability to withstand stress, while simultaneously increasing the stress of the surrounding environment by reducing dissolved oxygen (DO), altering pH, and altering other physical properties of the water body.

Life histories of Atlantic sturgeon (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose sturgeon to long-term, repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979, NMFS 1998). However, there has been little work on the effects of contaminants on sturgeon to date. Shortnose sturgeon collected from the Delaware and Kennebec Rivers had total toxicity equivalent concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), PCBs, DDE, aluminum, cadmium, and copper above adverse effect concentration levels reported in the literature (ERC 2002, 2003). Dioxin and furans were detected in ovarian tissue from shortnose sturgeon caught in the Sampit River/Winyah Bay system (South Carolina). Early life stage Atlantic and shortnose sturgeon are vulnerable to PCB and TCDD toxicities of less than 0.1 part per billion (Chambers *et al.* 2012).

Heavy metals and organochlorine compounds accumulate in sturgeon tissue, but their long-term effects are not known (Ruelle and Henry 1992, Ruelle and Keenlyne 1993). High levels of contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Cameron *et al*. 1992, Longwell *et al*. 1992, Hammerschmidt *et al.* 2002, Giesy *et al.* 1986, Mac and Edsall 1991, Matta *et al*. 1998, Billsson *et al.* 1998), reduced survival of larval fish (Berlin *et al.* 1981, Giesy *et al*. 1986), delayed maturity (Jorgensen *et al.* 2004) and posterior malformations (Billsson e*t al.* 1998). Pesticide exposure in fish may affect

anti-predator and homing behavior, reproductive function, physiological maturity, swimming speed, and distance (Beauvais *et al*. 2000, Scholz *et al*. 2000, Moore and Waring 2001, Waring and Moore 2004).

Sensitivity to environmental contaminants also varies by life stage. Early life stages of fish appear to be more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). Increased doses of PCBs and TCDD have been correlated with reduced physical development of Atlantic sturgeon larvae, including reductions in head size, body size, eye development and the quantity of yolk reserves (Chambers et al. 2012). Juvenile shortnose sturgeon raised for 28 days in North Carolina's Roanoke River had a 9% survival rate compared to a 64% survival rate at non-riverine control sites; the reduced survival rate could not be correlated with contaminants, but significant quantities of retene, a paper mill by-product with dioxin-like effects on early life stage fish, were detected in the river (Cope et al. 2010). Dwyer *et al*. (2005) compared the relative sensitivities of common surrogate species used in contaminant studies to 17 listed species including Atlantic sturgeons. The study examined 96-hour acute water exposures using early life stages where mortality is an endpoint. Chemicals tested were carbaryl, copper, 4-nonphenol, pentachlorophenal and permethrin. Of the listed species, Atlantic sturgeon were ranked the most sensitive species tested for four of the five chemicals (Atlantic and shortnose sturgeon were found to be equally sensitive to permethrin). (Dwyer *et al.* 2005). Additionally, a study examining the effects of coal tar, a byproduct of the process of destructive distillation of bituminous coal, indicated that components of coal tar are toxic to shortnose sturgeon embryos and larvae in whole sediment flow-through and coal tar elutriate static renewal (Kocan *et al.* 1993).

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

Contaminants in North Carolina waters

According to the NC Division of Water Quality, all watersheds and river basins in the state are currently considered "impaired" under Section 303(d) of the Clean Water Act (CWA) due to mercury loads in fish that exceed 0.3 mg methylmercury (MeHg) / kg. The highest levels of organic chemicals such as PCBs, pesticides, dioxins and PBDEs are found in the Tar/Pamlico, Neuse, Cape Fear, Yadkin and French Broad basins. North Carolina's coastal plain is characterized by intensive agriculture that results in non-point source pollution in the form of fertilizers, pesticides and waste from animal feedlots. In the Pamlico and Neuse systems,

nutrient-loading and seasonal anoxia are occurring, associated in part with concentrated animal feeding operations. Heavy industrial development and concentrated animal feeding operations have degraded water quality in the Cape Fear River. From 1980 to 2010, DO concentrations have shown significantly decreasing trends in the Chowan River and the Neuse River, as well as the Pamlico Sound including the Pamlico River, Lower Neuse, and White Oak sub-basins. Moser and Ross (1995) suggested that certain deformities and ulcerations found in Atlantic sturgeon in North Carolina's Brunswick River may be due to poor water quality in addition to possible boat propeller inflicted injuries.

Dams

Hydroelectric dams affect Atlantic sturgeon by restricting habitat, altering river flows necessary for successful spawning and/or migration, and causing mortalities to fish that become entrained in turbines. In addition to impediments to migration and associated mortalities, Hill (1996) identified the following potential impacts from hydropower plants: altered DO concentrations and temperature; artificial destratification; water withdrawal; changed sediment load and channel morphology; accelerated eutrophication and change in nutrient cycling; and contamination of water and sediment.

Because sturgeon require adequate river flows and water temperatures for spawning, any alterations that dam operations pose on a river's natural flow pattern, including increased or reduced discharges, can be detrimental to sturgeon reproductive success. Additionally, dam maintenance activities, such as minor excavations along the shore, release silt and other fine river sediments that could be deposited in nearby spawning sites and degrade critical spawning habitat. The prevalence of dams throughout East Coast rivers means that all Atlantic sturgeon life stages generally occur downstream of dams, leaving them vulnerable to perturbations of natural river conditions. Atlantic sturgeon spawning sites remain unknown for the majority of rivers in their range. However, they have been observed spawning hundreds of miles upstream in Southern non-tidal rivers that are unobstructed by dams, suggesting that dams may prevent them from reaching preferred spawning areas. Observations of Atlantic sturgeon spawning immediately below dams further suggests that they are unable to reach their preferred spawning habitat upriver. Overall, 91% of historic Atlantic sturgeon habitat seems to be accessible, but the quality of the remaining portions of habitat as spawning and nursery grounds is unknown, therefore estimates of percentages of availability do not necessarily equate to functionality (NMFS 2007).

Sturgeon appear unable to use some fishways (e.g., ladders) but have been transported in fish lifts (Kynard 1998). Data on the effects of the fish lift at the Holyoke Hydroelectric Project on the Connecticut River suggest that fish lifts that successfully attract other species (i.e, shad, salmon etc.) do a poor job of attracting sturgeon, with attraction and lifting efficiencies for shortnose sturgeon at the Holyoke Project estimated at approximately 11% (NMFS 2013b). Despite decades of effort, fish passage infrastructure retrofitted at hydroelectric dams has largely failed to restore diadromous fish to historical spawning habitat (Brown et al 2013). While improvements to fish passage are often required when hydroelectric dams go through Federal Energy Regulatory Commission relicensing, this relicensing process occurs infrequently, with some licenses lasting as long as 50 years. Over 95% of dams on the eastern seaboard are not

hydroelectric facilities and are thus not subject to continual relicensing and fish passage improvement measures (ASMFC 2008).

Dams in North Carolina

According to the Army Corps of engineers there are 3,262 dams throughout the state's rivers and streams, including 103 hydroelectric dams. Dams have curtailed Atlantic sturgeon spawning and juvenile developmental habitat by blocking more than 60% of historical Atlantic sturgeon habitat upstream of the dams in the Cape Fear and Santee-Cooper River systems. A fish passage in the form of rock arch rapids was installed in 2012 at the first of three major dams on the Cape Fear River; as of November 2013, American shad and striped bass had successfully passed the dam but sturgeon had not.

Atlantic sturgeon have been documented spawning downstream of the first major dam on the Roanoke River, the Roanoke Rapids Dam, where no fish passage capacity exists (other than for American eels) and none is planned. It is estimated based on geographic information systems (GIS) data that the Roanoke Rapids Dam has removed 18% of historical Atlantic sturgeon spawning habitat. On the Tar River, Atlantic sturgeon are not able to pass upstream beyond the Rocky Mount Mills Dam where no fish passage exists nor is planned. Adult Atlantic sturgeon no longer occupy the Neuse River (juvenile and sub-adults have been reported), where the Milburnie Dam, located 218 miles from the river's mouth, obstructs historical migration habitat. On the Pee Dee River, Atlantic sturgeon are known to spawn downstream of the Blewett Falls hydroelectric dam, located at river mile 195. The fact that these dams are so far upstream, well into fresh water, means Atlantic sturgeon are able to spawn and survive in these rivers even if in a limited portion of their historic range.

The Yadkin Pee Dee Hydroelectric Project includes dams on the Yadkin/Pee Dee River system and also the Blewett Falls dam in North Carolina. In its biological opinion on the Federal Energy Regulatory Commission's relicensing of the Yadkin Pee Dee Hydroelectric Project (NMFS 2013d), NMFS estimated and exempted the non-lethal take of 400 Atlantic sturgeon (300 adults and sub-adults/ 100 juveniles) and the lethal take of six adult Atlantic sturgeon from the Carolina DPS over a five year period.

Power Plants

Stressors to Atlantic sturgeon related to power plants include impingement or entrainment; thermal discharges; chemical discharges; and the indirect effect of prey reduction. Impingement occurs when organisms are trapped against cooling water intake screens, racks, or removal equipment by the force of moving water. Adult, juvenile, and larval shortnose sturgeon are known to be killed or impinged on the screens that cover the cooling water intake screens (Hoff and Klauda 1979, Dadswell *et al.* 1984, NMFS 1993). Generally, 100 percent of impingement is assumed to result in mortality. Entrainment refers to fish at any life stage that enter the intake water flow and pass through a cooling water intake structure and into a cooling water system. Adult sturgeon are too large to be entrained, but sturgeon eggs and larvae are potentially susceptible to entrainment.

Power plants withdraw water from rivers, pumping the water through the plants to cool the reactors, then discharging the heated water back to rivers. These thermal discharges have the

potential to cause lethal or sublethal effects to sturgeon and to create barriers, preventing or delaying access to other areas within a river. A thermal plume study conducted at the Indian Point nuclear facility in New York found the warmest water remains close to the surface, and plume temperatures tend to decrease with depth with waters deeper than five meters not likely to exceed 32.22°C (Swanson *et al.* 2011). The maximum observed temperature of the thermal discharge in New York was approximately 35°C, though some discharges have been measured as high as 46°C (Hester and Doyle 2011). Atlantic sturgeon experience lower survival when water temperatures exceed 28°C (Niklitshek and Secor 2005).

Increases in water temperature have been shown to increase the susceptibility of sturgeon to hypoxia (Secor and Niklitschek 2001). Sturgeon are more sensitive to low level dissolved oxygen conditions than other fishes, possessing limited behavioral and physiological capacity to respond to hypoxia (Secor and Niklitschek 2001, Secor and Niklitschek 2002). In experiments on Atlantic sturgeon, the effect of oxygen level on routine metabolism, consumption, feeding metabolism, growth, and survival has been shown to be conditional on temperature (Secor and Niklitschek 2001). The coupling of low dissolved oxygen and high water temperatures amplifies the effect of hypoxia on sturgeon due to a temperature-oxygen habitat squeeze (Coutant 1987). In Southern rivers during the summer, when ambient river temperatures can exceed 32°C, any increase in water temperatures would further increase sturgeon susceptibility to hypoxia. To avoid lethal and sublethal effects, sturgeon must avoid temperatures above 33.7°C with complete oxygen saturation (Ziegweld *et al.* 2008) or hypoxic conditions, particularly as water exceeds about 15°C (Cech *et al.* 1984, Secor and Gunderson 1998). As described above, thermal plumes are known to exceed these parameters. Thus thermal plumes resulting from cooling water intake structure represent one of a suite of factors that can interact with one another to affect the fitness of sturgeon.

Chemical discharges from cooling water intake structure may include radionuclides, including: tritium, strontium, nickel, and cesium. Chlorine, lithium hydroxide, boron, and total suspended solids may also be discharged from cooling water intake structure. Total residual chlorine at cooling water intake structure is often limited to a maximum daily average of 0.2mg/L, as measured at the point of discharge, prior to dilution in the water body. Campbell and Davidson (2007) describe a 50 percent mortality rate (i.e., 96 hour LC50) of young and juvenile white sturgeon when kept for 4 hours at chlorine concentrations of 0.034 – 0.042 mg/L.

Sturgeon feed primarily on benthic invertebrates including amphipods and oligochates (Guilbard 2007). These prey species have limited mobility and are thus unlikely to be entrained. Also, while the benthic macroinvertebrate adults may not be affected by thermal or chemical plumes or discharges of radionuclides, the larvae may be exposed to these stressors in the water column.

There are numerous power plants throughout the migratory ranges of the five Atlantic sturgeon DPSs. In North Carolina, the Brunswick nuclear plant near the mouth of the Cape Fear River overlaps with Atlantic sturgeon migratory habitat. Additionally, there are a number of smaller operational power plants of various types (e.g., hydro, steam, coal) in the action area as well as numerous industrial plants that operate on rivers used by Atlantic sturgeon.

Climate Change

The global mean temperature has risen 0.76ºC over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007b). Precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures as well as related changes in ice cover, salinity, oxygen levels, and circulation. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b). These trends are most apparent over the past few decades.

Primary effects of climate change on individual species include habitat loss or alteration, distribution changes, geographic isolation or extirpation of populations that are unable to adapt. Secondary effects include increased stress, disease susceptibility and predation, and reduced prey availability. The effects of climate change on Atlantic sturgeon will not occur independently from other stressors. Rather, the anthropogenic stressors already affecting the fitness and survival of Atlantic sturgeon – including bycatch, loss of migratory habitat from dams, contamination of riverine habitat and overall decreased water quality – will be compounded by the anticipated effects of climate change.

Atlantic sturgeon could be affected by changes in river ecology resulting from increases in precipitation and changes in water temperature which may affect recruitment and distribution in these rivers. The effects of increased water temperature and decreased water availability are likely to have a more immediate effect on Atlantic sturgeon populations that migrate and spawn in river systems with existing water temperatures that are at or near the maximum for the species, including the South Atlantic and Carolina DPSs. Atlantic sturgeon prefer water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats. The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas, while flooding events could cause temporary decreases in water quality. Rising temperatures predicted for all of the US could exacerbate existing water quality problems with dissolved oxygen and temperature.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all Atlantic sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat.

Changes in oceanic conditions could also affect the marine distribution of Atlantic sturgeon or their marine and estuarine prey resources. Rising sea level may result in the salt wedge moving

upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. In river systems with dams or natural falls that are impassable by sturgeon, movement of the salt wedge further upstream would further restrict Atlantic sturgeon spawning and rearing habitat.

Information on current effects of global climate change on Atlantic sturgeon is not available and while it is speculated that future climate change may affect sturgeon, it is difficult to quantify the extent to which effects may occur.

Dredging

Riverine, nearshore, and offshore areas are often dredged to support commercial shipping, recreational boating, construction of infrastructure, and marine mining. Dredging in spawning and nursery grounds modifies the quality of the habitat and curtails the extent of available habitat in some rivers where Atlantic sturgeon habitat has already been modified and curtailed by the presence of dams (e.g., the Cape Fear and Savannah Rivers). Dissolved oxygen concentrations can also be affected by maintenance dredging of federal navigation channels and other waters. Some of the consequences of dredging include entrainment on the pump heads and changing dissolved oxygen and salinity gradients in, and around, the channels (Jenkins *et al.* 1993, Secor and Niklitschek 2001, Campbell and Goodman 2004). Dredging operations may also pose risks to sturgeon by destroying or adversely modifying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. As sturgeon are benthic omnivores, modification of the benthos could affect the quality, quantity and availability of sturgeon prey species.

According to Smith and Clugston (1997), dredging and filling impact important habitat features of Atlantic sturgeon as they disturb benthic fauna, eliminate deep holes, and alter rock substrates. Similarly, Hatin et al. tested whether dredging operations affected Atlantic sturgeon behavior by comparing catch per unit effort (CPUE) before and after dredging events in 1999 and 2000. The authors documented a three to seven-fold reduction in Atlantic sturgeon presence after dredging operations began, indicating that sturgeon avoid these areas during operations(Hatin *et al.* 2007).

In addition to indirect impacts, hydraulic dredging can directly harm sturgeon by lethally entraining fish up through the dredge drag-arms and impeller pumps. Between 1990 and 2005, 10 Atlantic sturgeon were reported captured by hopper dredges (ASSRT and NMFS 2007). Atlantic sturgeon have been taken in both hydraulic pipeline and bucket-and-barge operations in the Cape Fear River, North Carolina (Moser and Ross 1995). Mechanical dredges (i.e., clamshell) have also been documented to kill Atlantic sturgeon (Hastings 1983; NMFS 1998). Dickerson (2011) reported 15 Atlantic sturgeon taken in dredging activities conducted by the US Army Corps of Engineers from 1990-2010, most captured by hopper dredge. Notably, reports include only those trips when an observer was on board to document capture.

Research

Atlantic sturgeon have been the focus of field studies since the 1970s. The primary purposes of most studies are for monitoring populations and gathering data for physiological, behavioral, and ecological studies. At the time of this consultation NMFS has issued scientific research permits authorizing take in the form of capture and handling for 5,648 Atlantic sturgeon per year

including mortalities for 1,065 eggs/larvae and 16 adult/sub-adult/juvenile mortalities. Research on sturgeon in the US is carefully controlled and managed so that it does not operate to the disadvantage of the species. As such, all scientific research permits are also conditioned with mitigation measures to ensure that the research impacts target and non-target species as minimally as possible.

Permitted researchers are also required to notify the appropriate NMFS Regional Office at least two weeks in advance of any planned field work so that the Regional Office can facilitate this coordination and take other steps appropriate to minimize disturbance from multiple permits. An biological opinion was issued for each of the permits authorized for Atlantic sturgeon (Table 7), including the requirement for consideration of cumulative effects to the species (as defined for the ESA). For each permit, an Opinion concluded that issuance was not likely to jeopardize the continued existence of the Atlantic sturgeon, either individually or cumulatively.

Table 7: Research Permits issued for Atlantic sturgeon along the US Coast.

Permit Number	Location	Authorized Take	Research Activity
16526 Expires: 4/6/2017	Gulf of Maine Rivers and coastal areas	875 adult/juv, 300 ELS, 3 morts	Capture, handle, measure, weigh, PIT tag, Floy/T-bar tag, tissue sample, internal tag, external tag, collect ELS, blood sample, apical spine sample, fin ray sample, anesthetize, boroscope, lavage.
16323 Expires: 4/6/2017	Connecticut River and Long Island Sound	200 adult/sub-adult	Capture, handle, weigh, measure, PIT tag, Floy/T-bar tag, transmitter tag, tissue sample, anesthetize, fin ray section
16422 Expires: 4/6/2017	Coastal water between Long Island Sound and Delaware River	325 adult/sub-adult	Capture, handle, measure, weigh, PIT tag, dart tag, tissue sample, fin-ray section, anesthetize, blood collection, gill biopsy, external/PSAT tag, body tissue biopsy
16436 Expires: 4/6/2017	Hudson River and estuary	1550 adult/juv 2 morts	Capture, handle, measure, weigh, dart tag, PIT tag, genetic tissue sample, anesthetize, gastric lavage, internal tag, external tag
16507 Expires: 4/6/2017	Delaware River and coastal waters	510 juv., 350 ELS	Capture, handle, weigh, measure, Floy tag, PIT tag, genetic tissue sample; anesthetize, fin ray section, gonad tissue sample, internal sonic tag, external satellite tag,
16431 Expires: 4/6/2017	Delaware River estuary	240 juv., 1 mort	Capture, handle, weigh, measure, Floy tag, PIT tag, genetic tissue sample, anesthetize, internal acoustic tag, gastric lavage, fin ray section
16438 Expires: 4/6/2017	Delaware River Estuary	284 juv., 50 ELS, 1 mort	Capture, handle, measure, weigh, Floy tag, PIT tag, tissue sample, anesthetize,

			internal sonic tag, laparoscopy, blood collection, gastric lavage, collect ELS
16547 Expires: 4/6/2017	Chesapeake Bay and its Tributaries, MD and VA	600 adult/juv., 25 ELS, 3 morts	Capture, handle, measure, weigh, Floy tag, PIT tag, genetic tissue sample, anesthetize, external sonic tag, internal sonic tag, fin ray section
16375 Expires: 4/6/2017	North Carolina Rivers and Albemarle Sound	200 adult/juv.	Capture, handle, weigh, measure, PIT tag, floy tag, genetic tissue sample, anesthetize, internal tag,
16442 Expires: 4/6/2017	South Carolina Rivers	400 adult/juv 50 ELS	Capture, handle, measure, weigh, PIT tag, dart tag, genetic tissue sample, anesthetize, internal acoustic tag, gonad biopsy, collect ELS
16482 Expires: 4/6/2017	Georgia Rivers and coastal waters	204 adult/sub-adult, 3270 juv., 250 ELS, 6 morts.	Capture, handle, measure, weigh, tissue sample, PIT tag, floy tag, anesthetize, internal/external acoustic tag, fin ray section, laparoscopy, internal acoustic tag, gonad biopsy, collect ELS
16508 Expires: 4/6/2017	Florida/Georgia Rivers	60 adult/sub-adult	Capture, handle, measure, weigh, tissue sample, PIT tag, floy tag, external sonic tag
17095 Expires: 7/25/2017	Hudson River	200 adult/sub-adult/juvenile Atlantic and 40 ELS	Capture, handle, measure, weigh, tissue sample, PIT tag, dart tag

6. EFFECTS OF THE PROPOSED ACTION

In this section of the Opinion, we assess the probable effects resulting from the issuance of the 10(a)(1)(B) permit and implementation of the Conservation Plan and other permit conditions, which will allow all inshore commercial gill net fisheries and incidental take of Atlantic sturgeon in the action area. We assess the probable amount of lethal and non-lethal take and estimate the proportion of those takes that affect each DPS. We also summarize the results of studies that have examined effects of various fisheries on Atlantic sturgeon. We rely on these summaries of the literature to determine how individual sturgeon are likely to respond upon being captured in commercial gill nets. Based on this body of information, we then assess the risks bycatch in gill nets poses first to individual sturgeon, then sturgeon populations, then to the species as it is listed (each Atlantic sturgeon DPS).

The stressors associated with the proposed action are capture in set gill nets, handling, and release of captured individuals by fishermen and observers, and monitoring by observers as well as NCDMF biologists to include PIT tagging and genetic sampling of individuals prior to release. The following sections provide estimates of the number of Atlantic sturgeon to interact with gill nets, estimates of the mortality rates, estimates of the DPSs to be affected, a discussion of the stress caused by bycatch, and the probability of harm and harassment.

6.1 Exposure Analysis

This section of the Opinion estimates the number of Atlantic sturgeon that will be incidentally taken by North Carolina's inshore gill net fisheries at the level of mesh size in each management unit, each season, of each year for the next 10 years. Estimating bycatch is difficult, especially for an endangered species, because Atlantic sturgeon are relatively rare in the environment and they are not the target species of the fishermen, so in the vast majority of the fishermen's net sets, there are no Atlantic sturgeon captured. The potential models need to provide an estimate of take seasonally, by mesh size, and in each management unit for each of the years of the proposed Conservation Plan.

6.1.1 Identification of Variables

Given a comprehensive data set between 2004 and 2011, to appropriately estimate Atlantic sturgeon bycatch most conservatively, season, management unit, and mesh size are variables in the data that need definition. Management units are defined by NCDMF and will remain consistent throughout this project (Figure 1). Seasons and the identification of 'large' and 'small' mesh will also remain consistent throughout the Conservation Plan. The seasons are identified as winter (December through February), spring (March through May), summer (June through August), and fall (September through November). Small mesh gill nets are all nets smaller than five inches stretch mesh, while large mesh gill nets are all nets five inches stretch mesh and larger.

6.1.2 Determining the Rate of Bycatch

The first step in an assessment to determine the anticipated take requires understanding the total amount of fisheries effort in each season and management unit by mesh size. This information from 2004 to 2011 is available based on required reporting during the fishing season. The total fishing effort could then be compared with the Observer coverage from the same time period. These two pieces of information will reveal a rate of bycatch that could be very specific (Spring, Unit A, large mesh gill net fisheries in 2010) or more general (bycatch rates for 2010).

Observer coverage and striped bass monitoring studies conducted by NCDMF between 2004 and 2011 were shared with NMFS. This monitoring covered approximately 2% of fisheries in that time and was inadequate for understanding trends in bycatch rates. Coverage was generally only good for large mesh gill nets in the fall for management unit B. In every other combination of mesh size, season, and management unit, coverage was insufficient and in many cases there was no coverage at all. Between 2004 and 2011, fisheries activities in management unit D were never observed or monitored. So, it is impossible to estimate potential Atlantic sturgeon bycatch rates in that management unit. Similarly, small mesh gill netting in management unit E during the summer has never been conducted. In other cases, observer coverage was missing during some combination of years, mesh sizes, seasons, or management units and so despite the NOAA Observer data being the best available information, there are some data groupings that a bycatch rate would have been based on so few data points that the rate may not be very reliable or accurate. For instance, if there was only observer coverage during two years between 2004 and 2011 for small mesh gill nets in the fall for management unit C and that only covered 0.5% of the

total fisheries effort, the bycatch rate for small mesh gill nets in the fall for management unit C may be an unreliable number.

6.1.3 Modeling Efforts to Estimate Atlantic Sturgeon Captured

Modeling Atlantic sturgeon takes is complicated and required several attempts before identifying the appropriate approach. An explanation of the initial modeling efforts is available in Appendix A. The model identified by NMFS OPR and NCDMF as the best model is the zero inflated Poisson model, a type of general linear model. NMFS OPR had the model peer reviewed by statisticians and sturgeon biologists to ensure it was the best model to use. The comments provided by the peer reviewers are available in the administrative record.

The most common regression analysis is a general linear model. There are several types of general linear models, but Poisson models are designed to analyze count data, like that obtained by observer monitoring. The general linear model assumes normally distributed data, but when working with bycatch of an endangered species, the data is skewed towards zero. The best model to estimate bycatch, given the data monitoring has produced, is a zero-inflated Poisson model. The zero-inflated Poisson accounts for the skewed nature of the data, dominated by zeros (no sturgeon observed as bycatch). Even when data is pooled for an entire category, there are many areas and seasons with no observed Atlantic sturgeon bycatch.

Using a zero-inflated Poisson model, which was peer-reviewed and determined to be the most appropriate modeling technique, each variable (year, mesh size, management unit, and season) was statistically significant at the α=.05 level. Furthermore, differences within a treatment (management unit A vs. unit B vs. unit C vs. unit E) were often statistically significant. Ideally, because there was a significant difference between years in our data set, there would have been enough observer effort and sturgeon observations each year to make predictions on future interactions without relying on pooled bycatch observations between 2004 and 2011.

Calculating the coefficients in the regression model is complicated and requires a statistical program. Once the coefficients are calculated, the take can be estimated by plugging the coefficients into the regression equation. The zero-inflated Poisson model was run in the statistical program, R. The NCDMF used the following equation to estimate the number of Atlantic sturgeon likely to be captured in each mesh size in every management unit, season, and year:

zeroinfl (Sturgeon ~ Year + Mesh + Season + Unit | Season, offset=lnEffort, dist="poisson", link="logit", data=bycatch)

This model provided coefficients, standard deviations, and significance levels for each year, mesh, season, and management unit (NCDMF 2014). Using those coefficients, we could produce a predictive equation for sturgeon bycatch:

$$\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 = \text{sturgeon bycatch}$$

By plugging in the coefficients and appropriate categorical information, the following take estimates (Tables 8 and 9) were produced for the inshore North Carolina gill net fisheries:

Table 8: Annual Atlantic sturgeon take in North Carolina inshore large mesh gill net fisheries estimated using 2010 effort and a zero-inflated Poisson regression analysis.

Season	Management Unit	2010 Fisheries Effort (net hours fished)	Modeled Atlantic sturgeon take estimate
Spring	A	3877643.8	614
Spring	B	1024568.5	2
Spring	C	605836.3	3
Spring	D	Not Reported	2
Spring	E	217367.7	2
Summer	A	680574.8	209
Summer	B	1070392.9	6
Summer	C	214364.5	3
Summer	D	Not Reported	2
Summer	E	115786.1	2
Fall	A	2948148.6	1,117
Fall	B	3512732.7	23
Fall	C	370722.6	6
Fall	D	Not Reported	2
Fall	E	186910.3	2
Winter	A	1182739.3	199
Winter	B	58439.4	2
Winter	C	35005.5	2
Winter	D	Not Reported	2
Winter	E	31681.5	2
Total		16132914.5	2203

Table 9: Annual Atlantic sturgeon take in North Carolina inshore small mesh gill net fisheries estimated using 2010 effort and a zero-inflated Poisson regression analysis.

Season	Management Unit	2010 Fisheries Effort (net hours fished)	Modeled Atlantic sturgeon take estimate
Spring	A	1009249.6	263
Spring	B	1577641.2	7
Spring	C	172968.0	2
Spring	D	Not Reported	2
Spring	E	39447.0	2
Summer	A	170800.0	86
Summer	B	483642.0	4
Summer	C	24896.4	2
Summer	D	Not Reported	2
Summer	E	23352.6	2
Fall	A	198400.0	124
Fall	B	421033.4	4

Fall	C	26130.6	2
Fall	D	Not Reported	2
Fall	E	145520.3	2
Winter	A	759407.1	210
Winter	B	301857.3	2
Winter	C	123402.8	2
Winter	D	Not Reported	2
Winter	E	129593.1	2
Total		5607341.4	724

In some cases, the predicted number of Atlantic sturgeon being captured was less than one because of data limitations, so in those cases, NCDMF assumed two Atlantic sturgeon would be captured in that management unit and season. While this increases the number of predicted Atlantic sturgeon interactions by approximately 50 fish per year, it is likely that two Atlantic sturgeon are captured in some of those management units and seasons, but that level of take will not be exceeded because increased observer coverage will ensure that no more than two are captured then.

The zero inflated Poisson bycatch model using 2010 effort estimates large mesh gill nets will capture 2,203 Atlantic sturgeon and small mesh gill nets will capture 724 Atlantic sturgeon. An annual Atlantic sturgeon bycatch estimate of 2,927 has not distinguished the proportion of Atlantic sturgeon that will be released alive or the subset of these fish that is likely to be killed. The mortality estimates are addressed in the response analysis below. Much like above, large mesh and small mesh gill nets target very general sizes of Atlantic sturgeon.

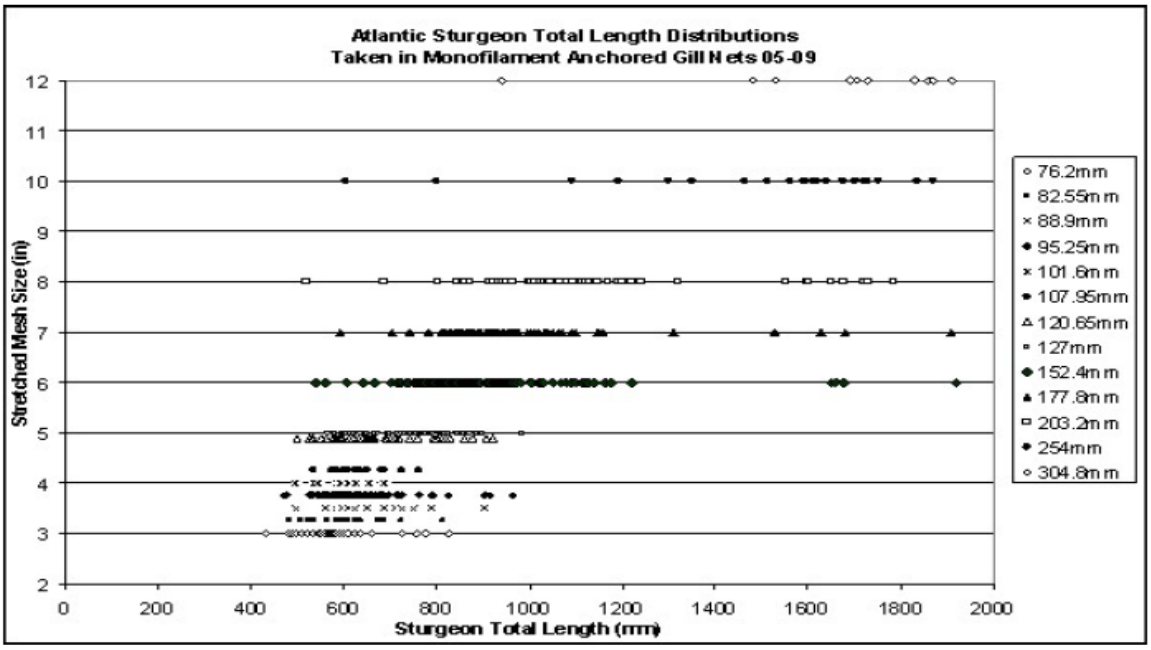
6.1.4 Sturgeon Life Stages Captured

Most sturgeon caught as bycatch are less than 800mm, which means the fisheries are catching primarily juvenile and small sub-adult fish (Armstrong and Hightower 2002, NCDMF 2014). Telemetry data on juvenile Atlantic sturgeon tagged in the Albemarle Sound, as well as NCDMF survey data, indicate that juvenile Atlantic sturgeon are most abundant in shallow nearshore areas, where commercial gill-netting is also concentrated (Armstrong and Hightower 2002). Sturgeon are benthic feeders and as a result they are generally captured near the seabed unless they are actively migrating (McCleave *et al.* 1977; Moser and Ross 1995). Therefore bycatch rates in any particular year are strongly influenced by the previous year's reproductive success, water and habitat quality, juvenile survival, and migration. This means that the bycatch rate for any size gill net, even if future fishing effort is consistent at the 2010 level, will vary depending on the density of Atlantic sturgeon in each management area, during each season, each year. The NCDMF chose to use an annual maximum number of takes as opposed to a temporal average (for instance, a number of Atlantic sturgeon authorized over a 3 year period). Therefore, monitoring will be used in all management units during all seasons to ensure the take levels authorized have not been exceeded.

Capture rates associated with mesh size may be dependent on Atlantic sturgeon life stage. ASMFC (2007) reported capture rates were correlated with mesh size, with increased mesh size resulting in higher capture rates. The majority of the captures analyzed by ASFMC occurred in coastal and marine waters where sturgeons encountered were likely to be sub-adults and adults.

Experiments on sturgeon capture in gill nets of various mesh sizes confirms that the size of captured sturgeon vary depending on mesh size (Figure 2).

Figure 2: Atlantic sturgeon size distributions captured in anchored gill nets in Virginia (Chris Hager, Chesapeake Scientific LLC., unpublished data, as cited in Damon-Randall *et al.* 2010).



6.2 Response Analysis

In this section, we summarize information on the probable physical, physiological, behavioral, and ecological responses of Atlantic sturgeon given exposure to capture in gill nets, handling, and activities associated with data collection. Our purpose is not to provide a comprehensive review of the probable responses of Atlantic sturgeon to these stressors; instead, our intention is to identify the range of representative responses we would expect Atlantic sturgeon to exhibit given exposure to these stressors.

6.2.1 Injury and Mortality from gill net interactions

Atlantic sturgeon morphology may make them particularly prone to entanglement in gill nets. Their cone-shaped snout enables the transfer of net meshes over the head and along the body facilitating gilling or wedging. Atlantic sturgeon skin is covered in bony scutes that also increase the likelihood of entanglement and wedging. Once entangled, larger fish may become wrapped in nets as they struggle to free themselves while smaller fish may be entangled by a single monofilament strand hung around a scute (Damon-Randall *et al.* 2010).

Capture in gill net gear can result in injury, mortality, reduced fecundity, and delayed or aborted spawning migrations of sturgeon (Moser and Ross 1995, Collins *et al.* 2000, Moser *et al.* 2000). When sturgeon are captured in gill nets, either for research or as unintended bycatch, adverse effects are caused by numerous factors including water temperature, low dissolved oxygen concentration, soak time, mesh size, net composition, and handling care.

All of the fisheries considered in this Opinion employ sink gill nets that are anchored or staked to the seafloor and remain there unattended for hours or days at a time. Bycatch-related mortality among Atlantic sturgeon in federal fisheries has been demonstrated to be significantly higher in sink gill nets than in other types of fishing gear (ASMFC 2007; Stein *et al.* 2004; Miller and Shepherd 2011). Stein *et al*. (2004) examined observer data from federal fisheries in the Northeast and Mid-Atlantic, reporting a 22% mortality rate for Atlantic sturgeon captured in sink gill nets. ASMFC (2007) analyzed data from the NEFSC observer program for the period 2001-2006 and reported a 13.8% mortality rate in sink gill nets, also concluding that Atlantic sturgeon mortality was significantly higher in sink gill nets than in trawls. Miller and Shepherd (2011) calculated a 20% mortality rate for Atlantic sturgeon in sink gill nets across the federal fisheries from Maine to North Carolina based on observer data collected from 2006 to 2010. While these mortality rates are higher than has been observed in North Carolina, that is likely because these studies are focused on offshore fisheries with no soak time restrictions. Longer soak times are associated with higher mortality rates (Kahn and Mohead 2010).

6.2.2 Lethal Effects

Modeling of Atlantic sturgeon captures in North Carolina gill net fisheries based on observer data and 2010 fishing effort suggests that CPUE in large mesh (≥5.0 ISM) gill net fisheries and small mesh (<5.0 ISM) gill net fisheries are not significantly different (total captures as reported by NCDMF have historically been higher in large mesh fisheries as a result of higher levels of effort). Based on observer data, NCDMF reported a higher at-net mortality rate for Atlantic sturgeon in small mesh gear (0.059 mortalities per capture) versus in large mesh gear (0.03 mortalities per capture). However it should be noted that these rates are based on only 13 reported mortalities. Additionally, observer reported mortality does not account for interruptions in spawning, injuries and delayed mortality as a result of capture.

Results from a five year fisheries independent anchored gill net survey in Virginia with standard 24 hour sets and mesh sizes ranging from 4.88 to 12 inch stretched mesh showed mortality likelihood did not increase consistently across mesh sizes with rising water temperature (n=430, 6-24°C). Predicted mortality did significantly increase across mesh sizes with fish size, with larger adults experiencing higher mortality than smaller, more resident individuals, but adult presence was correlated with increased water temperatures, particularly over 18°C (Chris Hager, Chesapeake Scientific, LLC., unpublished data from 2004-2007).

Atlantic sturgeon survival is naturally limited by the interaction between high water temperatures, low dissolved oxygen, and salinity (Jenkins *et al.* 1993, Secor and Niklitshcek 2001, Niklitschek 2001, Niklitschek and Secor 2009a, 2009b); however, when combined with the stress of capture in gill nets, as soak times increase, so does the probability of mortality (Collins *et al.* 1996, Buchanan *et al.* 2002, Bettoli and Scholten 2006, Moser 1995). Tolerance to elevated temperatures and low dissolved oxygen concentrations also appears to increase with age (body size) (Jenkins *et al.* 1993, Ziegeweid *et al.* 2008). Sturgeon experience elevated natural mortality when temperatures exceed 28°C (Moser *et al.* 1998, Secor and Niklitschek 2005). Secor and Niklitshcek (2002) and Secor and Gunderson (1998) reported that dissolved oxygen levels at or below 3.3 mg/L, regardless of temperature, can cause mortality in Atlantic sturgeon juveniles. Survival of Atlantic sturgeon was observed to be 100% in water

temperatures of 26°C with 7 mg/L DO (Secor and Gunderson 1998). In experiments on young of the year shortnose sturgeon critical thermal maxima was found to significantly increase with an increase in acclimation temperature (Ziegeweid *et al.* 2007).

Studies of Atlantic sturgeon captured in North Carolina rivers during summer found mortality rates to be 24% (24/100, Moser and Ross 1995) and 25% (22/88, Moser 1998) when water temperatures exceeded 28°C. Armstrong and White (2000) reported 131 Atlantic sturgeon captured in the North Carolina southern flounder fishery with no mortalities in waters between 8.9°C and 28.4°C in estuaries. In cooler rivers from January through April in South Carolina and Georgia, mortality rates were 16% (Collins *et al.* 1996) and 2.3% (Bahn *et al.* 2012), respectively.

A key finding of the 2006 Sturgeon Technical Committee Workshop on sturgeon bycatch was that soak times exceeding 24 hours were associated with substantially higher sturgeon mortality rates. Observer data of marine gill net fisheries (ASMFC 2007) concluded that water temperature and soak time both lead to increased mortality regardless of capture method. Across the range of temperatures, mortality increased with rising temperatures but mortality also increased with soak times, with soak times over 24 hours resulting in a 40% mortality and those under 24 hours resulting in only 14%. Likewise, research on those same fisheries found Atlantic sturgeon mortality rates increased from approximately 54% at 24h to 65% at 48h, 76% at 72h, and 84% at a soak time of 96h (Fox *et al.* 2012).

The ASMFC (2007) analysis of marine gill net fisheries observer data found a significant correlation between tie-down use and Atlantic sturgeon mortality. ASMFC (2007) concluded that the strongest gear factor associated with Atlantic sturgeon mortality was the increase in mesh size when tie-downs were used, regardless of target species. Tie-downs are added to some sink gill nets to create bags or pockets within the nets by increasing webbing mobility and meshes per unit area (Damon-Randall 2010). These pockets make it more difficult for ensnared fish to escape, increasing the capture rate of targeted and incidentally captured fishes. Tie-downs likely result in increased retention rates of Atlantic sturgeon as they are largely bottom-dwellers and are easily entangled (Damon-Randall 2010). Trials on captive Atlantic sturgeon have shown that enlarging twine (0.4-0.52 mm), augmenting hanging ratio (0.5-0.625), and removing tie downs (30" tie downs on 45" net) all significantly reduce retention rates (retained/interacted) (Hager 2007).

The majority of incidental Atlantic sturgeon captures in inshore state waters are concentrated in management unit A (NCDMF 2014). Tie downs are permitted in all gill nets in Management Unit A, where large mesh gill nets must be checked every 24 hours while small mesh gill nets have unlimited soak times but must be attended from May 15th through November 18th. We would expect Atlantic sturgeon to be more prone to capture – and the resultant effects on sturgeon fitness, reproduction and survival to be magnified – in areas where tie down use is permitted. As increased soak times have been proven to lead to higher mortality rates among captured Atlantic sturgeon, we would expect mortalities and occurrences of sub-lethal impacts of capture to be higher in areas that lack soak time restrictions.

In some cases, gear alterations can help avoid Atlantic sturgeon bycatch. In the James River, Virginia, results of experiments in the striped bass fishery that occurs in shallow riverine waters indicated a reduction in Atlantic sturgeon bycatch when a raised footrope was used, effectively lifting the net off the river bottom and significantly reduced Atlantic sturgeon bycatch (Chris Hager, Chesapeake Scientific, LLC, unpublished data from 2004-2008). In the monkfish sink gill net fishery that occurs offshore of New Jersey, experiments compared capture rates of both Atlantic sturgeon and target species in standard sink gill nets (12 meshes with 48 in. tie-downs) and low profile sink gill nets that did not reach as high into in the water column (six meshes with 24 in. tie-downs). Results, though not statistically significant, indicated the rate of Atlantic sturgeon captured in the low profile nets was 20% lower than the rate of capture in control nets (Fox *et al.* 2012).

Using mortality data observed between 2004 and 2011, the zero inflated Poisson model anticipates the annual mortality of 101 Atlantic sturgeon from large mesh gill net fisheries and 68 from small mesh gill net fisheries. The probability of Atlantic sturgeon from any particular DPS being killed will vary by chance as well as the percentage abundance in the area. NMFS anticipates that mortalities caused by the large mesh gill net fisheries may affect up to 76 of the 101 juvenile and sub-adult Atlantic sturgeon from the Carolina DPS. However, it is possible that as many as 41 of the 101 Atlantic sturgeon killed each year could be from the Chesapeake Bay DPS, or 41 of those 101 could be from the South Atlantic DPS, or as many as 11 of the 101 could be from the New York Bight DPS, and up to 4 of the 101 could be from the Gulf of Maine DPS. NMFS anticipates that mortalities caused by small mesh gill net fisheries may affect up to 51 Carolina DPS juvenile and sub-adult Atlantic sturgeon of the 68 that may die. However, it is possible that as many as 28 of the 68 juvenile and sub-adult Atlantic sturgeon killed each year could be from the Chesapeake Bay DPS, or up to 28 of the 68 sturgeon could be from the South Atlantic DPS, or up to 7 of the 68 Atlantic sturgeon could be from the New York Bight DPS, and up to 3 of the 68 Atlantic sturgeon could be from the Gulf of Maine DPS.

6.2.3 Sub-lethal Effects

In addition to the potential for mortality, capture in fishing gear can result in sub-lethal effects to sturgeon reproduction and fitness that last beyond catch and release (Moser and Ross 1995, Boreman 1997, Kynard 1997, Clark and Hare 1998, Caswell *et al.* 1999, Stein *et al.* 2004). The severity of sub-lethal interactions with gill net fisheries is influenced by the level of stress of the individual fish which is a product of gill net soak time as well as the environmental factors of water temperature, DO, salinity, air temperature, and handling time.

A study on post-release survival among Atlantic sturgeon captured in benthic otter trawl fisheries in the Bay of Fundy found that longer handling times resulted in elevated levels of blood lactate, an indicator of stress, in fish that were captured relative to experimental control fish (Beardsall *et al.* 2013). Handling and restraining sturgeon may cause short-term stress responses, but those responses are not expected to result in pathologies because commercial fishermen release sturgeon immediately after they are removed from their nets.

Secor and Niklitschek (2002) suggest that dissolved oxygen at 60% saturation (4.3-4.7 mg/L at 22-27°C) or higher is necessary for Atlantic sturgeon to avoid sub-lethal bioenergetic responses, such as reduced growth and reduced metabolic function. Niklitschek (2001) reported that

hatchery-raised juvenile Atlantic sturgeon originating from the Hudson River reduced metabolic function and food consumption at 26°C.

Moser and Ross (1995) reported that handling prior to release as a result of capture in the commercial shad fishery appeared to cause interruption or abandonment of spawning migrations for 80% (n=5) of shortnose sturgeon tracked in the Cape Fear River. Weber (1996) documented a shortnose sturgeon aborting its eggs upon capture by a shad fisherman in the Ogeechee River in Georgia.

Sturgeon may inflate their swim bladder when held out of water (Moser *et al.* 2000) and if they are not returned to neutral buoyancy prior to release, they will float and be susceptible to sunburn and predation. Collins *et al.* (1996) reported 20% (n=41) of captured Atlantic sturgeon in South Carolina's Winyah Bay American shad fishery in anchored gill nets were released with injuries of varying severity. Bahn *et al.* (2012) discussed post-release mortality without mentioning any injuries; therefore, we assume there were likely no injuries observed because they would have been an important consideration in the post-release mortality discussion. We anticipate the number of sturgeon injured as bycatch to be between the number observed in South Carolina (20%) and the number reported during monitoring of the Altamaha River (0%), resulting in no more than 10% of the sturgeon bycatch being injured.

6.2.4 Effects Specific to Data Collection

During monitoring activities, NCDMF or NOAA observers will take small (1 cm^2) genetic tissue samples, clipped with surgical scissors, from sections of the soft fin rays of each captured Atlantic sturgeon. The resulting DNA data will improve our understanding of population structure seasonal movement patterns and homing fidelity of Atlantic sturgeon to their natal estuaries and will provide information on the Atlantic Sturgeon DPSs present in North Carolina waters. For instance, Wirgin *et al.* (2007) used mtDNA data to demonstrate that a genetically distinct population of Atlantic sturgeon is reproducing in the Delaware River, but that the river also hosts migrant subadults from elsewhere. This information will assist in adaptive management during future years of this Conservation Plan and is essential to the recovery of Atlantic sturgeon as a whole. This sampling technique does not appear to impair the ability to swim and is not thought to have any long-term adverse impact (Kahn and Mohead 2010). Many tissue samples have been removed according to this same protocol with no adverse effects (Wydoski and Emery 1983); therefore, NMFS does not anticipate any long-term adverse effects to the sturgeon from this activity.

During monitoring activities, NCDMF will also PIT tag all Atlantic sturgeon larger than 300 mm TL that do not already have PIT tags. PIT tags have been used with a wide variety of animal species that include fish (Clugston 1996, Skalski *et al.* 1998, Dare 2003), amphibians (Thompson 2004), reptiles (Cheatwood *et al.* 2003, Germano and Williams 2005), birds (Boisvert and Sherry 2000, Green *et al.* 2004), and mammals (Wright *et al.* 1998). When PIT tags are inserted into animals that have large body sizes relative to the size of the tag, empirical studies have generally demonstrated that the tags have no adverse effect on the growth, survival, reproductive success, or behavior of individual animals (Brännäs *et al.* 1994, Elbin and Burger 1994, Keck 1994, Jemison *et al.* 1995, Clugston 1996, Skalski *et al.* 1998, Hockersmith *et al.* 2003). As with all invasive sampling procedures, there is some risk associated with PIT tagging. Smaller sturgeon

may experience mortality as a result of inserting a tag too deeply or from pathogenic infection. Henne et al. (2003) found that 14-mm PIT tags inserted into smaller shortnose sturgeon (150 to 220 mm total length TL) caused 40% mortality after 48 hours; however, no mortality occurred in a larger group of juvenile sturgeon measuring 250 to 330 mm TL using smaller 11.5mm PIT tags. Most sturgeon encountered in both large mesh and small mesh fisheries in North Carolina estuarine fisheries are likely to be juveniles or small sub-adults (Armstrong and Hightower 2002; NCDMF Conservation Plan Application 2014). To avoid any unintended mortality to small fish, NCDMF will not PIT tag sturgeon <300 mm TL. As such, PIT tagging is unlikely to have significant adverse impacts on Atlantic sturgeon. Gries and Letcher (2002) and Dare (2003) found that there is a small amount of long-term mortality associated with tagging juvenile salmonids. Lake sturgeon (*Acipenser fulvescens*) captured in gill nets (24 h net sets) and PIT tagged in temperatures 18°C and below showed significant responses in several physiological stress indicators but recovered nearly completely within 3 days of sampling, with no documented mortality (Baker *et al.* 2008). There is no way to measure long-term mortality associated with this project, but all indications are that there will be no affects because of the sizes of sturgeon that will receive PIT tags.

6.2.5 Effects of Repeated Capture

Repeat captures of individual fish are likely to occur at varying rates depending on factors such as season, soak time and the Atlantic sturgeon population density of the area being fished. Published research on the physiological effects of repeat captures is largely lacking. Lankford *et al.* (2005) noted that chronically stressed green sturgeon experienced reduced swimming performance. Iwama (1989) noted that cortisol, a hormone associated with stress response, takes 24 hours to return to baseline levels after sturgeon are captured and handled. Based on the known effects of single captures it is assumed that repeated captures within 24 hours are likely to result in stress responses similar to those seen in chronically stressed fish. Moser and Ross (1995) reported that repeated capture or excessive handling of shortnose sturgeons in the lower Cape Fear River appeared to interrupt or abort the spawning migration of 80% (4/5) fish that were tracked.

6.3 Risk Analysis

In this section, we summarize the interaction of the likelihood of exposure and the expected responses of Atlantic sturgeon given exposure to capture in gill nets, handling, and activities associated with data collection. Whereas the Response Analysis assessed the potential responses to capture, handling, and activities associated with data collection, this section assesses the most probable responses and how those individual responses may affect spawning populations as well as entire DPSs. It will also evaluate whether the Conservation Plan, as proposed, ensures NCDMF is not likely to jeopardize threatened and endangered DPSs of Atlantic sturgeon.

6.3.1 Gill net Interactions and Responses

In any given year, NMFS and NCDMF believe it is likely that as many as 2,203 Atlantic sturgeon will be captured in large mesh gill nets and 724 will be captured in small mesh gill nets. Of those 2,927 Atlantic sturgeon that are captured, a subset of those fish will be killed while the rest will be released alive. Using the same zero-inflated Poisson model of mortality data, NMFS expects large mesh gill nets are likely to kill 101 Atlantic sturgeon each year and small mesh gill

nets are likely to kill 68 Atlantic sturgeon each year. These captures and mortalities are limited to specific estimates in each season and management unit, which means that to reach these total anticipated numbers, fishermen in North Carolina would have to catch and kill the maximum number of Atlantic sturgeon authorized in 5 different management units during 4 different seasons in both large and small mesh gill net fisheries.

When broken down by management unit, it becomes clear that most of the interactions with Atlantic sturgeon will happen in management unit A, which is the Albemarle Sound (Table 10). In management unit A, 97.1% of all Atlantic sturgeon bycatch in large mesh gill nets in North Carolina and 94.3% of all Atlantic sturgeon bycatch in small mesh gill nets in North Carolina will occur. Fisheries bycatch in management unit A account for 85.1% of anticipated mortalities in large mesh gill nets and 80.9% of anticipated mortalities in small mesh gill nets in the entire state.

Table 10: Anticipated bycatch and associated mortalities from bycatch in management unit A each year.

Mesh Size	Season	Bycatch	Mortalities	Mortality Rate
Large	Spring	614	25	4.1%
Large	Summer	209	8	3.8%
Large	Fall	1,117	45	4.0%
Large	Winter	199	8	4.0%
Small	Spring	263	21	8.0%
Small	Summer	86	7	8.1%
Small	Fall	124	10	8.1%
Small	Winter	210	17	8.1%
Large	All Seasons	2,139	86	4.0%
Small	All Seasons	683	55	8.1%
Both	All Seasons	2,822	141	5.0%

The 86 mortalities caused by large mesh gill nets and 55 mortalities caused by small mesh gill nets every year in management unit A would result in a mortality rate of total sturgeon captured of 5.0% (Table 10). Boreman (1997) evaluated the total lifetime potential egg production of a single female sturgeon from the Hudson River, assuming a 1:1 male to female ratio to determine the loss of potential fecundity caused by fisheries that remove Atlantic sturgeon from the population. Atlantic sturgeon from the Hudson River live longer and reach reproductive maturity later than sturgeon in the Roanoke River. However due to differing growth rates, they reach approximately the same maximum size and likely produce the same number of eggs in their lifetimes. Therefore Atlantic sturgeon juveniles and sub-adults removed from the population by the inshore North Carolina gill net fisheries will never contribute any progeny to the Roanoke River population. Because the population is assumed to be composed of equal numbers of males and females, each egg produced would need to survive and produce two viable eggs just to keep the population trend at zero (no increase or decrease). And given the proportion of the population that is female, the fecundity of those females, and the natural mortality rate, we can determine the tolerable mortality rate due to fishing to ensure survival or recovery of a population.

If we were to look at Atlantic sturgeon bycatch as a directed fishery and manage the bycatch to ensure recovery, then it is possible to use fisheries biology as a surrogate for understanding the

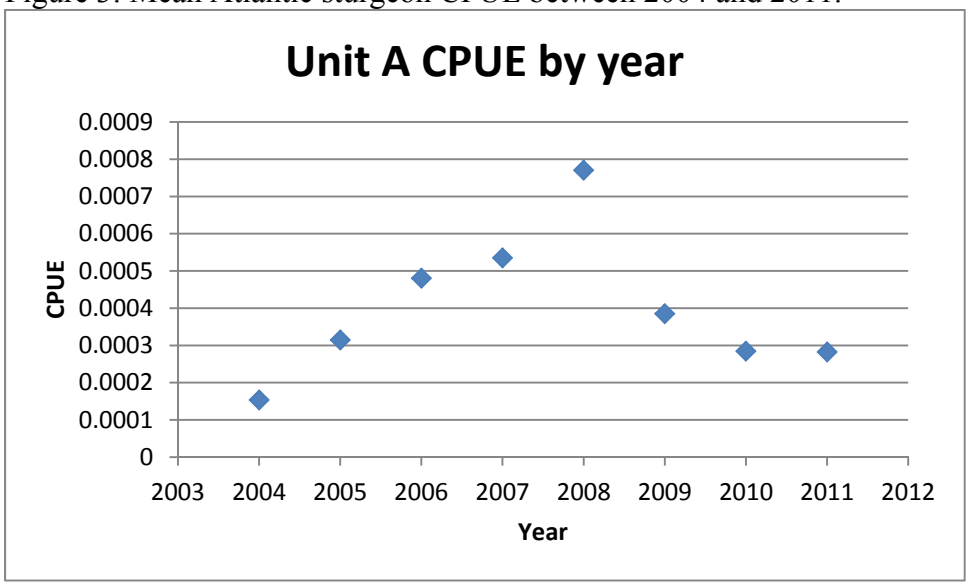
potential for North Carolina's inshore gill net fishery to jeopardize Atlantic sturgeon. Goodyear (1993) suggests that in order to maintain a steady population, at least 20% of the population must be of spawning age, but this number is highly variable and depends on the life stage of the fish targeted by the fishery. In order to promote population recovery, a more conservative 50% of the population must be of spawning age (Boreman *et al.* 1984). Using these values, Boreman (1997) estimated that 14% fishing mortality would cause no change in the Atlantic sturgeon population and 5% fishing mortality would allow for the Atlantic sturgeon population to increase and recover. Because the overall annual mortality rate in North Carolina's inshore gill net fishery is approximately 5%, this level of bycatch should allow Atlantic sturgeon to recover assuming there are no other threats to the population, which of course there are. As long as the other threats to the population do not account for a 9% mortality rate, the population should not decline as a result of North Carolina's inshore gill net bycatch.

6.3.2 Observer Coverage and Monitoring Population Trends

Observer coverage is the best monitoring option because it allows NCDMF to observe fishermen's catch while on board their vessels. Observers have been monitoring North Carolina's inshore gill net fisheries since 2004. Between 2004 and 2011, observer coverage in North Carolina was 1.16%. Since 2010, observer coverage across the entire state has only been 1.69%. However, in management unit A, observer coverage between 2004 and 2011 was only 0.56% and since 2010 has only been 0.60%. Because so many more Atlantic sturgeon have been observed in management unit A, increased observer coverage would help provide more accurate bycatch estimates in the future. The Conservation Plan (NCDMF 2014) proposes to increase observer coverage to 7-10% of large mesh gill net effort and 1-2% of small mesh gill net effort. In addition, they will monitor each of the management units seasonally and by fishery with weighted coverage derived from estimated Atlantic sturgeon takes. Because most Atlantic sturgeon take occurs in management unit A during every season (Tables 8 and 9), most observer coverage will occur in management unit A.

Because most of the Atlantic sturgeon that will be captured in the inshore North Carolina gill net fishery will be from the Carolina DPS, the amount of observer coverage is critical to evaluating the status of Atlantic sturgeon in the action area. Based on observed Atlantic sturgeon captures and the amount of fishing effort that was observed each year between 2004 and 2011, the mean catch per unit effort of each year can be plotted, which correlates to changes in the trend of Atlantic sturgeon in Albemarle Sound each year (Figure 3). While it appears there has been a declining trend in Atlantic sturgeon catch per unit effort since reaching a peak in 2008, this may not actually be the case. Due to the limited observer coverage statewide and the even more limited coverage in management unit A between 2004 and 2011, the coefficient of variation in the data is larger than the mean itself. When the coefficient of variation is that large, it is possible to plot the annual mean CPUE (Figure 3), but it isn't possible to make management decisions based on trends of Atlantic sturgeon catch per unit effort through time.

Figure 3: Mean Atlantic sturgeon CPUE between 2004 and 2011.



With increased observer coverage during the next 10 years, as proposed in the Conservation Plan and explained in the previous paragraph, the increased data will result in a smaller coefficient of variation between years and the ability to detect statistically significant trends in Atlantic sturgeon catch per unit effort. Following a three year monitoring period with this improved data, NCDMF will evaluate the trends in annual CPUE, a surrogate for Atlantic sturgeon abundance, to determine if it is necessary to reduce Atlantic sturgeon bycatch using proposed measures to minimize effects of bycatch and adaptive management to limit the factors causing the biggest problems.

The Atlantic sturgeon population in North Carolina is unknown, as are the densities of juveniles, sub-adults, or adults in the area seasonally. There is a known reproductive population in the Roanoke River that flows into management unit A. In Table 40 of the Conservation Plan Application (NCDMF 2014), the location nearest the mouth of the Roanoke River is the primary location for juvenile and sub-adult Atlantic sturgeon bycatch with an average size over the 21 years of collections being 461 mm. Wirgin *et al.* (2007) and Grunwald *et al.* (2008) consider sturgeon under 450 mm total length to be juveniles for the purposes of genetic identification to a spawning river and note that sturgeon larger than this could be either juvenile or sub-adult. However, fishermen in other areas within Albemarle Sound catch some juvenile Atlantic sturgeon, but mostly sub-adult fish of an average of 498 mm. There has never been an analysis of the mixed stock composition of sub-adult Atlantic sturgeon in the Albemarle Sound, and no way to know the probability of capturing sturgeon from each DPS. However, given mixed stock assessments made near the mouths of other sturgeon spawning locations (Bartron *et al.* 2007, Wirgin and King 2011), it is likely that at least half of the sub-adult sturgeon are from the Roanoke River and the remaining Atlantic sturgeon in the area are from other DPSs, with more from the nearby Chesapeake and South Atlantic DPSs than the more populous New York Bight DPS. It is likely that Gulf of Maine DPS sturgeon are rare in Albemarle Sound. Only one adult fish was captured in those 21 years of fishery independent surveys in all of Albemarle Sound and it likely was from the Carolina DPS.

To address the uncertainty of stock origin of the fish captured by North Carolina's inshore gill net fishery, the Conservation Plan proposes to have observers take genetic samples, a $1cm^2$ pelvic fin clip, from all Atlantic sturgeon captured throughout the state to determine the proportion of Atlantic sturgeon captured from each DPS. The annual analyses of these fin clips will provide NCDMF and NMFS with more certainty of the DPSs that are encountered by the inshore gill net fisheries. With more precise knowledge of the DPSs captured as bycatch, appropriate adaptive management measures may be taken in the future to protect sturgeon from certain areas or during certain times, if that would be appropriate.

6.3.3 Effects of Bycatch on DPSs

While NMFS will know more about the probability of each DPS being affected by these fisheries by the end of year three, at this time, NCDMF has provided information on the sizes of Atlantic sturgeon captured in previous monitoring. The sizes indicate the majority of Altnatic sturgeon captured as bycatch range from juveniles to small sub-adults. Because of this NMFS believes that as many as 75% of the sturgeon bycaught in the inshore North Carolina gill net fishery could be from Carolina DPS. This is because approximately half of the Atlantic sturgeon captured will be juvenile sturgeon and half of the sub-adult sturgeon will likely be from the Carolina DPS. That percentage during any given year, however could be lower due to a small juvenile population and a higher percentage of sub-adult fish present from other areas. There will be years when as many as 40% of the Atlantic sturgeon captured could be from the South Atlantic or Chesapeake Bay DPSs. The Hudson River population, based on mixed stock assessments from the Chesapeake Bay (Bartron *et al.* 2007), New York (Wirgin and King 2011), and Canada (Wirgin *et al.* 2012) is more concentrated around the northeast coast of North America, with fewer proportional individuals in Canada and fewer individuals south of the Chesapeake Bay. The highest composition of New York Bight DPS fish likely to be present in North Carolina during any year could be as high as 10%. The Gulf of Maine, which makes up less than 3% of the Atlantic sturgeon identified as far south as the Chesapeake Bay (Bartron *et al.* 2007) is not likely to account for any more than 3% of the sturgeon captured in North Carolina.

The Atlantic sturgeon that are captured and released alive will suffer sub-lethal effects. The most problematic sub-lethal effects observed in sturgeon research is the loss of eggs or abortion of a spawning run (Moser and Ross 1995, Weber 1996). Because the fish captured here are juveniles and small sub-adults, this will not be a problem. The most likely sub-lethal effect would be a short term stress response in most individuals and the potential for some of these individuals to be captured multiple times, leading to a chronic stress response. At this time, there is no way to determine the numbers of fish that may be captured multiple times, but the Conservation Plan includes the use of PIT tags to identify individuals so we will be able to estimate recapture rates in the future. Furthermore, there is limited information on the effects of chronic stress, however it has been suggested that one response to stress is reduced growth (Niklitschek 2001). Because the NOAA observer program will measure the fish that are captured and recaptured, it will be possible to monitor the trends in Atlantic sturgeon growth to determine whether some sturgeon are experiencing stunted growth in response to these fisheries.

In addition to potential growth responses, approximately 10% of captured sturgeon that are released alive may suffer from some type of injury (Collins *et al.* 1996, Bahn *et al.* 2012). Based on the number of Atlantic sturgeon from each DPS expected to be captured (Tables 8 and 9), this

would amount to as many as 220, 117, 117, 29, and 9 juvenile and small Atlantic sturgeon each year from the Carolina, Chesapeake Bay, South Atlantic, New York Bight, and Gulf of Maine DPS, respectively, that could be injured, but released alive back to the inshore waters of North Carolina. The extent of injuries was not reported by Collins *et al.* (1996), and no injuries were reported as a result of gill netting by Bahn *et al.* (2012); however, sturgeon heal quickly from injuries in waters between 8° and 27°C (Moser *et al.* 2000, Ream *et al.* 2003), which are normal conditions most of the year in North Carolina. It is possible that some of the injuries could be potentially life threatening, though there is no way of knowing the survival rates of the fish that are released. Injured juvenile and small sub-adult sturgeon that survive after being released would not be expected to suffer any loss of fecundity.

The total number of Atlantic sturgeon expected to be captured will be 2,927 with a subset of 169 of those fish dying. Using the likely maximum proportions of each DPS that could be affected (identified above), the maximum number of Atlantic sturgeon that will be captured from each DPS will be approximately 2,196, 1,171, 1,171, 293, and 88 captures from the Carolina, Chesapeake Bay, South Atlantic, New York Bight, and Gulf of Maine DPSs, respectively. Of those, a maximum of 127, 68, 68, 17, and 6 Atlantic sturgeon will die from the Carolina, Chesapeake Bay, South Atlantic, New York Bight, and Gulf of Maine DPSs, respectively. Because these fish will be juveniles and small-sub adults, primarily between the ages of one and five years old, their natural mortality rate is between 12 and 16%, declining slightly as they age (Kahnle *et al.* 2007). Natural mortality rate is often high for juvenile and young sub-adult fish because they are still vulnerable to predation, they have a limited tolerance for environmental extremes, and they are subject to considerable intraspecific competition. The loss of any of these fish is the loss a 100% of that fish's reproductive potential but may not actually have any effect on the reproductive potential of the future adult population.

The total mortality rate of 5.0% (Table 10) anticipated to occur as a result of North Carolina's inshore fisheries is well below natural mortality rates. While there are certainly other threats to these five DPSs of Atlantic sturgeon (ASSRT 2007) in addition to North Carolina's inshore gill net fisheries, those threats are at worst affecting sturgeon populations the same as they were in the mid 1990s when there was an Atlantic sturgeon commercial fishery. Therefore, it is reasonable to conclude that as long as the anthropogenic mortality rate remains approximately 5.0%, Atlantic sturgeon populations should be allowed to recover given enough time (Boreman 1997). Therefore, NMFS would not expect the take levels identified by the zero-inflated Poisson model or the associated mortality rates to jeopardize any of the five DPSs of Atlantic sturgeon along the U.S. East Coast.

Given the data available at this time, it is not possible to anticipate the extent to which the 95% of Atlantic sturgeon that survive capture in North Carolina's inshore gill net fisheries each year are later subjected to capture in another fishery or how cumulative threats along the East Coast affect the anthropogenic mortality rate. This Conservation Plan proposes to PIT tag the fish that survive capture in these fisheries to help determine the rate at which these fish are recaptured in other state and federal fisheries, among many other benefits. The NCDMF, separately from this Conservation Plan, are assisting in the completion of a range-wide stock assessment of Atlantic sturgeon to better understand how many of various age classes of Atlantic sturgeon are likely swimming along the East Coast, which should be completed in 2014. The result of that stock

assessment, along with the other mitigation measures contained in the Conservation Plan should allow for better management of bycatch rates and ensure that Atlantic sturgeon are not jeopardized as a result of North Carolina's inshore gill net fisheries.

7. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. Water withdrawal, recreation, commercial shipping, urbanization, and changes in watershed use will continue in North Carolina's rivers, watersheds and estuaries in the future. In some cases, Federal permits will be required for these impacts, but in others these actions will be at the state, tribal, or local level. As the human population grows and is expected to continue to increase within the state of North Carolina, water withdrawal will increasingly be required for agriculture, drinking water, vessel ballast, etc.

Future recreational and commercial fishing activities in state waters may affect Atlantic sturgeon. Trawl fisheries for striped bass and flounder operate in state waters and are likely to capture Atlantic sturgeon, though no data are available on sturgeon interactions or mortality rates in these fisheries. As described in the Baseline section, mortalities among Atlantic sturgeon incidentally captured in trawls is typically lower than in gill net fisheries. Other state fisheries that may take Atlantic sturgeon in the future include drift gill net, beach seine, and pound net fisheries. Information on interactions with Atlantic sturgeon for these and other fisheries operating in state waters is not available. However, 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 and Environmental Baseline sections.

Counties and local governments are typically responsible for permitting the conversion of forested land for agriculture. As agriculture represents one of the most significant economic drivers for much of the state's coastal plain region, the clearing of land for agricultural use is expected to continue in the future. Agricultural runoff can include fertilizers, pesticides and animal waste from intensive animal feedlot operations, and results in increased nutrient loading, eutrophication and hypoxic conditions in streams and rivers. Atlantic sturgeon are already highly susceptible to the effects of hypoxia, especially at higher temperatures such as those experienced in North Carolina's rivers in summer and fall, as discussed in the Baseline and Effects sections of this Opinion. Conversion of forested land to agricultural use also leads to increased sediment build-up in rivers used by Atlantic sturgeon as migratory and spawning habitat. As discussed in the Status of the Species section, Atlantic sturgeon rely on hard river substrates (such as cobble) for deposition of eggs and thus the sedimentation of rivers can negatively impact spawning (Smith and Clugston 1997). All of these factors are expected to further limit the availability of suitable habitat for Atlantic sturgeon.

8. CONCLUSION

After reviewing the current status of endangered South Atlantic, Carolina, Chesapeake Bay, and New York Bight DPSs of Atlantic sturgeon and threatened Gulf of Maine Atlantic sturgeon, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' Opinion that the issuance of this incidental take permit to the state of North Carolina is not likely to jeopardize the continued existence of South Atlantic, Carolina, Chesapeake Bay, New York Bight, or Gulf of Maine DPS Atlantic sturgeon. Critical habitat has not been designated or proposed for these DPSs. Critical habitat will therefore not be affected by this action.

9. INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the USFWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

This incidental take statement specifies the impact of any incidental taking of endangered or threatened species, as well as the specific levels of incidental take allowed. Because section 10(a)(2)(B)(ii) requires the Conservation Plan to minimize and mitigate the impacts of these takes to the maximum extent practicable, no reasonable and prudent measures or terms and conditions are specified in this section of the Opinion.

Amount or Extent of Take

For the sturgeon assessment of the inshore anchored gill net fisheries of North Carolina, take is authorized for South Atlantic, Carolina, Chesapeake Bay, New York Bight, and Gulf of Maine DPSs of Atlantic sturgeon in management units A, B, C, D, and E during all four seasons for the next 10 years. Limitations of take are specific to both lethal and non-lethal take, measured for each management unit, during each season, using each mesh size (large and small as defined) in each year covered by the Conservation Plan. Because of the uncertainty about the exact proportion of each DPS in inshore waters of North Carolina, the fact that a sample of the entire population will be representative of the actual proportion of each DPS but will vary around the mean, and the fact that the proportions of each DPS in inshore North Carolina waters will naturally fluctuate seasonally and annually, the take estimates provide a maximum proportion of

each DPS to be affected and do not attempt to estimate the exact proportion of each DPS to be taken.

Incidental take will occur starting in 2014 continuing through the end of 2023. Each year, up to 2,927 juvenile and small sub-adult Atlantic sturgeon can potentially be captured (Table 11). The take will be in the form of primarily capture and harassment, but in some cases, mortality (Table 12). NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as, "to trouble, torment, or confuse by continual persistent attacks, questions, etc." The USFWS defines "harass" in its regulations as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to breeding, feeding, or sheltering (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the USFWS's interpretation of the term.

Table 11: Total annual harassment caused by small mesh and large mesh gill nets in North Carolina.

Atlantic sturgeon DPS	Annual small mesh	Annual large mesh	Total
Total	**724**	**2,203**	**2,927**
Carolina DPS	Up to 543 of 724*	Up to 1,653 of 2,203*	Up to 2,196 of 2,927*
Chesapeake Bay DPS	Up to 290 of 724*	Up to 882 of 2,203*	Up to 1,171 of 2,927*
South Atlantic DPS	Up to 290 of 724*	Up to 882 of 2,203*	Up to 1,171 of 2,927*
New York Bight DPS	Up to 73 of 724*	Up to 221 of 2,203*	Up to 293 of 2,927*
Gulf of Maine DPS	Up to 22 of 724*	Up to 67 of 2,203*	Up to 88 of 2,927*

* Total annual take will not exceed the identified totals, however the DPS make-up of that total take may fluctuate annually.

Table 12: Total annual mortalities caused by small mesh and large mesh gill nets in North Carolina.

Atlantic sturgeon DPS	Annual small mesh	Annual large mesh	Total
Total	**68**	**101**	**169**
Carolina DPS	Up to 51 of 68*	Up to 76 of 101*	Up to 127 of 169*
Chesapeake Bay DPS	Up to 28 of 68*	Up to 41 of 101*	Up to 68 of 169*
South Atlantic DPS	Up to 28 of 68*	Up to 41 of 101*	Up to 68 of 169*
New York Bight DPS	Up to 7 of 68*	Up to 11 of 101*	Up to 17 of 169*
Gulf of Maine DPS	Up to 3 of 68*	Up to 4 of 101*	Up to 6 of 169*

* Total annual take will not exceed the identified totals, however the DPS make-up of that total take may fluctuate annually.

While annual takes and mortalities are large, they are broken into five management units, four seasons, and two mesh sizes, which means that the total amount of authorized take may be met during any season for a particular management unit and mesh size, but it is unlikely that each management unit, season, and mesh size (Table 13) will reach their full authorized takes in any year, so these take authorizations truly represent an absolute maximum number of takes, and it is likely that in any given year, fewer than the total authorized takes are reached.

Table 13: Annual total number of Atlantic sturgeon harassed and killed in each mesh size, season, and management unit.

Mesh Size	Season	Management Unit	Atlantic sturgeon harassed	Atlantic sturgeon killed***
Small	Spring	A	263	21
Small		B	7	2
Small		C	2	1
Small		D	2	*
Small		E	2	*
Small	Summer	A	86	7
Small		B	4	1
Small		C	2	1
Small		D	2	*
Small		E	2	*
Small	Fall	A	124	10
Small		B	4	1
Small		C	2	1
Small		D	2	*
Small		E	2	*
Small	Winter	A	210	17
Small		B	2	1
Small		C	2	1
Small		D	2	*
Small		E	2	*
Large	Spring	A	614	25
Large		B	2	1
Large		C	3	1
Large		D	2	**
Large		E	2	**
Large	Summer	A	209	8
Large		B	6	2
Large		C	3	1
Large		D	2	**
Large		E	2	**
Large	Fall	A	1,117	45
Large		B	23	2
Large		C	6	2
Large		D	2	**
Large		E	2	**
Large	Winter	A	199	8
Large		B	2	1
Large		C	2	1
Large		D	2	**
Large		E	2	**
Annual Total			2,927	169

* A total of four small mesh gill net mortalities each year in management units D and E, with no more than two of the mortalities occurring in one management unit.
** A total of four large mesh gill net mortalities each year in management units D and E, with no more than two of the mortalities occurring in one management unit.
*** The mortalities associated with this project are a subset of the total number of Atlantic sturgeon that will be captured, not in addition to those captures.

10. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened 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. There are no conservation recommendations associated with this proposed action.

11. REINITIATION NOTICE

This concludes formal consultation on OPR's proposed issuance of an incidental take permit to the NCDMF pursuant to the provisions of section 10(a)(1)(B) of the Endangered Species Act. 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 allowable take is exceeded; (2) new information reveals effects of North Carolina's inshore gill net fisheries that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

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Appendix A

North Carolina Division of Marine Fisheries estimated the number of Atlantic sturgeon likely to be encountered between 2014 and 2024 using bycatch rates from NOAA's Observer program and their own gill net monitoring program coupled with total fisheries effort. These statistical methods were peer-reviewed by sturgeon biologists and statisticians and verified for this Opinion as the best available methods for predicting bycatch.

First Attempt at a Bycatch Estimate. The first attempt at estimating the total number of sturgeon captured as bycatch during a year of gill netting in inshore North Carolina waters used a direct extrapolation method. This method assessed the number of Atlantic sturgeon observed by NOAA's observer program and then compared the overall effort with the amount of effort that had been observed:

$$\textbf{Total \# of Atlantic sturgeon} = \textbf{sturgeon observed annually} \times \frac{\textbf{Average annual fisheries effort}}{\textbf{Amount of effort observed}}$$

This direct extrapolation model could be used to estimate take for large mesh and small mesh gill nets, in all management units, during any season except for management unit D or small mesh gill nets in unit E in the summer because of deficiencies with observer effort. While we were unable to estimate take in those locations, using averages from each of the categories, we were able to estimate the potential take everywhere else in North Carolina's inshore waters (Tables 1 and 2).

Table 1: Direct extrapolation of sturgeon takes in inshore large mesh gill net fisheries using total effort and observed effort.

Season	Management Unit	Average fisheries effort	Average observed effort	Average sturgeon observed	Projected Atlantic sturgeon takes
Spring	A	3744442.8	25529.3	9.5	1393
Spring	B	1551907.3	10428.5	0	0
Spring	C	947164.2	19508.6	0.14285	7
Spring	E	299708.9	4984.0	0	0
Summer	A	3195246.5	23138.2	5	691
Summer	B	3427839.5	22758.9	0.857	129
Summer	C	636547.7	10132.8	0.42857	27
Summer	E	588108.1	9448.1	0	0
Fall	A	6024169.8	7150.0	4.1428	3491
Fall	B	3287034.0	194376.4	1.286	22
Fall	C	832772.2	10166.145	0	0
Fall	E	522025.4	5670.0	0.5	46
Winter	A	2111874.8	20258.7	4.857	506
Winter	B	66235.4	1328.1	0	0
Winter	C	139926.8	6802.1	0	0
Winter	E	43883.4	5475.0	0	0
Total		27418886.8	377154.7	26.71422	6312

Table 2: Direct extrapolation of sturgeon takes in inshore small mesh gill net fisheries using total effort and observed effort.

Season	Management Unit	Average fisheries effort	Average observed effort	Average sturgeon observed	Projected Atlantic sturgeon takes
Spring	A	1076553	9528.8	2.8	**316**
Spring	B	1704048.6	6476.2	0.3	**79**
Spring	C	297851.1	1480.5	0	**0**
Spring	E	101861.6	462.5	0	**0**
Summer	A	80019.6	83	0	**0**
Summer	B	331539.6	390.9	0	**0**
Summer	C	38399.5	27	0	**0**
Summer	E	66283.1	0	0	**No Data**
Fall	A	331791	3809.8	4.9	**427**
Fall	B	685004.1	5506.1	0.3	**37**
Fall	C	80662.5	93.5	0	**0**
Fall	E	84664.5	227.5	0	**0**
Winter	A	888297.6	15057.9	6.5	**383**
Winter	B	471564.8	5359.4	0	**0**
Winter	C	179655.1	1350.1	0	**0**
Winter	E	62638.9	2178.8	0	**0**
Total		6480834.6	52032	14.8	1242

While this direct extrapolation provides an estimate of the number of sturgeon that may be caught as bycatch in the large (Table 1) and small (Table 2) mesh gill net fisheries, there are problems with this method. The primary issue is that in 2010, NCDMF changed their fishing rules to protect sea turtles and this caused a reduction in overall fishing effort (Figures 2 and 3).

The direct extrapolation method resulted in a large mesh gill net bycatch estimate of 6,312 Atlantic sturgeon captured. This same method estimated 1,242 Atlantic sturgeon would be captured in small mesh gill nets. Most of NCDMF's inshore gill net fisheries are in estuarine and riverine areas and catch sturgeon ranging from 153 mm to 1498 mm (NCDMF ITP Application). Overall, since 1991, the average length of Atlantic sturgeon that was captured has been under 500 mm. An annual estimate of 7,554 Atlantic sturgeon captured as bycatch in North Carolina's inshore gill net fishery is higher than would be expected given the status of the species in the area even assuming a mixed stock in the estuaries and multiple potential recaptures each year. In order to get a more realistic annual estimate of the expected bycatch numbers, NCDMF first chose to correct for the reduced effort observed in 2010.

Figure 1: Annual changes in large mesh gill net commercial fishing effort seasonally between 2004 and 2011.

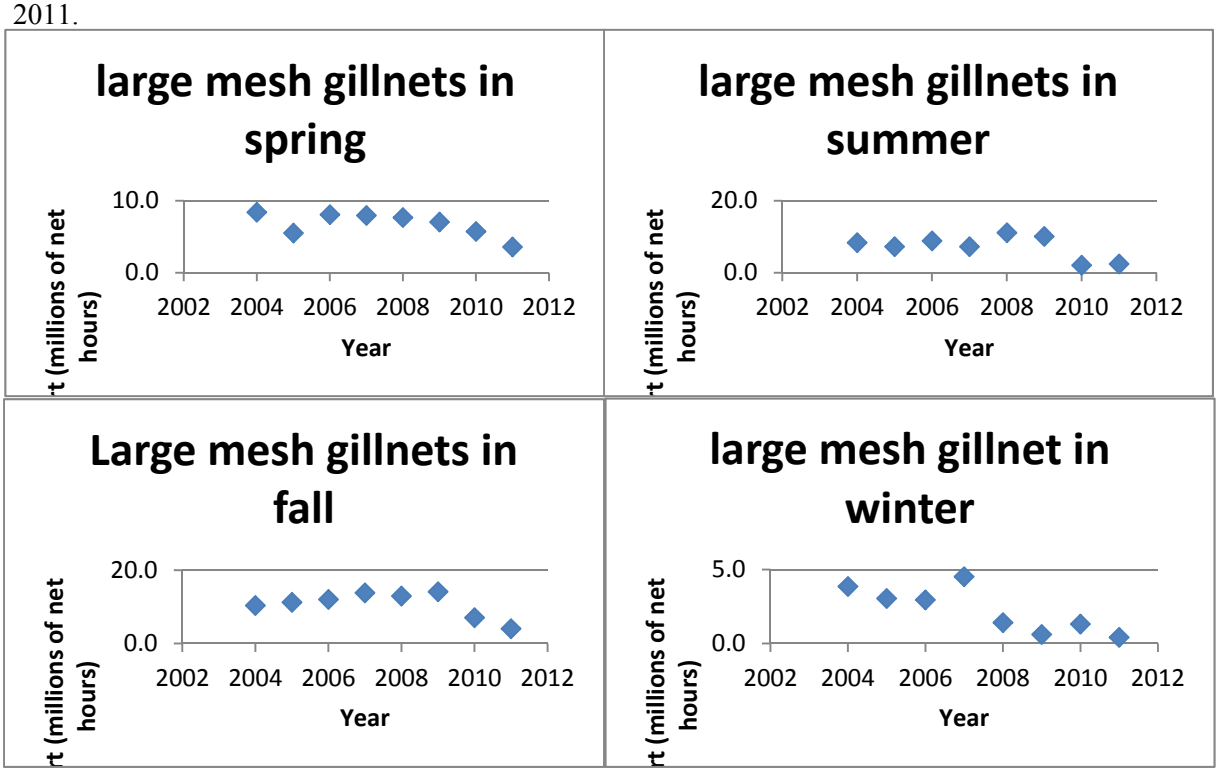
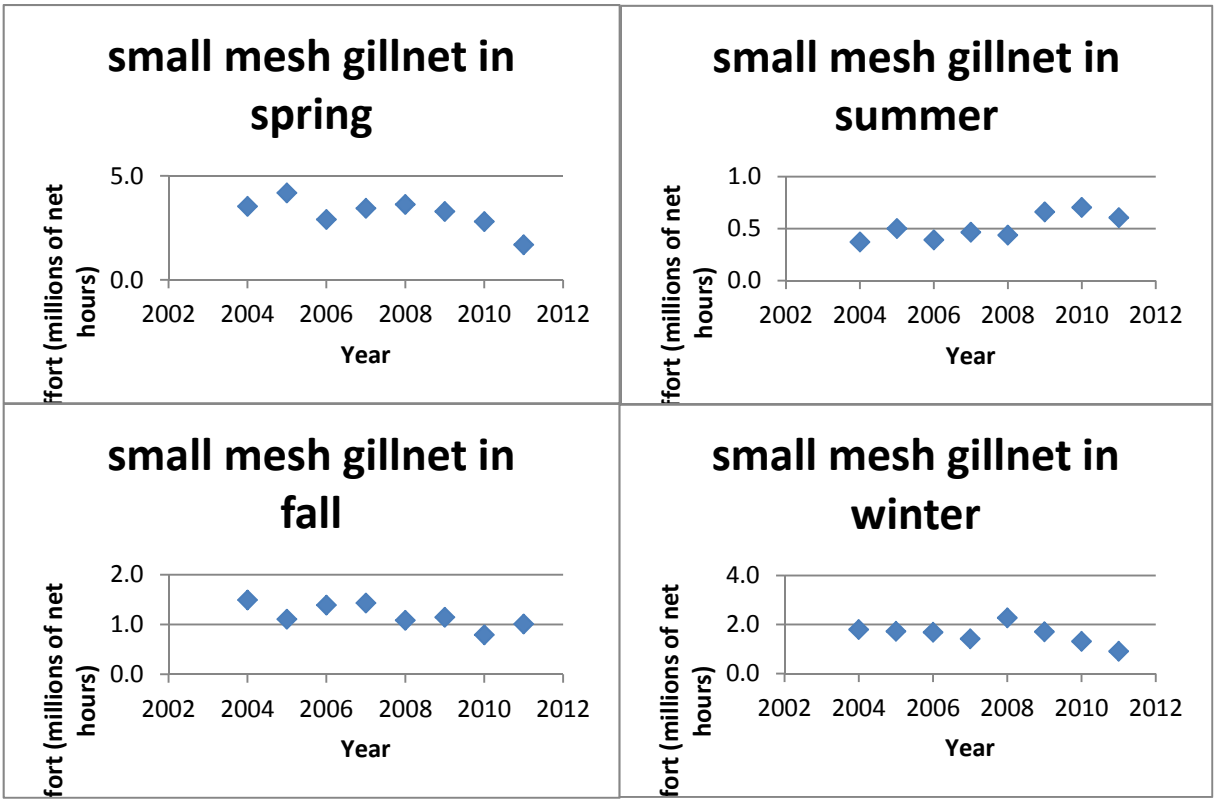


Figure 2: Annual changes in small mesh gill net commercial fishing effort seasonally between 2004 and 2011.



Second Bycatch estimate using Direct Extrapolation at 2010 effort. NCDMF believes future fisheries effort will be maintained at or below the 2010 effort and not revert back to earlier, higher levels. Therefore, NCDMF proposed estimating future take using 2010 fishery effort as opposed to an average of all effort since 2004. This approach is likely acceptable even though small mesh gill net use in the summer of 2010 was higher than at any time during that nine year span (Figure 3). A direct extrapolation of sturgeon interactions using 2010 data would use the following equation:

$$\textbf{Total \# of Atlantic sturgeon} = \textbf{sturgeon observed annually} \times \frac{\textbf{2010 fisheries effort}}{\textbf{Amount of effort observed}}$$

The 2010 fisheries effort model still uses the average number of sturgeon observed between 2004 and 2011 and the average observed effort from the same time because only 14 sturgeon were observed in 2010 observations (eight large mesh, six small mesh). These observations were too few to provide meaningful take estimates for all of 2010. By using the average number of sturgeon observed for each management unit and season, almost all management units had observed sturgeon, so it was possible to make seasonal estimates for the entire state.

Using 2010 commercial fishing effort to extrapolate the likely amount of Atlantic sturgeon fishery interactions reduces the estimate from Tables 1 and 2. As seen in Figures 1 and 2, effort is generally lower in 2010 than in other years and therefore, it's not surprising that estimated amounts of bycatch would be lower using 2010 fisheries effort (Tables 3 and 4). However, the bycatch rate is determined by using NOAA Observer data collected between 2004 and 2011, which remained consistent from the previous model. Where Figure 2 indicates an increase in effort during the summer, the model projections for the summer between Tables 2 and 4 do not predict an increase in bycatch because no Atlantic sturgeon were observed as bycatch during any observations between 2004 and 2011.

Table 10: Projected number of Atlantic sturgeon captured as bycatch in the North Carolina inshore large mesh commercial gill net fisheries using 2010 commercial fisheries effort.

Season	Management Unit	2010 fisheries effort	Average observed effort	Average sturgeon observed	Projected Atlantic sturgeon takes
Spring	A	3877643.8	25529.3	9.5	1443
Spring	B	1024568.5	10428.5	0	0
Spring	C	605836.3	19508.6	0.14285	4
Spring	E	217367.7	4984.0	0	0
Summer	A	680574.8	23138.2	5	147
Summer	B	1070392.9	22758.9	0.857	40
Summer	C	214364.5	10132.8	0.42857	9
Summer	E	115786.1	9448.1	0	0
Fall	A	2948148.6	7150.0	4.1428	1708
Fall	B	3512732.7	194376.4	1.286	23
Fall	C	370722.6	10166.145	0	0
Fall	E	186910.3	5670.0	0.5	17
Winter	A	1182739.3	20258.7	4.857	284

Winter	B	58439.4	1328.1	0	0
Winter	C	35005.5	6802.1	0	0
Winter	E	31681.5	5475.0	0	0
Total		16132914.5	377154.7	26.71422	3675

Table 11: Projected number of Atlantic sturgeon captured as bycatch in the North Carolina inshore small mesh commercial gill net fisheries using 2010 commercial fisheries effort.

Season	Management Unit	2010 fisheries effort	Average observed effort	Average sturgeon observed	Projected Atlantic sturgeon takes
Spring	A	1009249.6	9528.8	2.8	297
Spring	B	1577641.2	6476.2	0.3	73
Spring	C	172968.0	1480.5	0	0
Spring	E	39447.0	462.5	0	0
Summer	A	170800.0	83	0	0
Summer	B	483642.0	390.9	0	0
Summer	C	24896.4	27	0	0
Summer	E	23352.6	0	0	No Data
Fall	A	198400.0	3809.8	4.9	255
Fall	B	421033.4	5506.1	0.3	23
Fall	C	26130.6	93.5	0	0
Fall	E	145520.3	227.5	0	0
Winter	A	759407.1	15057.9	6.5	328
Winter	B	301857.3	5359.4	0	0
Winter	C	123402.8	1350.1	0	0
Winter	E	129593.1	2178.8	0	0
Total		5607341.4	52032	14.8	976

The revised bycatch model using 2010 effort estimates large mesh gill nets will capture 3,675 Atlantic sturgeon and small mesh gill nets will capture 976 Atlantic sturgeon. An annual Atlantic sturgeon bycatch estimate of 4,651 is much less than the first attempt at an extrapolation estimate. Much like above, large mesh and small mesh gill nets target very general sizes of Atlantic sturgeon.

While this estimate is more accurate than the first because it accounts for the lower annual fishing effort in North Carolina since 2010, it is still not estimating take in some seasons and management units because no sturgeon bycatch has ever been observed in those locations before. To address the lack of data in those areas, a more complicated method will be required. A regression analysis will provide an estimate of Atlantic sturgeon bycatch by producing a linear equation from the data to estimate bycatch at any combination of season, management unit, mesh size, or effort.