UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

APR 13 2010

ENVIRONMENTAL ASSESSMENT
ON THE EFFECTS OF THE ISSUANCE OF A SCIENTIFIC RESEARCH PERMIT (File No. 14604) TO CONDUCT SCIENTIFIC RESEARCH ON SHORTNOSE STURGEON IN THE DELAWARE RIVER,
APRIL 2010

Lead Agency: USDC, National Oceanic and Atmospheric Administration National Marine Fisheries Service, Office of Protected Resources

Responsible Official: James H. Lecky, Director, Office of Protected Resources

For Further Information Contact: Office of Protected Resources
National Marine Fisheries Service
1315 East West Highway
Silver Spring, MD 20910
(301) 713-2289

Location: Delaware River and Estuary

Abstract: The National Marine Fisheries Service (NMFS) proposes to issue a scientific research permit to Harold Brundage (Environmental Research and Consulting, Inc., Kennett Square, Pennsylvania) for takes of shortnose sturgeon (*Acipenser brevirostrum*) in the wild, pursuant to the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq.*).

The applicant is seeking a five-year scientific research permit to characterize habitat use, relative abundance, reproduction, juvenile recruitment, temporal and spatial distributions, and reproductive health of the shortnose sturgeon population in the Delaware River and Estuary. The proposed permit requests annual authorization for non-lethal sampling methods on up to 1,000 adult and juvenile shortnose sturgeon. Research activities would include: capturing via gill net, trammel net, and trawl net; measuring and weighing; tagging with PIT and Floy T-bar tags; and sampling tissue for genetic analysis. A subset of 30 adults and 30 juveniles would be tagged with acoustic transmitters. Another subset of 24 adults would be examined internally using laparoscopic techniques and each would potentially also have gonad biopsy and blood sample taken for analyses. Another subset of 20 adults per year would be included in hydroacoustic gear testing. Additionally, lethal collection of up to 300 eggs and larvae each year (not exceeding 900 over five years) would take place during seasonal spawning activity by artificial substrate, D-frame ichthyoplankton net, and/or epibenthic sled. Finally, one annual unintended mortality or serious harm resulting from research, or up to three over the life of the permit, is requested.

Printed on Recycled Paper

TABLE OF CONTENTS

CHAPTER 1: PURPOSE AND NEED FOR ACTION **4**

.

1.1 DESCRIPTION OF ACTION 4
1.1.1 *Purpose and Need* 4
1.1.2 *Objectives of the Research* 4
1.2 OTHER EAs INFLUENCING THE SCOPE OF THIS EA **4**
1.3 SCOPING SUMMARY **5**
1.4 APPLICABLE LAWS AND NECESSARY FEDERAL PERMITS, LICENSES, AND ENTITLEMENTS **6**
1.4.1 *National Environmental Policy Act* 6
1.4.2 *Endangered Species Act* 6
1.4.3 *Magnuson-Stevens Fishery Conservation and Management Act* 7

CHAPTER 2: ALTERNATIVES INCLUDING THE PROPOSED ACTION **8**

2.1 ALTERNATIVE No. 1: NO ACTION **8**
2.2 ALTERNATIVE No. 2: PROPOSED ACTION – ISSUANCE OF PERMIT WITH STANDARD CONDITIONS **8**
2.3 DESCRIPTION OF THE PROPOSED ACTION **8**
2.3.1 *Action Area* 8
2.3.2 *Research Activities* 10

CHAPTER 3: DESCRIPTION OF THE AFFECTED ENVIRONMENT **19**

3.1 SOCIAL AND ECONOMIC ENVIRONMENT **19**
3.2 PHYSICAL ENVIRONMENT **19**
3.2.1 *Description of the Delaware River System* 19
3.2.2 *Essential Fish Habitat (EFH), Critical Habitat and National Marine Sanctuaries* 20
3.3 BIOLOGICAL ENVIRONMENT **21**
3.3.1 *ESA Target Species Under NMFS Jurisdiction* 21
3.3.2 *Non Target Species* 23

CHAPTER 4: ENVIRONMENTAL CONSEQUENSES **27**

4.1 EFFECTS OF ALTERNATIVE 1: NO ACTION **27**
4.2 EFFECTS OF PROPOSED ALTERNATIVE 2: ISSUANCE OF PERMIT WITH STANDARD CONDITIONS **27**
4.2.1 *Effects of Research Activities* 27
4.3 SUMMARY OF COMPLIANCE WITH APPLICABLE LAWS, NECESSARY FEDERAL PERMITS, LICENSES AND ENTITLEMENTS **38**
4.3.1 *Compliance with the Endangered Species Act (ESA)* 38
4.3.2 *Compliance with the Magnuson-Stevens Fishery Conservation & Management Act* 38
4.4 COMPARISONS OF ALTERNATIVES **39**
4.5 MITIGATION MEASURES **39**
4.5.1 *Netting, Holding, and Handling Conditions* 39
4.5.2 *Larval Sampling with Artificial Substrates, D-nets and Epibenthic Sleds* 41
4.5.3 *Genetic Tissue Sampling* 41
4.5.4 *Tagging Conditions* 41
4.5.5 *Anesthetization* 42
4.5.6 *Laparoscopic Examination, Gonad Biopsy, and Blood Collection* 43
4.5.7 *Marine Mammal and Sea Turtle Interaction* 43
4.5.8 *Atlantic Sturgeon Interaction* 44

4.5.9 *Aquatic Nuisance Species*……..…… 44
4.5.10 *Incidental Mortality of Shortnose Sturgeon*…..…… 44
4.5.11 *Other Mitigation Measures*……... 44
4.6 ***UNAVOIDABLE ADVERSE EFFECTS***..... **45**
4.7 ***CUMULATIVE EFFECTS***..... **45**
4.7.1 *Other Shortnose Sturgeon Research Permits*..... 45
4.7.2 *Bycatch and Poaching*…… 46
4.7.3 *Artificial Propagation*……..... 47
4.7.4 *Dams*……..... 47
4.7.5 *Dredging and Blasting*……... 48
4.7.6 *Water Quality and Contaminants*……... 50
4.7.7 *Summary of Cumulative Impacts*…… 53

CHAPTER 5: LIST OF PREPARERS AND AGENCIES CONSULTED..... **54**

LITERATURE CITED..... **55**

APPENDICES..... **66**

CHAPTER 1 PURPOSE AND NEED FOR ACTION

1.1 DESCRIPTION OF ACTION

In response to a request from Harold Brundage (Environmental Research and Consulting, Inc., Kennett Square, Pennsylvania), (File No. 14604) the National Marine Fisheries Service Office of Protected Resources (NMFS-PR) proposes to issue a scientific research permit. The permit would authorize "takes"[1] of shortnose sturgeon (*Acipenser brevirostrum*) in the Delaware River pursuant to the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 *et seq*.) and the regulations governing the taking, importing, and exporting of endangered and threatened species (50 CFR Parts 222-226).

1.1.1 *Purpose and Need*:

The purpose of the aforementioned scientific research would be to gather information used to help inform conservation management decisions to recover shortnose sturgeon in the wild. Section 10(a)(1)(A) of the ESA allows NMFS to issue permits and permit modifications to take ESA-listed shortnose sturgeon. The applicant requires a permit to conduct the proposed research.

The primary purpose of the permit, therefore, is to provide an exemption from the take prohibitions under the ESA to allow "takes" of shortnose sturgeon for bona fide scientific research. The need for issuance of the permit is related to NMFS's mandates under the ESA. Specifically, NMFS has a responsibility to implement the ESA to protect, conserve, and recover threatened and endangered species under its jurisdiction. The ESA prohibits takes of threatened and endangered species, respectively, with only a few very specific exceptions, including for scientific research and enhancement purposes. Permit issuance criteria require that research activities are consistent with the purposes and policies of these federal laws and will not have a significant adverse impact on the species.

1.1.2 *Objectives of the research*:

The applicant is seeking a five-year scientific research permit to characterize habitat use, relative abundance, reproduction, juvenile recruitment, temporal and spatial distributions, and reproductive health of the shortnose sturgeon population in the Delaware River and Estuary.

1.2 OTHER EAs INFLUENCING THE SCOPE OF THIS EA

A number of EAs have been prepared on the effects of similar research techniques related to the proposed action. Appendix 2 lists recently issued NMFS permits or permit modifications for shortnose sturgeon for which EAs or SEAs were prepared. Each EA resulted in a Finding of No Significant Impact (FONSI) determination and has not been controversial.

If the applicant's current application (File 14604) results in a permit being issued, the permit would replace an existing permit (NMFS Permit 1486, expiring January 31, 2010) and would utilize similar methods and take authorizations studying shortnose sturgeon in the Delaware River.

---

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 modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering."

The original EA for File 1486 was prepared on December 21, 2004, entitled *"Environmental Assessment Scientific Research Permit to Harold M. Brundage, Environmental Research and Consulting, Inc., (File No. 1486)."* This EA evaluated the effects for non-lethal research capturing up to 1,750 juvenile and adults shortnose sturgeon annually, handling, weighing, measuring, anesthetizing, tagging, taking genetic tissue samples, implanting sonic transmitters, and lethal taking of eggs.

A Supplemental Environmental Assessment (SEA) was prepared May 17, 2006, entitled *"Supplemental Environmental Assessment of the Issuance of a Modification to Permit No. 1486, Mr. Harold M. Brundage, Environmental Research and Consulting, Inc."* This SEA evaluated the effects of adding the non-lethal research of collecting blood and biopsy tissue and performing laparoscopy on 24 shortnose sturgeon annually.

On August 8, 2006, the researcher was then issued a minor modification extending the action area of research to include the mouth of the C&D Canal.

Another SEA was prepared March 7, 2007, entitled *"Supplemental Environmental Assessment for Issuance of a Modification to Scientific Research Permit No. 1486-02 Held by Harold M. Brundage, Environmental Research and Consulting, Inc., to Conduct Research on Endangered Shortnose Sturgeon (Acipenser brevirostrum)."* This SEA evaluated the effects of collecting up to 1,000 shortnose sturgeon eggs and larvae annually by artificial substrate, ichthyoplanton net, epibenthic sled, and/or pump sampling.

In the original EA and the two SEAs, there were two alternatives considered: (1) the Proposed Action alternative (*i.e.*, approving the authorizations requested), and (2) the No Action alternative (*i.e.*, not approving the requested permit). The Proposed Action of issuing the specific scientific research permits was in each case the preferred alternative. The No Action alternative was not preferred in each case because the opportunity to collect information contributing to the better understanding of shortnose sturgeon and provide information to NMFS, needed to implement NMFS management activities, would be lost. Further, each proposed action was found to help conserve, manage, and recover shortnose sturgeon as required by the ESA and implementing regulations.

Based on the best available information a Finding of No Significant Impact (FONSI) was signed by the Assistant Administrator for Fisheries for each action, finding the activities analyzed and the issuance of the permits would not significantly impact the quality of the human environment, including the target species, shortnose sturgeon, or any non-target species.

1.3 SCOPING SUMMARY

The purpose of scoping is to identify the issues to be addressed and the significant issues related to the proposed action, as well as identify and eliminate from detailed study the issues not significant or have been covered by prior environmental review. An additional purpose of the scoping process is to identify the concerns of the affected public and Federal agencies, states, and Indian tribes. CEQ regulations implementing the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq.*) do not require that a draft EA be made available for public comment as part of the scoping process. A Notice of Receipt of the application was published in the Federal Register announcing the availability of the permit application and related documents for public comment (File No. 14604;

November 19, 2009; 74 FR 59961). No comments were received from the public regarding this application.

1.4 APPLICABLE LAWS AND NECESSARY FEDERAL PERMITS, LICENSES, AND ENTITLEMENTS

This section summarizes federal, state, and local permits, licenses, approvals, and consultation requirements necessary to implement the proposed action, as well as who is responsible for obtaining them. Even when it is the applicant's responsibility to obtain such permissions, NMFS is obligated under NEPA to ascertain whether the applicant is seeking other federal, state, or local approvals for their action.

1.4.1 *National Environmental Policy Act*:

The National Environmental Policy Act (NEPA) was enacted in 1969 and is applicable to all "major" federal actions significantly affecting the quality of the human environment. A major federal action is an activity that is fully or partially funded, regulated, conducted, or approved by a federal agency. NMFS issuance of permits for research represents approval and regulation of activities. While NEPA does not dictate substantive requirements for permits, licenses, etc., it requires consideration of environmental issues in federal agency planning and decision making. The procedural provisions outlining federal agency responsibilities under NEPA are provided in the Council on Environmental Quality's implementing regulations (40 CFR Parts 1500-1508).

NOAA has, through NOAA Administrative Order (NAO) 216-6, established agency procedures for complying with NEPA and the implementing regulations issued by the Council on Environmental Quality. NAO 216-6 specifies that issuance of scientific research permits under the MMPA and ESA is among a category of actions that are generally exempted (categorically excluded) from further environmental review, except under extraordinary circumstances. When a proposed action, otherwise categorically excluded, is (1) the subject of public controversy based on potential environmental consequences; (2) has uncertain environmental impacts or unknown risks; (3) establishes a precedent or decision in principle about future proposals, may result in cumulatively significant impacts; or (4) may have an adverse effect upon endangered or threatened species or their habitats, preparation of an Environmental Assessment (EA) or Environmental Impact Statement (EIS) is required.

While issuance of scientific research permits is typically subject to a categorical exclusion, as described in NAO 216-6, NMFS is preparing an EA for this action to provide a more detailed analysis of effects to ESA-listed species. This EA is prepared in accordance with NEPA, its implementing regulations, and NAO 216-6.

1.4.2 *Endangered Species Act*:

Section 9 of the ESA, as amended, and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption such as by a permit. Permits to take ESA-listed species for scientific purposes, or for the purpose of enhancing the propagation or survival of the species, may be granted pursuant to Section 10(a)(1)(A) of the ESA.

NMFS has promulgated regulations to implement the permit provisions of the ESA (50 CFR Part 222) and has produced OMB-approved application instructions that prescribe the procedures necessary to apply for permits. All applicants must comply with these regulations and application instructions in addition to the provisions of the ESA.

Section 10(d) of the ESA stipulates that, for NMFS to issue permits under section 10(a)(1)(A) of the ESA, the Agency must find that the permit: was applied for in good faith; if granted and exercised will not operate to the disadvantage of the species; and will be consistent with the purposes and policy set forth in Section 2 of the ESA.

Section 2 of the ESA sets forth the purposes and policy of the Act. The purposes of the ESA are to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in section 2(a) of the ESA. It is the policy of the ESA that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of the ESA. In consideration of the ESA's definition of conserve, which indicates an ultimate goal of bringing a species to the point where listing under the ESA is no longer necessary for its continued existence (i.e., the species is recovered), exemption permits issued pursuant to section 10 of the ESA are for activities that are likely to further the conservation of the affected species.

Section 7 of the ESA requires consultation with the appropriate federal agency (either NMFS or the U.S. Fish and Wildlife Service, (USFWS)) for federal actions that "may affect" a listed species or adversely modify critical habitat. NMFS issuance of a permit affecting ESA-listed species or designated critical habitat, directly or indirectly, is a federal action subject to these Section 7 consultation requirements. Section 7 requires federal agencies to use their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of endangered and threatened species. NMFS is further required to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any threatened or endangered species or result in destruction or adverse modification of habitat for such species. Regulations specify the procedural requirements for these consultations (50 Part CFR 402).

1.4.3 *Magnuson-Stevens Fishery Conservation and Management Act*

Under the MSFCMA Congress defined Essential Fish Habitat (EFH) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). The EFH provisions of the MSFCMA offer resource managers means to accomplish the goal of giving heightened consideration to fish habitat in resource management. NMFS Office of Protected Resources is required to consult with NMFS Office of Habitat Conservation for any action it authorizes (*e.g.*, research permits), funds, or undertakes, or proposes to authorize, fund, or undertake that may adversely affect EFH. This includes renewals, reviews or substantial revisions of actions.

CHAPTER 2: ALTERNATIVES INCLUDING THE PROPOSED ACTION

This chapter describes the range of potential actions (alternatives) determined reasonable with respect to achieving the stated objectives. The expected outputs and any related mitigation of each alternative is also included. Alternative Number 1 is the "No Action" alternative where the proposed permit would not be issued. The No Action alternative is the baseline for the rest of the analyses. Alternative No. 2 is the "Proposed Action" alternative representing the research proposed in the submitted application for a permit, with standard permit terms and conditions specified by NMFS.

2.1 ALTERNATIVE No. 1: NO ACTION

Under this alternative, the No Action alternative, the scientific research permit (File No. 14604) authorizing capture of shortnose sturgeon with gill and trammel nets, and trawls; measure, weigh tag with PIT and Floy tags and sonic tags; sample tissue for genetic analysis; laparoscopy, blood work, biopsy samples, and lethally collection of eggs and larvae samples, would not be issued at this time.

2.2 ALTERNATIVE No. 2: PROPOSED ACTION –ISSUANCE OF PERMIT WITH STANDARD CONDITIONS

Under this alternative, the Proposed Action alternative, a permit would be issued for research activities by the applicant, the permit terms and conditions standard to such permits as issued by NMFS. The permit takes would be valid for five years and would authorize non-lethal, year round sampling methods on up to 1,000 adult and juvenile shortnose sturgeon annually (a total of 3,600 over the course of five years). Research would include: capturing via gill net, trammel net, and trawl net; measuring, weighing; tagging with PIT and Floy T-bar tags; and sampling tissue for genetic analysis. A subset of 30 adults and 30 juveniles would be tagged with acoustic transmitters. Another subset of 24 adults would be examined internally using laparoscopic techniques and each would potentially also have gonad biopsy and blood sample taken for analyses. Another subset of 20 adults per year would be included in hydroacoustic gear testing. Additionally, lethal collection of up to 300 eggs and larvae each year would take place during seasonal spawning activity by artificial substrate, D-frame ichthyoplankton net, and/or epibenthic sled. Finally, one annual unintended sturgeon mortality or serious harm resulting from research, or up to three for the life of the permit, is requested. A table of the proposed take is summarized in Appendix 1.

2.3 DESCRIPTION OF THE PROPOSED ACTION

2.3.1 *Action Area*:

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The proposed action area consists of the Delaware Bay, tidal river, and freshwater sections of the Delaware River extending from the mouth of the Delaware Bay (rkm 0) to just upstream of Lambertville, New Jersey (rkm 245). The Delaware River Estuary and mixed tidal river extends from the mouth of Delaware Bay at Cape May, New Jersey (rkm 0) to the fall line at Trenton, New Jersey (rkm 215). The Delaware Bay region of the estuary is 72 kilometers extending from the Capes to a line between stone markers at Liston Point, Delaware and Hope Creek, New Jersey (Polis *et al*. 1973). The estuary varies in width from 18 kilometers at the Capes; to 43 kilometers at its widest point (near Miah Maull Shoals). Water depth in the bay is less than 9 meters in 80 percent of the bay, excluding the dredged channel, and is less than 3 meters deep in much of the tidal river area. Artificial Island (rkm 79) is located

Figure 1: Map of Action Area

approximately seven kilometers upstream of the hypothetical line demarking the head of Delaware Bay. The tidal river upstream of this area narrows makes a northwesterly 60 degree bend accentuated by Artificial Island on the New Jersey shore. More than half of the typical river width in this area is relatively shallow — less than 5.5 meters — while the deeper part, including the dredged channel has depths of up to 12.2 meters. The Delaware River between Philadelphia (rkm 161) and Trenton (rkm 215) is tidal freshwater with semidiurnal tides. Mean tidal range at Philadelphia, Pennsylvania is 1.8 meters (USACE, Philadelphia District 2009), and water pH generally is about 6-8.

Average tidal flow, as measured near the Delaware Memorial Bridge (rkm 108) approximately 32 kilometers above Artificial Island, amounts to 11,320 cubic meters per second (NMFS 2009). At this point, tidal flow of this magnitude is 17 times greater than the total average freshwater flow rate flowing into the estuary. Proceeding south (toward the mouth of the estuary), tidal flow increasingly dominates freshwater downstream flow; proceeding upstream, the ratio of tidal flow to net downstream flow becomes smaller as tidal influence decreases.

The freshwater portion of the action area extends above the fall line at Trenton, New Jersey (rkm 215) to just north of Lambertville, New Jersey (rkm 245), and is characterized by bottom substrate consisting of rocky shoals and cobble substrate suitable for shortnose sturgeon spawning habitat.

2.3.2 *Research Activities*:

Attempts would be made to capture up to 1,000 shortnose sturgeon annually fishing bottom-set gill nets, trammel nets, and trawl nets. Sampling effort and timing would vary based on the type of gear used, the year class of sturgeon targeted, the seasonality of the effort, the existing bottom habitat, and the environmental effects on sturgeon abundance in portions of the river (i.e., temperature, salinity present, dissolved oxygen). Shortnose sturgeon are proposed to be collected using gear and methodologies described in "A Protocol for Use of Shortnose and Atlantic Sturgeons" (Moser *et al*., 2000) as amended by NMFS-PR. Objectives of research would include the following procedures: capturing, general handling, hydroacoustic tests, genetic tissue sampling, PIT tagging, Floy tagging, implant telemetry tagging, anesthesia, laparoscopy/biopsy, and blood collection. To minimize procedure time and stress on animals, sturgeon selected for acoustic tagging, laparoscopy and acoustics testing would not be subject to more than one of these procedures.

2.3.2.1 Capturing:

Gill and Trammel Netting:

Gill nets of 12.7 cm (5-inch) or 15.2 cm (6-inch) stretched mesh would be used to sample for adult shortnose sturgeon. Gill nets of 2.5 cm (1-inch) to 10.2 cm (4-inch) stretched mesh would be used to sample for juveniles. Gill nets would typically be 100 m in length and 1.8 m deep, although shorter shots of net may sometimes be used. Trammel nets 50 m in length and 1.8 m deep, consisting of two outer panels of 60.8-cm (24-inch) stretched multifilament nylon mesh and an inner panel of 2.5-cm (1-inch) stretched multifilament nylon mesh, may also be used to sample for juveniles.

The net-set protocol summarized in Table 1 below would be adhered to. Gill nets and trammel nets would be set in waters having minimum dissolved oxygen (D.O.) concentrations no less than 4.5 mg/L. Netting would cease in waters above 28ºC until consulting with NMFS-PR. The maximum

net set duration is 14 hours, but this duration is limited to between rkm 186 and 215 when temperature is 15 ºC or below and D.O. is 4.5 mg/L or greater. Outside of this river location range, nets could be set for 10 hours in daylight hours only.

Table 1: Summary of Netting Conditions

Water Temperature (ºC)	Minimum D.O. Level (mg/L)[1]	Maximum Net Set Duration (hr)
< 15	4.5	14*
< 15	4.5	10
15 < 25	4.5	4
25 < 28	4.5	2
>28		Cease netting until consulting with NMFS

* Net set duration for 14 hours is limited to the river range of rkm 186 to 215 and would be subject to temperature and dissolved oxygen levels indicated.

Gill and trammel netting to mark/ recapture adult shortnose sturgeon for population estimates would be performed in two distinct phases each year. Overwintering sturgeon would be sampled between November and March in the tidal Delaware River between Roebling and Trenton, New Jersey (approximately rkm 186-215). Dispersed-phase sampling would be performed between May and October throughout the tidal Delaware River from Artificial Island to Trenton (rkm 79-215). It is anticipated the overwintering areas would be sampled most intensively to develop population estimates using the Chapman modification of the Schnabel method (Ricker 1975) which assumes closed populations due to confined overwintering areas of shortnose sturgeon in the Delaware River.

Gill/trammel and trawl netting for juvenile shortnose sturgeon would be conducted within the tidal Delaware River from Artificial Island, NJ to Trenton (approximately rkm 79-215). Juvenile sampling would be conducted year-round, subject to temperature limitations given in Table 1 above.

Trawling:
Trawling would be performed year round expressly to sample juvenile shortnose sturgeon, subject to the netting environmental conditions in Table 1. Dovel and Berggren (1983) found small trawls effective while collecting juvenile shortnose sturgeon in the Hudson River. Trawling for juvenile shortnose sturgeon would similarly be performed in the tidal Delaware River from Artificial Island to Trenton (rkm 79-215) using a 4.9 m otter trawl and/or a 14.6 m yankee trawl. Specifications for these trawls are provided in Table 2 below:

Table 2: Description of Proposed Trawling Gear

	4.9 m Otter Trawl	14.6 m Yankee Trawl
Headrope (m)	5.2	14.6
Footrope (m)	6.4	21
Net body mesh (mm)	38	50 and 80
Codend mesh (mm)	32	50
Innerliner mesh (mm)	13	14

Trawls would be towed at a maximum speed of approximately 2.5 knots (5 mph) for 10 to 15 minutes with an outboard powered boat. To lessen benthic disturbances, a GPS would be used to direct trawls so that nets would not be towed over the same exact location more than once in a 24-hour period. Further, trawling would be conducted primarily over sand substrates avoiding hard bottoms, vegetated areas, organic material, or woody debris. If a trawl became snagged on bottom substrate and debris, it would be untangled immediately to reduce stress on captured animals.

2.3.2.2 Collecting Eggs/Larvae with Mats, D-nets, and Epibenthic Sleds:

Three hundred eggs and or larvae (ELS) are requested by the applicant annually to meet the following research objectives: 1) determine the upstream limit of shortnose sturgeon spawning in the Delaware River; 2) document habitat characteristics at shortnose sturgeon spawning locations; 3) estimate the relative intensity and periodicity of spawning by sampling region; and 4) document the genetic diversity component of the population derived in-part from analyses of early life stage nDNA and/or mtDNA. Once a total of 300 eggs have been collected, all egg collecting gear would be removed from the river until sampling is resumed the following year. A total take of 900 eggs over the life of the five-year permit would be allowed.

Sampling ELS would be performed using egg mats, D-nets, or epibenthic sleds (described below) in previously documented spawning habitat for shortnose sturgeon between Trenton and five kilometers upstream of Lambertville, New Jersey (rkm 215-245). Sampling would be performed between late March and May, but could also be extended into June if shortnose sturgeon ELS are still present and the authorized take has not been exceeded. The positions and early spring movements of previously telemetered sturgeon would be monitored to aid in documenting spawning runs (i.e., locate spawning areas and document the spawning activity) at various locations in the river. Positions of tagged fish would be identified and recorded using portable GPS units, after which, measures of key habitat attributes (water temperature, depth, current velocity, substrate, etc.) would be obtained. Once the location of spawning activity is suspected — typically between 10 ^{O}C and 18 ^{O}C — sampling devices would be deployed just downstream. Egg density, distribution, and spawning periodicity would be closely monitored throughout the spawning season so that annual egg deposition could be estimated for all suspected spawning areas.

ELS samples would then typically be placed in container(s) filled with a 10 percent aqueous formalin solution and stored for laboratory analysis to make positive species identification; however, some samples also would be preserved in 95% ETOH for genetic testing. In this instance, genetic tissue samples from both the parents and the larvae/eggs would be compared to develop a population estimate based on the level of genetic diversity discovered in subsequent year classes (T. King; *pers comm.* October 2009). Once a total of 300 shortnose sturgeon eggs or larvae have been taken annually (also not exceeding 900 over five years), artificial substrates, d-nets, or epibenthic sleds would be removed from the river.

Egg Mat Substrate Samplers:

Egg mat samplers proposed to sample ELS are 56cm diameter circular polyester floor-buffing pads anchored to the river bottom with concrete pavers and marked with a float. They are designed to passively collect eggs adrift deployed in a stratified fashion to cover likely spawning habitats (McCabe and Beckman 1990). They would be checked and reset at least once daily during the spawning season and collected eggs would immediately be transported to shore, photographed,

removed from artificial substrates, and preserved for later laboratory analysis. Mats would then be returned to the river in their anchored position; and any excess eggs would be allowed to remain on the mat to potentially hatch in the river.

D-Net Frame Ichthyoplanton Nets:
To document spawning success, periodicity, and spawning D-frame ichthyoplankton nets (76 cm across the base, 54 cm high, fitted with a knotless 1600 µm mesh 317.5 cm nylon bag with a detachable cod end) would be bottom set within and just downstream of various suspected locations for up to 1-3 hours (Taubert 1980, Auer and Baker 2002). The float and anchor configuration would hold the net upright in currents up to 1 m s^{-1} A calibrated digital flow meter mounted in the center of the net mouth would be used to calculate the volume of water filtered for each sample to develop an index of abundance and spawning success (# ELS/ volume of water sampled). Ichthyoplankton net samples would be examined in the field, if possible, or preserved and processed in the laboratory.

Epibenthic Sled with an Attached D-net:
A similarly constructed D-frame ichthyoplankton net (as described above) would be fitted to an epibenthic sled towed slowly near documented spawning areas to collect eggs and larval samples. The sled is designed to be towed against the prevailing current for 5 minutes averaging approximately 1.0 m/second speed through water. A calibrated mouth would be used. Following deployment and retrieval of the sampling gear, net rinsing would be performed to concentrate the sample into the cod end bucket. The samples would then be examined to observe sturgeon egg/or larval species and the contents preserved for laboratory analysis and stored.

2.3.2.3 General Handling (e.g., Holding, Measuring, and Weighing):
Once captured, sturgeon would be held temporarily in boat-side net pens measuring approximately 200 cm long x 150 cm wide x 200 cm deep. Additional net pens would be onboard to accommodate excess holding of sturgeon and/or bycatch. Handling of fish would be kept to a minimum and fish would not be held for more than two hours after removal from capture gear, typically less than 30 minutes. Once recovered, sturgeon would be transferred to an onboard holding tank, they would be weighed, measured, fin clipped, tagged, photographed and further processed. To minimize handling, sturgeon would be moved and handled by researchers using latex gloves and, when in onboard holding tanks, sturgeon would be immersed in a continuous stream of water supplied by a pump-hose assembly mounted over the side of the research vessel. Dissolved oxygen (D.O.) would be supplemented with compressed oxygen to ensure the D.O. concentration does not fall below saturation. Sturgeon would be weighed on a platform scale fitted with a small waterproof cushion attached to the surface of weighing platform. Total length of each sturgeon would be measured with a standard measuring board and, by using calipers, mouth width and interorbital width would be measured to confirm species (Moser *et al*. 2000).

The time required to complete routine, non-invasive methods (*i.e.,* PIT tagging, measuring, weighing) would be less than one minute per fish. The cumulative time required for procedures such as anesthesia induction, telemetry tagging, and genetic tissue sampling would vary, but would typically average less than 15 to 20 minutes per fish, not accounting for recovery time from anesthesia. During processing, all fish would be treated with a slime coat restorative in the onboard live well, and, if anesthetized or otherwise necessary, placed in a separate net pen to ensure full recovery prior to release.

2.3.2.4 Hydroacoustic Testing:

Hydroacoustic/sonar testing is proposed to remotely scan and identify sturgeon while still in nets to ground truth instruments. Testing would occur on overwintering sturgeon sampled between November and March in the tidal Delaware River between Roebling and Trenton, New Jersey (approximately rkm 186-215). Acoustic data would be collected using a SciFish 2100 broadband sonar system (http://www.alaska.net/~scifish/Products/SciFish2000/SciFish2000.html). Data would be collected over a frequency range of 110-220 kHz, using a pulse length of 1 meter and an acoustic pulse repetition rate of 3 pings per second. However, the current proposal also includes collection of data at a ping rate higher than that used in previous the investigation, using both broadband and narrowband sonar at ping rates of over 30 pings per second alternating between broadband single-beam and narrowband split-beam signals. Narrowband split-beam processing allows locating a target with an accurate bearing angle with the broadband spectrum capable of being adjusted according to transducer sensitivity and the beam plot across the band. For that reason, it is also proposed to collect data from fish tethered in a specially designed frame (or sock) where the aspect angles could be controlled allowing better detail and specification, (Jung *et al.* 2004).

Methods proposed would follow those of Brundage and Jung (2009) and Nealson and Brundage, (2007) where shortnose sturgeon and three other fish species for hydroacoustic data collection were captured using anchored bottom-set gill nets fished parallel to the current at navigation channel depth (approximately 10–12 m). The nets would be 100 m long by 1.8 m deep and consisted of either 12.7-cm or 15.2-cm stretched monofilament mesh. Hydroacoustic measurements would be collected by passing over the netted fish with a downward looking broadband transducer. Following acoustic data collection, the netted fish would be recovered, identified, and measured for total length.

The additional time required for this scanning would conform to netting summary of conditions in Table 1. Additionally, up to 20 shortnose sturgeon would be captured and tethered at different depths in soft nylon or cotton mesh sleeves for periods not exceeding two hours. The objectives of this investigation would be to: 1) determine if adult shortnose sturgeon can readily be detected with hydroacoustic/sonar systems under varying field conditions; 2) determine how close to the bottom the species can be resolved; and 3) determine the efficiency and characteristics of the technology which would best enable sturgeon to be remotely identified and enumerated in a mixed-species environment.

2.3.2.5 Genetic Tissue Sampling:

Genetic information would be obtained from tissue samples of sturgeon to help characterize the genetic "uniqueness" of the Delaware River population and would also help quantify the current level of genetic diversity within the population. Immediately prior to release, a small (1.0 cm^2) soft tissue sample would be collected from the trailing margin of soft tissue of one of the pectoral fins or caudal fin using sharp sterilized scissors. Tissue samples would be preserved in individually labeled vials containing 95% ethanol. The researcher has agreed to provide genetic tissue samples collected from shortnose sturgeon for archival purposes to the NOAA/NOS Tissue Archive in Charleston, South Carolina, or to Co-investigators (CIs) identified in the permit. Proper certification, identity, and chain of custody of samples would be maintained during transfer of tissue samples.

Additionally, some ELS samples would be preserved in 95% ETOH for genetic tissue analysis to develop a population estimates based on the level of genetic diversity discovered in subsequent year

classes. In this instance, genetic diversity measurements of DNA samples taken from both the parental generation and the ELS would be compared to make inferences on the minimum number of adults required to achieve the level of genetic diversity found. Genetic tissue samples from other matched pairs of year classes (i.e., 2007 and 2009) would also be compared for similar objectives.

2.3.2.6 PIT Tagging:

Prior to PIT tagging, the entire dorsal surface of captured sturgeon would be scanned using a PIT tag reader to detect PIT tags of previously captured fish. All unmarked shortnose sturgeon (≥330 mm TL) would be tagged using 11.9 mm x 2.1 mm PIT tags injected using a 12 gauge needle at an angle of 60 to 80° in the dorsal musculature (left and just anterior to the dorsal fin). No fish would be double-tagged with PIT tags. The last step after injecting PIT tags would be to verify and record the PIT tag code with a tag reader. During the study, the rate of PIT tag retention would be documented, comparing presence of PIT tags to Floy tags, and reported to NMFS in annual reports.

2.3.2.7 Floy (T-bar Anchor) Tagging:

The researcher proposes to tag shortnose sturgeon with Floy (T-bar anchor) tags to incorporate incidental recaptures by commercial or recreational fishermen and other researchers to make possible collection of information useful for the assessment of the sturgeon population. In all captured shortnose sturgeon, Floy tags would be anchored in the dorsal fin musculature base and inserted forwardly and slightly downward from the left side to the right through the dorsal pterygiophores. After removing the injecting needle, the tag would be spun between the fingers and gently tugged to be certain it is locked in place. During the study, the rate of Floy tag retention would be documented and reported to NMFS in annual reports.

2.3.2.8 Implanting Acoustic Transmitters:

A maximum of 30 adult (≥ 600 mm) and 30 juvenile (<600 mm) shortnose sturgeon annually would be surgically implanted with an internal acoustic transmitter. Although the total weight of tags would not exceed 2 percent of the fish's total body weight, adult sturgeon would be tagged with VEMCO V16-5H acoustic tags, and juvenile sturgeon would be tagged with either VEMCO V7-4L; V9-6L; or V13-1H tags, depending on the weight of the individual sturgeon. Specifications for these transmitters are as follows:

Table 3: Proposed Vemco Acoustic Tag Models and Specifications

Model	Length	Diameter	Weight (H^20)	Weight (O^2)
V7-4L	22.5 mm	7 mm	1.0 g	1.8 g
V9-6L	21.0 mm	9 mm	1.6 g	2.9 g
V13-1H	36.0 mm	13 mm	6.0 g	11.0 g
V16-5H	95.0 mm	16 mm	16.0g	36.0 g

Anesthesia for Implanting Acoustic Tags:

Shortnose sturgeon selected for transmitter implantation, would be netted at temperatures between and including 9 to 27 °C. Each sturgeon prepared for surgery would be anaesthetized using a solution of up to 150 mg/L of tricaine methane sulfonate (MS-222) buffered to neutral pH with sodium bicarbonate. A low volume pump would deliver the anesthetic over the fish's gills through a

tube placed within the sturgeon's mouth until reaching a sedated to deep state of anesthesia (i.e., loss of equilibrium, some reaction to touch stimuli, opercula movement). The anesthetic's induction and recovery time would vary between 5 and 9 minutes, but would be appropriate for shortnose sturgeon under the specific water temperature and oxygen conditions present (Fox *et al*. 2000).

Surgery for Implanting Acoustic Tags:
Just prior to a planned 5 to 8 minute surgical procedure, the tube supplying the anesthetic would be removed and the sturgeon would be placed on a moist surgery rack where respiration would be maintained by directing fresh ambient water pumped across the gills with tube inserted in the animals' mouth. The incision site for implanting the tag (40 to 60 mm anterior to the pelvic fins, although the specific location would vary with fish size) would be disinfected with povidone iodine (10 percent solution). A sterile surgical packet containing all surgical instruments and supplies, would be used to make a 10 mm incision in individual fish selected for surgery. A sterilized sonic transmitter, coated with an inert polymer compound, would be inserted into the surgical openings of sturgeon and the incision closed with interrupted sutures of 3-0 polydioxanone (PDS) and treated with povidone iodine to prevent infection. Post-surgery fish would be held in an aerated holding tank and released upon recovery from anesthesia. Based on the implantation of over 175 acoustic tags in shortnose sturgeon under previous permits, the applicant estimated the surgical procedure would require approximately 5 to 8 minutes to complete, with a total holding time (anesthesia induction, surgery, and recovery) of 20 minutes or less. Internal tags would not be implanted in unhealthy or stressed fish or pre-spawning fish in the spring.

While in the onboard live well, all fish would be treated with a slime coat restorative and after surgery placed in a separate net pen to ensure full recovery prior to release. Any fish not responding readily would be recovered further in the net pen by holding the fish upright and immersed in river water and gently moved in a frontward motion to aid freshwater passage over the gills to stimulate the fish. When showing signs of being able to swim away strongly, the fish would be released and a spotter would watch to make sure the fish remains down and fully recovered.

2.3.2.9 Laparoscopic Examination, Gonad Biopsy and Blood Collection of Adults:
A variety of waterborne pollutants have been linked to adverse health or reproductive changes in fish, including altered gonadal development, changes in hormone concentrations, and production of female-specific proteins (e.g., vitellogenin) in male fish. The current health and reproductive status of shortnose sturgeon and level of estrogenic activity of pollutants in the tributaries they occupy are unknown. Mark Matsche, a CI on the applicant's previous permit (NMFS Permit 1486), and a proposed CI on the current application, has established normal baseline testosterone, estradiol, vitellogenin and hematological ranges for hatchery and wild shortnose sturgeon during the past four years (NMFS Permit 1486, 1505 & 1604). He would again cooperate with the applicant comparing these ranges to values obtained from wild Delaware River shortnose sturgeon using a combination of research activities including anesthesia, laparoscopy, gonadal biopsy and venipuncture (blood collection).

Anesthesia for Laparoscopic Surgery:
The proposed anesthesia protocol calls for a rapid induction of surgical anesthesia using a buffered solution of 250 mg/L MS-222 followed immediately by an 87.5 mg/L maintenance solution of MS-222 during surgery. Each animal chosen for laparoscopic examination (up to 24 proposed annually)

would be selected in excellent, non-stressed condition when netted. When removed from the net, each fish would be immediately transported (two to three minute transport) to a near-by field laboratory providing a 110-v electrical outlet to operate the lab and surgical equipment. Upon arrival, the animal would be anesthetized with a 250 mg/L solution of buffered tricaine and fitted with a heart rate monitor to assist determining when a state of surgical anesthesia has been reached.

The researcher's goal would be to rapidly achieve the desired plane of surgical anesthesia while minimizing the stressful effects on animals during laparoscopy (Summerfelt and Smith 1990). Surgical anesthesia would be reached when the fish exhibits complete loss of equilibrium, decreased muscle tone and reaction to massive stimulation, while maintaining a depressed ventilation rate and a regular heart rate (Ross and Ross 1999; Summerfelt and Smith 1990). Just prior to laparoscopy, the animal would be positioned in lateral recumbence within a recirculating anesthesia machine delivering a maintenance dose of 87.5 mg/L buffered tricaine over the fish's gills. The time required to reach the proper plane of anesthesia would average 2 to 7 minutes (Matsche; unpublished).

Laparoscopic Surgery:
Laparoscopic examinations have been used extensively in fisheries research (Murray, *et al.* 1998; Moccia *et al*. 1984; Ortenberger *et al*. 1996; and Stoskopf 1993) and refined for sturgeon work by Hernandez-Divers *et al*. (2004). Minimally invasive procedures (such as examining internal organs, determining sex, and performing biopsies) have been used by members of the researcher's staff on the Delaware River for the past four years (Permit 1486) who have also conducted training courses on the same procedures for other researchers. The researcher now proposes to continue these same techniques determining the sex and reproductive health of 24 adult shortnose sturgeon annually.

Using sterile technique, a small (~5 mm) incision would be made in the ventral body wall slightly off midline at a level midway between the pectoral girdle and the cloaca through which a 5-mm trocar would be inserted. A 5-mm rigid laparoscope would then be inserted through the trocar to allow visualization of gonads to determine sex and reproductive health of the animal. If necessary, the body cavity would be insufflated with ambient air by attaching a battery-powered air pump to the insufflation port of the trocar increasing the working space within the body cavity. Additionally, on rare occasions, the swim bladder would be punctured with a hypodermic needle guided by the laparoscope in order to gain a general visual assessment of all internal organs. For each animal, a modified version of a quantitative health assessment index for rapid evaluation of fish (Adams *et al*. 1993) would be made in a standardized fashion so results could be compared between individuals. Determination of the sex and reproductive status of the animal would be made and recorded. In those instances where the sex of the animal is not readily apparent, a biopsy of the gonad would be taken.

Biopsy Procedure:
In some instances where the sexes of the animal are not readily apparent, biopsies of the gonad material would be taken and preserved for histological evaluation and sex determination. To accomplish the biopsy, a second small (~5mm) incision would be made midway between the first incision and the pectoral girdle on the lateral aspect of the body approximately 1 cm dorsal to the ventral scutes. A second 5 mm trocar would then be inserted through the new incision, followed by a laparoscopic biopsy instrument to biopsy the gonad material. The sample would be approximately

5 mm in size (2-3g sample) and would be placed in 10% neutral, buffered formalin for preservation. Upon completion of the biopsy, the body cavity and biopsy site would again be visually assessed to ensure that there was no obvious hemorrhaged or herniated tissue requiring additional attention. The laparoscope and the two trocars would then be removed from the body and the incisions would be closed with a single suture in a cruciate pattern using PDS suture material.

Blood Collection:
Blood would be collected from the caudal veins of 24 shortnose sturgeon adults annually to ascertain if estrogenic compounds might be adversely affecting the Delaware River shortnose sturgeon population. This would be achieved by inserting a hypodermic needle perpendicular to the ventral midline at a point immediately caudal to the anal fin. The needle would be slowly advanced while applying gentle negative pressure with the syringe until blood freely flows into the syringe. Once a blood sample is collected, direct pressure would be applied to the site of to ensure clotting and prevent further blood loss (Stoskopf 1993). Needle and syringe size, as well as blood volume collected, would be dependent on the fish size, as presented below.

Table 4: Needle and Syringe Sizes Proposed Based on Fish Weight

Weight (gr)	Sample Size (ml.)	Needle Size (Gauge x Length)	Syringe Size (ml.)
≤ 1000	2	22g x 5/8”	3
1000 - 2000	3	22g x 5/8”	3
> 2000	6	20g x 1”	6

Each blood sample would be divided equally between two tubes, one tube containing the anti-coagulant lithium heparin and one tube containing none. Blood samples would then be centrifuged and placed in a cool dry place until they could be transferred by common carrier to CI identified in the permit for diagnostic work. In addition, a blood smear would be made at this time.

2.3.2.10 Unintentional Mortality of Shortnose Sturgeon:
The researcher has requested one annual unintended mortality or serious harm resulting from research, or up to three over the life of the permit. This request was based on the cumulative stress anticipated from the additional volume of research activity required to sample sturgeon and meet the researcher’s objectives. If a greater incidence of mortality or serious injury should occur, research would cease and NMFS-OPR would need to be consulted to determine the cause of mortality and to discuss any remedial changes in research methods before a decision could be made to resume research. The Permits Division could grant authorization to resume permitted activities based on review of the incident depending on the circumstances, or else suspend activities.

Additionally, it is possible research activities (gill netting and handling) could result in unintentional mortality of non-target species. However, from past experience of the researchers and their practice of monitoring nets with short soak-times, NMFS anticipates by-catch mortality would be minimal.

CHAPTER 3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

This EA evaluates the potential impacts to the human environment from issuance of the proposed permit and the potential impacts on the social, economic, physical, and biological environment (*i.e.*, targeted shortnose sturgeon), specifically those that may result from the proposed research activities requested.

3.1 SOCIAL AND ECONOMIC ENVIRONMENT

Although economic and social factors are listed in the definition of effects in the NEPA regulations, the definition of human environment states that "economic and social effects are not intended by themselves to require preparation of an EIS." However, an EIS or EA must include a discussion of a proposed action's economic and social effects when these effects are related to effects on the natural or physical environment. The social and economic effects of the proposed action mainly involve the effects on the people involved in the research, as well as any industries that support the research, such as suppliers of equipment needed to accomplish the research. There are no significant social or economic impacts of the proposed action interrelated with significant natural or physical environmental effects. Thus, the EA does not include any further analysis of social or economic effects of the proposed action.

3.2 PHYSICAL ENVIRONMENT

The following section provides a description of the critical resources within the action area.

3.2.1 *Description of the Delaware River System:*

The Delaware River is one of the major rivers of the eastern United States draining an area of 31,000 sq km. Beginning on the western Catskill Mountains in eastern New York, the river consists of two branches: the West Branch, 145 km long, and the East Branch, 121 km long. The West Branch is larger flowing southwest to Deposit, New York, before turning southeast at the confluence at Hancock, New York (rkm 452). From here, the Delaware, continues flowing southeasterly along the New York-Pennsylvania boundary as far as Port Jervis, New York. Bordering Pennsylvania and New Jersey, it then follows a generally eastward course to its mouth in the Delaware Bay. The last 100 kilometers is bounded by New Jersey to the north and Delaware to the south (DRBC 2009).

The Delaware River, a source of hydroelectric power, is a vital commercial and recreational waterway. It is navigable by large, oceangoing vessels as far inland as Philadelphia and by smaller vessels to Trenton, New Jersey. The Chesapeake and Delaware Canal is navigable by oceangoing vessels, connecting the Delaware River below Wilmington, Delaware, with the Chesapeake Bay. The Delaware River Basin Commission, the federal government, and the four Delaware Basin states—New York, Pennsylvania, New Jersey, and Delaware—jointly manage assets and concerns of the Basin. The U.S. Army, Corps of Engineers has responsibility for maintaining navigation on the river and has historically dredged the Delaware River's federal shipping channel since the late 1800s when the controlling depth of the Delaware River was 18 feet (USACE 2009). Channelization plans include appropriated construction funds to deepen and maintain the existing shipping channel from 40 feet to 45 feet from Philadelphia Harbor, Pennsylvania, and Beckett Street Terminal, Camden, New Jersey, to the mouth of the Delaware Bay. Although this is a total distance of 165 kilometers, the lower portion of the river channel (53 km), mostly in the Delaware Bay, is already at 45 feet or deeper (USACOE 2009).

3.2.2 *Essential Fish Habitat (EFH), Critical Habitat and National Marine Sanctuaries*: There are no designated critical habitats located within the area for the proposed activities. Additionally, there are no protected areas (e.g., National Estuarine Research Reserves or state protected aquatic areas) affected by the research, nor are there eligible historic resources in the project location. However, designated EFH exists for 26 managed species in the tidal portion of the Delaware River extending to rkm 148 at the mouth of the Schuylkill River in Pennsylvania.

NMFS therefore considered the potential for adverse impacts on EFH in the Delaware River would be defined by the area proposed for boating activities (rkm 0 to 245), and by the boundaries proposed for netting activities, the later coinciding with the freshwater-tidally mixed area of the river (rkm 79 to 148) (Figure 1).

Although the researcher's boats would pass through and over the water column — transiting to collect data from telemetry receivers located between rkm 0 and 245 (Figure 1) — NMFS determined this portion of the researcher's activity would not adversely impact the physical environment, including any portion considered EFH.

The tidally mixed area of the river, coinciding with the netting activities (rkm 79 to 148), has designated EFH for all life stages of winter flounder and windowpane, juvenile and adult bluefish, and summer flounder juvenile Atlantic sea herring, Atlantic butterfish, scup, and black sea bass and all life stages king mackerel, Spanish mackerel and cobia (http://www.nero.noaa.gov/hcd/nj2.html). Additionally, because anadromous fish (striped bass, American shad, alewife, blueback herring etc) use this section of the river for spawning, nursery, and migratory pathway, and because juvenile anadromous fish are a food source for the managed bluefish species, any impact to these species would also be considered an adverse effect on EFH based upon the EFH rules[2].

With respect to effects on EFH of gill and trammel nets fished in this area (see Section 2.3.2.1), trammel and gill netting gear would be anchored in position on the bottom of rocky or sandy substrate resulting in very little bottom drag and disturbance by nets on the bottom habitat. Consequently, NMFS concluded the effects on EFH caused by gill and trammel nets (and anchors) on the bottom habitat would be small.

Additionally, effects of trawling on EFH were also considered when sampling sturgeon in the tidally mixed zone of the Delaware River (rkm 79-148). Dovel and Berggren (1983) found trawling with smaller trawls were effective for collecting juvenile shortnose sturgeon in the Hudson River with little impact to bottom substrate. Similar results have been had when trawling for sturgeon in the upper and lower Connecticut River, the Merrimack River, the Delaware River, and in five South Carolina rivers (NMFS Permit Nos. 1549, 1516, 1486, and 1505). Conditions placed in these

2 The EFH final rule at 50 CFR Section 600.810 defines an adverse effect on EFH as "any impact which reduces the quality and/or quantity of EFH." The rule further states: "An adverse effect may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from action occurring within EFH or outside EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions."

permits resulted in no sturgeon mortality and minimal impacts documented to EFH over the past five years (Savoy, Kynard, Post; and Brundage; *pers. comm.*; Nov 2009). Therefore, based on similar trawling restrictions placed in the proposed permit — including short tow-times (10 min), small vessel size, low horsepower, slow maximum speed (5 mph), selecting bottom areas conducive to trawling, and using a GPS system to limit substrate disturbance — NMFS considered such trawling activity would also not adversely impact the physical environment in the Delaware River, including any portion having EFH.

NMFS, Northeast Office of Habitat Conservation, was contacted by email on December 21, 2009, to ask for concurrence whether the proposed action, as conditioned, would have adverse impacts on designated EFH in the Delaware River. The results of this informal consultation appear in Section 4.3.2 of this EA.

3.3 BIOLOGICAL ENVIRONMENT

The following is a brief summary of the status and occurrence of targeted shortnose sturgeon range-wide, including the proposed study area. Further descriptions of the status of these species can be found in the Biological Opinion accompanying this document as well as NMFS Recovery Plans and other documents at http://www.nmfs.noaa.gov/pr/publications/.

3.3.1 *ESA Target Species Under NMFS Jurisdiction*:

ESA Endangered: Shortnose sturgeon (*Acipenser brevirostrum*)

3.3.1.1 Range-wide distribution of shortnose sturgeon:

Shortnose sturgeon occur along the east coast of North America in rivers, estuaries and the sea. They were once present in most major rivers systems along the Atlantic coast (Kynard, 1997). Their current distribution extends north to the Saint John River, New Brunswick, Canada, which has the only known population in Canada (Scott and Scott 1988). Their southerly distribution historically extended to the Indian River, Florida (Everman and Bean 1898) but the southern limit of their range is currently believed to be in the Saint Johns River, FL (NMFS 1998). They are sympatric with the Atlantic sturgeon throughout much of their range. However, the Atlantic sturgeon spends more of its life cycle in the open ocean. In rivers, shortnose sturgeon and Atlantic sturgeon may share foraging habitat and resources but shortnose sturgeon generally spawn farther upriver and earlier than Atlantic sturgeon (Kynard 1997, Bain 1997). Magnin (1963) theorized the species was primarily found in freshwater on the basis of growth (i.e., if shortnose sturgeons spent more time in the ocean they would grow to larger sizes). In recent years, telemetry data and genetic analyses have demonstrated coastal migrations of shortnose sturgeon between adjacent rivers may be relatively common in some areas (S. Fenandes, Maine Rivers; & D. Peterson, S.E. Rivers, *pers. comm.*, 2009).

3.3.1.2 Status of Shortnose sturgeon in the Delaware River:

Current Distribution and Abundance in the Delaware River:

Shortnose sturgeon occur throughout the Delaware River estuary (Brundage and Meadows 1982). In spring, spawning adults migrate up-river in the non-tidal river in freshwater, and are common at least as far upstream as Scudders Falls (rkm 223). According to Dadswell, *et al*. (1984), ripe adults have been captured as far upstream as Lambertville (rkm 240). The farthest upstream confirmed account

of a shortnose sturgeon in the Delaware River is from 1998 when a fish was captured during electrofishing for American shad below the lower tip of Old Sow Island near Raubsville, Pennsylvania (rkm 287) (H. Brundage, *pers. comm*., October 21, 2009).

Hastings *et al.* (1987) estimated a modified Schnabel estimate of adult shortnose sturgeon in the Delaware River at 12, 796 (95% confidence interval – 10,228 to 16,367) based on mark recapture data collected during 1981-1984. Environmental Research and Consulting, Inc. (2006b) later estimated the population at 12,047 adult shortnose sturgeon, with a 95% confidence interval of 10,757 – 13,580. A Chapman modification of the Schnabel estimate was used based on mark-recapture data collected from January 1999 through March 2003.

Similarity between the two estimates suggests that the Delaware River shortnose sturgeon population is stable but has not increased in the 20+ years between studies. The recapture of 168 shortnose sturgeon during the later study, tagged as adults by Hastings *et al*. (1987), suggests older fish comprise a substantial portion of the Delaware River population (ERC, Inc. 2006b).

Natural History and Habitat Information:

Spawning**:** Delaware River shortnose sturgeon are documented to spawn from late March through early May with spawning occurring primarily between Scudders Falls and the Trenton rapids (rkm. 223-215) in Mercer County, although shortnose sturgeon eggs were also collected upstream of Titusville, NJ (rkm 229) in spring 2008 (H. Brundage, ERC, *pers. comm*. 2008). The river in the non-tidal area, beginning at the fall line at Trenton Rapids, is relatively shallow (< 3 meters in summer) and characterized by pools, riffles and rapids (O'Herron *et al*. 1993) and the substrate is composed primarily of sand, gravel, and cobble, with soft sediments found in areas of weaker currents. Spawning can occur between 8 and 25 ^{O}C, with most spawning occurring within the 10-18 ^{O}C range. Recent surveys by ERC, Inc. for early life stages, as well as observations from impingement/entrainment studies, confirm the presence of shortnose sturgeon larvae and/or eggs between Scudders Falls (rkm 223) and Trenton (rkm 215). Larvae collected at a Fairless Hills, Pennsylvania, cogeneration plant (approximately rkm 191) (well south of the spawning/rearing area), may have been carried there during a one day flood event

Foraging: After spawning, most adult shortnose sturgeon spend the summer and early fall foraging throughout the river, between the vicinity of Trenton south to Artificial Island (rkm 79). However, little evidence is available shortnose sturgeon forage much south of Artificial Island (J. O'Herron, *pers. comm*. 2008) although it has been suggested shortnose sturgeon enter into more brackish environments during winter months (D. Peterson, *pers. comm*. September 2009). Some foraging may also occur in winter in the Delaware River, though sturgeon are not feeding heavily at this time (J. O'Herron, *pers. comm*. 2008). Predominate substrates in the tidal river include fine grain sediments (silt, sand and clay). Larger substrates ranging from gravel to bedrock can be found in certain areas, such as the Marcus Hook location (ERC, Inc. 2006b). Though gut analysis has not been performed on Delaware River shortnose sturgeon, according to J. O'Herron (*pers. comm.* 2008), oligochaetes, Asian clams and chironomids were observed over occupied sturgeon habitats during macroinvertebrate sampling conducted in the early 1980's.

Overwintering/resting: Shortnose sturgeon were found to overwinter in the Roebling (rkm 199), Bordentown, (rkm 207) or Trenton reaches from December through March with the channel off Duck Island (rkm 208) known to be used heavily by overwintering sturgeon (O'Herron 1993). Recent acoustic tagging studies indicate the existence of a minor overwintering area in the lower portion of the river, below Wilmington, DE (ERC, Inc. 2006a). Wintering adults are normally observed in tight aggregations and movement at this time appears to be minimal. In addition, results from a preliminary tracking study of juvenile shortnose sturgeon suggest that the entire lower Delaware River from Philadelphia (approx. rkm 161) to Artificial Island (rkm 79) may be utilized as an overwintering area by juvenile shortnose sturgeon (ERC, Inc. 2007b). According to ERC, Inc. (2007b), juvenile sturgeon in the Delaware River appear to overwinter in a dispersed fashion rather than in dense aggregations like adults.

Migration corridor/seasonal movements: Acoustic tagging studies by ERC, Inc.(2006a) indicate adult shortnose sturgeon demonstrate one of two generalized movement patterns, either making long excursions from the upper to the lower tidal river (Pattern 'A' Migration) or remaining in and utilizing the upper tidal river (Pattern 'B' Migration) (ERC, Inc. 2006a). Fish with Pattern A movements made long distance excursions, often moving between the upper tidal river and the area of the Chesapeake and Delaware Canal (C&D Canal) (rkm 95) or farther downstream. Movements were often rapid, with one fish swimming 121 kilometers in six days. The long distance excursions often occurred in spring, after the spawning period (likely movement to summer foraging areas), and in early to mid-winter (likely movement to overwintering areas) (ERC, Inc. 2006a). Most of the tagged shortnose sturgeon occupied known overwintering areas in the Roebling, Bordentown and Trenton reaches of the upper tidal river during December through March. Three fish, however, appear to have overwintered in the downriver, below Wilmington (rkm 113). This suggests the existence of an overwintering area in the lower river. Downriver overwintering areas are known to occur in other river systems, but previously there had been no evidence of such in the Delaware River (ERC, Inc. 2006a). Movement patterns observed in the ERC study indicate that some, but not all, of the adult shortnose sturgeon overwintering in the upper tidal Delaware River move to the spawning area in the lower non-tidal river in late March and April (ERC, Inc. 2006a). One fish, whose tag was active in late spring and summer, showed movement spanning approximately 25 kilometers between the Chester and Deepwater Point ranges (rkm 130-101), spending much of its time in the vicinity of Marcus Hook (rkm 128; ERC, Inc. 2007b).

3.3.2 *Non Target Species*:

3.3.2.1 ESA Protected Species Potentially Affected by the Proposed Action:

The researcher's activities would include netting in the freshwater-tidally mixed areas between river kilometers 79 and 245, and between river kilometers 0 to 215 while transiting by boat to monitor the established acoustic array receivers (See Figure 1). Highlighted below is a listing of all the non-target ESA-listed species (threatened or endangered) under NMFS and USFWS jurisdiction with habitat occurring in the Delaware Basin states of Delaware, New Jersey and Pennsylvania.

In Delaware NMFS Species include — green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's ridley sea turtle (*Lepidochelys kempii*), Leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), finback whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), and right whale (*Balaena glacialis*).

USFWS species include — Delmarva Peninsula fox squirrel (*Sciurus niger cinereus*), bog turtle (*Clemmys muhlenbergii*), seabeach amaranth (*Amaranthus pumilus*), Canby's dropwort (*Oxypolis canbyi*), swamp pink (*Helonias bullata*), small whorled pogonia (*Isotria medeoloides*), and piping plover (*Charadrius melodus).*

In New Jersey NMFS Species include —hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), finback whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), and right whale (*Balaena glacialis*). USFWS species include — bog turtle (*Clemmys muhlenbergii*), dwarf wedgemussel (*Alasmidonta heterodon*), Knieskern's beaked-rush (*Rhynchospora knieskernii*), American chaffseed, (*Schwalbea americana*), sensitive joint-vetch, (*Aeschynomene virginica*), swamp pink (*Helonias bullata*), small whorled pogonia (*Isotria medeoloides*), seabeach amaranth, (*Amaranthus pumilus*), northeastern beach tiger beetle, (*Cicindela dorsalis dorsalis*), Indiana bat (*Myotis sodalis*), piping plover (*Charadrius melodus*), and roseate tern (*Sterna dougallii dougallii*).

In Pennsylvania USFWS species include — clubshell (*Pleurobema clava*), pink mucket (*Lampsilis abrupta*), rough pigtoe (Pleurobema plenum), orangefoot pimpleback, (*Plethobasus cooperianus*), northern riffleshell, (*Epioblasma torulosa rangiana*), pink ring (*Obovaria retusa*), dwarf wedgemussel (Alasmidonta heterodon), bog turtle (*Clemmys muhlenbergii*), northeastern bulrush (*Scirpus ancistrochaetus*), small whorled pogonia (*Isotria medeoloides*), and Indiana bat (*Myotis sodalis*).

3.3.2.2 Potential Interactions With Listed Species Occurring in the Action Area:
Based on the reported ranges of protected species under the jurisdiction of the USFWS occupying habitat well outside of the defined action area of the proposed permit application, NMFS determined the researcher's impact in the Delaware River would not affect these species recorded in this assessment. Discussion of non-target species interaction of listed species under USFWS jurisdiction is therefore concluded here and summarized in Section 4.3.1.

However, several of the above listed species (under NMFS jurisdiction species) have varying potential for interaction by the proposed research activity including: finback whale, humpback whale, and right whale, leatherback sea turtle, Kemp's ridley sea turtle, hawksbill sea turtle, loggerhead sea turtle, and green sea turtle.

Potential Whale Interaction:
While right and humpback whales have been documented near the mouth of Delaware Bay occurring seasonally off the Atlantic coast of Delaware and New Jersey, no listed whales are known to occur in the action area. Although the likelihood of interaction with whales by research activity is highly unlikely, in all boating activities (including travel to acoustic receiver arrays) researchers would be advised to keep a close watch for all marine mammals to avoid harassment or interaction and also advised to review the NMFS Northeast Region Marine Mammal Approach and Viewing Guidelines located online at http://www.nero.noaa.gov/prot_res/mmv/ (See also Section 4.5.7 of this EA).

Potential Sea Turtle Interaction:
Four species of sea turtle have been reliably documented within Delaware waters from early June to late October, by strandings, sightings, incidental capture, and targeted capture (Stetzar 2002). Loggerhead sea turtles are the most commonly encountered followed by juvenile Kemp's ridley and more rarely, juvenile green turtles. However, the hawksbill is considered extremely rare in the Mid-Atlantic, but a few have been documented as far north as New England, carried by storm events from tropical waters (Shoop and Kenney 1992). However, there have been no verified reports of hawksbill within Delaware waters. Further only one leatherback sea turtle has been documented stranded off New Jersey coastal waters, but are considered very rare. As such, these latter two species are discounted in this analysis.

Kemp's ridley, loggerhead, and green sea turtles have occasionally been taken during warmer months on the trash racks of the Salem and Hope Creek Nuclear Generating Stations located on Artificial Island (rkm 79) (Stetzar 2002). Between 1979 and 1992, a total of 2 green, 23 Kemp's ridley and 60 loggerhead sea turtles have been captured at the intakes. However, no sea turtles have been observed at the Hope Creek intakes, and no sea turtles have been captured at the Salem plant since 2001 (Stetzar 2002).

Additionally, the researcher commented in his application he has conducted fisheries field work on the Delaware River, including extensive gill netting and trawling, for over 30 years and has never captured a sea turtle during sampling, nor has he heard of any other fishery researchers working in the river collecting one (H. Brundage; *pers. comm*.; email, November 11, 2009). Interviews with two other university researchers on the river confirmed the lack of interaction during fisheries sampling within the applicant's action area (D. Fox and M. Fisher; *pers. comm*.; November 21, 2009).

Based on the available above information suggesting sea turtle occurrence in the lower action area would be present but rare, plus the researcher's record of no turtle bycatch over a 30 year period, NMFS PR believes the probability of encountering one during the proposed sampling is unlikely. However, to gain concurrence on our opinion, NMFS-PR held informal consultations with sea turtle specialists within NMFS-PR divisions. Results of these informal consultations appear in Section 4.3.1 of this EA.

3.3.2.3 Marine Mammal Protected Species Potentially Affected by the Proposed Action:

Following is a listing of marine mammals, either protected under the MMPA or ESA, with various rare sightings documented in the Delaware River estuary with some potential to enter the action of area of the proposed research.

Harbor seal, *Phoca vitulina* (MMPA, relatively common occurrence, lower river)
Harp seal, *Phoca groenlandica* (MMPA, rare occurrence)
Hooded seal, *Cystophora cristata* (MMPA, rare occurrence)
Gray seal, *Halichoerus grypus* (MMPA, rare occurrence)
Harbor porpoise, *Phocoena phocoena* (MMPA, periodical occurrence)
Bottlenose dolphin *Tursiops truncatus* (MMPA, relatively common occurrence; lower river)
Beluga whale *Delphinapterus leucas* (MMPA & ESA, extremely rare occurrence)
Florida manatee, *Trichechus manatus latirostris* (MMPA & ESA, extremely rare occurrence)

Bottlenose dolphin, harbor seal, and harbor porpoise are the most abundant marine mammal species potentially affected by the proposed research. However, only occasionally are these reported in upriver locations affected by netting activities. Rather, they are more frequently encountered by boaters and researchers in the lowest part of Delaware Bay bordering coastal waters of Delaware and New Jersey. Email (9/21/09) from Amanda Johnson (NMFS marine mammal specialist; NE Regional Office) confirmed the nearest haul out for Harbor seal is located on the Atlantic coast near Great Bay, New Jersey, located approximately 17 kilometers north of Atlantic City, New Jersey. The protected Florida manatee, documented only once in the Delaware River in 2008, and the beluga whale, sighted as far as Trenton, New Jersey, during 2005, are considered extremely rare incidental occurrences in the Delaware River, well outside their officially recognized range.

NMFS, Northeast Regional Office reviewed the application for potential interaction with these marine mammals and agreed with NMFS-PR that netting in areas detailed in Figure 1 would be far enough north of Delaware Bay (rkm 79) to limit interactions. However, in the unlikely event researchers do come into close contact with any of these marine mammals, either through boating or netting activities, the Northeast Regional Office suggested appropriate precautionary measures. Namely, netting would not be deployed when animals are observed within the vicinity of the research; and animals would be allowed to either leave or pass through the area safely before net setting is initiated. Netting activities must cease if a marine mammal is sighted within a 100-foot radius of the research vessel or net, and may resume only when the animal is no longer within this safety zone, or 30 minutes has elapsed since the mammal was last observed within the safety zone. Additionally, in all boating activities (including travel to acoustic receiver arrays outside of the netting area), researchers would be advised to keep a close watch for marine mammals to avoid harassment or interaction and also to review the NMFS Northeast Region Marine Mammal Approach and Viewing Guidelines (http://www.nero.noaa.gov/prot_res/mmv/ See also Section 4.5.7 of this EA).

3.3.2.4 Non-Listed By-catch Species:

Based on the last thirty years of netting familiarity on the Delaware River, the researcher would expect some other non-target species such as American shad (*Alosa sapidissima*), Atlantic menhaden (*Brevoortia tyrannus*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), striped bass (*Morone saxatilis*), white perch (*Morone americana*), channel catfish (*Ictalurus punctatus*), and white catfish (*Ameiurus catus*) would become enmeshed. However, nets would typically be checked at short intervals and it is believed virtually all bycatch would be released alive. Additionally, because potential for capturing Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), a NMFS species of concern, is very likely in the Delaware River, the following discussion on Atlantic sturgeon is highlighted below.

Atlantic sturgeon:

Atlantic sturgeon is currently considered a "candidate species" under NMFS jurisdiction, co-occurring in the Delaware River study area with shortnose sturgeon. Thus, there is potential for Atlantic sturgeon to be caught during research activities. Reviewed in 1998, NMFS and USFWS received a petition to list Atlantic sturgeon as endangered. Although a protective ESA status was denied at that time, the species remained a 'species of concern' under NMFS's jurisdiction. In 2007, NMFS completed a second status review for this species and has since accepted a petition evaluating whether the species warrants listing under the ESA. However, currently a proposed rule has not

been published, and thus this species does not receive protections under the ESA. Consequently, NMFS considers should a subsequent listing of Atlantic sturgeon occur coinciding with the proposed research activities, the effects of researcher's actions on Atlantic sturgeon would be analyzed at that time. Appropriately, the researcher would monitor gill nets closely, and if an Atlantic sturgeon were captured prior to its listing, NMFS would request the same netting protocols and standard research conditions protective for shortnose sturgeon be used to ensure Atlantic sturgeon survival (See Section 4.5.8 of this EA).

3.3.2.5 Aquatic Nuisance Species:

The U.S. Geological Survey has documented several aquatic nuisance species (USGS 2009) occurring in the Delaware River watershed potentially in the action area of researchers including: bowfin (*Amia calva*); flathead catfish (*Pylodictis olivaris*); Asian clam (*Corbicula fluminea*); water hyacinth (*Eichhornia crassipes*); hydrilla (*Hydrilla verticillata*); parrot feather (*Myriophyllum aquaticum*); Eurasian water milfoil (*Myriophyllum spicatum*) and water chestnut (*Trapa natans*). Because the proposed research activities have the potential to spread such aquatic nuisance species to other watersheds, measures proposed by NMFS, outlined in Section 4.5.9 of this EA, were agreed to by the researcher to be implemented as standard research protocol. For further information on the affected biological environment, please refer to the Biological Opinion (April 2010) written for this proposed action.

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES

This chapter represents the scientific and analytic basis for comparison of the direct, indirect, and cumulative effects of the alternatives. Regulations for implementing the provisions of NEPA require consideration of both the context and intensity of a proposed action (40 CFR Parts 1500-1508).

4.1 EFFECTS OF ALTERNATIVE 1: NO ACTION

An alternative to the proposed action is no action, i.e., denial of the permit request. This alternative would eliminate any potential risk to all aspects of the environment from the proposed research activities. However, it would also prohibit researchers from gathering information that could help endangered and protected shortnose sturgeon.

4.2 EFFECTS OF PROPOSED ALTERNATIVE 2: ISSUANCE OF PERMIT WITH STANDARD CONDITIONS

Any impacts of the proposed action would be limited primarily to the biological environment, specifically the animals that would be studied or affected by the research. The type of action proposed in the permit request would have a negligible effect on the physical environment and would be unlikely to affect the socioeconomic environment or pose a risk to public health and safety.

4.2.1 *Effects of Research Activities*:

4.2.1.1 Effects of Capturing:

The applicant proposes to use bottom-set gill nets, trammel nets, and trawl nets to capture up to 1,000 annually, or totaling 3,600 shortnose sturgeon over five years. Entanglement in nets or damage suffered in trawls could result in injury and mortality, reduced fecundity, and delayed or

aborted spawning migrations of sturgeon (Moser and Ross 1995, Collins *et al.* 2000, Moser *et al.* 2000). Historically, the majority of shortnose sturgeon mortality during scientific investigations using nets or trawls has been related to such factors as water temperature, low D.O concentration, netting duration, meshes size, net composition, and netting experience of the researcher (Table 5).

Table 5: The number and percentage of shortnose sturgeon killed by gill nets associated with scientific research permits prior to 2005

	Permit Number					
	1051	1174	1189	1226	1239	1247
Time Interval	1997, 1999 – 2004	1999–2004	1999, 2001 – 2004	2003–2004	2000 – 2004	1988 – 2004
Sturgeon captured	126	3262	113	134	1206	1068
Sturgeon mortality	1	7	0	0	5	13
Percentage	0.79	0.22	0	0	0.41	1.22

In 2005, NMFS-PR began analyzing the results of previous research and updating permit conditions to reduce the chances of stress and mortality to shortnose sturgeon during capture. Since that time, there have been no mortalities caused during their capture (Table 6). The primary causes of mortality identified during a review of permits issued prior to 2005 were high temperatures, low dissolved oxygen, and long net set durations. Despite the permit modifications reducing mortality of sturgeon in nets, there is a chance of delayed mortality occurring without being reported. There is no way to estimate the rate of delayed mortality, but NMFS believes it would be less than one percent based on reports of various species of sturgeon captured and transported to rearing facilities.

Table 6: Number of shortnose sturgeon killed during capture under existing scientific research permits

Permit Number	Shortnose sturgeon captured	Shortnose sturgeon mortalities
1420 (2005-2009)	1472	0
1447 (2006-2009)	107	0
1449 (2007-2008)	50	0
1486* (2006-2009)	416	0
1505 (2006-2009)	276	0
1516 (2007-2009)	160	0
1547 (2006-2009)	112	0
1549 (2006-2009)	390	0
1575 (2007-2009)	12	0
1580 (2007-2008)	66	0
1595 (2007-2009)	505	0
10037 (2007-2009)	235	0
10115 (2008-2009)	1	0
Totals	3802	0

* NMFS Permit No. 1486 is the current permit proposed to be replaced by Permit File 14604.

The researcher has maintained a record of verifiable mortality while engaged in other authorized research on shortnose sturgeon within the same proposed action area. Annual reports from 1999 to 2004 (Permit 1174) documented a mortality rate of 0.22%, or 7 fish out of a total of 3,286 captured. However, while working under more conservative sampling effort since 2005 (Permit No. 1486), the researcher has reported no shortnose sturgeon deaths capturing 311 in four years of research.

Nevertheless, in the current application requesting authorization for 3,600 captures over five years, the applicant outlines goals requiring increased netting activity. Thus, NMFS would anticipate some mortality and/or delayed mortality associated with capture due to the volume of netting activity and numbers of fish targeted (See Section 4.2.1.8 of this EA).

Gill /Trammel Netting:
To limit stress and mortality of sturgeon due to capture, the permit would require at temperatures less than 15°C, soak times must not exceed 10 hours; at temperatures between 15°C and 20°C, net sets must not exceed 4 hours; and at temperatures between 20°C and 28°C, soak times must not exceed 2 hours. Netting activities must also cease at above 28°C. Further, dissolved oxygen would also be measured prior to each net set to ensure that at least 5.0 mg/L concentration is maintained. Also, to minimize injury, heavy multifilament (size 208-233) mesh would be used instead of monofilament or light twine, which is more apt to cut into the fish causing injury. Due to the low ventilation rate and open operculum, the use of trammel nets, as proposed, would allow the fish to become entangled rather than gilled which would reduce the stress level.

Historically, the researcher has reported no interactions with marine mammals or turtles in over thirty years of research on the Delaware River. Nevertheless, effects of netting on marine mammals and turtles would be mitigated by the researcher by his regular practice of tending nets when fished and by pulling nets immediately if one were captured (See Section 4.5.7 of this EA). Additionally, the longer net sets of 10 and 14 hours are authorized only in temperatures below 15°C, a period when marine mammals and turtles do not frequent the river.

Trawling:
Most negative effects resulting from trawling to capture juvenile sturgeon occur as a result of the speed and duration of the trawl (Moser *et al.* 2000). However, by proposing similar methods of trawling as employed in the upper and lower Connecticut River, in five South Carolina rivers and in the applicant's pervious permit on the Delaware River (NMFS Permit No. 1549, 1516, 1505 and 1486) — these trawling methods have yielded no mortalities and limited impacts on the bottom substrate — NMFS anticipates the applicant's proposed trawling in the Delaware River would have similar outcomes.

To limit effects of trawling, measures would include trawling at slow speeds, towing for no more than ten minutes, and avoiding multiple trawls over the same area during the day using a GPS unit. Trawling would primarily be conducted over sand substrates avoiding hard bottoms, vegetated areas, organic material, or woody debris. If the trawl does become entangled in debris, efforts would begin immediately to free the gear to avoid injuring any captured target or non-target species. Based on proposed capture methods with the trawl, and results from similar efforts from other permits, no mortality or serious injury to target and non-target species, or damage to habitat, is anticipated while trawling. Any adverse effects to shortnose sturgeon, non-target species, or habitat would be localized and minor.

4.2.1.2 Effects of Sampling Eggs/Larvae with Mats, D-Nets, and Epibenthic Sleds:
Collection of shortnose sturgeon eggs and larvae is essential to document the presence and location of spawning areas and the spawning periodicity in the Delaware River. The artificial substrates deployed would be low profile pads, designed to passively collecting eggs adrift in the water. Due

to their small size, these pads would not disrupt the flow of the water or the habitat around it. Embryos dislodged or drifting would settle on the pads and later identified. Those not useful for further analyses would immediately be returned to the river or allowed to mature on the egg mats.

A towed epibenthic sled fitted with an ichthyoplankton net, as well as a passive ichthyoplankton net, are also proposed to be used for the collection of shortnose sturgeon early life stages. The passive ichthyoplankton net is not expected to adversely affect the river bottom. To minimize any potential effects on the shortnose sturgeon larvae captured, the passive nets would be fished for a period of three hours prior to checking for eggs. The epibenthic sled would only be used in suitable locations for deployment of such equipment, and may have a negative impact on the characteristics and quality of the research environment. Benthic trawling, as proposed, would affect the bottom by scraping and ploughing, resuspending sediment, or destroying non-target benthos (Jones, 1992). To minimize these effects, mitigating measures would be imposed on the researchers, such that they may not tow trawl gear for longer than 5 minutes at a speed of no more than one meter per second, and repeated tows over the same area will be avoided to the extent possible. With these mitigation measures implemented, the temporal extent of impact to the river bottom, as well as sediment and benthic organism disturbance would be limited. The applicant would attempt to return as many eggs and larvae as possible to the river, in hopes of avoiding lethal take, but as a conservative estimate, it is assumed that all eggs and larvae would be killed and samples would be transported to the lab and preserved in either 70% isopropyl alcohol or 95 ethyl-alcohol while awaiting examination.

Each adult female sturgeon produces between 94,000 and 200,000 eggs every 3 years (COSEWIC, 2005). The most recent population estimate in the Delaware River, including large juvenile and adult shortnose sturgeon, is 12,047 (Brundage and O'Herron, 2003). The survival from egg to juvenile is likely the most critical aspect in determining the strength of the year class (COSEWIC, 2005). As a conservative estimate, if sturgeon only reproduce once every 5 years (1,204 adult females) and produce a minimal number of eggs (94,000), over 113 million eggs (1,204 x 94,000) would be produced. In this conservative scenario, the annual take of 300 eggs would be a small fraction of the total annual egg production and thus would have a negligible effect on the Delaware River shortnose sturgeon population.

4.2.1.3 Effects of General Handling (e.g., Holding, Measuring, Weighing):
Sturgeon are a hardy species, but sensitive to handling stress when water temperatures are high or D.O. is low. Handling stress can escalate if sturgeon are held for long periods after capture; and conversely, stress is reduced the sooner fish are returned to their natural environment to recover (D. Peterson, *pers. comm.* November 2008). Signs of handling stress are redness around the neck and fins and soft fleshy areas, excess mucus production on the skin, and a rapid flaring of the gills. Additionally, sturgeon tend to inflate their swim bladder when stressed and when handled in air (Moser *et al.* 2000). If not returned to neutral buoyancy prior to release, sturgeon tend to float and would be susceptible to sunburn and bird attacks. In some cases, if pre-spawning adults are captured and handled, it is possible that they would interrupt or abandon their spawning migrations after being handled (Moser and Ross 1995).

Although sturgeon are sensitive to handling stress, the proposed methods of handling fish described in the application are consistent with the best management practices recommended by Moser *et al*. (2000) and endorsed by NMFS and, as such, should minimize the potential handling stress and therefore minimize indirect effects resulting from handling in the proposed research. Moreover,

with conservative permit conditions in place (see Section 4.5.1 of this EA), the likelihood of harm or mortality due to handling and restraint is expected to be minimal.

4.2.1.4 Effects of Hydroacoustic Testing:

Remote detection and identification of shortnose sturgeon using hydroacoustic/sonar equipment data collection is proposed (Brundage and Jung 2009 and Nealson and Brundage 2007). Although most sturgeon included in testing would be scanned while still in nets, up to 20 adults would be selected after capture and tethered in soft nylon or cotton mesh sleeves. Potential adverse effects from such testing could come from extended netting or handling effects magnified by conditions of low D.O. or related temperature stress while fish remain netted or tethered. To lessen stress, the permit would conditioned to limit the total time required for all activities performed — PIT tagging, weighing, measuring, and tissue sampling, in addition to the time tethered during scanning — would not exceed two hours and would not take place when D.O. is below 4.5 mg/l and when temperature is above 15°C. Further, NMFS verified the frequencies of sound emitted by the hydroacoustic and sonar equipment (110 kHz-1.8 mHz) is much higher than the hearing range of fish (Popper, 2005) and thus would be inaudible. Although the hearing of bottlenose dolphin is within the range of testing, (120 Hz to 160 KHz; B. Southhall, pers. comm.), no impacts to bottlenose dolphin would be anticipated because no netting or testing of acoustic equipment would be done when dolphin are present. Additionally, the location and timing of sampling would not overlap the normal range of dolphin in the Delaware River (rkm 186 to 215).

4.2.1.5 Effects of Genetic Tissue Sampling:

The applicant proposes to take small (1 cm^2), non-deleterious tissue samples, clipped with sterile surgical scissors from sections of soft pectoral fin rays of captured sturgeon. Tissue sampling does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact (Wydoski and Emery 1983). Many researchers, including the applicant, have reported removing tissue samples with no adverse effects; therefore, NMFS does not anticipate any long-term adverse effects to sturgeon from this activity.

4.2.1.6 Effects of PIT Tagging:

The PIT tags used for permanently marking and identifying individual captured fish will be Destron 12 mm TX1700L tags, nominally 11.5 mm by 2.1 mm, activated at a radio frequency of 125 kHz. The PIT tags would be injected 1 cm into the left dorsal musculature just anterior to the dorsal fin using a syringe equipped with a 12 gauge needle. These biologically inert tags have been shown not to cause problems associated with some other methods of tagging fish; that is, scarring and damaging tissue or otherwise adversely affecting growth or survival (Brännäs *et al*. 1994). PIT tags have the highest reported retention rate of all identification tags, though they are not visible to the researcher or fisherman upon capture. Smith *et al.* (1990) noted 100% retention after 60 days in wild shortnose sturgeon. In the Penobscot River, retention rates for PIT tags in Atlantic sturgeon were 93% after as much as 8.8 years (Fernandes, *pers. comm.*). Consequently, NMFS does not anticipate adverse effects to the environment from PIT tags due to the small numbers not retained.

As such, the proposed tagging of shortnose sturgeon with PIT tags is unlikely to have significant impact on the reproduction, numbers, or distribution of shortnose sturgeon. However, there is one record of young fish mortality within the first 24-48 hours of PIT tag insertion as a result of the tags being inserted too deeply. Henne *et al*. (2008) found 14 mm tags injected into smaller shortnose

sturgeon caused mortality after 48 hours; also he inferred from his results, either 11.5 or 14 mm PIT tags would not cause mortality in sturgeon equal to or longer than 330 mm (TL). To address this concern, the applicant would not PIT tag sturgeon less than 330 mm (TL) or perform other surgical procedures. And to avoid duplicate tagging, all sturgeon captured would be scanned with a PIT tag reader prior to the insertion of a PIT tag. Additionally, results of PIT tag retention would be reported to NMFS in annual reports to document PIT tag retention.

4.2.1.7 Effects of Floy (T-bar Anchor) Tagging:

The applicant requested an additional externally identifiable tagging method using Floy tags during the study suggesting the additional information gained from visible tags would be important because a sizable percentage of sturgeon recaptures from the Delaware River are reported by a sizable number of commercial and recreational fishermen, as well as scientific community.

Smith *et al.* (1990) compared the effectiveness of dart tags with nylon T-bars, anchor tags, and Carlin tags in shortnose and Atlantic sturgeon. Carlin tags applied at the dorsal fin and anchor tags in the abdomen showed the best retention, and it was noted that anchor tags resulted in lesions and eventual breakdown of the body wall if fish entered brackish water prior to their wounds healing. However, Collins *et al.* (1994) found no significant difference in healing rates (with T-bar tags) between fish tagged in freshwater or brackish water. Clugston (1996) also looked at T-bar anchor tags placed at the base of the pectoral fins and found that beyond two years, retention rates were about 60%. Collins *et al.* (1994) compared T-bar tags inserted near the dorsal fin, T-anchor tags implanted abdominally, dart tags attached near the dorsal fin, and disk anchor tags implanted abdominally. They found, long-term, T-bar anchor tags were most effective (92%), but also noted minor, slow-healing lesions at the insertion points.

NMFS concludes the use of Floy tags to externally mark shortnose sturgeon is an acceptable duplicative means to identify recaptured fish. The practice is not expected to significantly impact sturgeon health. To lessen known negative impacts described using Floy tags, researchers would use sterile tagging technique and subsequently monitor dorsal fins tag sites of recaptured sturgeon. Also, shed tags would not be considered an adverse impact to the environment, as these tags are small in size and the numbers insignificant. Additionally, results of tag retention and fish health would be reported to NMFS-PR in annual reports and as periodically requested by NMFS. If impacts of the Floy tags on the health of fish are other than insignificant, NMFS would reevaluate their use.

4.2.1.8 Effects of Implanting Acoustic Transmitters:

In each year of the study, a maximum of 30 adult and 30 juvenile shortnose sturgeon are proposed to be anesthetized and surgically implanted with an internal acoustic transmitter using the outlined protocol presented in Section 2.2.3.7 of this EA.

The researcher has recorded in annual reports to NMFS surgically implanting acoustic tags in over 175 adult and juvenile shortnose sturgeon with no mortalities or adverse effects directly attributable to such implanting. According to the applicant, the behavior of acoustically tagged shortnose sturgeon in past studies (with some fish tracked for periods greater than two years) suggests the research methods used have had little verifiable negative effects on individual animals. Other precautions would include implanting transmitters only in non-stressed fish of excellent condition, and not attempting the procedure with pre-spawning fish in spring, or when the water temperature is

outside the range of 7 to 27 °C. To verify normal mobility and swimming behavior of sturgeon receiving internal transmitters, the total weight of all transmitters and tags would not exceed 2% of the weight of the fish. Additionally, the applicant would regularly document tag adaptation by manually and passively tracking individual fish (using boats and passive receiver arrays), recording swimming behavior, logging the number of times and the periods between detection, and noting the number of unrelocated individuals.

In other research, Dr. Collins in South Carolina (M. Collins, *pers. comm.,* November 2006) tracked radio tagged shortnose sturgeon for two years and documented no mortality from surgical implantation of internal transmitters. Additionally, Kieffer and Kynard (*In press*) reported tag rejection internally was reduced by coating tags with an inert elastomer and by anchoring tags to the body wall with internal sutures. All fish retained tags for their operational life, and in most cases, lasted much longer (mean, 1,370.7 days). However, Devries (2006) reported movements of 8 male and 4 female (≥ 768 mm TL) shortnose sturgeon internally radio-tagged between November 14, 2004 and January 14, 2005, in the Altamaha River, Georgia. Nine of these fish were tracked until the end of 2005. Although no mortality or serious harm was directly documented for these fish, the remaining five individuals not accounted for were censored after movement was not detected, or they were not relocated, after a period of four months.

This later account signals the potential for adverse delayed or indirect effects from such tagging. Thus, while often not verifiable, NMFS believes the surgical implantation of acoustic transmitters does have the potential to injure or kill shortnose sturgeon. Although more invasive surgical procedures are required for internal implantation, this tagging procedure does provide greater retention rates than external attachment. In general, direct effects of the proposed tagging procedure could include pain, handling discomfort, hemorrhage at the site of incision, risk of infection from surgery, affected swimming ability, and/or abandonment of spawning runs. However, use of proper anesthesia, sterilized conditions, and the surgical techniques described above, would minimize potential short-term effects from tagging and greatly lower the long-term risks of injury and mortality. NMFS therefore expects the tagging would result in primarily short-term stress to the animal with some unverifiable mortality resulting from such tagging.

Lastly, many fish have sensitivity to sound energy from 200 Hz up to 800 Hz, and some species are able to detect lower frequency sounds (Popper 2005). However, the potential for the proposed internal sonic transmitters to affect sturgeon carrying them would be small because the frequency of the acoustic tags is 69 kHz, well above the audible threshold of most fish. However, NMFS also considered unverified potential for predation on tagged sturgeon by seals or sea lions which have been reported to have hearing capability in the range of the proposed tags (B. Southall, *pers. comm*., November 2009). However, based on the implantation and subsequent successful tracking of over 175 acoustic tags in shortnose sturgeon under the applicant's previous permits, NMFS does not believe such predation is an extensive risk for shortnose sturgeon tagged with acoustic tags in the Delaware River.

4.2.1.9 Effects of Anesthesia:

The researcher proposes to use tricaine methane sulphonate (MS-222) to anesthetize shortnose sturgeon at two levels of concentrations: one, up to 150 mg/L for surgically implanting sonic

transmitters, and the other, at 250 mg/L for inducing surgical anesthesia in sturgeon undergoing laparoscopic examinations.

Anesthesia for Transmitter Implantation:
The proposed anesthetic concentration of up to 150 mg/L MS-222 is commonly used by sturgeon biologists to induce light to deep planes of anesthesia for internal acoustic tagging (D. Peterson, D. Fox, M. Collins, T. Savoy, *pers. comm*. Nov. 2009). The induction varies with dosage, water temperature and water chemistry; however, typical induction times are from five to eight minutes. Because telemetry tags can be inserted into the coelom in less than a minute with little reaction to the external stimuli (muscle spasm, contraction) when incised, there is little risk to the sturgeon in this regard (M. Matsche; pers. comm.; December 2009). Complete recovery time from the anesthetic averages four to six minutes (Brown 1988).

Risks associated with anesthetizing with MS-222 at this level would include hypoxia from overexposure (caused by inexperience at recognizing the proper level of narcosis) (Coyle *et al.* 2004), anesthetizing fish in poor health or stressed conditions, and injury from thrashing during the excited phase of anesthetic induction. To reduce such risks, the applicant is personally experienced and accomplished in the use of MS-222. He has performed over 175 surgical tagging procedures using similar anesthetic protocol over the past twenty years. Only non-stressed animals in good health would be anesthetized for internal tagging. Fish would be monitored closely during induction to reach the proper level of anesthesia prior to surgery, and would be watched to ensure proper recovery from anesthetic narcosis prior to release. To avoid injury while being anesthetized, sturgeon would be restrained with netting to prevent animals from jumping or falling out the anesthetic bath. Also, because MS-222 is an acidifying solution, potentially extending the induction time for narcosis, the bath solution would be buffered to a neutral pH with sodium bicarbonate, as well as oxygenated prior to use.

Finally, because MS-222 would be excreted in fish urine within 24 hours—tissue levels decline to near zero in the same amount of time (Coyle *et al*., 2004) — sturgeon released after treatment would not present a sizable risk to the environment should potential predators consume a sturgeon. Further, an existing FDA 21-day withdrawal period for MS-222, applied to food-fish for human consumption, would not be applicable for endangered shortnose sturgeon since they are a federally protected species with prohibitions against take. (F. Pell; FDA; *pers. comm*.; email; 2/24/2009).

Therefore, NMFS considers this anesthetizing protocol for internal tagging to be well established with known risks minimized to produce limited effects on the sturgeon and the environment.

Anesthesia for Laparoscopic Surgery:
The proposed anesthesia protocol for laparoscopic surgery calls for rapid induction of surgical anesthesia with a 250 mg/L buffer solution of MS-222 followed immediately by an 87.5 mg/L maintenance dose of MS-222 during surgery. The researcher's goal would be to rapidly achieve the desired plane of surgical anesthesia while minimizing stressful effects on animals during laparoscopic examination (Summerfelt and Smith 1990). Surgical anesthesia would be reached when the fish exhibits complete loss of equilibrium, decreased muscle tone and reaction to massive stimulation, while maintaining a depressed ventilation rate and regular heart rate (Ross and Ross 1999; Summerfelt and Smith 1990).

Invasive research activities can be stressful to fish, even if they are immobilized, and using an anesthetic thereby reduces the stress and risk of resulting mortality of these procedures (Iwama *et al.* 1989, Small 2003, Wagner *et al.* 2003, Coyle *et al.* 2004, Roubach *et al.* 2005, Wanner *et al.* 2007). Anesthetization, therefore, serves two purposes — it immobilizes the sturgeon while researchers perform very precise procedures, and numbs its stress response to pain during and after an invasive procedure. The primary risks of inducing anesthesia on sturgeon are therefore typically overexposure or overdosing and the buildup of stress response hormones, such as cortisol. Overexposure occurs when sturgeon are left in an anesthetic bath longer than necessary to achieve narcosis. Overdosing takes place when the concentration of anesthetic is higher than the fish can tolerate. Both can cause lethal or sub-lethal effects. Further, the rate at which anesthesia is induced in fish is also important in minimizing stress. Marking and Meyer (1985) provided characteristics of an appropriate anesthetic protocol stating it should include both a rapid induction time (<5 minutes) and rapid recovery time (<10 minutes, faster for sedation). Using the proposed 250 mg/L MS-222 anesthetic protocol to induce surgical anesthesia, the applicant's CI Mark Matsche (2009, unpublished data), reported average induction times of 2-5 minutes. Fish recovery times of 2-7 minutes were also reported by Matsche (2009, unpublished) using this same protocol.

Further, the researcher's request for 250 mg/L MS-222 to induce surgical anesthesia is based on the lessening potential for inadvertent trauma to internal organs caused by laparoscopic instruments. When lower doses of MS-222 (i.e., 100, 150 & 200 mg/L) were used, researchers found shortnose and Atlantic sturgeon were not adequately anesthetized to nociceptive stimuli, reacting with tail flexions and body arching when cannulas were inserted into the coelom during laparoscopic examinations (Matsche, unpublished data). Such tail flexions and other body movements would greatly increase the risk of traumatic injury by instruments, which could lead to impaired organ function, septicemia or hemorrhage. However, in tests using the prescribed surgical anesthesia protocol, shortnose sturgeon remained stable and experienced no such reactions throughout laparoscopic examinations (Matsche, unpublished data).

Additionally, with regard to cortisol stress response, Matsche (unpublished data) found cortisol hormone levels differ with respect to the level of anesthesia used for laparoscopic surgery. Specifically, Matsche found Atlantic sturgeon anesthetized with a 100 mg/L concentration of MS-222 experienced elevated cortisol levels at 2 and 24 hours after surgery; however, no differences in cortisol and plasma chemistry were found between resting fish and fish undergoing laparoscopy after surgical anesthesia was induced (250 mg/L and maintained with an 87.5 mg/L dose of MS-222).

The researcher has demonstrated the proposed anesthesia protocol for laparoscopy— involving a rapid surgical anesthesia induction phase followed by a lower maintaining concentration— achieves a desired plane of surgical anesthesia limiting both the hormonal stress response and unpredictable reactions to nociceptive stimuli, each potentially harmful to sturgeon during a laparoscopy examination. However, NMFS also recognizes the potential for lethal or sub-lethal effects on sturgeon while inducing surgical anesthesia at the prescribed rate, particularly if sturgeon are left unattended or are overexposed to the high concentration. Overexposure to such concentrations could be linked to a lack of experience or the researcher's inability to recognize the induction point of surgical anesthesia. In interviews with other biologists performing similar anesthetic and laparoscopy protocols (D. Peterson, W. Post, and , J. Gibbons; *pers. comm.*; November 2009),

proper training and experience in the procedure — knowing what to expect, as well as using proper equipment — were acknowledged as very important in developing proficiencies in the protocol.

To minimize exposure risks, the researcher has CI on his staff with extensive experience in the anesthetic protocol, each having routinely performed several hundred similar procedures without complication (Permit Nos. 1486, 1505 and 1604). Additionally, equipment used to induce surgical anesthesia would also include a heart monitor to assist researchers identifying the proper induction point of surgical anesthesia, thereby minimizing the exposure time of the animals to higher concentrations of MS-222 prior to transferring them to the lower maintenance dosage.

Therefore, NMFS believes the use of higher concentrations of the anesthetic compound MS-222, for short-term durations, and under constant observation by experienced researchers, is a safe procedure with manageable risks to the animals. Importantly, no other researchers than designated on the permit would be authorized to use the protocol without extensive, documented prior experience reported to NMFS-PR.

4.2.1.10 Effects of Laparoscopic Examination, Gonad Biopsy and Blood Collection:

Laparoscopy and Biopsy:
Laparoscopy is a modified minimally invasive procedure refined for sturgeon research to determine the general morphological health and to visually identify the sex of study fish accurately and for obtaining biopsy samples. These procedures for other fish species (Murray, *et al.*, 1998; Moccia *et al*., 1984; Ortenberger *et al*., 1996; Stoskopf, 1993) have been advanced for sturgeon and used extensively by Warm Springs Regional Fisheries Center (Hernandez-Divers *et al*. 2004). During the procedure (~5-8 minutes), a 5 mm incision is made in the ventral body wall slightly off midline at a level midway between the pectoral girdle and the cloaca. A 5-mm trocar would be inserted through the incision and a 5-mm rigid laparoscope would then be inserted through the trocar to allow visualization of the internal anatomy of the animal. In those instances where the sex of the animal is not readily apparent during examination, an added exploratory biopsy (~5-minutes) procedure of the gonadal tissues would be undertaken through a secondary small incision made below the first. Gonad samples do not cause disruptive hemorrhaging of the sampled site because of the lack of blood vessels in the vicinity of the sampled site.

The procedures would increase the risk of complications associated with the added stress of surgical procedures and the time under anesthesia. Because the sutures used to close the laparoscopy sites penetrate the body wall, they would also provide a route of possible infection. To combat these risks of surgery, the researchers would use sterile surgical technique and small incisions, minimizing the amount of suture necessary and decreasing the healing time. Finally, suture ties would be kept as short as possible and povidone iodine ointment would be applied to the sutures prior to recovery from anesthesia. This treatment would help prevent fungal growth on the sutures that could possibly infect the animal prior to healing of the incision wounds.

Each of the project staff performing laparoscopic examinations and obtaining biopsy samples would be trained professionals in fish pathology and veterinarian medicine, routinely having performed several hundred similar procedures on shortnose sturgeon without complication in other NMFS permitted activity (Permit No. 1486, 1505 and 1604). Under proper anesthesia, the small incisions

and insertions of the laparoscope and biopsy sample would have little probability of killing or producing sub-lethal effects as the healing process is rapid for this procedure.

Blood Collection: Effects of drawing blood samples with syringes from the caudal vein of shortnose sturgeon could include pain, handling discomfort, possible hemorrhage at the site, or risk of infection. To mitigate these effects, the needle would be slowly advanced while applying gentle negative pressure to the syringe until blood freely flows into the syringe. Once blood is collected, direct pressure would be applied to the site to ensure clotting and prevent subsequent blood hemorrhaging (Stoskopf, 1993). The site would then be disinfected and checked again after recovery prior to release. Additionally, the project staff responsible for obtaining these samples would have received extensive experience in the procedure. Drawing blood in the manner described, appears to have little probability of killing shortnose sturgeon or producing sub-lethal effects.

4.2.1.11 Effects of Incidental Mortality (or Serious Harm):

The researcher has maintained a record of verifiable mortality while engaged in other authorized research with shortnose sturgeon in the same action on the Delaware River. Annual reports from the applicant between 1999 and 2004 (Permit No. 1174) documented a mortality rate of 0.22%, or 7 fish out of a total of 3,286 captured over five years. However, while working under more conservative sampling effort since 2005, capturing 416 shortnose sturgeon (NMFS Permit 1486), he reported no shortnose sturgeon deaths or serious injuries.

Recent changes in permit modifications issued by NMFS have resulted in significantly reduced research related mortality reported for shortnose sturgeon. However, there is still increased risk of direct and delayed mortality occurring under a heavy schedule of netting. Moreover, there is evidence of incidental mortality potentially being underreported for internally tagged fish in studies where no known mortalities have been directly attributable to implanting internal transmitters. For example, the status of five unrelocated individual sturgeon internally telemetry tagged was left unknown in a study by Devries (2006) where eight male and four female shortnose sturgeon were internally radio-tagged between November 2004 and January 2005. Only nine of these fish were tracked until the end of 2005. The remaining individuals were censored after movement was not detected, or they were not relocated, after a period of only four months. Periodic checks for an additional two months also showed no movement. There were no known mortalities directly attributable to the implantation procedure; however, the status of individuals not relocated was unknown. There is no way to estimate the rate of delayed mortality, but NMFS believes it would be an insignificant percentage based on reports of various species of sturgeon captured and transported to rearing facilities.

Because the researcher anticipates collecting up to 3,600 adult and juvenile shortnose sturgeon, including procedures of anesthetizing, acoustically tagging, laparoscopic examination, biopsy, and veinipunture over five years, NMFS believes the increased potential for serious injury, or mortality would result in a total of three unintended mortalities or serious harm over the permit. However, because the Delaware River population of shortnose sturgeon is estimated as one of the larger stable stocks within its range, having an estimated spawning population of 12,000 adults (Brundage 2003), the anticipated impact of three sturgeon mortalities (or serious harm) on the population would be small, (~ 0.025%) based on this abundance estimate.

If a greater incidence of mortality or serious injury should occur, researchers would be required to cease the study and consult with NMFS-PR to determine the cause of mortality and to discuss any remedial changes in research methods. The Permits Division could grant authorization to resume permitted activities based on review of the incident depending on the circumstances, or else suspend activities indefinitely.

4.3 SUMMARY OF COMPLIANCE WITH APPLICABLE LAWS, NECESSARY FEDERAL PERMITS, LICENSES, AND ENTITLEMENTS

4.3.1 *Compliance with Endangered Species Act* (*ESA*):

To comply with Section 7 of the regulations governing takes of shortnose sturgeon (50 CFR 402.14(c)), a Section 7 consultation was initiated by the NMFS, Permits, Conservation and Education Division, Office of Protected Resources under the ESA. In accordance with Section 7 of the ESA of 1973, as amended (16 U.S.C. 1531 *et seq*.), a Biological Opinion (April 2010) was prepared for this proposed action by the NMFS' Endangered Species Division, Office of Protected Resources. It concluded, after reviewing the current status of shortnose sturgeon, the environmental baseline for the action areas, the effects of the take authorized in the permits, and the probable cumulative effects of the proposed permit, would not likely jeopardize the continued existence of shortnose sturgeon or any other NMFS ESA-listed species; nor would it likely destroy or adversely modify designated critical habitat.

Based on the information currently available, none of the non-target threatened or endangered (or proposed) species, or any related critical habitat, under the jurisdiction of the USFWS identified in Section 3.3.2.1 of this EA, are known to occur in the project area. Therefore, NMFS-PR concludes the researcher's activity in the Delaware River would not affect any of these threatened or endangered species, or their defined critical habitat. Thus no coordination under Section 7 of the Endangered Species Act is required with the USFWS.

Likewise communications with NMFS Northeast Region specialists indicated interactions with ESA protected sea turtles due to the proposed netting activities appear to be unlikely (Carrie Upite, *pers. comm*., by email 8/31/09 and Ellen Keane, *pers. comm*., by email 11/19/09). However, because sea turtles have been taken as far up-river as Artificial Island, New Jersey (rkm 79), NMPS-PR will add precautionary safeguards in the permit as outlined in Section 4.5.7 of this EA to ensure limited interactions with sea turtles, as well as marine mammals potentially entering the action area.

4.3.2 *Compliance with the Magnuson-Stevens Fishery Conservation & Management Act*:

NMFS determined the applicant's proposed netting and boating activity would occur within designated EFH zones for managed species in the Delaware River (described in Section 3.2.2 of this EA). However, NMFS concluded the activities would likely only have minimal impacts based on the history of mitigation conditions contained other permits for similar permitting actions.

NMFS PR requested concurrence by email on December 21, 2009, from NMFS, Northeast Office of Habitat Conservation whether the proposed action, as conditioned, would have adverse impacts on designated EFH in the Delaware River. On January 8, 2010, Karen Greene, Habitat Specialist, responded by email agreeing the proposed boating and netting activities would have no more than minimal impact to EFH in the action area for the proposed research.

4.4 COMPARISON OF ALTERNATIVES

While the "no action" alternative would have no environmental effects, the opportunity to conduct this particular research would be lost. Initiation of this research is important to collect information that would contribute to better understanding of shortnose sturgeon and to provide information to NMFS that would be needed to implement NMFS management activities if shortnose sturgeon are present in these river systems. This is important information that would help conserve and manage shortnose sturgeon as required by the ESA and implementing regulations.

The environmental effects of the preferred alternative would mainly be limited to individual shortnose sturgeon. However, effects would be minimal and this alternative would allow collection of valuable information assisting NMFS' efforts to recover shortnose sturgeon. Neither option is expected to have adverse population nor stock-level effects on shortnose sturgeon. Given the preferred option's minimal impact to the environment and the potential positive benefits of the research, NMFS believes the information gained would outweigh any likely negative affect to the target species.

4.5 MITIGATION MEASURES

4.5.1 *Netting, Holding, and Handling Condition:*

- The Permit Holder must take all necessary precautions to ensure sturgeon are not harmed during capture, including use of appropriate net mesh size and twine preventing shutting gill opercula, restricting gill netting activities and decreasing the time of net sets.

- Location (GPS), temperature, dissolved oxygen., gear used (e.g., mesh size, trawl, gill net, trammel), soak time, species captured, and any mortalities should be measured and recorded (at the depth fished) each time nets are set to ensure appropriate values according to the conditions below. This data must be made available to NMFS in annual reports or upon request.

- After removal from capture gear, researchers must hold sturgeon in floating net pens or in onboard live wells while shielding them from direct sunlight.

- To accommodate larger catches, researchers must carry secondary net pen(s) in the research vessel; overcrowded fish must be transferred to the spare net pen or else released.

- Any sturgeon overly stressed from capture must be resuscitated and/or allowed to recover inside a net pen or live well and also released without further handling, with exception of PIT tagging, weighing, and measuring.

- When water temperatures are below 15°C, nets may set in daylight hours for a total of 10 hours with one exception; that is, 14 hours net sets may take place overnight between rkm 186 and 215when temperatures are below 15 ^{O}C.

- At water temperatures between 15°C and 25°C, net sets must not exceed 4 hours.

- Soak times of nets must not exceed 2 hrs at water temperatures between 25°C and 28°C.

- Netting activities must cease at 28°C or higher until consulting with NMFS-PR.

- Gear must be deployed only in waters where D.O. levels $\geq$ 4.5 mg/L at the deepest depth sampled by the gear for the entire duration of deployment.

- All netting must cease in waters with D.O. concentrations less than 4.5 mg/L.

- Trawls may be towed at a maximum speed of 2.5 knots and for no more than 10 minutes.

- A depth sounder/global positioning system must be used to monitor trawling position to minimize disturbance of substrate while netting or trawling. Trawls may not cover the same area within 24 hours. If a net or trawl becomes snagged (on bottom substrate, debris, etc.), it must be untangled immediately to reduce stress on the animals.

- When fish are onboard the research vessel for processing, the flow-through holding tank must allow for total replacement of water volume every 15 minutes. Backup oxygenation of holding tanks with compressed oxygen is necessary to ensure sturgeon do not become stressed and D.O. levels remain above 5 mg/L.

- The total holding time of shortnose sturgeon after removal from the capture gear must not exceed two hours, unless the fish have not recovered from anesthesia.

- The total holding time of shortnose sturgeon after removal from the capture gear, must never be longer than 30 minutes when water temperature exceeds 27°C.

- The total handling time during onboard research procedures must not exceed 20 minutes.

- If water temperature is above 27°C, or is less than 7 ^{O}C, research must be limited to non-invasive procedures (e.g., PIT and Floy taggs, measure, weigh, and genetic tissue clip).

- Fish must be handled carefully, kept in water as much as possible during processing.

- Hydroacoustic/sonar testing must take place when temperatures are 15 ^{O}C or below and when D.O. is above 4.5 mg/L concentration; however, the time required for testing must not exceed two hours.

- During onboard handling, sturgeon must be supported using a sling or net, and handling should be minimized throughout the procedure.

- Smooth rubber gloves must be worn to reduce abrasion of skin and removal of mucus.

- Shortnose sturgeon (and bycatch) must be allowed to recover before they are released to ensure full recovery, and they must be treated with an electrolyte bath prior to release to help reduce stress and restore slime coat.

- Sturgeon are extremely sensitive to chlorine; therefore, thorough flushing of holding tanks sterilized with bleach would be required between sampling periods.

4.5.2. *Larval Sampling with Artificial Substrates, D-nets and Epibenthic Sleds:*

- The total number of shortnose sturgeon eggs or larvae collected by artificial substrates, d-nets or epibenthic sleds must not exceed 300 annually (or over 900 over five years).

- Once a total of 300 shortnose sturgeon eggs or larvae have been taken annually (or 900 over five years), artificial substrates, d-nets, or epibenthic sleds must be removed from the river.

- All artificial substrates, d-nets, or epibenthic sleds must be removed from the river upon completion of this project, or by the expiration date of this permit, whichever comes first.

- Ichthyoplankton net samples must be examined at least every three hours after deployed.

- The epibenthic sled should be towed against the prevailing current for 5 minutes averaging approximately 1.0 m/second speed through water.

4.5.3 *Genetic Tissue Sampling:*

- Care must be used when collecting genetic tissue samples (soft fin clips). Instruments should be changed/disinfected and gloves changed between each fish sampled to avoid possible disease transmission or cross contamination of genetic material.

- Submission and archival of genetic tissue samples must be coordinated with Julie Carter at the NOAA-NOS tissue archive in Charleston, SC (843)762-8547. Samples must be submitted between six and twelve months after collection.

- The Permit Holder may not transfer biological samples to anyone not listed in the application without obtaining prior written approval from NMFS. Any such transfer will be subject to such conditions as NMFS deems appropriate.

- The terms and conditions concerning samples collected under this authorization will remain in effect as long as the material taken is maintained under the authority and responsibility of the Permit Holder.

4.5.4 *Tagging Conditions:*

- PIT tags must be used to individually identify all captured fish not previously tagged. Prior to placement of PIT tags, the entire dorsal surface of each fish must be scanned with a waterproof PIT tag reader and visually inspected to ensure detection of fish tagged in other studies. Previously PIT-tagged fish must not be retagged.

- Researchers must not insert PIT tags or perform other surgical procedures on juvenile shortnose sturgeon less than 330 mm in length.

- PIT tags must be injected in the left, dorsal musculature just anterior to the dorsal fin with the copper antenna oriented up for maximum signal strength and scanned after implantation to ensure proper tag function.

- Numbered Floy tags must be anchored in the dorsal fin musculature base, inserted forwardly and slightly downward from the left side to the right through the dorsal pterygiophores.

- The rate of PIT tag and Floy tag retention and the condition of fish at the site of tag injection must be documented during the study and results reported to NMFS in annual and final reports.

- Surgical implantation of internal tags must only be attempted when fish are in excellent condition, and must not be attempted on pre-spawning fish in spring or fish on the spawning ground.

- During surgical procedures, instruments must be sterilized or changed between uses.

- To ensure proper closure of surgical incisions, a single interrupted suturing technique should be applied.

- The total weight of tags must not exceed 2% of the sturgeon's total body weight unless otherwise authorized by NMFS-PR.

4.5.5 *Anesthetization*:

- Researchers performing anesthesia on shortnose sturgeon must have first received supervised training on shortnose sturgeon or another surrogate species before doing so. The Responsible Party or PI must report this training to NMFS prior to the activity.

- Researchers may use MS-222 at concentrations up to 150 mg/L when anesthetizing shortnose sturgeon to implant acoustic transmitters, and up to 250 mg/L when anesthetizing shortnose sturgeon for laparoscopic examinations; such solutions should be made fresh daily.

- Only researchers designated in the permit are authorized to induce anesthesia using MS-222 at concentrations above 150 mg/L MS-222.

- Should a researcher while performing a surgical procedure encounter a sudden reflex reaction from an anesthetized fish, the procedure should be stopped and the level of anesthesia reevaluated before proceeding.

- Prior to anesthetizing shortnose sturgeon with MS-222, researchers must saturate the solution with dissolved oxygen and buffer it to a neutral pH with sodium bicarbonate.

- Only non-stressed animals in good health can be anesthetized for a surgical procedure.

- To avoid injury to anesthetized sturgeon, researchers must use restraint (e.g., netting) to prevent animals from jumping or falling out.

- When anesthetizing shortnose sturgeon, researchers must observe fish closely to establish the proper level of anesthesia, and use a heart monitor when using concentrations of MS-222 above 150 mg/L.

- Researchers must observe shortnose sturgeon closely during anesthetic recovery; and prior to release to their environment, sturgeon must be fully recovered.

- All researchers are required to wear protective clothing, gloves, and goggles when handling MS-222 powder.

- Unused MS-222 solution must be disposed of by using state adopted procedures.

4.5.6. *Laparoscopic Examination, Gonad Biopsy and Blood Collection*:

- Only the researchers designated in the permit are authorized to conduct laparoscopy, blood sampling, or biopsy procedures.

- Should an uncontrolled hemorrhage occur while performing a surgical procedure, the procedure should be stopped and the bleeding stabilized before proceeding.

- Blood and biopsy samples may be sent for analyses to the Maryland DNR, Oxford Maryland Laboratory. Blood samples may also be sent to the Antech Diagnostics Laboratory, Lake Success, New York.

- Blood and biopsy samples, not consumed during testing, must be properly disposed of immediately after all testing is completed.

4.5.7 *Marine Mammal and Sea Turtle Interaction:*

- In all boating and research activities within the study area, a close watch must be made for marine mammals and sea turtles to avoid interaction and harassment. Researchers are advised to review the marine mammal approach and viewing guidelines online at http://www.nero.noaa.gov/prot_res/mmv/.

- Nets must not be deployed if animals are sighted within the netting area unless they are on seen on a path moving away.

- Netting must cease if a marine mammal is sighted within 100-foot of the research vessel or net, and may resume only when the animal is no longer within this safety zone, or 30 minutes has elapsed since the mammal was last observed within the safety zone.

- In the unlikely event a marine mammal or sea turtle is captured, the animal must be assessed and, if possible, and if safe for the researchers and animal, the animal must be supported to prevent it from drowning. The NOAA Northeast Region Marine Mammal and Sea Turtle Stranding and Entanglement Hotline must be immediately contacted at 978-281-9351 as well as the New Jersey Marine Mammal Stranding Center at (609) 266-0538 (in New Jersey waters) and/or the Marine Education Research and Rehabilitation Institute at (302) 228-5029 (in Delaware waters).

- In the unlikely event a captured marine mammal or sea turtle dies, or is severely injured, all permitted activities must cease and researchers must contact the NOAA, NE Region Marine Mammal and Sea Turtle Stranding and Entanglement Hotline at 978-281-9351, as well as the Chief, Permits Division and/or the permit analyst at (301) 713-2289.

4.5.8 *Atlantic Sturgeon Interaction*:

- If an Atlantic sturgeon is incidentally captured, NMFS requests that it minimally be PIT tagged, genetically sampled, and released. NMFS also requests that all other netting protocols and research conditions protective of shortnose sturgeon be used by researchers to ensure survival of Atlantic sturgeon during research activities.

- NMFS requests Atlantic sturgeon interactions to be reported to Lynn Lankshear, NMFS-PR at 978-281-9300 x 6535; (Lynn.Lankshear@noaa.gov). This report should contain descriptions of take, including lethal take, location, and final disposition of the sturgeon. Specimens or body parts of dead Atlantic sturgeon should be preserved (preferably on ice or refrigeration) until sampling and disposal procedures are discussed with NMFS.

4.5.9 *Aquatic Nuisance Species*:

- To prevent potential spread of aquatic nuisance species identified in the watershed, all equipment assigned to the research should not be reassigned to other watersheds until the research is completed or is suspended.

- If the research has been completed or is suspended, all gear and equipment used will be bleached, washed and air dried before being redeployed to another location.

4.5.10 *Incidental Mortality of Shortnose Sturgeon*:

- If a greater incidence of mortality or serious injury should occur than is authorized, NMFS-PR would need to be consulted to determine the cause of mortality and to discuss any remedial changes in research methods. The Permits Division could grant authorization to resume permitted activities based on review of the incident depending on the circumstances, or else suspend activities.

4.5.11 *Other Mitigation Measures*:

- Environmental sampling data (e.g., dissolved oxygen, temperature, net set duration, and other data associated with capture) must be recorded and be made available to NMFS in annual reports, or when requested periodically.

- Careful and detailed records should be reported to NMFS annually on the time of recovery and other responses from anesthesia, handling, tissue sampling, as well the condition and health and tag retention of any recaptured shortnose sturgeon.

4.6 UNAVOIDABLE ADVERSE EFFECTS

The measures required by permit conditions are intended to reduce, to the maximum extent practical, the potential for adverse effects of the research on all species. However, because the research involves wild animals not accustomed to being captured, the research activities would unavoidably result in harassment.

The research activities would cause unavoidable disturbance, stress, and minor injury to the captured shortnose sturgeon and other non-target species (temporarily interrupting normal activities such as feeding). The proposed research could also have some incidental lethal or sub-lethal effects on some individuals based on planned invasive surgery and heavy schedule of netting over five years. However, these risks are not expected to have long-term effects on target or non-target individuals or populations.

4.7 CUMULATIVE EFFECTS

In addition to the direct and indirect effects assessed above, in accordance with NEPA, this EA considers the potential for cumulative effects. Cumulative effects are those that result from incremental impacts of a proposed action which when added to other past, present, and reasonably foreseeable future threats or actions, regardless of which agency (federal or nonfederal) or person(s) undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions that take place over a period of time. For shortnose sturgeon range-wide, these effects include: research, bycatch, poaching, artificial propagation, dams, dredging, blasting, water quality and contaminants.

4.7.1 *Other Shortnose Sturgeon Research Permits*:

Shortnose sturgeon have been the focus of field studies since the 1970's. The primary purpose of this research is for monitoring populations and gathering data for physiological, behavioral and ecological studies. Over time, NMFS has issued dozens of permits for takes of shortnose sturgeon within its range for a variety of activities including capture, handling, lavage, laparoscopy, bloodwork, habitat, spawning verification, genetics, aging, and tracking. Research on shortnose sturgeon in the U.S. is carefully controlled and managed so 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.

Range wide, there are 16 active scientific research permits targeting wild shortnose sturgeon populations with similar objectives as the proposed Delaware River permit (See Appendix 2). There are also four captive shortnose sturgeon permits eliminating collection from the wild. Current shortnose sturgeon research in the Delaware River is associated with the applicant's current permit (Permit No. 1486, ERC Consultants) focusing on industrial development and dredging effects. Various other researchers studying the Atlantic sturgeon population in the Delaware River also impact shortnose sturgeon and its habitat to some extent.

A Biological Opinion was issued for each of these permits including the requirement for consideration of cumulative effects to the species (as defined for ESA). For each permit, the Biological Opinion concluded that issuance, as conditioned, was not likely to jeopardize the continued existence of the shortnose sturgeon, either individually or cumulatively.

4.7.2 *Bycatch and Poaching*:

4.7.2.1 Bycatch:

Directed harvest of both shortnose and Atlantic sturgeon is prohibited. As stated, shortnose sturgeon are listed as endangered under the ESA and therefore, prohibited from take. In 1998, the Atlantic States Marine Fisheries Commission (ASMFC) imposed a coast-wide fishing moratorium on Atlantic sturgeon until 20 year classes of adult females could be established (ASMFC 1998). NMFS followed this action by closing the Exclusive Economic Zone (EEZ) to Atlantic sturgeon take in 1999. Shortnose sturgeon has likely benefited from this closure as any bycatch in the fishery targeting Atlantic sturgeon (primarily for meat since the 1950s) has been eliminated.

Although directed harvest of shortnose sturgeons has been prohibited since 1967, bycatch of this species has been documented in other fisheries throughout its range. Adults are believed to be especially vulnerable to fishing gears for other anadromous species (such as shad, striped bass and herring) during times of extensive migration – particularly the spawning migration upstream, followed by movement back downstream (Litwiler 2001). Additionally, bycatch in the southern trawl fishery for shrimp *Penaeus* spp. was estimated at 8% in one study (Collins *et al*. 1996).

The 1998 Recovery Plan for shortnose sturgeon lists commercial and recreational shad fisheries as a source of shortnose bycatch. Although shortnose sturgeon are primarily captured in gill nets, they have also been documented with pound nets, fyke/hoop nets, catfish traps, shrimp trawls and hook and line fisheries (recreational angling).

Bycatch in the gill net fisheries can be quite substantial and is believed a significant threat to the species. The catch rates in drift gill nets are believed to be lower than for fixed nets; longer soak times of the fixed nets appear to be correlated with higher rates of mortalities. In an American shad gill net fishery in South Carolina, of 51 fish caught, 16% were bycatch mortality and another 20% of the fish were visibly injured (Collins *et al*. 1996).

4.7.2.2 Poaching:

There is evidence of shortnose sturgeon targeted by poachers throughout their range, and particularly where they appear in abundance (such as on the spawning grounds) but the extent this is occurring is difficult to assess (Dadswell 1979, Dovel *et al*. 1992, Collins *et al*. 1996). There have been several documented cases of shortnose sturgeon caught by recreational anglers. One shortnose sturgeon illegally taken on the Delaware River was documented by a New Jersey Department of Fish and Wildlife conservation officer in Trenton New Jersey (NJCOA 2006). Additionally, citations have been issued for illegal recreational fishing of shortnose in the vicinity of Troy, New York on the Hudson River and on the Cooper River in South Carolina. Poaching has also been documented for other sturgeon species in the United States. Cohen (1997) documented poaching of Columbia River white sturgeon sold to buyers on the U.S. east coast. Poaching of Atlantic sturgeon has also been documented by law enforcement agencies in Virginia, South Carolina and New York and is

considered a potentially significant threat to the species, but the present extent and magnitude is largely unknown (ASPRT 2008).

4.7.3 *Artificial Propagation*:

Since there are aquaculture or research facilities currently raising captive shortnose sturgeon on watersheds of native shortnose sturgeon, there is a potential for escapement and impact to the wild population. Potential threats from aquaculture escapement include the genetic alterations to native populations and potential competition for space and resources between hatchery-reared and wild fish. Further, since most sturgeon diseases have been documented in captive-reared fish, there is also the chance that escapees could spread pathogens and disease. To date, there have been no reports of escapees from the two facilities in Canada or from the USFWS facilities in South Carolina and Georgia. However, on the Connecticut River six fish artificially spawned from adults captured at Holyoke were released with radio tags upstream of the Holyoke Dam in 1989 and 1990 and they were subsequently never recovered. Additionally, several juveniles were accidentally released in 2006 and unrecovered.

There are currently two private companies producing shortnose sturgeon in Canada. Both are located on the St. John River and one is currently operating at a commercial scale. In the United States, the USFWS has been raising shortnose sturgeon (NMFS Permit No. 1604) for approximately 22 years. Until recently Bears Bluff National Fish Hatchery located on Wadmalaw Island in South Carolina raised the bulk of these fish while some fish were also reared at the USFWS' Warm Springs, GA and Orangeburg, SC hatcheries. Propagation of shortnose sturgeon at the Bears Bluff facility ended in the spring of 2008 but a subset of the broodstock and offspring are still maintained at Warm Springs and Orangeburg.

Captive shortnose sturgeon are also maintained by the USGS at the Conte Anadromous Fish Research Center (Permit No. 1549) located on the Connecticut River. These stocks are held in quarantine and are primarily used as test animals for upstream and downstream fish passage studies, but some progeny are also made available to other research facilities and educational display aquaria when requested. The F-1 progeny are produced periodically using wild native fish from the Connecticut River in a *living stream* natural spawning environment; however, hatchery protocol is not a research objective at the facility.

4.7.4 *Dams*:

Dams are used to impound water for water resource projects such as hydropower generation, irrigation, navigation, flood control, industrial and municipal water supply, and recreation. Dams can have profound effects on diadromous fish species by fragmenting populations, eliminating or impeding access to historic habitat, modifying free-flowing rivers to reservoirs and altering downstream flows and water temperatures. Direct physical damage and mortality can occur to diadromous fish that migrate through the turbines of traditional hydropower facilities or as they attempt to move upstream using fish passage devices.

In addition to dams impeding anadromous fish migration and associated mortalities, Hill (1996) identified the following potential impacts from hydropower plants: altered DO concentrations; artificial destratification; water withdrawal; changed sediment load and channel morphology; accelerated eutrophication and change in nutrient cycling; and contamination of water and sediment.

Furthermore, activities associated with dam maintenance, such as dredging and minor excavations along the shore, can release silt and other fine river sediments that can be deposited in nearby spawning habitat. Dams can also reduce habitat diversity by forming a series of homogeneous reservoirs; these changes generally favor different predators, competitors and prey, than were historically present in the system (Auer 1996a).

The effects of dams on populations of shortnose sturgeon are generally well documented (Kynard 1998, Cooke *et al.* 2004). However, there may be some rivers where shortnose sturgeon have been extirpated almost without notice due to the construction of impassable dams. In these rivers historical presence of shortnose sturgeon was likely but unknown; there are historical accounts of sturgeon but it is unclear if both Atlantic and shortnose sturgeon used the river and if the river supported spawning of either species. For example, the Susquehanna River is the second largest river on the east coast of the U.S. and there are historical and anecdotal accounts of plentiful "sturgeon" upriver. Currently the Susquehanna has four mainstem dams, the lowermost of which is at approximately rkm 16. The dam has a fish lift but it is not used by shortnose sturgeon. If the Susquehanna River once supported a population of shortnose sturgeon, it is no longer available to them.

Perhaps the biggest impact dams have on shortnose sturgeon is the loss of upriver spawning and rearing habitat. Migrations of shortnose sturgeon in rivers without barriers are wide-ranging with total distances exceeding 200 km or more depending on the river system (Kynard 1997). The construction of dams has blocked upriver passage for the majority of the shortnose sturgeon populations. Dams have restricted spawning activities to areas below the impoundment, often in close proximity to the dam (Kynard 1997, Cooke *et al*. 2004). The suitability of riverine habitat for shortnose sturgeon spawning and rearing depends on annual fluctuations in flow, which can be greatly altered or reduced by the presence and operation of dams (Cooke *et al*. 2004). Effects on spawning and rearing may be most dramatic in hydropower facilities that operate in peaking mode (Auer 1996a). Daily peaking operations store water above the dam when demand is low and release water for electricity generation when demand is high, creating substantial, daily fluctuations in flow and temperature regimes. Kieffer and Kynard (*in press*), have documented that flow fluctuations for hydroelectric power generation affected access to spawning habitat and possibly deterred spawning of shortnose sturgeon on the Connecticut River. Similar results were reported in studies conducted for lake sturgeon *A. fulvescens* in the Sturgeon River, Michigan (Auer 1996b) and white sturgeon *A. transmontanus* in the Columbia River, Oregon and Washington (Parsley and Beckman 1994). Kieffer and Kynard (in review), have also observed flow regimes from an upstream hydroelectric facility that were either so forceful that they scoured the shortnose sturgeon rearing shoals or so low that the shoals were dry and exposed. Auer (1996b) demonstrated that there is greater spawning success of lake sturgeon on the Sturgeon River, MI, when facilities operated in the more natural "run-of-the-river" mode.

4.7.5 *Dredging and Blasting:*

4.7.5.1 Dredging:

Many rivers and estuaries are periodically dredged for flood control or to support commercial shipping and recreational boating. Dredging also aids in construction of infrastructure and in marine mining. Dredging may have adverse impacts on aquatic ecosystems including direct removal/burial

of organisms; turbidity; contaminant resuspension; noise/disturbance; alterations to hydrodynamic regime and physical habitat and actual loss of riparian habitat (Chytalo 1996, Winger *et al.* 2000).

Dredges are generally either mechanical or hydraulic. Mechanical dredges are used to scoop or grab bottom substrate and are capable of removing hard-packed materials and debris. Mechanical dredge types are clamshell buckets; endless bucket conveyor, or single backhoe or scoop bucket types; however, these dredge types often have difficulty retaining fine materials in the buckets and do not dredge continuously. Material excavated from mechanical dredging is often loaded onto barges for transport to a designated placement site (USACOE 2008).

Hydraulic dredges are used principally to dredge silt, sand and small gravel. Hydraulic dredges include cutterhead pipeline dredges and self-propelled hopper dredges. Hydraulic dredges remove material from the bottom by suction, producing slurry of dredged material and water, either pumped directly to a placement site, or in the case of a hopper dredge, into a hopper and later transported to a dredge spoil site. Cutterhead pipeline dredges can excavate most materials including some rock without blasting and can dredge almost continuously (USACOE 2008).

The impacts of dredging operations on sturgeon are often difficult to assess. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge drag arms and impeller pumps (NMFS 1998). Mechanical dredges have also been documented to lethally take shortnose sturgeon (Dickerson 2006). In addition to direct effects, indirect effects from either mechanical or hydraulic dredging include destruction of benthic feeding areas, disruption of spawning migrations, and deposition of resuspended fine sediments in spawning habitat (NMFS 1998).

Another critical impact of dredging is the encroachment of low D.O. and high salinities upriver after channelization (Collins *et al.* 2001). Adult shortnose sturgeon can tolerate at least short periods of low D.O. and high salinities, but juveniles are less tolerant of these conditions in laboratory studies. Collins *et al*. (2001) concluded harbor modifications in the lower Savannah River have altered hydrographic conditions for juvenile sturgeon by extending high salinities and low D.O. upriver.

In addition to impacts of dredging noted above, Smith and Clugston (1997) reported dredging and filling eliminates deep holes, and alters rock substrates. Nellis *et al.* (2007) documented dredge spoil drifted 12 km downstream over a 10 year period in the Saint Lawrence River, and spoils significantly lessened macrobenthic biomass compared to control sites. Using an acoustic trawl survey, researchers found Atlantic and lake sturgeon were substrate dependent avoiding spoil dumping grounds (McQuinn and Nellis, 2007). Similarly, Hatin *et al*. (2007) tested whether dredging operations affected Atlantic sturgeon behavior comparing CPUE before and after dredging events in 1999 and 2000. The authors documented three to seven-fold reduction in Atlantic sturgeon presence after dredging operations began, indicating sturgeon avoided these areas during operations.

4.7.5.2 Blasting:

Bridge demolition and other projects may include plans for blasting with powerful explosives. Fish are particularly susceptible to effects of underwater explosions and are killed over a greater range than other organisms (Lewis 1996). Unless proper precautions mitigate the damaging effects of shock wave transmission to physostomous fish like shortnose sturgeon, internal damage and/or death may result (NMFS 1998).

A study testing the effects of underwater blasting on juvenile shortnose sturgeon and striped bass was conducted in Wilmington Harbor, NC in December 1998, and January 1999 (Moser 1999). There were seven test runs including 32-33 blasts (3 rows with 10-11 blast holes per row and each hole ~ 10 ft apart) with about 24-28 kg explosives per hole. For each blast 50 hatchery reared shortnose sturgeon and striped bass were placed in cages three feet from the bottom at distances of 35, 70, 140, 280 and 560 ft upstream and downstream of the blast area. A control group of 200 fish was held 0.5 miles from the blast site (Moser 1999). Test blasting was conducted with and without an air curtain in-place 50 ft from the blast site. Survival was similar for both species. External assessments of impacts to the caged fish were conducted immediately after the blasts and 24 h later. After the 24 h period, a subsample of the caged fish, primarily from those cages nearest the blast, at 35 ft and some from 70 ft, were sacrificed for later necropsy.

Externally, shortnose sturgeon and striped bass selected for necropsy all appeared to be in good condition externally and behaviorally after blasts. However, results of necropsies found many had substantial internal injuries. Moser concluded many of the injuries would have resulted in eventual mortality (Moser 1999). Therefore, based on necropsy results, an apparent estimate of mortality was conducted finding that fish held in cages at 70 ft from blast sites were less seriously impacted by the test blasting than those held at 35 ft. Lastly, it was concluded shortnose sturgeon suffered fewer, less severe internal injuries than striped bass tested. For striped bass and shortnose sturgeon held in cages at 35 ft, approximately 66 and 12 percent, respectively, would have probably not survived the blasts due to their internal injuries. Also there appeared to be no reduction of injury in fish experiencing blasts while air curtains were in place

4.7.6 *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 discharges of pollutants, changes in water temperature and levels of D.O., 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. 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 water quality over the range of shortnose sturgeon varies by watershed but is notably poorer in the north than in the south. The U.S. Environmental Protection Agency (EPA) published its second edition of the National Coastal Condition Report (NCCR II) in 2005, a “report card” summarizing the status of coastal environments along the coast of the United States (USEPA 2005; See Table 7 below). The report analyzes water quality, sediment, coastal habitat, benthos, and fish contaminant indices to determine status. The northeast region and the Chesapeake Bay received grades of F. The Southeast region received an overall grade of B-, the best rating in the nation.

Table 7. Summary of the USEPA National Coastal Condition Report (NCCR II) for the U.S. east coast published by the U.S. Environmental Protection Agency (2005) grading coastal environments. (Northeast Region = ME through VA; southeast region = NC-FL; and the Chesapeake Bay = the central region).

	Region		
Status Index	**Northeast**	**Chesapeake Bay**	**Southeast**
Water Quality	D	F	B
Sediment	F	F	B
Coastal Habitat	B	-	C
Benthos	F	F	C
Fish Tissue	F	F	A
Overall	**F**	**F**	**B-**

Areas of concern having poor index scores were: 1) Hudson River – water quality, sediment, and tissue contaminants, 2) Delaware River – water quality and tissue contaminants, 3) Upper Chesapeake Bay – water quality and sediment, 4) Potomac River – sediment, 5) Pamlico Sound – water quality, 6) ACE Basin – water quality, and 7) St. Johns River – sediment. There was also a mixture of poor benthic scores scattered along the Northeast and Southeast region.

Although the south region scored relatively well in terms of water quality, low D.O. and elevated temperatures in the south may limit available habitat and survival of juvenile shortnose sturgeon. Secor (1995) noted a correlation between low abundances of sturgeon during this century and decreasing water quality caused by increased nutrient loading and the increased spatial and temporal frequency of hypoxic conditions. Further, Secor and Gunderson (1998) and Collins *et al* (2001) hypothesized survival of juvenile sturgeon in estuaries may be compromised due to combined effects of increased hypoxia and temperature in nursery areas impacted by human activity. Hypoxia affects sturgeon species more than other fish species due to their limited ability to oxyregulate at low D.O. (Secor and Gunderson 1998, Secor 2002). Sturgeon's first year of life may leave it particularly susceptible to hypoxia owing to high sensitivities to low D.O. at early life stages and the limited means to escape from hypoxic waters (Secor and Niklitschek 2001).

Niklitschek (2001) modeled suitable habitat availability for juvenile shortnose and Atlantic sturgeon in the Chesapeake Bay using a multivariable bioenergetics and survival model. Results indicated the cumulative stresses of hypoxia, high temperatures and salinity during summer months caused large reductions in potential nursery habitat for both species during 1990-1999 (Niklitschek 2001). The modeling established during dry years, when persistent hypoxia in deeper areas consistently precluded access to thermal refuges, there may little suitable habitat for juvenile sturgeon.

The EPA adjusted open water minimum DO-criteria for the Chesapeake Bay (increased from ~2 ppm to 3.5 mg/L) to provide protection specifically for sturgeon species, requiring higher levels of D.O. than other fish species (USEPA 2003). Niklitschek and Secor (2005) modeled the achievement of EPA's D.O. criteria for Atlantic sturgeon predicting available habitat for Atlantic sturgeon would increase by 13% per year, while an increase of water temperature by 1°C would reduce available habitat by 65%. Similar results may occur for sturgeons in southern rivers where high water temperatures and low D.O. are a common occurrence during the summer months.

Life history of shortnose sturgeon (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose them 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 shortnose sturgeon to date.

Chemicals and metals such as chlordane, dichlorodiphenyl dichloroethylene (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 DO, altering pH, and altering other physical properties of the water body.

Although there have been very few analyses of shortnose sturgeon tissues for contaminants, 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). In the Hudson, six fish have been tested over the past 37 years. Most fish carried very high burden load of PCBs, or one of its derivatives (DDT).

Dioxin and furans were detected in ovarian tissue from shortnose sturgeon caught in the Sampit River/Winyah Bay system (SC). Results showed that four out of seven fish tissues analyzed contained tetrachlorodibenzo-*p*-dioxin (TCDD) concentrations greater than 50 pg/g (parts-per-trillion), a level which can adversely affect the development of sturgeon fry (J. Iliff, NOAA Habitat Restoration Division, Silver Spring, MD, unpublished data).

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*. 2003) and posterior malformations (Billsson *et 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). Dwyer *et al*. (2005) compared the relative sensitivities of common surrogate species used in contaminant studies to 17 listed species including shortnose and 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 (PCP) and permethrin. Of the listed species, Atlantic and shortnose sturgeon were ranked the two most sensitive species tested (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 elutrtraite static renewal (Kocan *et al*. 1993).

Lastly, the operation of power plants can have unforeseen and detrimental impacts to water quality which can affect shortnose sturgeon. For example, the St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June 1991 when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates (Balciunas *et al.* 2002). Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low D.O. water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that twenty shortnose sturgeon were killed during this low D.O. event.

4.7.7 *Summary of Cumulative Impacts*:

Effects of past and ongoing human and natural factors and current threats (fisheries, water quality, dredging, dams, existing NMFS research permits, and other actions) are occurring (or have occurred) in or near the action area that have contributed to the current status of the species, are described above, and are also included in the baseline section of the Biological Opinion issued for this proposed research activity. These activities and threats are expected to continue into the future.

Overall, the preferred alternative would not be expected to have more than short-term effects on shortnose sturgeon if sturgeon are present in the research locations. The impacts of the non-lethal research activities are not expected to have more than short-term effects on individual animals and any increase in stress levels from the capture and handling would dissipate rapidly. Even if an animal was exposed to additional capture (e.g., a week later), no significant cumulative effects from the research itself would be expected given the nature of the effects. Based on the analysis in this EA and supported by the Biological Opinion (April 2010) NMFS expects the proposed authorization of shortnose sturgeon research activities of the preferred alternative would not appreciably reduce the species likelihood of survival and recovery in the wild nor would it adversely affect spawning, mortality rates, or recruitment rates. In particular, NMFS expects the proposed research activities not to affect adult reproductive adults in a way that appreciably reduces their reproductive success, the survival of young, or the number of young that annually recruit into the breeding populations.

The incremental impact of the proposed research on these animals, when added to other past, present, and reasonably foreseeable future actions discussed here, would not be significant at an individual or a population level. Therefore, no species level events would result from the capture, handling, and release of shortnose sturgeon. The data collected during sampling activities linked with the proposed action would help assess movement and habitat use of juvenile shortnose sturgeon found in the Delaware River action area. The research would provide information helpful in managing, conserving, and recovering this species and would outweigh any adverse impacts.

Moreover, the Biological Opinion prepared for File No. 14604 provides an integration and synthesis of the information about the status of the species, past and present activities affecting the species, possible future actions that might affect the species, and effects of the proposed action to provide a basis for determining the additive effects of the take authorized in this permit on ESA listed sturgeon, in light of their present and anticipated future status. The conclusion of the biological opinion for File No. 14604 was the proposed action would not likely jeopardize the continued existence of the species.

The opinion also indicated that NMFS is not aware of any future State, tribal, local, or private actions in the action area that may have a bearing on the risk assessment, and finds that the that the issuance of the proposed permit would have only negligible impacts to shortnose sturgeon. The analysis of past, present and reasonably foreseeable actions indicates that no cumulatively significant impacts would occur associated with the proposed action.

CHAPTER 5 LIST OF PREPARERS AND AGENCIES CONSULTED

Preparers:
Office of Protected Resources
National Marine Fisheries Service
Permits, Conservation and Education Division
Office of Protected Resources
Silver Spring, MD 20910

Agencies and Personnel Consulted:

Office of Protected Resources National Marine Fisheries Service Endangered Species Division, Silver Spring, MD 20910	Section 7 Formal Consultations on Effects on ESA Target Species (shortnose sturgeon)
Office of Protected Resources Northeast Regional Office, NMFS 55 Great Republic Drive Gloucester, MA 01930	Informal Consultations on Effects on ESA & MMPA Non-target Species (marine mammals & sea turtles)
Habitat Conservation Division National Marine Fisheries Service James J. Howard Marine Sciences Laboratory Highlands, NJ 07732	Informal Consultations on Effects on EFH on Federally managed species

LITERATURE CITED

Adams, S. M., A. M. Brown, and R. W. Goede. 1993. A quantitative health assessment index for rapid evaluation of fish condition in the field. Trans. Am. Fish. Soc. 122:63-73.

Atlantic Sturgeon Plan Development Team (ASPRT). 1998. Amendment 1 to the Interstate Fishery Management Plan for Atlantic Sturgeon. Atlantic States Marine Fisheries Commission, Washington, D.C. Fishery Management Report No. 31:1-43.

ASMFC 1998. Amendment 1 to the interstate fishery management plan for Atlantic sturgeon. Management Report No. 31, 43 pp.

Atlantic Sturgeon Plan Development Team (ASPRT). 1998. Amendment 1 to the Interstate Fishery Management Plan for Atlantic Sturgeon. Atlantic States Marine Fisheries Commission, Washington, D.C. Fishery Management Report No. 31:1-43.

Auer, N. A. 1996a. Importance of habitat and migration to sturgeons with emphasis on lake sturgeon. *Canadian Journal of Fisheries and Aquatic Sciences* 53(S1): 152-160.

Auer, N. A. 1996b. Response of spawning lake sturgeons to change in hydroelectric facility operation. *Transactions of the American Fisheries Society* 125: 66-77.

Auer, N. A., and E. A. Baker. 2002. Duration and drift of larval lake sturgeon in the Sturgeon River, Michigan. Journal of Applied Ichthyology 18:557-564

Bain, M. B. 1997. Atlantic and shortnose sturgeons of the Hudson River: Common and Divergent Life History Attributes. *Environmental Biology of Fishes* 48: 347-358.

Balciunas F.K., M. J. Grodowitz, A.F Cofrancesco, J.F. Shearer. 2002. Hydrilla. *In*: Van Driesche, R., *et al.*, 2002, Biological Control of Invasive Plants in the Eastern United States, USDA Forest Service Publication FHTET-2002-04, 413 p.

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

Berlin, W.H., R.J. Hesselberg, and M.J. Mac. 1981. Chlorinated hydrocarbons as a factor in the reproduction and survival of Lake Trout (*Salvelinus namaycush*) in Lake Michigan. Technical Paper 105, U.S. Fish and Wildlife Service. 42 pp.

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

Brännäs, E., H. Lundqvist, E. Prentice, M. Schmitz, K. Brännäs and B. Wiklund. 1994. Use of the passive integrated transponder (PIT) in a fish identification and monitoring system for fish behavioral studies. Transactions of the American Fisheries Society Symposium 123:395-401.

Brundage, H.M. and J.C. O'Herron. 2003. Population estimate for shortnose sturgeon in the Delaware River. Presented at the 2003 Shortnose Sturgeon Conference, 7-9 July 2003.

Brundage, H.M. and R.E. Meadows. 1982. Occurrence of the endangered shortnose sturgeon, Acipenser brevirostrum, in the Delaware River estuary. Estuaries 5(3):203-208.

Brundage, H. M., and J. B. Jung. 2009. Experiments with broadband sonar for the detection and identification of endangered shortnose sturgeon. Marine Technology Society

Brown L.A. 1988. Anesthesia in fish. *In:* Veterinary Clinics of North America: *Small Animal Practice,* 1988, vol 18, pp. 317-330.

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

Chytalo, K. 1996. Summary of Long Island Sound dredging windows strategy workshop. In: Management of Atlantic Coastal Marine Fish Habitat: Proceedings of a Workshop for Habitat Managers. ASMFC Habitat Management Series #2.

Clugston, J.P. 1996. Retention of T-bar anchor tags and passive integrated transponder tags by gulf sturgeon. North American Journal of Fisheries Management 16:682-685.

Cohen, A. 1997. Sturgeon poaching and black market caviar: a case study. *Env. Biol. Fish*. 48:423-426.

Collins, M.R., T.I.J. Smith, and L.D. Heyward. 1994. Effectiveness of six methods for marking juvenile shortnose sturgeon. Progressive Fish Culturist 56:250–254.

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

Collins, M.R., S.G. Rogers, T.I.J. Smith, and M.L. Moser. 2000. Primary factors affecting sturgeon populations in the southeastern United States: fishing mortality and degradation of essential habitats. *Bulletin of Marine Science* 66(3):917-928.

Collins, M.R., W.C Post, and D.C. Russ. 2001. Distribution of Shortnose Sturgeon in the Lower Savannah River. Final Report to the Georgia Ports Authority, 2001. 21pp.

Cooke, D.W., J.P. Kirk, J.V. Morrow, Jr., and S.D. Leach. 2004. Population dynamics of a migration limited shortnose sturgeon population. *Proceedings of the Annual Conference, Southeastern Association of Fish and Wildlife Agencies* 58:82-91.

COSEWIC. 2005. Assessment and Update Status Report on the Shortnose Sturgeon *Acipenser brevirostrum* in Canada. Ottawa, Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Canada.vi + 27 pp.

Coyle, S.D., Durborow, R.M., and Tidwell, J.H. 2004. Anesthetics in aquaculture. SRAC, Nov 2004., Publication No. 3900; 6 pp.

DRBC (Delaware River Basin Commission) 2009. http://www.state.nj.us/drbc/

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* LeSueur, 1818. NOAA Technical Report-14. 53pp.

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

DeVries, R.D. 2006. Population dynamics, movments, and spawning habitat of the shortnose sturgeon, *Acipenser brevirostrum*, in the Altahmha River System, Georgia. (MS Thesis) University of Georgia; 103pp.

Dickerson, D. 2006. Observed takes of sturgeon and turtles from dredging operations along the Atlantic Coast. Supplemental data provided by U.S. Army Engineer R&D Center Environmental Laboratory, Vicksburg, Mississippi.

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

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

Dwyer, F. J., D. K. Hardesty, C. E. Henke, C. G. Ingersoll, D. W. Whites, T. Augspurger, T. J. Canfield, D. R. Mount, and F. L. Mayer. 2005. Assessing contaminant sensitivity of endangered and threatened aquatic species: part III. Effluent toxicity tests. Archives of Environmental Contamination and Toxicology 48: 174-183.

Environmental Protection Agency (USEPA). 2003. Ambient water quality criteria for dissolved oxygen, water clarity and chlorophyll-a for the Chesapeake Bay and its tributaries. pp. 343, U.S. Environmental Protection Agency, Washington, DC (USA). http://www.epa.gov/Region3/chesapeake/baycriteria.htm

Environmental Protection Agency (USEPA). 2005. National Coastal Condition Report II. Washington, DC. EPA-620/R-03/002.

Environmental Research and Consulting, Inc. (ERC). 2002. Contaminant analysis of tissues from two shortnose sturgeon (Acipenser brevirostrum) collected in the Delaware River. Prepared for National Marine Fisheries Service. 16 pp. + appendices.

Environmental Research and Consulting, Inc. (ERC). 2003. Contaminant analysis of tissues from a shortnose sturgeon (Acipenser brevirostrum) from the Kennebec River, Maine. Report submitted to National Marine Fisheries Service, Protected Resources Division, Gloucester, MA. 5 pp.

ERC, Inc. 2006a. Acoustic telemetry study of the movements of shortnose sturgeon in the Delaware River and bay: progress report for 2003-2004. Prepared for NOAA Fisheries. 11 pp.

ERC, Inc. 2006b. Final report of shortnose sturgeon population studies in the Delaware River, January 1999 through March 2004. Prepared for NOAA Fisheries and NJ Division of Fish and Wildlife. 11 pp.

ERC Inc. 2007b. Preliminary acoustic tracking study of juvenile shortnose sturgeon and Atlantic sturgeon in the Delaware River. May 2006 through March 2007. Prepared for NOAA Fisheries. 9 pp.

ERC, Inc. 2008. Investigations of shortnose sturgeon early life stages in the Delaware River. Progress report for the period March 1 – May 22, 2008. Prepared for the NJ Division of Fish and Wildlife. 2 pp.

Everman, B.W., and B.A. Bean. 1898. Indian River and its fishes. Report of United States Fisheries Commission 1896:227-248.

Fernandes, S.J. 2008. Population demography, distribution, and movement patterns of Atlantic and shortnose sturgeons in the Penobscot River estuary, Maine. University of Maine. Masters thesis. 88 pp.

Fox, D. A., J. E. Hightower, and F. M. Parauka. 2000. Gulf Sturgeon spawning migration, and habitat in the Choctawhatchee River System, Alabama-Florida. Transactions of the American Fisheries Society 129:811-826.

Fried, S.M. and J.D. McCleave. 1973. Occurrence of shortnose sturgeon (Acipenser brevirostrum) an endangered species, in Montsweag Bay, Maine. *Journal of the Fisheries Board of Canada* 30: 563-564.

Giesy, J.P., J. Newsted, and D.L. Garling. 1986. Relationships between chlorinated hydrocarbon concentrations and rearing mortality of chinook salmon (*Oncorhynchus tshawytscha*) eggs from Lake Michigan. Journal of Great Lakes Research 12(1):82-98.

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

Harms, C. A. and R. S. Bakal. 1994. Techniques in fish anesthesia. American Association of Zoo Veterinarians Annual Proceedings 1994:202-210.

Hastings, R.W., J.C. O'Herron II, K. Schick, and M.A. Lazzari. 1987. Occurrence and distribution of shortnose sturgeon, Acipenser brevirostrum, in the upper tidal Delaware River. Estuaries 10:337-341.

Hatin, D, S. Lachance and D. Fournier. 2007. Effect of dredged sediment deposition on use by Atlantic sturgeon and lake sturgeon at an open-water disposal site in the St. Lawrence estuarine transition zone. Pages 235-256 in J. Munro, D. Hatin, J.E. Hightower, K. McKown, K.J. Sulak, A.W. Kahnle and F. Caron, editors. Anadromous sturgeons: habitats, threats and management. American Fisheries Society, Symposium 56, Bethesda, Maryland.

Henne, J.P., R.L. Crumpton, J. Fleming, and R. Martin. 2003. Preliminary development of guidelines for administering PIT tags in juvenile shortnose sturgeon, *Acipenser brevirostrum*. 6pp., U.S. Fish and Wildlife Service, Report to NMFS.

Hernandez-Divers S.J., Bakal R.S., Hickson B.H., Rawlings C.A., Wilson G.H., Radlinsky M., Hernandez-Divers S.M. and Dover S.R. 2004. Endoscopic sex determination and gonadal manipulation in Gulf of Mexico sturgeon (Acipenser oxyrinchus desotoi). Journal of Zoo & Wildlife Medicine, 35: 459-470. July 2004.

Hill, J. 1996. Environmental Considerations in Licensing Hydropower Projects: Policies and Practices at the Federal Energy Regulatory Commission. American Fisheries Society Symposium 16: 190-199.

Iwama, G.K., J.C. McGeer, and M.P. Pawluk. 1989. The effects of five fish anesthetics on acid-base balance, hematocrit, blood gases, cortisol, and adrenaline in rainbow trout. Canadian Journal of Zoology 67:2065-2073.

Jones, J.B. 1992. Environmental Impact of Trawling on the Seabed: A Review. New Zealand Journal of Marine and Freshwater Research 26:59-67.

Jorgensen, E. H., O. Aas-Hansen, Al G. Maule, J. E. T. Strand, M. M. Vijayan. 2004. PCB impairs smoltification and seawater performance in anadromous Arctic char (*Salvelinus alpinus*). *Comparative Biochemsitry and Physiology*, Part C 138: 203-212.

Jung, J. B., Weiland, M. A., Ploskey, G. R., Mueller, R. P., Johnson, R. L. 2004. Demonstration of broadband sonar technology for Columbia River chinook salmon smolt identification. Northwest National Laboratory, Report No. PNNL-14883. Pacific Northwest Laboratory,

Richland, WA. Kocan, R. M., M. B. Matta, and S. Salazar. 1993. A laboratory evaluation of Connecticut River coal tar toxicity to shortnose sturgeon (*Acipenser brevirostrum*) embryos and larvae. Final Report, December 20, 1993. 23 pp.

Kieffer, M. and B. Kynard. *In press.* Long-term evaluation of external and internal telemetry-tagged shortnose sturgeon. Ch. 11: 52 pp. In: D. Peterson and B. Kynard, editors. Behavior and life history of Connecticut River Shortnose Sturgeon. AFS Monographs (*In press*).

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

Kynard, B. 1998. Twenty-two years of passing shortnose sturgeon in fish lifts on the Connecticut River: What has been learned? Pages 255–264. In M. Jungwirth, S. Schmutz, and S. Weiss, editors. Fish migration and fish bypasses. Fishing News Books, London.

Lewis, J.A. 1996. Effects of underwater explosions on life in the sea. Autrailian Government, Defense, Science, and Technology Organization. http://dspace.dsto.defence.gov.au/dspace/.

Litwiler, T.L. (2001) "Conservation plan for sea turtles, marine mammals, and the shortnose sturgeon in Maryland," Maryland Department of Natural Resources Technical Report FS-SCOL-01-2, Oxford, Maryland. 134 pp.

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

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

Mangin, E. 1964. Croissance en Longueur de Trois Esturgeons d'Amerique du Nord: Acipenser oxyrhynchus, Mitchill, *Acipenser fulvescens*, Rafinesque, et *Acipenser brevirostrum* LeSueur. Verh. Int. Ver. *Limnology* 15: 968-974.

Marking L.L., P.P. Meyer. 1985. Are better anesthetics needed in fisheries? Fisheries, 10, 6: 2-5.

Matsche, M. 2009. Anesthesia in shortnose and Atlantic sturgeon. Preliminary status report to NMFS, Maryland Department of Natural Resources.

Matta, M.B., C. Cairncross, and R.M. Kocan. 1998. Possible Effects of Polychlorinated Biphenyls on Sex Determination in Rainbow Trout. *Environ. Toxicol. Chem. 17*:26-29.

McCabe, G. T., and L. G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76: 248-250.

McCord, J.W., M.R. Collins, W.C. Post, and T.I.J Smith. 2007. Attempts to develop a recruitment index for age-1 Atlantic sturgeon in South Carolina, USA. In: J. Munro, D. Hatin, K. McKown, J. Hightower, K. Sulak, A. Kahne, and F. Caron (editors). Proceedings of the Symposium on Anadromous Sturgeons: Status and Trends, Anthropogenic Impacts, and Essential Habitats. American Fisheries Society Symposium 56:397-403. American Fisheries Society, Bethesda, Maryland.

McQuinn, I.H. and P. Nellis. 2007. An acoustic-trawl survey of middle St. Lawrence estuary demersal fishes to investigate the effects of dredged sediment disposal on Atlantic sturgeon and lake sturgeon distribution. Pages 257-272 in J. Munro, D. Hatin, J.E. Hightower, K. McKown, K.J. Sulak, A.W. Kahnle and F. Caron, editors. Anadromous sturgeons: habitats, threats and management. American Fisheries Society, Symposium 56, Bethesda, Maryland.

Moccia, R. D., E. J. Wilkie, K. R. Munkittrick, and W. D. Thompson. 1984. The use of fine needle fibre endoscopy in fish for in vivo examination of visceral organs, with special reference to ovarian evaluation. Aquaculture 40:255-259.

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

Moser, M.L. and S.W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the Lower Cape Fear River, North Carolina. *Transactions of the American Fisheries Society* 124:225-234.

Moser, M.L. 1999. Cape Fear River Blast Mitigation Tests: Results of Caged Fish Necropsies. Final Report to CZR, Inc. under Contract to U.S. Army Corps of Engineers, Wilmington District.

Moser, M. L., M. Bain, M. R. Collins, N. Haley, B. Kynard, J. C. O'Herron II, G. Rogers and T. S. Squiers. 2000. A Protocol for use of shortnose and Atlantic sturgeons. U.S. Department of Commerce NOAA Technical Memorandum-NMFS-PR-18:18 pp.

Murray, M. J. 1998. Endoscopy in fish. Pages 59-75 in: M. J. Murray, B. Schildger, and M. Taylor (eds). Endoscopy in Birds, Reptiles, Amphibians, and Fish. Tuttlingen, Germany: Endo-Press.

Nealson, P. A., and H. M. Brundage. 2007. Feasibility assessment of split-beam hydroacoustic techniques for monitoring adult shortnose sturgeon in the Delaware River. Pages 405-415 in J. Munro, D. Hatin, J. E. Hightower, K. McKown, K. L. Sulak, A. W. Kahnle, and F. Caron, editors. Anadromous sturgeons: habitats, threats, and management. American Fisheries Society Symposium 56, Bethesda, MD.

Nellis, P., S. Senneville, J. Munro, G. Drapeau, D. Hatin, G. Desrosiers and F.J. Saucier. 2007. Tracking the dumping and bed load transport of dredged sediment in the St. Lawrence estuarine transition zone and assessing their impacts on macrobenthos in Atlantic sturgeon habitat. Pages 215-234 in J. Munro, D. Hatin, J.E. Hightower, K. McKown, K.J. Sulak, A.W. Kahnle and F. Caron, editors. Anadromous sturgeons: habitats, threats and management. American Fisheries Society, Symposium 56, Bethesda, Maryland.

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

Niklitschek, E. J. 2001. Bioenergetics modeling and assessment of suitable habitat for juvenile Atlantic and shortnose sturgeons (*Acipenser oxyrinchus* and *A. brevirostrum*) in the Chesapeake Bay. Dissertation. University of Maryland at College Park, College Park.

NJCOA. 2006. Monthly Highlights. New Jersey Division of Fish and Wildlife. Beureau of Law Enforcement, April 2006. http://www.njcoa.com/highlights/H_06_04.html.

NMFS 1998. Final recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. 104 pages.

NMFS 2009. Biological Opinion on effects of the deepening of the Delaware River Federal Navigation Channel, June 15. p.5.

O'Herron, J. C., II, K. W. Able, and R. W. Hastings. 1993. Movements of shortnose sturgeon (Acipenser brevirostrum) in the Delaware River. Estuaries 16:235–240.

Ortenburger, A. I., M. E. Jansen, and S. K. Whyte. 1996. Nonsurgical video laparoscopy for determination of reproductive status of artic char. Canadian Veterinary Journal 37:96-100.

Parsley,M.J. and Beckman,L.G. 1994. White sturgeon spawning and rearing habitat in the Lower Columbia River. North American Journal of Fisheries Management 14:812-827.

Polis, D.F. & S.L. Kupferman (1973). *Physical Oceanography*. Newark, DE, Univ. of Delaware: 143.

Popper, A.N. 2005. A Review of Hearing by Sturgeon and Lamprey. Environmental BioAcoustics, LLC. Rockville, Maryland. Submitted to the U.S. Army Corps of Engineers, Portland District. August 12, 2005.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191. 382 p.

Roubach, R. L.C. Gomes, F.A.L. Fonseca, and A.L. Val. 2005. Eugenol as an efficacious anaesthetic for tambaqui, *Collosoma macropomum* (Culvier). Aquaculture Research 36:1056-1061.

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

Rose, J.D. 2002. The Neurobehavioral Nature of Fishes and the Question of Awareness of Pain. Reviews in Fisheries Sciences, 10 (1): pp. 1-38.

Ross, L.G. and B. Ross. 1999. Anaesthetic and sedative techniques for aquatic animals. Blackwell Science, Oxford, UK.

Ruelle, R., and C. Henry. 1992. Organochlorine Compounds in Pallid Sturgeon. Contaminant Information Bulletin, June, 1992.

Ruelle, R., and K.D. Keenlyne. 1993. Contaminants in Missouri River Pallid Sturgeon. *Bulletin of Environmental Contamination and Toxicology* 50:898-906.

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

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. *Canadian Bulletin of Fisheries and Aquatic Sciences* No. 219.

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

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

Secor, D. H. 2002. Atlantic sturgeon fisheries and stock abundances during the late nineteenth century. American Fisheries Society Sympos. 28: 89-98.

Secor, D.H. and E.J. Niklitschek. 2002. Sensitivity of sturgeons to environmental hypoxia: A review of physiological and ecological evidence, p. 61-78 In: R.V. Thurston (Ed.) Fish Physiology, Toxicology, and Water Quality. Proceedings of the Sixth International Symposium, La Paz, MX, 22-26 Jan. 2001. U.S. Environmental Protection Agency Office of Research and Development, Ecosystems Research Division, Athens, GA. EPA/600/R-02/097. 372 pp.

Shoop, C.R. amd R.D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the Northeastern United States. Herpetological Monographs. 6:43-67.

Small, B.C. 2003. Anesthetic efficacy of metomidate and comparison of plasma cortisol responses to tricaine methanesulfonate, quinaldine and clove oil anesthetized channel catfish (*Ictalurus punctatus*). Aquaculture 218:177-185.

Smith, T.I.J., S.D. Lamprecht, and J.W. Hall. 1990. Evaluation of Tagging Techniques for Shortnose Sturgeon and Atlantic Sturgeon. American Fisheries Society Symposium 7:134-141.

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

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

Stetzar, E. 2002. Population characterization of sea turtles that seasonally inhabit the Delaware Estuary. Masters Thesis. Delaware State University, Dover, Delaware.

Stoskopf, M. K. 1993. Clinical examination and procedures. Pages 62-78 in: M. K. Stoskopf (ed). Fish Medicine. W. B. Saunders Co., Philadelphia, PA.

Summerfelt R.C. & Smith L.S. (1990) Anaesthesia, surgery and related techniques. In: Methods for Fish Biology . (eds. C.B. Schreck & P.B. Moyle), pp. 213-272.

Taubert, B. D. 1980. Reproduction of shortnose sturgeon (Acipenser brevirostrum) in Holyoke Pool, Connecticut River, Massachusetts. Copeia 1980:114-117.

USFWS 2009. Species Reports. Environmental Conservation Online System. http://www.fws.gov/endangered/wildlife.html#Species.

USGS 2009. Nonindigenous Aquatic Species Database; Center for Aquatic Resource Studies. <http://nas.er.usgs.gov/>.

USACOE. 2008. Dredging. <http://www.nap.usace.army.mil/dredge/d2.htm>

USACOE 2009a Philadelphia District. http://www.nap.usace.army.mil/index.htm.

USACOE. 2009b. Delaware River Main Channel Deepening Project http://www.nap.usace.army.mil/cenap-pl/drmcdp/drmc.htm.

Vladykov, V.D. and J.R. Greeley. 1963. Order Acipenseroidea. Pages 24-60 in Fishes of the Western North Atlantic. Memoir Sears Foundation for Marine Research 1(Part III). xxi + 630 pp.

Wagner, G.N., T.D. Singer, and R.S. McKinley. 2003. The ability of clove oil and MS-222 to minimize handling stress in rainbow trout (*Oncorhynchus mykiss* Walbaum). Aquaculture Research 34:1139-1146.

Wanner, G.A., R.A. Klumb, W.J. Stancill, and G.R. Jordan. 2007. Habitat use and movement of adult pallid sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota and Nebraska. Proceedings of the South Dakota Academy of Science 86(2007):21-33.

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

Wilk, S. J., and M.J. Silverman. 1976. Summer benthic fish fauna of Sandy Hook Bay, New Jersey. NOAA Technical Report SSRF-698. National Marine Fisheries Science Center, Woods Hole, Massachusetts.

Winger, P.V., P.J. Lasier, D.H. White, J.T. Seginak. 2000. Effects of contaminants in dredge material from the lower Savannah River. *Archives of Environmental Contamination and Toxicology* 38: 128-136.

Wydoski, R. and L. Emery. 1983. Tagging and marking. Pages 215-237 in: L.A. Nielson and D.L. Johnson (Eds.). *Fisheries Techniques*. American Fisheries Society, Bethesda, Maryland.

Appendix 1

Requested Annual Take

Species	**Life Stage**	**Sex**	**Expected Annual Take**	**Take Action**	**Location**
Shortnose sturgeon (*Acipenser brevirostrum*)	Juvenile & adult	Male & female	896 annually; or total of 3,600 over 5yrs	Capture, hold, measure, weigh, photograph, scan (for tags), Floy T-bar tag, PIT tag, & tissue sample	Delaware River (netting area=rkm 79-215; secondary sampling area= rkm 0-215)
Shortnose sturgeon (*Acipenser brevirostrum*)	Adult	Male & female	Up to 30 annually	Capture, measure, weigh, scan (for tags), Floy T-bar tag, PIT tag, tissue sample, anesthetize (MS-222) & implant acoustic tag	Delaware River (netting area=rkm 79-215; secondary sampling area= rkm 0-215)
Shortnose sturgeon (*Acipenser brevirostrum*)	Juvenile	Male & female	Up to 30 annually	Capture, measure, weigh, scan (for tags), Floy T-bar tag, PIT tag, tissue sample, anesthetize (MS-222) & implant acoustic tag,	Delaware River (netting area=rkm 79-215)
Shortnose sturgeon (*Acipenser brevirostrum*)	Adult	Male & female	Up to 24 annually	Capture, measure, weigh, scan (for tags), Floy T-bar tag, PIT tag, tissue sample, anesthetize (MS-222), laparoscopically evaluate (coelomic cavity, collect blood, & collect biopsy of gonads (if sex unclear)	Delaware River (netting area =rkm 79-215; secondary sampling area= rkm 0-215)
Shortnose sturgeon (*Acipenser brevirostrum*)	Adult	Male & female	Up to 20 annually	Capture, hold, measure, weigh, photograph, scan (for tags), Floy T-bar tag, PIT tag, tissue sample, & hydroacoustic testing (tethered in nylon sock)	Delaware River (netting area =rkm 79-215; secondary sampling area= rkm 0-215)
Shortnose sturgeon (*Acipenser brevirostrum*)	Juvenile & adult	Male & female	1 annual (unplanned serious injury or mortality) Total of 3 over 5 yrs	Unintentional mortality, storage, measure, weigh, photograph, fin clip, freeze, transport arrangements made with NMFS for further sampling and disposal	Delaware River (netting area =rkm 79-215; secondary sampling area= rkm 0-215)
Shortnose sturgeon (*Acipenser brevirostrum*)	eggs & larvae	Male & female	300 annually; Not to exceed 900 over 5 yrs	Intentional (directed mortality)	Delaware River (netting area=rkm 215-245)

Appendix 2

Existing shortnose sturgeon research permits similar to the proposed action.			
Permit No.	**Location**	**Authorized Take**	**Research Activity**
10115 Expires: 8/3/2013	Saltilla & Saint Marys Rivers, GA & FL	85 adult/juv 20 ELS	Capture, handle, measure, weigh, PIT tag, tissue sample, collect ELS
14394 Expires: 9/30/14	Altamaha River and Estuary, GA	500 adult/juv. (1 lethal), 100 ELS	Capture, handle, weigh, measure, PIT tag, transmitter tag, tissue sample, anesthetize, laparoscopy, blood collection, fin ray section, collect ELS
10037 Expires: 4/30/2013	Ogeechee River and Estuary, GA	150 adult/juv. (2 lethal), 40 ELS	Capture, handle, measure, weigh, PIT tag, tissue sample, fin-ray section, anesthetize, laparoscopy, blood collection, radio tag, collect ELS
1447 Expires: 2/28/2012	S. Carolina Rivers and Estuaries	100 adult/juv. (2 lethal), 100 ELS	Capture, handle, measure, weigh, PIT and DART tag, transmitter tag, anesthetize, tissue sample, gastric lavage, collect ELS
1505 Expires: 5/15/2011	S. Carolina Rivers and Estuaries	98 adult/juv. (2 lethal), 200 ELS	Capture, handle, measure, weigh, PIT and DART tag, transmitter tag, anesthetize, laparoscopy, blood collection, tissue sample, gastric lavage, collect ELS
1542 Expires: 7/31/2011	Upper Santee River Basin, SC	5 adult/juv.; 100 ELS	Capture, handle, weigh, measure, PIT and dart tag, tissue sample, ELS collection
1543 Expires:11/30/2011	Upper Santee River Basin, SC	3 adult/juv.	Capture, handle, weigh, measure, tissue sample
1486 * **Expires: 1/31/2010**	**Delaware River and Estuary NJ & DE**	**1,750 adult/juv. (10 lethal), 1000 ELS**	**Capture, handle, measure, weigh, Floy & T-bar tag, PIT tag, tissue sample, anesthetize, ultrasonic tag, laparoscopy, blood collection, collect ELS**
1547 Expires:10/31/2011	Hudson River, (Haverstraw & Newburgh), NY	500 adults/juv.	Capture, handle, weigh, measure, PIT & Carlin tag, tissue sample
1575 Expires11/30/2011	Hudson River (Tappan-Zee), NY	250 adult/juv.	Capture, handle, measure
1580 Expires: 3/31/2012	Hudson River and Estuary, NY	82 adult/juv.; 40 ELS	Capture, handle, measure, weigh, PIT tag, Carlin tag, photograph, tissue sample, collect ELS
1449 Expires: 3/31/2010	Upper Conn. River, MA	80 adult/juv.; 200 ELS	Capture, handle, measure, weigh, PIT tag, external radio tag, collect ELS
1549 Expires: 1/31/2012	Upper Conn. River, MA	673 adult/juv (5 lethal), 1,430 ELS from East Coast rivers	Capture, handle, measure, weigh, anesthetize, PIT tag, TIRIS tag, radio tag, temperature/depth tag, tissue sample, borescope, laboratory tests, photographs, collect ELS
1516 Expires: 5/15/2011	Lower Conn. River & Estuary., CT	500 adult/juv (2 lethal); 300 ELS	Capture, handle, measure, weigh, PIT tag, sonic/radio tag, gastric lavage, fin ray section, collect ELS
1578 Expires: 11/30/2011	Kennebec River and Estuary, ME	500 adult/juv.; 30 ELS	Capture, handle, measure, weigh, tissue sample, PIT tag, acoustic tag, anesthetize, collect ELS
1595-03 Expires: 3/31/2012	Penobscot River and Estuary, ME	200 adult/juv. (2 lethal); 50 ELS	Capture, handle, measure, weigh, borescope, photograph, tissue sample, blood sample, Carlin tag, PIT tag, anesthetize, transmitter tag, collect ELS

* Applicant's current permit in the Delaware River expiring January 31, 2010.