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

Biological Opinion

Agency: Permits, Conservation and Education Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Activity Considered: Biological Opinion on the Permits, Conservation and Education Division's proposal to issue a Permit (Number 14759) to Joseph Hightower, North Carolina Cooperative Fish and Wildlife Research Unit, for research on shortnose sturgeon in three North Carolina river basins (Chowan, Roanoke, and Cape Fear) and estuary (Albemarle Sound) pursuant to section 10(a)(1)(A) of the Endangered Species Act of 1973.

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

Approved by: ______________________

Date: AUG 17 2010

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. 1531 *et seq.*) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat that has been designated for them, that agency is required to consult with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the listed resources that may be affected. For the action described in this document, the action agency is NMFS' Office of Protected Resources – Permits, Conservation and Education Division. The consulting agency is NMFS' Office of Protected Resources – Endangered Species Division.

This document represents NMFS' biological opinion (Opinion) on the effects of the proposed studies on endangered and threatened species and designated critical habitat, and has been prepared in accordance with section 7 of the ESA. This Opinion is based on our review of the Permits, Conservation and Education Division's draft Environmental Assessment, draft amendment to Permit Number 14759, the most current shortnose sturgeon stock assessment reports, recovery plan, scientific and technical reports from government agencies and the peer-reviewed literature, biological opinions on similar research, and other sources of information.

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

CONSULTATION HISTORY

This consultation examines the NMFS Permit Division's (PR1) authorization of proposed permit 14759 to conduct scientific research activities on shortnose sturgeon in the Chowan, Roanoke, and Cape Fear Rivers as well as Albemarle Sound.

On April 7, 2010, PR1 emailed a brief description of this proposed action to the NMFS Endangered Species Division (PR3). On April 13, 2010, PR3 participated with PR1 and researchers in a phone call discussing the proposed action. On June 21, 2010, PR1 sent an initiation package to PR3 for permit 14759, and on July 8, 2010, PR3 initiated consultation.

BIOLOGICAL OPINION

I. DESCRIPTION OF THE PROPOSED ACTION

The proposed action addressed in this Opinion is PR1's authorization of permit 14759 to Joseph Hightower, North Carolina Cooperative Fish and Wildlife Research Unit. The authority for PR1's permit issuance is section 10(a)(1)(A) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq*.). The proposed activities involve purposeful harassment, harm, wounding, trapping, capture, or collection ("take[1]") of endangered shortnose sturgeon (*Acipenser brevirostrum*) for scientific purposes.

The activities proposed under permit 14759 are to assess the presence, abundance, and distribution of shortnose sturgeon within three North Carolina river basins (Chowan, Roanoke, and Cape Fear Rivers) and Albemarle Sound using directed non-lethal sampling methods. Permit 14759 would be valid for five years from the date of issuance and would authorize sampling methods on up to 10 shortnose sturgeon annually from the Chowan and Cape Fear River Basins and Albemarle Sound. Permit 14759 would also authorize sampling methods on up to 20 shortnose sturgeon annually from the Roanoke River Basin. A subset of up to five adult or juveniles from each river basin and Albemarle Sound would be anesthetized and implanted with sonic transmitters each year. Manual tracking and passive detections of telemetered fish at fixed receiver stations would provide information about movement, seasonal distribution, and habitat use. The proposed take is summarized in Table 1 as follows.

[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."

Table 1. Activities proposed to be authorized for Hightower's research on endangered shortnose sturgeon (*Acipenser brevirostrum*) in North Carolina under Permit 14759.

Life Stage	Sex	Expected Annual Take	Take Action	Location
Juvenile & adult	Male & female	Up to 10 annually, or a total of 20 over 5yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Chowan River and all tributaries; NC/VA
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	
Juvenile & Adult	Male & female	Up to 20 annually; or a total of 40 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Roanoke River and all tributaries; NC
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	
Juvenile & Adult	Male & female	Up to 10 annually, or a total of 20 over 5yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Cape Fear River and all tributaries; NC
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	
Juvenile & Adult	Male & female	Up to 10 annually, or a total of 20 over 5yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Albemarle Sound and all tributaries; NC
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	

Capture

Hydroacoustic Surveys/Side-scan Sonar. Using hydroacoustic surveys (side-scan, DIDSON) and/or gill nets, adult and juvenile sturgeon would be captured using a standardized netting protocol (anchored gill nets) approximately 1-3 days per week throughout the duration of the study. All sampling of sturgeon would be conducted following the guidelines established in

"A Protocol For the Use of Shortnose and Atlantic Sturgeon" (Moser *et al.* 2000) and as supplemented by newer NMFS guidance. All necessary precautions would be taken to ensure shortnose sturgeons are not harmed during capture and handling.

Gill Netting. Gill nets of 12.7 cm (5-inch) or 15.2 cm (6-inch) stretched mesh monofilament would be used to sample for adult and juvenile shortnose sturgeon. Gill nets would typically be 100 meters long and 1.8 meters deep, although shorter shots of net may sometimes be used. Netting would cease in waters above 28ºC. The maximum net set duration in freshwater areas (< 2ppt salinity) would be 14 hours when water temperature is 15 ºC or below. Above 2ppt salinity (also at 15 ºC or below), nets could be set for 10 hours, while attended and in daylight hours only to avoid marine mammal or sea turtle interactions. At water temperatures between 15 ºC and 25 ºC, net sets would not exceed 4 hours; and at water temperatures between 25 ºC and 28 ºC soak times would not exceed 1 hr. Additionally, gill nets would be set in waters having minimum dissolved oxygen (D.O.) concentrations of 4.5 mg/L for the entire deployment.

Additionally, other seasonal netting conditions based on temperature and location would be applied in the Albemarle Sound to avoid impacts with sea turtles and marine mammals. Specifically, netting in the eastern range of the Albemarle would take place in the fall and winter while netting in the western range would take place in the spring.

Table 2: Summary of General Netting Conditions

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

1. Net set durations of 14 hours (overnight sets permitted) with < 2ppt salinity & < 15ºC
2. Net set durations of 10 hours (daylight sets only permitted) > 2ppt salinity & < 15ºC

Hydroacoustic Monitoring. The applicant proposes to use two types of sonar devices. Side-scan sonar would be used to provide very high resolution images of bottom structure and topography, covering large areas quickly identifying potential target sturgeon as the boat passes by at about three-knot speed; whereas, DIDSON multi-beam sonar would be used for obtaining short-range video clips, accurately identifying target fish prior to deploying gill nets. This combination of high-resolution sonar approaches with gill netting sampling would allow for more directed sampling for sturgeon over larger areas with the potential for greatly reduced by-catch of non-target species.

The Edgetech 4125P-D side-scan unit (http://www.edgetech.com/edgetech/gallery/item/4125-p-side-scan-sonar-system/category/side-scan-sonar-systems) can be used in either low (400 kHz) or high (1250 kHz) frequency modes, but, for the purposes of this study, the researcher would only propose using the high-frequency mode. In this mode, the sonar beam would extend 20-50 m to either side of the boat's path traveling about 3 knots, resulting in a high-resolution image of the bottom along the transect.

The DIDSON multi-beam sonar (http://www.soundmetrics.com/) would be used in high-frequency mode (1.8 MHz), with a range setting of up to 15 m. It would typically be deployed by lowering the sounder to the bottom from an anchored boat to positively identify sturgeon species. It would also be used in a mobile survey, by fixing the DIDSON to the boat and getting images along transects. The DIDSON sonar is somewhat similar to a fish finder in that both use sound to detect objects in the water. Conventional fish finders use single beam whereas the DIDSON unit uses 96 narrow beams to form composite images showing fish shape and movement). DIDSON files are extremely large so it would only be used in specific situations (typically recording five or ten minute files).
(http://www.soundmetrics.com/FM/fm_fisheries.html)

General Handling (e.g., holding, measuring, weighing)

Once captured, sturgeon would be held onboard research vessels in live wells or in temporary in boat-side net pens measuring approximately 200 cm long x 150 cm wide x 200 cm deep. If increased catches (including bycatch) becomes apparent, additional net pens would also be included onboard to accommodate excess holding of sturgeon and bycatch. Handling of fish would be kept to a minimum and fish would not be held for more than two hours after removed 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 held live wells onboard, 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 would be supplemented with compressed oxygen to ensure D.O. concentrations do 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.,* handling, PIT and Floy tagging, measuring, weighing, and photographing) would be less than two minutes 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 minutes per fish, not accounting for recovery time from anesthesia. While onboard, 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.

Any sturgeon not responding readily would be recovered further in the net pen by holding upright and immersed in river water and gently moved in a frontward motion to aid freshwater passage over the gills to stimulate. When showing signs of being able to swim away strongly, the fish would be released and a spotter would watch to make sure it remains down and fully recovered.

Genetic Tissue Sample

Genetic information would be obtained from tissue samples of sturgeon helping characterize the genetic "uniqueness" and current level of genetic diversity of North Carolina populations. 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 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 NOAA/NOS in Charleston, South Carolina, or to Co-investigators identified in the permit. Proper certification, identity, and chain of custody of samples would be maintained during transfer of tissue samples.

PIT Tag

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 (≥300 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 and reported to NMFS in annual reports.

Floy (T-bar Anchor) Tag

The NMFS PR1 proposes to authorize the tagging of 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 the tag is locked in place. During the study, the rate of Floy tag retention would be documented and reported to NMFS in annual reports.

Implanting Acoustic Transmitters

Annually, a maximum of five shortnose sturgeon would be surgically implanted with VEMCO acoustic tags in each river basin and Albemarle Sound. Adult sturgeon (≥ 600 mm) would be tagged with model V16-5H tags, whereas juveniles would be tagged with either VEMCO V7-4L, V9-6L, or V13-1H tags. The applicant proposes tagging juvenile fish with a fork length of 450 mm and larger, which would result in a minimum 783g weight (See Length/Weight relationship, Huff 1975). Specifications for these transmitters are listed in Table 3 below.

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

Surgery for Implanting Acoustic Transmitters. The following 4 to 6 minute transmitter implantation surgery under anesthesia would be used. Just prior to the surgical procedure, fish would be removed from an anesthetic bath (described below) and placed on a moist surgery rack. A tube supplying fresh water over the gills would be placed in the mouth of the fish to maintain respiration. 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 to 20 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 into the live well or net pen to recover from anesthesia. The applicant estimated the surgical procedure and total holding time would require no more than 15 minutes (including anesthesia induction, surgery and recovery). Further, internal tags would not be implanted in unhealthy or stressed fish or pre-spawning fish in the spring.

Anesthesia for Implanting Acoustic Transmitters. Shortnose sturgeon selected for transmitter implantation, would be netted at temperatures 27 ºC or below and 7 ºC or above. Each sturgeon prepared for surgery would be anaesthetized using a bath solution of up to 150 mg/L of tricaine methane sulfonate (MS-222) buffered to neutral pH with sodium bicarbonate. Upon reaching a sedated anesthesia stage (i.e., slow movement and breathing reduced) animals would be removed from the solution and placed on a surgery rack to implant the tag. The anesthetic's induction and surgery would vary between 3 and 5 minutes, but would be appropriate for shortnose sturgeon under the specific water temperature and oxygen conditions present (Fox *et al*. 2000).

II. PERMIT CONDITIONS

Number and Kind(s) of Protected Species, Location(s) and Manner of Taking

1. Appendix 1 of the permit outlines the number of shortnose sturgeon allowed to be taken, and the locations, manner, and time period in which they may be taken.

2. Researchers must comply with the following conditions related to the manner of taking:

a. *Netting, Holding, and Handling Conditions*:

i. 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.

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

iii. After removal from capture gear, sturgeon must be allow to recover in floating net pens or in onboard live wells while shielding them from direct sunlight.

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

v. Any shortnose sturgeon overly stressed from capture must be resuscitated and allowed to recover inside net pen or live well; prior to release, it may only be PIT and Floy tagged, weighed, measured and photographed.

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

vii. Gill netting for shortnose sturgeon is regulated by environmental conditions appearing in Table 1 below. Seasonal netting conditions in eastern and western Albemarle Sound appear in Table 2.

Table 1: Summary of Environmental Netting Conditions

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

a. Nets can be deployed for 14 hours overnight when water temperature is less than 15 ºC and salinity is < 2.0 ppt.
b. Nets can be deployed for 10 hours when attended in daylight hours and when water temperature is < 15 ºC and salinity is > than 2ppt.

Table 2: Summary of Seasonal Netting Conditions for Albemarle Sound (A.S.)

Location	Season	Minimum D.O. Level (mg/L)	Maximum Temperature
Western A.S.[1]	Early Spring (Mar 1-May 31)	4.5	<25°C
Eastern A.S.[2]	Fall/Winter (Nov 1 – Feb 28)	4.5	<15°C

1. The boundary for the western A.S. sampling area extends from the mouths of the Roanoke and Chowan Rivers to 6 km downstream.
2. The boundary of the eastern A.S. sampling area extends from a north-south line crossing the Albemarle Sound at Point Harbor, NC (Currituck County) to Mashoes, NC (Dare County), westward to 6 km downstream of the mouths of the Roanoke and Chowan Rivers.

viii. 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 at or above 4.5 mg/L.

vix The total handling time, including onboard research procedures, must not exceed 15 minutes (does not including recovery from anesthesia or a stressed condition).

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

xi. The total holding time of shortnose sturgeon when water temperature exceeds 27ºC must never be longer than 30 minutes.

xii. Netting may take place down to 0 ºC; however, between 7 ºC and 27 ºC, research procedures must be non-invasive only (e.g., PIT and Floy tag, measure, weigh, photograph, and genetic tissue clip).

xiii. Onboard handling of sturgeon should be minimized, keeping fish in water as much as possible and supporting with a sling or net.

xiv. Shortnose sturgeon (and bycatch) must be allowed to recover before they are released to ensure full recovery; and it is recommended, if possible, they be treated with an electrolyte bath (e.g., salt) prior to release to help reduce stress and restore slime coat.

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

b. *Genetic Tissue Sampling*:

i. Care must be used when collecting genetic tissue samples from the soft fin rays of sturgeon (pectoral fins). Instruments should be changed or disinfected and gloves changed between each fish sampled to avoid possible disease transmission or cross contamination of genetic material.

ii. Submission and archival of genetic tissue samples must be coordinated with Julie Carter (or the current designated PI on NOS Permit No. 13599) at the NOAA-NOS tissue archive in Charleston, SC (843) 762-8547. Samples must be submitted between six and twelve months after collection, or when periodically solicited by the Permits Division.

c. *Tagging Conditions*:

i. 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.

ii. Researchers must not insert PIT tags or perform other surgical procedures on juvenile shortnose sturgeon less than 300 mm in length.

iii. PIT tags should 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.

iv. When inserting numbered Floy tags, tags must be anchored in the dorsal fin musculature base by inserting forward and slightly downward from the left side to the right through the dorsal pterygiophores.

v. The rate of PIT tag and Floy tag retention and the condition of fish at the site of tag injection should be documented during the study and results reported to the Permits Division in annual and final reports.

vi. The total weight of all tags used to mark fish must not exceed 2% of the sturgeon's total body weight unless otherwise authorized by the Permits Division.

vii. 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.

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

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

d. *Anesthetization*:

i. Researchers performing anesthesia on shortnose sturgeon must have first received supervised training on shortnose sturgeon or another surrogate species before doing so. The Permit Holder must report this training to the Permits Division prior to the activity.

ii. Researchers may use MS-222 at concentrations up to 150 mg/L when anesthetizing shortnose sturgeon to implant sonic transmitters; such solutions must be made fresh daily.

iii. 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.

iv. Only non-stressed animals in excellent health should be anesthetized.

v. To avoid injury while anesthetizing sturgeon in bath treatments, researchers must use restraint (e.g., netting) to prevent animals from jumping or falling out of the container.

vi. When inducing anesthesia on shortnose sturgeon, researchers must observe fish closely to establish the proper level of narcosis.

vii. While performing a surgical procedure, if sudden reflex reaction from an anesthetized fish is encountered, the Researcher must stop the procedure and evaluate the level of anesthesia before proceeding.

viii. Researchers must observe shortnose sturgeon closely during recovery from anesthesia, ensuring full recovery prior to release.

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

x. MS-222 solutions must be disposed of by using state adopted procedures.

e. *Sea Turtles*: (The following condition was suggested by the NMFS SEFSC as a precautionary measure addressing how researchers would handle/resuscitate a sea turtle if one were incidentally captured.)

i. If a sea turtle were incidentally captured during netting, the Permit Holder, Principal Investigator, Co-investigator(s), or Research Assistant(s) acting on the Permit Holder's behalf must use care when handling a live turtle to minimize any possible injury; and appropriate resuscitation techniques must be used on any comatose turtle prior to returning it to the water. All turtles must be handled according to procedures specified in 50 CFR 223.206(d)(1)(i).

f. *Atlantic Sturgeon Interaction*:

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

Reports

1. The Permit Holder must submit annual, final, and incident reports, and any papers or publications resulting from the research authorized herein to the Permits Division. Reports may be submitted:

- through the online system at https://apps.nmfs.noaa.gov
- by email attachment to the permit analyst for this permit
- by hard copy mailed or faxed to the Chief, Permits Division, Office of Protected Resources, NMFS, 1315 East-West Highway, Suite 13705, Silver Spring, MD 20910; phone (301) 713-2289; fax (301) 713-0376.

2. Written incident reports related to serious injury and mortality events or to exceeding authorized takes, must be submitted to the Chief, Permits Division within two weeks of the incident. The incident report must include a complete description of the events and identification of steps that will be taken to reduce the potential for additional research-related mortality or exceedence of authorized take.

3. An annual report must be submitted to the Chief, Permits Division for each year the permit is valid. The annual report describing activities conducted during the previous permit year must follow the format in Appendix 2 of the permit.

4. A final report must be submitted to the Chief, Permits Division within 180 days after expiration of the permit, five years after the date of issuance, or, if the research concludes prior to permit expiration, within 180 days of completion of the research. The final report must follow the format in Appendix 2 of the permit.

5. Careful and detailed records must be kept on the time of recovery and other responses from anesthesia, handling, tissue sampling, tag retention and healing, and condition and health of any shortnose sturgeon.

6. A *Biological Sample Certification, Identification and Chain of Custody Form* (Appendix 3a of the permit) must accompany shipments of genetic tissue samples to the NOAA-NOS archive in Charleston, South Carolina. Samples must be submitted between six and twelve months after collection.

7. A *Field Collection Report* appearing in Appendix 3b (of the permit) should also accompany multiple genetic tissue samples (hard copy or spreadsheet) when shipping to the archive.

8. Environmental sampling data (e.g., dissolved oxygen, temperature, net set duration, and other data associated with capture) must be recorded (See Appendix 4 of the permit) and be made available to NMFS in annual reports or when requested periodically.

9. Specimens or body parts of dead shortnose sturgeon should be individually preserved — preferably on ice or refrigeration — until sampling and disposal procedures are discussed with NMFS. The take should be documented by completing the sturgeon salvage form (Appendix 5 of the permit).

10. NMFS requests all Atlantic sturgeon interactions are reported to Lynn Lankshear, (Lynn.Lankshear@noaa.gov or 978-281-9300 x 6535). If dead specimens are collected, this report should be documented by completing the sturgeon salvage form (Appendix 5 of the permit). 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.

11. Research results must be published or made available to the scientific community in a reasonable period of time, or to NMFS when requested periodically.

Notification and Coordination

1. The Permit Holder must provide written notification of planned field work to the Assistant Regional Administrator for Protected Resources at the address listed below. Such notification must be made at least two weeks prior to initiation of

any field trip/season and must include the locations of the intended field study and/or survey routes, estimated dates of research, and number and roles (for example: PI, CI,
veterinarian, boat driver, safety diver, animal restrainer, Research Assistant "in training") of participants.

Southeast Region, NMFS, 263 13th Ave South, St. Petersburg, FL 33701; phone (727) 824-5312; fax (727) 824-5309.

2. To the maximum extent practical, the Permit Holder must coordinate permitted activities with activities of other Permit Holders conducting the same or similar activities on the same species, in the same locations, or at the same times of year to avoid unnecessary disturbance of animals. The appropriate Regional Office may be contacted at the address listed above for information about coordinating with other Permit Holders.

III. APPROACH TO THE ASSESSMENT

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

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

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

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

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

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

Reducing the viability of a population is not always sufficient to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of the Species* section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the evidence available to us. This evidence might consist of monitoring reports submitted by past and present permit holders; reports from NMFS Science Centers; reports prepared by natural resource agencies in states, and other countries; reports from foreign and domestic nongovernmental organizations involved in marine conservation issues; the information provided by PR1 when it initiates formal consultation; information from commercial interests; and the general scientific literature.

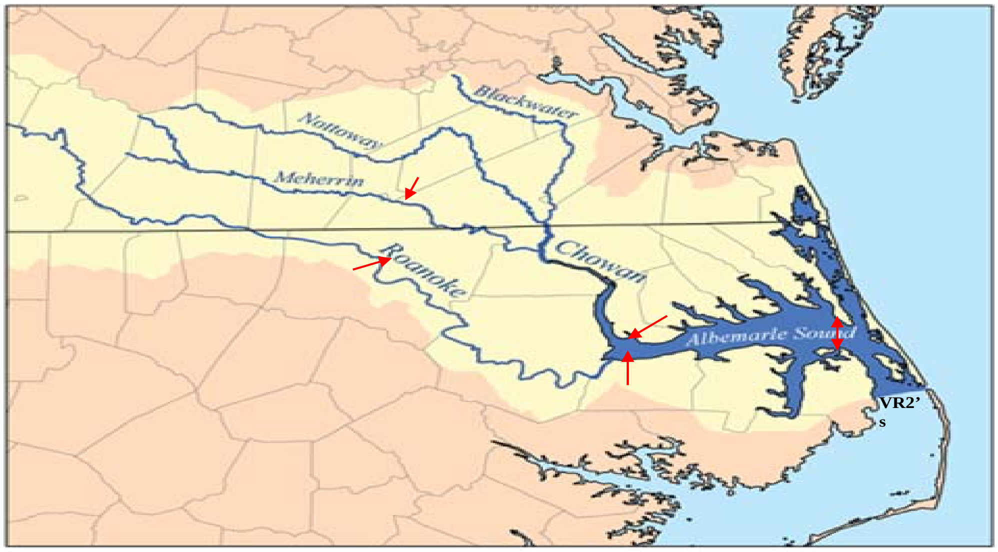
During each consultation, we conduct electronic searches of the general scientific literature using *American Fisheries Society*, *Google Scholar*, *ScienceDirect*, *BioOne*, *Conference Papers Index, JSTOR,* and *Aquatic Sciences and Fisheries Abstracts* search engines. We supplement these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically try to identify data or other information that supports a particular conclusion (for example, a study that suggests shortnose sturgeon will exhibit a particular response to DO concentrations) as well as data that does not support that conclusion. When data are equivocal, or in the face of substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action would not have an adverse effect on listed species when, in fact, such adverse effects are likely.

We rank the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. Carefully designed field experiments (for example, experiments that control potentially confounding variables) are rated higher than field experiments that are not designed to control those variables. Carefully designed field experiments are generally ranked higher than computer simulations. Studies that produce large sample sizes with small variances are generally ranked higher than studies with small sample sizes or large variances.

IV. DESCRIPTION OF THE ACTION AREA

The action area is defined in 50 CFR 402.2 as "all areas to be affected directly or indirectly by the Federal Action and not merely the immediate area involved in the action." The action area under these proposed activities would be the Chowan, Roanoke, and Cape Fear River Basins, as well as Albemarle Sound.

Figure 1: Maps of Action Areas



Albemarle Sound, Chowan and Roanoke River Basins. Arrows depicting upper limits of research at first dams located at Emporia, VA, and Roanoke Rapids, NC, lower limits of river research at the mouths of the Chowan and Roanoke Rivers, and the eastern limits of Albemarle Sound.

Cape Fear River Basin. Arrows depicting upper river limits of research at first dam at Riegelwood, NC and lower river boundary near Wilmington, NC

Albemarle Sound is the receiving waters of the Chowan, Roanoke, and Pasquotank Rivers which together drain over 18,000 square miles of northern North Carolina (NC) and southern Virginia (VA) (NC DWR 2001). The two major western tributaries, the Chowan and Roanoke Rivers, provide well over half the mean annual freshwater discharge into the sound (mean annual total freshwater inflow value 17,000 cfs). The watershed includes approximately 9,300 miles of freshwater rivers and streams. Albemarle Sound alone covers 500 square miles and is a significant portion of the NC coastal ecosystem.

The proposed activities in the Albemarle Sound would be bounded to the west at the mouths of the Roanoke River (near the mouth but including Bachelor Bay) and the Chowan River (6 km downstream of the 17 bridge). The eastern boundary of the Albemarle Sound is bounded by a north-south line crossing the Sound beginning at Point Harbor (Currituck County), NC to Mashoes (Dare County), NC.

The Chowan River Basin is located in the northeastern Coastal Plain of NC and southeastern VA and occupies approximately 5,415 square miles. The basin is part of the Albemarle-Pamlico National Estuary Program. Approximately 75 percent of the basin (4,061 square miles) is located in the VA portion of the watershed (Basinwide Planning Section 2007), with the remaining 1,378 square miles in NC (NC DENR, NCSU 2008). The river is formed at the border of NC and VA by the confluence of the Nottoway and Blackwater Rivers. A third major tributary, the Meherrin River, joins the Chowan River south of the VA border. There are 782 stream miles in the basin (NCSU 2008).

The proposed activities in the Chowan River would extend from the mouth of the Chowan River at Albemarle Sound (6 km south of the highway 17 bridge) to the upper reaches of the basin in VA (including the tributaries Blackwater, Nottoway, and Meherrin Rivers). The first dam is located at Emporia, VA on the Meherrin River at the intersection of Interstate 95.

The Roanoke River Basin begins in the Blue Ridge Mountains of northwestern VA and flows for more than 400 miles in a generally southeastern direction, emptying into Albemarle Sounds in northeastern NC (TNC 2005, Basinwide Planning Section 2006). At the fall line near Roanoke Rapids, the drainage area is nearly 8,000 square miles; from Roanoke Rapids to the coast, the river drains another 2,000 square miles. Discharge from Roanoke River is greater than other NC river (Basinwide Planning Section 2006). About 36% of the watershed is within NC with the remainder in VA; much of the NC portion is comprised by the Dan River and its tributaries.

The proposed activities in the Roanoke River would extend 4 kilometers from the mouth of the Roanoke into Albemarle Sound (including Bachelor Bay) to the base of the first impassible dam located at Roanoke Rapids (rkm 221). Additionally, all branches and tributaries within the Roanoke River Basin would be potential sampling sites.

The Cape Fear River Basin is NC's largest basin. The river basin is located entirely within NC's boundaries and flows southeast from the north central piedmont region near Greensboro to the Atlantic Ocean near Wilmington. The Cape Fear River is formed at the confluence of the Haw and Deep Rivers on the border of Chatham and Lee Counties, just below the B. Everett Jordan Reservoir dam. From there, the river flows across the coastal plain past Fayetteville through three locks and dams into Wilmington before entering the ocean. The Black and Northeast Cape Fear Rivers are blackwater rivers meeting the Cape Fear River in Brunswick County. The basin includes four coastal Outstanding Resource Waters (ORW) (Stump, Middle, Topsail, and Masonboro Sounds) and one inland ORW (a portion of the Black River). Over one-half of the land in the river basin is forested. Statistics provided by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), indicate that during the 10-year period from 1982 to 1992, there was a significant increase in the amount of developed land (43%). The basin contains 54% of the state's swine operations, and swine populations in the basin have increased 90% between 1994 and 1998.

The proposed activities in the Cape Fear River would extend from near the city of Wilmington, NC from the mouth to the first dam, or Lock and Dam #1 located at rkm 97 near Riegelwood, NC. Additionally, all branches and tributaries within the Cape Fear River Basin (east of Lock and Dam #1) would be potential sampling sites.

V. STATUS OF THE SPECIES/CRITICAL HABITAT

NMFS has determined that the action being considered in this Opinion may affect the following species protected under the ESA:

Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Green sea turtle	*Chelonia mydas*	Endangered
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened

The following summarizes the biology and ecology of the endangered species in the action area that are relevant to the effects analysis in this Opinion. For more comprehensive treatments of the biology, ecology, and management of shortnose sturgeon, refer to Dadswell *et al.* (1984), Gilbert (1989), the Final Recovery Plan for Shortnose Sturgeon (NMFS 1998), and the Canadian Assessment and Update Status Report on the Shortnose Sturgeon (COSEWIC 2005).

A. Listed Resources Not Considered Further in this Opinion

Sea Turtles. The authorized activities would include netting in Albemarle Sound and the Cape Fear Basin estuarine areas, where green, Kemp's ridley, leatherback, loggerhead, or hawksbill sea turtles could be found. These five species of sea turtles have been documented in North Carolina waters. Green, loggerhead, and Kemp's ridley turtles can be relatively common in the Albemarle Sound or Cape Fear Basin estuarine areas, while leatherback and hawksbill turtle sightings are rare. Occurrences of hawksbill sea turtles are very rare within the action area of the Albemarle Sound or Cape Fear Basin due to their preferred feeding habits on sponges and corals (not abundant in these waters). Also, although leatherback sea turtles have been documented in the lower Cape Fear River, they occur almost exclusively in open ocean waters in relation to the outer banks, (Joanne B. McNeill, *pers. comm.*, NMFS Southeast Fisheries Science Center, Beaufort, NC). Because green turtles, Kemp's ridley, and loggerheads are more specialized, grazing on sea grasses and algae, they are thus more abundant in the both of the sounds and in the lower Cape Fear River. Therefore, ranked in order of occurrence, juvenile loggerheads, green and Kemp's ridley sea turtles are considered more common in the Albemarle Sound and the Cape Fear River (Epperly *et al.* 1995, McClellan 2009).

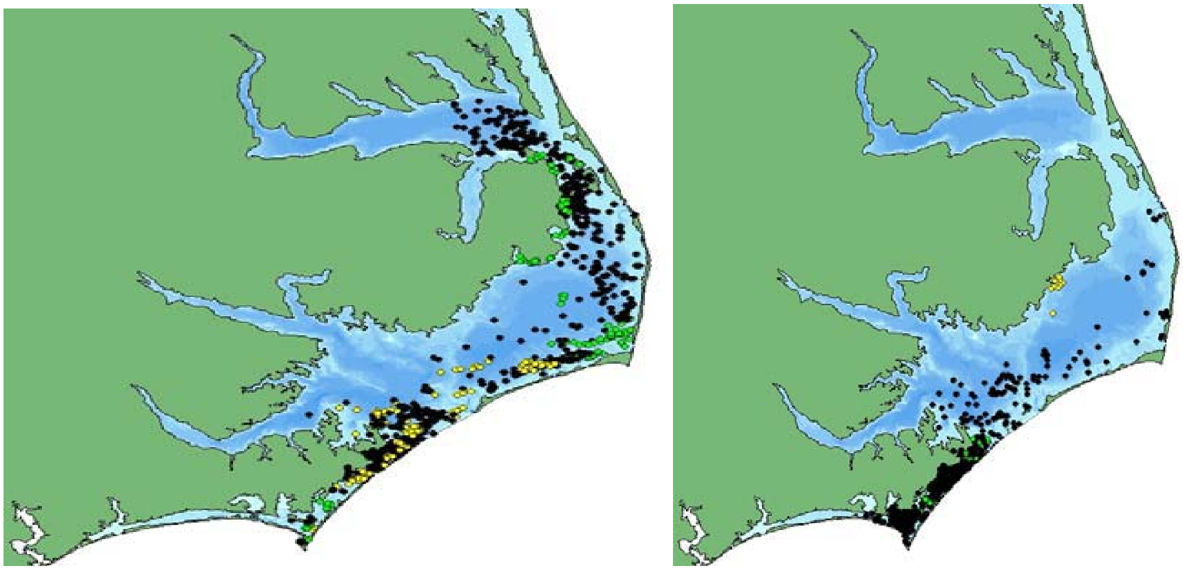
An understanding of sea turtle seasonal occurrence and movement patterns of turtles in the proposed action area is important for assessing the potential overlap with the proposed activities. During spring, as temperatures begin to rise, sea turtles migrate up the coast and into estuarine waters of the lower Cape Fear River, Pamlico and Albemarle Sounds (Braun-McNeill *et al*. 2004). In the fall, many sea turtles migrate southward out of the temperate latitudes to warmer waters (McClellan 2009). This general pattern is reversed the following spring as they again migrate estuarine and northward along the coast, repopulating estuarine waters and temperate latitudes. Since 1988, researchers with NMFS in Beaufort began monitoring distribution of sea turtles in North Carolina sounds and near-shore waters, employing three methods assessing turtle distributions: aerial surveys, public sightings and mark-recapture studies (NCDMF 2006). A distinct seasonal pattern of sea turtle distribution in the sounds and near-shore waters was discerned where in April, as coastal waters warm, sea turtles enter the sounds through five main inlets. During summer, turtles may be found from Albemarle Sound to Cape Fear and as far west as the lower reaches of the Neuse River estuary. The greatest densities occur in Core Sound (located just south of Pamlico Sound) and along the eastern shore of Pamlico Sound. In the fall, turtles leave the sounds as water temperatures cool and are rarely seen inside barrier islands from January to March. Sea turtles are observed offshore throughout the year.

While mark-recapture programs and sightings data offer indirect evidence of the movements of sea turtles, satellite telemetry on turtles in North Carolina waters from Albemarle Sound to the Cape Fear River has provided more detailed, direct data by tracking individual sea turtles continuously over a long period of time (NCDMF 2006, Snoddy 2009).

Beginning in 2002, satellite telemetry was employed to track the movements of loggerhead, green, and Kemp's ridley sea turtles examining their interactions with flounder gill nets in Pamlico Sound, (NCDMF 2006). Figure 2 below depicts cumulative location data for satellite tagged sea turtles between 2002 and 2003. Although other turtles were tagged in later years, results were similar (McClellan 2009).

Figure 2: Map of estuarine locations of sea turtles displaying cumulative satellite tracking data in the North Carolina Sounds between 2002 and 2003 (NCDMF 2006, McClellan 2009).

2002 2003



__Species Key__: Loggerhead sea turtle
Green sea turtle
Kemp's ridley sea turtle

Results of tracking turtle movement in the Albemarle Sound indicate sea turtles extend their range westward (typically during the summer) approximately to the mouth of Alligator River — the eastern most range of proposed sampling— and leave the area beginning in late summer and early fall as temperature declines. Most turtles moving into the sounds are found concentrated in the northern and southern Pamlico, and also found in high concentrations in Bogue and Core Sounds (Carteret County). Turtles migrate out of the sounds between September and December, most leaving in November (McClellan 2009). Based on five years of tracking, Dr. Catherine McClellan (*pers. comm*., University of Exeter) suggested it would be rare for turtles to venture far into the Alligator River or further west in Albemarle Sound (*i.e.,* Alligator River). To exit the sounds, turtles use every inlet from Oregon Inlet to Beaufort Inlet, but most exit through Barden Inlet at Cape Lookout. After leaving the sounds, turtles migrate to three general over-wintering areas: Florida, offshore North Carolina, and the North Atlantic via the Gulf Stream (NCDMF 2006).

In the Cape Fear River, juvenile sea turtles use the estuary as seasonal foraging habitat, present in large numbers in the summer. Snoddy (2009) documented seasonal movements of green and kemps ridley sea turtles in the shallow waters of the Cape Fear River Estuary using satellite telemetry. The researcher found turtle movement was limited to the lower river in the estuarine areas having 32 – 39ppt salinity, to rkm 25 downstream of Wilmington, North Carolina (rkm 45).

To avoid impacts with sea turtles in Albemarle Sound researchers would follow similar seasonal netting practices by the North Carolina Department of Marine Fisheries (Michael Loeffler, *pers. comm*., NC Department of Marine Fisheries) since 1995 in annual striped bass survey where no turtles have been reported captured. These practices would be amended to include two seasonal sampling periods in the Albemarle Sound to minimize impacts to turtles. Spring sampling would be concentrated in the western Albemarle (Mar-May) in water temperatures ranging from 12°C - 25°C. Western boundaries would include an area 6 km downstream of the mouth of the Roanoke River (including Bachelor Bay) and 6 km downstream of the mouth of the Chowan River (below Hwy 17 Bridge). Fall/Winter sampling (Nov –Feb) would take place in the eastern areas of Albemarle Sound in water temperatures ranging from 0°C - 15°. The eastern boundary for netting extends westward from a north-south line crossing the Albemarle Sound at Point Harbor, NC (Currituck County) to Mashoes, NC (Dare County), near the mouth of the Alligator River, to the previously described western boundary.

Areas of netting proposed in the Cape Fear River, where turtles have not been documented, would begin at Wilmington at rkm 45 extending upstream to more freshwater areas. In previous studies by the NCDMF and UNCW for the past eleven years, no interactions have taken place with listed turtles in this area of the river (Michael Loeffler, *pers. comm.*, NC Department of Marine Fisheries).

Researchers have had no record of interactions with sea turtles while surveying striped bass populations in the Albemarle Sound or in freshwater areas of the Cape Fear River since 1995. Additionally, they have agreed to mitigating conditions while sampling for sturgeon, to further limit turtle interactions, specifically: (1) tending nets continually during daylight hours; (2) fishing nets for specific shortened intervals related to water temperature; (3) netting in the western reaches of Albemarle Sound in early spring (Mar – May) (when warmer temperatures would be expected), and in the fall and winter (Nov – Feb) in the eastern sectors (at cooler temperatures when turtles would typically not be present); and (4) fishing in areas on the Cape Fear River not used by sea turtles. Also, gill nets would be removed if a turtle were observed in the area, and, if captured, they would be removed quickly and safely. Further, as a precaution, if a sea turtle were captured, the lead biologists have been trained by Dr. Southwood (University of North Carolina, Wilmington) on handling/resuscitation techniques of sea turtles.

Due to the seasonal restrictions on netting designed to avoid sea turtles, as well as daylight tending and other mitigative netting observations, we do not believe that sea turtles would be adversely affected by the proposed activities. For these reasons, we do not further consider sea turtles in this Biological Opinion.

Critical Habitat. No critical habitat has been designated for shortnose sturgeon; therefore, none will be affected by the proposed action.

B. Status of Species Considered in this Opinion

Species Description, Range-wide Distribution, and Population Structure. Shortnose sturgeon occur along the Atlantic Coast of North America, from the St. John River in Canada to the St. Johns River in Florida. The Shortnose Sturgeon Recovery Plan describes 20 shortnose sturgeon population segments that exist in the wild. Two additional geographically distinct populations occur behind dams in the Connecticut River (above the Holyoke Dam) and in Lake Marion on the Santee-Cooper River system in South Carolina (above the Wilson and Pinopolis

Dams). Although these populations are geographically isolated, genetic analyses suggest that individual shortnose sturgeon move between some of these populations each generation (Quattro *et al.* 2002, Wirgin *et al.* 2005).

At the northern end of the species' distribution, the highest rate of gene flow (which suggests migration) occurs between the Kennebec and Androscoggin Rivers. At the southern end of the species' distribution, populations south of the Pee Dee River appear to exchange between 1 and 10 individuals per generation, with the highest rates of exchange between the Ogeechee and Delaware Rivers (Wirgin *et al.* 2005). Wirgin *et al.* (2005) concluded that rivers separated by more than 400km were connected by very little migration while rivers separated by no more than 20km (such as the rivers flowing into coastal South Carolina) would experience high migration rates. Coincidentally, at the geographic center of the shortnose sturgeon range, there is a 400km stretch of river with no known populations occurring from the Delaware River, New Jersey to Cape Fear River, North Carolina (Kynard 1997). However, shortnose sturgeon are known to occur in the Chesapeake Bay, and may be transients from the Delaware River via the Chesapeake and Delaware Canal (Skjeveland *et al.* 2000, Welsh *et al.* 2002) or remnants of a population in the Potomac River.

Several authors have concluded that shortnose sturgeon populations in the southern end of the species geographic range are extinct. Rogers and Weber (1994), Kahnle *et al.* (1998), and Collins *et al.* (2000) concluded that shortnose sturgeon are extinct from the St. Johns River in Florida and the St. Marys River along the Florida and Georgia border. Rogers and Weber (1995b) also concluded that shortnose sturgeon have become extinct in Georgia's Satilla River.

Table 4. Estimated shortnose sturgeon population densities.

Population/Subpopulation	Distribution	Datum	Estimate	Confidence Interval	Authority
Saint John River	New Brunswick, Canada	1973/1977	18,000	30%	Dadswell 1979
Kennebecasis River	Canada	1998 – 2005	2,068	801 - 11,277	COSEWIC 2005
Penobscot River	ME	2006 - 2007	1,049	673 – 6,939	Univ. Maine, 2008 SJ Fernandes - 2008
Kennebec River	ME	1977/1981	7,200	5,046 - 10,765	Squiers *et al.* 1982
		2003	9,500	6,942 - 13,358	Squiers 2003
Androscoggin River	ME		7200	5000 - 10,800	Squiers *et al.* 1993
Merrimack River	MA	1989 – 1990	33	18 - 89	NMFS 1998
Connecticut River	MA, CT	2003	-	1,500 - 1,800	Connecticut DEP 2003
		1998-2002	-	1,042 - 1,580	Savoy 2004
Above Holyoke Dam		1976 – 1977	515	317 - 898	Taubert 1980, NMFS 1998
		1977 – 1978	370	235 - 623	Taubert 1980, NMFS 1998
		1976 – 1978	714	280 – 2,856	Taubert 1980, NMFS 1998

Population/Subpopulation	Distribution	Datum	Estimate	Confidence Interval	Authority
		1976 – 1978	297	267 - 618	Taubert 1980, NMFS 1998
Below Holyoke Dam		1988 – 1993	895	799 – 1,018	Savoy and Shake 1992,
Hudson River	NY	1980	30,311		Dovel 1979, NMFS 1998
		1995	38,000	26,427 - 55,072	Bain *et al.* 1995, NMFS 1998
		1997	61,000	52,898 - 72,191	Bain *et al.* 2000
Delaware River	NJ, DE, PA	1981/1984	12,796	10,288 - 16,367	Hastings *et al.* 1987
		1999/2003	12,047	10,757 - 13,589	Brundage and O'Herron 2003
Chesapeake Bay	MD, VA	no data	-	-	
Potomac River	MD, VA	no data	-	-	
Neuse River	NC	2001-2002	extirpated		Oakley 2003, Oakley and Hightower 2007
Cape Fear River	NC	1997	>100		Kynard 1997, NMFS 1998
Winyah Bay	NC, SC	no data	-	-	
Waccamaw - Pee Dee River	SC	no data	-	-	
Santee River	SC	no data	-	-	
Lake Marion (dam-locked)	SC	no data	-	-	
Cooper River	SC	no data	-	-	
ACE Basin	SC	no data	-	-	
Savannah River	SC, GA		1,000 - 3,000		Bill Post, SCDNR 2003
Ogeechee River	GA	1990s	266		Bryce *et al.* 2002
		1993	266	236 - 300	Kirk *et al.* 2005
		1993	361	326 - 400	Rogers and Weber 1994
		1999/2000	195	-	Bryce *et al.* 2002
		2000	147	105 - 249	Kirk *et al.* 2005
		2004	174	97 - 874	Kirk *et al.* 2005
		2008	368	244-745	Kirk 2008 NMFS Ann. Report
Delaware River	GA	1988	2,862	1,069 - 4,226	NMFS 1998
		1990	798	645 – 1,045	NMFS 1998
		1993	468	315 - 903	NMFS 1998
		2003-2005	6,320	4,387-9,249	DeVries 2006
Satilla River	GA		unknown	-	Kahnle *et al.* 1998
Saint Marys River	FL		unknown	-	Kahnle *et al.* 1998, Rogers and Weber 1994
Saint Johns River	FL	2002	1	-	FFWCC 2007

In addition to these wild populations there are several captive populations of shortnose sturgeon (Table 5). One captive population of shortnose sturgeon is maintained at the Conte Anadromous Fish Research Center in Massachusetts, which is operated by the United States Fish and Wildlife Service (USFWS). These sturgeon were taken from the Connecticut River population and are currently held by Dr. Boyd Kynard under Permit Number 1239. Captive populations of shortnose sturgeon captured from the Savannah River population are housed at three USFWS hatcheries: Bear's Bluff (South Carolina), Orangeburg (South Carolina), and Warm Springs (Georgia). The USFWS provides progeny of these captive shortnose sturgeon to other facilities for research, educational purposes, and public display. The University of Florida (Gainesville) recently acquired shortnose sturgeon from these hatcheries for research purposes.

Smaller, captive populations that have been developed from these USFWS facilities are maintained in several facilities for educational purposes. The South Carolina Aquarium in Charleston, South Carolina, maintains a population of eight juvenile shortnose sturgeon. The Springfield Science Museum in Springfield, Massachusetts, maintains a population of about five juvenile shortnose sturgeon. Captive populations are also held in the North Carolina Zoo in Asheboro, North Carolina; National Aquarium in Baltimore, Maryland; and the Riverbanks Zoological Park in Columbia, South Carolina.

Table 5: Populations reared in captivity

Conte Fish Research Center	MA
Bear's Bluff hatchery	SC
Orangeburg hatchery	SC
Warm Springs hatchery	GA

Life History Information. Shortnose sturgeon are anadromous fish that live primarily in slower moving rivers or nearshore estuaries near large river systems. They are benthic omnivores that feed on crustaceans, insect larvae, worms, and molluscs (Moser and Ross 1995, NMFS 1998) but they have also been observed feeding off plant surfaces and on fish bait (Dadswell *et al.* 1984).

During the summer and winter, adult shortnose sturgeon occur in freshwater reaches of rivers or river reaches that are influenced by tides; as a result, they often occupy only a few short reaches of a river's entire length (Buckley and Kynard 1985). During the summer, at the southern end of their range, shortnose sturgeon congregate in cool, deep, areas of rivers where adult and juvenile sturgeon can take refuge from high temperatures (Flournoy *et al.* 1992, Rogers and Weber 1994, Rogers and Weber 1995b, Weber 1996). Juvenile shortnose sturgeon generally move upstream for the spring and summer seasons and downstream for fall and winter; however, these movements usually occur above the salt- and freshwater interface of the rivers they inhabit (Dadswell *et al.* 1984, Hall *et al.* 1991). Adult shortnose sturgeon prefer deep, downstream areas with soft substrate and vegetated bottoms, if present. Because they rarely leave their natal rivers, Kieffer and Kynard (1993) considered shortnose sturgeon to be freshwater amphidromous (*i.e.* adults spawn in freshwater but regularly enter saltwater habitats during their life).

Shortnose sturgeon in the northern portion of the species' range live longer than individuals in the southern portion of the species' range (Gilbert 1989). The maximum age reported for a shortnose sturgeon in the St. John River in New Brunswick is 67 years (for a female), 40 years for the Kennebec River, 37 years for the Hudson River, 34 years in the Connecticut River, 20 years in the Pee Dee River, and 10 years in the Delaware River (Gilbert 1989 using data presented in Dadswell *et al.* 1984). Male shortnose sturgeon appear to have shorter life spans than females (Gilbert 1989).

Listing Status. Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001) pursuant to the Endangered Species Preservation Act of 1966. Shortnose sturgeon remained on the list as endangered with the enactment of the ESA in 1973. Shortnose sturgeon were first listed on the International Union for Conservation of Nature and Natural Resources Red List in 1986 where it is still listed as Vulnerable and facing a high risk of extinction based in part on: an estimated range reduction of greater than 30% over the past three generations, irreversible habitat losses, effects of habitat alteration and degradation, degraded water quality and extreme fluctuations in the number of mature individuals between rivers.

Status and Trends of Shortnose Sturgeon Populations. Despite the longevity of adult sturgeon, the viability of sturgeon populations are highly sensitive to juvenile mortality that result in reductions in the number of sub-adults that recruit into the adult breeding population (Anders *et al.* 2002, Gross *et al.* 2002, Secor *et al.* 2002). This relationship caused Secor *et al.* (2002) to conclude that sturgeon populations can be grouped into two demographic categories: populations that have reliable (albeit periodic) natural recruitment and those that do not. The shortnose sturgeon populations without reliable natural recruitment are at the greatest risk.

Several authors have also demonstrated that sturgeon populations generally, and shortnose sturgeon populations in particular, are much more sensitive to adult mortality than other species of fish (Boreman 1997, Gross *et al.* 2002, Secor *et al.* 2002). These authors concluded that sturgeon populations cannot survive fishing related mortalities that exceed five percent of an adult spawning run and they are vulnerable to declines and local extinction if juveniles die from fishing related mortalities.

Based on the information available, most shortnose sturgeon populations in the northern portion of the species range, from Delaware River north to the St. John River in Canada, appear to have sufficient juvenile survival to provide at least periodic recruitment into the adult age classes combined with relatively low adult mortality rates sufficient to maintain the viability of most of these populations. As a result, most of these populations appear to be relatively large and stable, except for shortnose sturgeon populations in the Merrimack and Connecticut Rivers (Table 4).

North Carolina Shortnose Sturgeon Population. The lack of records from most North Carolina rivers (Kynard 1997) may be due to their low abundance or the lack of directed survey effort. Shortnose sturgeon were thought to be extirpated from North Carolina until 1987, when Ross *et al*. (1988) obtained a shortnose sturgeon from the Brunswick River. Much additional gill net sampling from 1990 to 1993 established that shortnose sturgeon were present but rare within the lower Cape Fear River (Moser and Ross 1995). A shortnose sturgeon was captured in western Albemarle Sound in 1998 by the NC Division of Marine Fisheries (Armstrong and Hightower 1999). No shortnose sturgeon were collected in a survey of the Neuse River conducted in 2001-2002 (Oakley and Hightower 2007). Netting surveys for shortnose sturgeon have not been conducted in the Chowan and Roanoke Rivers. Data has recently been tabulated for all recorded shortnose sturgeon captures in NC waters and, when finalized, will be incorporated into the next shortnose sturgeon status review (Wilson Laney, U.S. Fish and Wildlife Service, South Atlantic Fisheries Coordination Office, unpublished) (Table 6).

Table 6. Recorded shortnose sturgeon captures in NC waters. (Wilson Laney, Unpublished)

WATERBODY	DATE: COLLECTOR/OBSERVER	LENGTH(S)	CATALOG #	REFERENCE
Chowan River (Salmon Creek)	April 12, 1881: J. Kite	185 mm TL	USNM 64330	Vladykov and Greely 1963
Cape Fear River Estuary	April 30, 1978: F.J. Schwartz *et al.*	575 mm TL	NCSM 28520	W.C. Starnes, NCSM, personal communication
Cape Fear River (Brunswick River)	January 29, 1987: S.W. Ross *et al.*	688 mm FL, 768 mm TL	NCSM 13827	Ross et al. 1988
Cape Fear River (Brunswick River)	February 16, 1989: M.L. Moser *et al.*	942 mm TL	released	Moser and Ross 1995
Cape Fear River (Brunswick River)	January 9, 1990: M.L. Moser *et al.*	900 mm TL	released	Moser and Ross 1995
Cape Fear River (Black River mouth)	May 4, 1991: M.L. Moser *et al.*	715 mm TL	released	Moser and Ross 1995
Cape Fear River (Brunswick River)	February 6, 1991: M.L. Moser	870 mm SL, 990 mm TL	NCSM 17539	Moser and Ross 1995
Cape Fear River (Brunswick River)	February 14, 1992: M.L. Moser *et al.*	812 mm TL	released	Moser and Ross 1995
Cape Fear River (rkm 90)	February 26, 1992: M.L. Moser *et al.*	753 mm TL	released	Moser and Ross 1995
Cape Fear River (rkm 90)	February 1, 1993: M.L. Moser *et al.*	525 mm FL, 623 mm TL	released	Moser and Ross 1995
Cape Fear River (rkm 90)	February 4, 1993: M.L. Moser *et al.*	568 mm FL, 643 mm TL	released	Moser and Ross 1995
Roanoke River (Bachelor's Bay)	April 18, 1998: J. Armstrong	730 mm TL	NCSM 27062	Armstrong and Hightower 1999

VI. ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR '402.02). The environmental baseline for this Opinion includes the effects of several activities that affect the survival and recovery of the listed species in the action area. The following information summarizes the primary human and natural phenomena in North Carolina that are believed to affect the status and trends of endangered shortnose sturgeon and the probable responses of the sturgeon to these phenomena.

Dams and Water Diversion. 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. The construction of dams throughout the shortnose sturgeon's range is probably the main factor reducing their reproductive success which, in turn, could be the primary reason for the reduction in population size for shortnose sturgeon.

There are several dams within the action area. The first dam preventing sturgeon passage on the Chowan River system is located at Emporia, Virginia, crossing the Meherrin River near the intersection of Interstate 95. The first impassible dam is of the Roanoke River is located at Roanoke Rapids (rkm 221). The Cape Fear River's first dam is Lock and Dam # 1 (rkm 97) near Riegelwood, North Carolina. From there, the Cape Fear River flows across the coastal plain past Fayetteville through three locks and dams to Wilmington before entering the ocean.

Bycatch. Directed harvest of shortnose sturgeon is prohibited. 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 benefitted from this closure as any bycatch in the fishery targeting Atlantic sturgeon has been eliminated.

Although directed harvest of shortnose sturgeon 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 eliminated 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 in the following gears: pound nets, fyke/hoop nets, catfish traps, shrimp trawls, and hook and line fisheries (recreational).

Bycatch in the gill net fisheries can be quite substantial and is believed to be 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).

Poaching. There is evidence of shortnose sturgeon targeted by poachers throughout their range, and particularly where they appear in abundance (such as on spawning grounds) but the extent of the poaching 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 NJ DFW 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).

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

Blasting. Bridge demolition, dredge, and other projects may include plans for blasting with powerful explosives. Fish are particularly susceptible to the effects of underwater explosions and are killed over a greater range than other organisms (Lewis 1996). Unless appropriate precautions are made to mitigate the potentially harmful effects of shock wave transmission to physostomous (i.e., air-bladder connected to the gut) 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 of 1998 and January of 1999 (Moser 1999). There were seven test runs that included 23-33 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 feet 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 (3) and without (4) an air curtain placed 50 ft from the blast area. External assessments of impacts to the caged fish were conducted immediately after the blasts and 24 hours after the blasts. After the 24 hour period, a subsample of the caged fish, primarily from those cages nearest the blast at 35 feet and some from 70 feet, were sacrificed for necropsy.

Shortnose sturgeon selected for necropsy all appeared to be in good condition externally and behaviorally. Results of the tests, including necropsies, indicated the fish that had survived the blast, lived through the 24 hour observation period, and appeared outwardly fine. However, they may have had substantial internal injuries. Moser concluded that many of the injuries would have resulted in eventual mortality (Moser 1999). The necropsy results also indicated in the fish held in cages at 70 feet were less seriously injured by test blasting than those held at 35 feet from the blast. Finally, shortnose sturgeon juveniles suffered fewer, less severe internal injuries than juvenile striped bass tested, and there appeared to be no reduction of injury in fish experiencing blasts while the air curtain was in place (Moser 1999).

Bridge Construction/Demolition. Bridge construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb areas of sturgeon concentrations. Bridge demolition projects may include plans for blasting piers with powerful explosives. Unless appropriate precautions are made to mitigate the potentially harmful effects of shock wave transmission to physostomous (i.e., airbladder connected to the gut) fish like shortnose sturgeon, internal damage and/or death may result. From 1993 through 1994, NMFS consulted with the Federal Highway Administration to assess the potential impacts of demolishing bridge piers to shortnose sturgeon. NMFS advised the Federal Highway Administration to employ several conservation measures designed to minimize the transmission of harmful shock waves. These measures included restricting the work to seasonal "work windows," installing double-walled cofferdams around each pier to be blasted, and dewatering the outer cofferdams. The use of an air gap (e.g., double-wall cofferdam, bubble screen) to attenuate shock waves is likely to reduce adverse effects to shortnose sturgeon and other swimbladder fish (Sonolysts 1994). Blast pressures below which negative impacts to shortnose sturgeon are unlikely to occur are not known. Wright (1982) determined that detonations producing instantaneous pressure changes greater than 100kPa (14.5psi) in the swimbladder of a fish will cause serious injury or death.

Water Quality and Contaminants. The quality of water in river/estuary systems is affected by human activities conducted in the riparian zone and those conducted more remotely in the upland portion of the watershed. Industrial activities can result in discharge of pollutants, changes in water temperature and levels of 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 Clean Water Act regulates pollution discharges into waters of the United States from point sources, however, it does not regulate non-point source pollution.

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 of the U.S. (Virginia to Maine) received grades of F. The southeast region of the U.S. (Florida to North Carolina) received an overall grade of B-, the best rating in the nation. Areas of concern having poor index scores for the southeast region/North Carolina were coastal habitat and benthos. Notably for sturgeon in North Carolina, fish tissue received an A rating.

Table 7. Summary of the EPA NCCR II for the U.S. east coast published by the EPA (2005) grading coastal environments. (Northeast region=VA to ME; southeast region=FL to NC; central region =Chesapeake Bay)

	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-**

Chemicals 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.

Life history of shortnose sturgeon (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose sturgeon to long-term, repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979, NMFS 1998). However, there has been little work on the effects of contaminants on shortnose sturgeon to date. Shortnose sturgeon collected from the Delaware and Kennebec Rivers had total toxicity equivalent concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), PCBs, DDE, aluminum, cadmium, and copper above adverse effect concentration levels reported in the literature (ERC 2002, 2003).

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 e*t al.* 1998). Pesticide exposure in fish may affect anti-predator and homing behavior, reproductive function, physiological maturity, swimming speed, and distance (Beauvais *et al*. 2000, Scholz *et al*. 2000, Moore and Waring 2001, Waring and Moore 2004).

Sensitivity to environmental contaminants also varies by life stage. Early life stages of fish appear to be more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). 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 elutriate static renewal (Kocan *et al.* 1993).

Land Use Practices. *Cape Fear and river basins.* The Cape Fear Estuary drains the largest watershed in North Carolina, containing 27% of the State's population (Mallin *et al*. 2000). The Cape Fear watershed is the most heavily industrialized basin in North Carolina, with numerous industries utilizing the Cape Fear in the upper watershed and eleven major industrial dischargers in the tidal basin itself (Mallin *et al*. 2000).

The largest human use of land in the entire Cape Fear watershed is devoted to crop agriculture, which represents about 24% of the land coverage (Mallin *et al*. 2000). In the northeast portion of Cape Fear River watershed, industrialized livestock production is the largest industry with silviculture also being an important industry. Much of the land adjacent to the Cape Fear tidal basin consists of swamp forests.

Albemarle Sound and river basins. The Albemarle Sound system supports mining, forestry, and agriculture (EPA 2001). The most significant land use in the watershed is agriculture, including crop farming and cattle farming (EPA 2001).

Power Plant Operations. Shortnose sturgeon are susceptible to impingement on cooling water intake screens at power plants. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. The operation of power plants can have unforeseen and extremely detrimental impacts to water quality which can affect shortnose sturgeon. Carolina Power and Light operates the Brunswick 1 and 2 nuclear power plants that exist within the Cape Fear portion of the action area near Wilmington, NC. There are several electric power plants within the action area.

Research. Research activities could also pose a threat to shortnose sturgeon. Excluding the proposed permit detailed in this Opinion, there are 17 permits (Table 8) authorizing take of shortnose sturgeon on the east coast of the United States. All of the permits authorize the sampling of adult or juvenile shortnose sturgeon. Although there are various other researchers studying the unlisted Atlantic sturgeon populations in North Carolina waters, which could potentially impact shortnose sturgeon and its habitat to some extent, there are no other current permitted activities sampling shortnose sturgeon in North Carolina waters.

Table 8. Existing shortnose sturgeon research permits similar to the proposed activities.

Permit No.	Location	Authorized Take	Research Activity
10115 Expires: 8/3/2013	Saint Marys & Saltilla Rivers, FL & GA	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

Permit No.	Location	Authorized Take	Research Activity
1543 Expires:11/30/2011	Upper Santee River Basin, SC	3 adult/juv.	Capture, handle, weigh, measure, tissue sample
14396 Expires: 12/31/2014	Delaware River and Estuary NJ & DE	100 adult/juv. (1 lethal),	Capture, handle, measure, weigh, Floy tag, PIT tag, tissue sample, anesthetize, ultrasonic tag,
14604 Expires: 4/19/2015	Delaware River and Estuary NJ & DE	1,000 adult/juv (1 lethal) 500 ELS	Capture, handle, weigh, measure, PIT tag, Floy tag, ultrasonic tag, tissue sample, anesthetize, laparoscopy, blood/biopsy 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

ELS = early life stages

Conservation. Section 303(d) of the Federal Clean Water Act (CWA) requires States to develop a list (303(d) List) of waterbodies for which existing pollution control activities are not sufficient to attain applicable water quality standards and to develop Total Maximum Daily Loads (TMDLs) for pollutants of concern. A TMDL sets a limit on the amount of a pollutant that can be discharged into a waterbody such that water quality standards are met. The states of Virginia and North Carolina are responsible for developing TMDLs for the action area.

All of the states along the action area basins – Virginia and North Carolina – each have State Departments of Conservation managing programs which impact the basins such as air, waste, soil, water, fish, and wildlife. The Virginia Department of Recreation and Conservation (VDRC) implements public educational programs such as pollution awareness, adopt-a-stream, healthy waters initiative, "Virginia Rivers - Jump Right In!", and nutrient management training opportunities. The VDRC also implements conservation program and regulations affecting the action area including Agricultural Best Management Practices, Clean Water Farm Awards, Conservation Reserve Enhancement Program, Virginia Stormwater Management Program, Erosion and Sediment Control, Local Conservation Water Quality Ordinances, Nutrient Management, Poultry Litter Transport Incentive Program, Soil and Water Conservation Districts, Shoreline Erosion Advisory Service, Soil and Water Conservation Board, Soil Surveys, and Stormwater Management. The Virginia Department of Game and Inland Fisheries manages wildlife programs.

The North Carolina Department of Environment and Natural Resources (NCDENR) has multiple divisions that work to conserve wildlife, fisheries, and conduct environmental and land management programs. Some of these management regimes and regulatory programs include estuary programs, clean water management trust funds, coastal reserve programs, sustainability teams, ecosystem enhancement program, stormwater program, wetlands restoration program, and conservation tax credit program.

The NCDENR participates in an Albemarle-Pamlico National Estuary Program where the Roanoke River Basin Regional Council meets to make decisions on issues surrounding the Roanoke Basin including negative impacts of seasonal flows and managed flow, low dissolved oxygen levels, water quality in relatively stagnant creeks, nutrient loads and sediment impacts, problems with small municipal waste treatment facilities, toxins, land use, and land use planning.

Integration of the Environmental Baseline. The above activities within the action area pose threats to its shortnose sturgeon population in the following ways. Many activities cause *death* – definite removal of individual fish from NC populations – at the adult, juvenile, and larval stages. Other activities cause *injury* to shortnose, increasing stress levels and decreasing their survival potential. Still, other activities *alter habitat*, potentially changing spawning and survival patterns of these fish.

Activities potentially causing death to individual shortnose sturgeon are bycatch in commercial and recreational fishing, cooling water intakes and power plants, dredging, blasting, bridge construction, and research. Hydroelectric or nuclear power plants must use rivers or lakes as sources of running turbines or as cooling mechanisms. Adult and larval shortnose sturgeon are known to be killed or impinged on the screens that cover the cooling water intake screens (Hoff and Klauda 1979, Dadswell *et al.* 1984, NMFS 1993). Dadswell *et al.* (1984) reported that larval and juvenile shortnose sturgeon in the different populations along the Atlantic have been killed after being impinged on the intake screens or entrained in the intake structures of power plants on the Delaware, Hudson, Connecticut, Savannah and Santee rivers. During dredging activities, hydraulic dredges can kill sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. Mechanical dredges have also been documented to kill shortnose sturgeon. Finally, some NMFS-permitted shortnose sturgeon research projects authorize take of early life stages and allow for 1 incidental shortnose sturgeon mortality throughout the life of the permit.

All of the activities identified in the Environmental Baseline section have the potential to injure individual shortnose sturgeon. Commercial and recreational fishing industries that catch shortnose incidentally might return living fish to the river, presumably unharmed, however each fish might have sustained injury in the process. The operation of power plants can also have unforeseen and detrimental impacts to water quality which can injure shortnose sturgeon.

Water quality changes from dredging, shipping, land use practices, point and non-point source pollution could also injure shortnose sturgeon by way of changes in DO concentration or introduction of waterborne contaminants. DO concentrations can be affected by maintenance dredging of Federal navigation channels and other waters. Apart from entrainment, dredging can also change DO and salinity gradients in, and around, the channels (Jenkins *et al.* 1993, Campbell and Goodman 2004, Secor and Niklitschek 2001). Dredging operations may pose risks to shortnose sturgeon by destroying or adversely modifying their benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. Since shortnose sturgeon are benthic omnivores, the modification of the benthos could affect the quality, quantity, and availability of sturgeon prey species.

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

Other NMFS-permitted research activities could also injure shortnose sturgeon. There are currently 17 research permits authorizing directed take of shortnose sturgeon. Although one gill netting mortality has been reported recently (June 3, 2010, Delaware River), no other shortnose sturgeon research mortalities have been reported since temperature and D.O. netting protocols were implemented. In addition, shortnose sturgeon could be injured in a way that is not observed or quantified by researchers. Excluding the permit authorization being considered here, there are no other shortnose sturgeon directed research permits in the action area at this time.

Activities potentially altering the habitat of shortnose sturgeon are dredging and land use activities. Due to their benthic nature, dredging for shipping and other activities destroys shortnose feeding areas, disrupts spawning migrations, and fills spawning habitat with resuspended fine sediments. Land use activities also have the capacity to fill spawning habitat with sediments if those activities release sand and silt into the action area.

The population size of shortnose sturgeon within the action area is incomplete and unknown. Shortnose sturgeon were thought to be extirpated from North Carolina until 1987, when Ross *et al*. (1988) obtained a shortnose sturgeon from the Brunswick River. Currently, we know that the Neuse River has been extirpated (Oakley 2003, Oakley and Hightower 2007), but the Cape Fear River is believed to have a population of >100 (Kynard 1997, NMFS 1998). Therefore, the current impact of human activities and recovery of shortnose sturgeon in North Carolina is unknown.

VII. Effects of the Proposed Action

Pursuant to Section 7(a)(2) of the ESA, federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed activities authorized by permit 14759 would expose shortnose sturgeon to capture, handling, genetic tissue sampling, PIT and Floy tags, sonic transmitter implantation, and anesthesia. In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed action, the probability of individuals of listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. As described in the *Approach to the Assessment* section, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment is to determine if it is reasonable to expect the proposed studies to have effects on listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

A. Potential Stressors

The assessment for this consultation identified several possible stressors associated with the proposed permitted activities. These include: 1) capture by gill net; 2) handling for procedures and measurements; 3) PIT tagging; 4) Floy tagging; 5) genetic tissue sampling; 6) anesthesia; 7) transmitter implantation; and 8) hydroacoustic surveys/side scan sonar. All captured shortnose sturgeon would be handled, weighed, measured, photographed, PIT tagged, Floy tagged, and genetic tissue sampled. Smaller subsets of these fish would be anesthetized for sonic transmitter implantation/surgery. Activities are expected to occur in the action area until the permit's expiration. Based on a review of available information, we determined that stressors 1 - 7 could pose a risk to shortnose sturgeon. Accordingly, the effects analysis of this consultation focused on potential stressors 1 - 7.

Stressor 8, or hydroacoustic surveys/side scan sonar, would not pose a risk to shortnose sturgeon. The frequencies being used 1250 kHz (side-scan sonar) and 1.8 MHz (DIDSON multi-beam sonar) are above the hearing range of most fishes (*see* Hastings and Popper 2005). The hearing range of sturgeon is unknown (Hastings and Popper 2005). Therefore, stressor 8 is not expected to adversely affect shortnose sturgeon and is not discussed further in this Opinion.

B. Exposure Analysis

Exposure analyses identify the co-occurrence of ESA-listed species with the actions' effects in space and time, and identify the nature of that co-occurrence. The Exposure Analysis identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulation(s) those individuals represent.

Table 9 identifies the numbers of shortnose sturgeon that are expected to be exposed annually for five years in the action area under the proposed permit 14759. All captured shortnose sturgeon would be handled, weighed, measured, PIT and Floy tagged, and genetic tissue sampled. Smaller subsets of these fish would be anesthetized for sonic transmitter implantation.

Table 9. Activities proposed to be authorized for Hightower's research on endangered shortnose sturgeon (*Acipenser brevirostrum*) in North Carolina under Permit 14759.

Life Stage	Sex	Expected Annual Take	Take Action	Location
Juvenile & adult	Male & female	Up to 10 annually, or a total of 20 over 5yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Chowan River and all tributaries; NC/VA
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	
Juvenile & Adult	Male & female	Up to 20 annually; or a total of 40 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Roanoke River and all tributaries; NC
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	
Juvenile & Adult	Male & female	Up to 10 annually, or a total of 20 over 5yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Cape Fear River and all tributaries; NC
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	
Juvenile & Adult	Male & female	Up to 10 annually, or a total of 20 over 5yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample	Albemarle Sound and all tributaries; NC
Juvenile & adult	Male & female	Up to 5 annually (subset of the above total); or a total of 10 over 5 yrs	Capture, hold, measure, weigh, photograph/video, Floy T-bar tag, PIT tag, & genetic tissue sample; anesthetize w/ MS-222; & implant acoustic tag	

The time required to complete routine, non-invasive methods (*i.e.,* PIT and Floy tagging, measuring, weighing) would be less than two minutes per fish. The cumulative time required for procedures such as anesthetizing, telemetry tagging, and genetic tissue sampling would vary, but would typically average less than 15 minutes per fish, not accounting for recovery time from anesthesia. While onboard, 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.

C. Response Analysis

As discussed in the *Approach to the Assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after being exposed to an action's effects on the environment or directly on listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might reduce the fitness of individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

Capture. Shortnose sturgeon would be captured using a combination of gill nets and side-scan or DIDSON sonar. In the Chowan River and tributaries, Cape Fear River and tributaries, and Albemarle Sound, up to 10 shortnose sturgeon annually (or a total of 20 over 5 years) would be captured in each. In the Roanoke River and tributaries, up to 20 shortnose sturgeon annually (or a total of 40 over 5 years) would be captured. Entanglement in nets 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). Hightower *et al*. (2002) experienced one Gulf sturgeon mortality in 1997 with gill netting and Mason and Clugston (1993) experienced some mortality in their gill nets. Recently, on June 3, 2010, Hal Brundage experienced one shortnose sturgeon gill net mortality in the Delaware River (7.7 ppm DO waters, 26.7C, in a 90 minute net set). The shortnose sturgeon was a post spawner and was 772 mm weighing about 2.9kg (6.5 lbs), which is a fairly small fish. It was also the fish's first time captured. However, historically, the majority of shortnose sturgeon mortality during scientific investigations has been directly related to netting mortality and as a function of numerous factors including water temperature, low D.O. concentration, soak time, mesh size, net composition, and netting experience.

To illustrate, shortnose sturgeon mortality resulting from six similar scientific research permits is summarized in Table 10 below. Mortality rates due to the netting activities ranged from 0 to 1.22%. Of the total 5,911 shortnose sturgeon captured by gill nets or trammel nets, only 23 died, yielding an average incidental mortality rate of 0.39%. However, all of the mortalities associated with these permits were due to high water temperature and low D.O. concentrations. Moser and Ross (1995) reported gill net mortalities approached 25% when water temperatures exceeded 28ºC even though soak times were often less than 4 hours.

Table 10: Number and percentage of shortnose sturgeon killed by gill nets or trammel nets associated with existing scientific research permits.*

	Permit Number					
	1051	1174	1189	1226	1239	1247
Time Interval	1997, 1999 – 2004	1999 – 2004	1999, 2001 – 2004	2003 – 2004	2000 – 2004	1988 – 2004
No. sturgeon captured	126	3262	113	134	1206	1068
No. sturgeon died in gill nets	1	7	0	0	5	13
Percentage	0.79	0.22	0	0	0.41	1.22

*Note that this table does not incorporate the recent June 3, 2010 Delaware River shortnose sturgeon mortality, as formal annual reporting has not yet been completed for this permit.

Under separate NMFS Permit No. 1247, between 4 and 7% of the shortnose sturgeon captured died in gill nets prior to 1999, whereas between 1999 and 2005, none of the more than 600 shortnose sturgeon gill netted died as a result of their capture. Also, in five years, under Permit Number 1189, none of the sturgeon captured died. Under Permit Number 1174, all seven of the reported shortnose sturgeon mortalities occurred during one sampling event. Since 2006, more conservative mitigation measures implemented by NMFS and researchers (e.g. reduced soak times at warmer temperatures or lower D.O. concentrations, minimal holding or handling time), have reduced the effects of capture by gill netting on sturgeon significantly with no documented mortalities except for the June 3, 2010 Delaware River mortality mentioned above. To limit stress and mortality of sturgeon due to gill netting, methods in the proposed research would adopt these more conservative measures for gill netting (discussed further in the section below). This analysis indicates that, if done in accordance with the NMFS's sturgeon protocols (Moser *et al.* 2000), gill netting for shortnose sturgeon could be done with lowered risk of direct mortality.

Expected Response to Capture. As demonstrated above, there is a chance that shortnose sturgeon could die in gill nets, but mitigation measures included in the proposed activities should reduce the risk associated with sturgeon capture. To limit stress and mortality of sturgeon due to capture efforts, the proposed methodologies would utilize more conservative netting conditions than is suggested by the Moser *et al*. (2000) protocol. The proposed methodology also limits the soak times of gill nets to 2 hours or less at water temperatures in the range of 20°C to 28°C and prohibits netting at temperatures above 28°C unless first contacting NMFS. Dissolved oxygen would also be measured prior to each net set and each time the net is checked to ensure that at least 5.0 mg/L concentration is maintained. Also, to minimize injury, heavy multifilament nylon (6, 9, or 10 cm stretch) mesh would be used instead of monofilament or light twine, which is more capable of cutting into the fish causing injury. Due to the low ventilation rate and open operculum, the use of trammel nets is encouraged, as they allow the fish to become entangled rather than gilled. However, trammel nets would not be required as permit condition because the risk from use of gill nets is considered very low. Based on the results of fish captures in recent years, the previous research conducted by the applicant, and the thorough mitigation measures included with these proposed activities, we expect the chances of a shortnose sturgeon being killed during capture to be low.

Therefore, the capture methodology as proposed is not likely to reduce the viability of the shortnose sturgeon population in North Carolina rivers. By extension, capture is not likely to reduce the viability of shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the netting protocols are used and closely followed.

Handling. Shortnose sturgeon would be handled for length and weight measurements and the other proposed methods under this proposed research authorization. In the Chowan River and tributaries, Cape Fear River and tributaries, and Albemarle Sound, up to 10 shortnose sturgeon annually (or a total of 20 over 5 years) would be handled in each. In the Roanoke River and tributaries, up to 20 shortnose sturgeon annually (or a total of 40 over 5 years) would be handled. Handling and restraining shortnose sturgeon may cause short term stress responses, but those responses are not likely to result in pathologies because of the short duration of handling. Sturgeon are a hardy species, but can be lethally stressed during handling when water temperatures are high or DO is low (Moser *et al.* 2000). Sturgeon may inflate their swim bladder when held out of water (Moser *et al.* 2000) and if they are not returned to neutral buoyancy prior to release, they will float and be susceptible to sunburn and bird attacks.

Sturgeon are 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. Conversely, stress is reduced the sooner fish are returned to their natural environment to recover. 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 or 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).

Expected Response to Handling. Although sturgeon are sensitive to handling stress, the proposed methods of handling fish 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. Mitigation measures described in the environmental assessment, such as wearing rubber gloves to reduce skin abrasions, short handling times, recovering in floating pens, total holding time of less than 2 hours, and an electrolyte bath prior to release, should lessen the chance of injury or mortality during handling and restraint in any of the river systems. To minimize capture and handling stress, the proposed research plans to hold shortnose sturgeon in net pens until they are processed, at which time they would be transferred to a processing station on board the research vessel. During processing, each fish would be immersed in a continuous stream of water supplied by a pump/hose assembly mounted to over the side of the research vessel. For most procedures planned, the total time required to complete routine handling and tagging would be no more than 15 minutes. Moreover, following processing, fish would be returned to the net pen for observation to ensure full (return to equilibrium, reaction to touch stimuli, return of full movement) recovery prior to release.

Therefore, the anesthesia handling as proposed is not likely to reduce the viability of the shortnose sturgeon population in North Carolina rivers. By extension, handling is not likely to reduce the viability of shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the proposed methodology and proposed mitigation measures are closely followed.

Passive Integrated Transponder (PIT) Tags. All shortnose sturgeon captured that are previously unmarked would be marked with PIT tags. No fish would be double-tagged with PIT tags. Prior to PIT tagging, the entire dorsal surface of each fish would be scanned to detect previous PIT tags. Unmarked shortnose sturgeon would receive PIT tags by injection using a 12 gauge needle at an angle of 60^{o} to 80^{o} in the dorsal musculature (anterior to the dorsal fin). The rate of PIT tag retention would be documented and reported to NMFS in annual reports.

PIT tags have been used with a wide variety of animal species that include fish (Clugston 1996, Skalski *et al.* 1998, Dare 2003), amphibians (Thompson 2004), reptiles (Cheatwood *et al.* 2003, Germano and Williams 2005), birds (Boisvert and Sherry 2000, Green *et al.* 2004), and mammals (Wright *et al.* 1998, Hilpert and Jones 2005). When PIT tags are inserted into animals that have large body sizes relative to the size of the tag, empirical studies have generally demonstrated that the tags have no adverse effect on the growth, survival, reproductive success, or behavior of individual animals (Brännäs *et al.* 1994, Elbin and Burger 1994, Keck 1994, Jemison *et al.* 1995, Clugston 1996, Skalski *et al.* 1998, Hockersmith *et al.* 2003). However, some fish, particularly juvenile fish, could die within 24 hours after tag insertion, others could die after several days or months, and some could have sub-lethal reactions to the tags.

If mortality of fish occurs, they often die within the first 24 hours, usually as a result of inserting the tags too deeply or from pathogen infection. About 1.3% of the yearling Chinook salmon (*Oncorhynchus tshawytscha*) and 0.3% of the yearling steelhead (*O. mykiss*) studied by Muir *et al.* (2001) died from PIT tag insertions after 24 hours. In the only study conducted on sturgeon mortality and PIT tags, Henne *et al.* (unpublished) found that 14 mm tags inserted into shortnose sturgeon under 330 mm causes 40% mortality after 48 hours, but no additional mortalities after 28 days. Henne *et al.* (unpublished) also show that there is no mortality to sturgeon under 330mm after 28 days if 11.5mm PIT tags are used. Gries and Letcher (2002) found that 0.7% of age-0 Atlantic salmon (*Salmo salar*) died within 12 hours of having PIT tags surgically implanted posterior to their pectoral fins, but nine months later, 5.7% of the 3,000 tagged fish had died. At the conclusion of a month long study by Dare (2003), 325 out of 144,450 tagged juvenile spring chinook salmon died, but only 42 died in the first 24 hours.

Studies on a variety of fish species suggest that attachment of tags, both internal and external, can result in a variety of sub-lethal effects including delayed growth and reduced swimming performance (Morgan and Roberts 1976, Isaksson and Bergman 1978, Bergman *et al.* 1992, Strand *et al.* 2002, Bégout Anras *et al.* 2003, Robertson *et al.* 2003, Sutton and Benson 2003, Brattey and Cadigan 2004, Lacroix *et al.* 2005). Larger tags and external tags have more adverse consequences, such as impaired swimming, than smaller tags (Bégout Anras *et al.* 2003, Sutton and Benson 2003).

Expected Response to PIT Tags. PIT tags would be used for permanently marking and identifying individual fish by injecting the tags intramuscularly anterior to the dorsal fin. 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). 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 sturgeon mortality within the first 24-48 hours of PIT tag insertion as a result of the tags being inserted too deeply. Henne *et al.* (unpublished) 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 use PIT tags sized 11.9 mm x 2.1 mm on fish ≥ 300 mm TL and would not use the 14 mm tags.

Therefore, the PIT tag methodology as proposed is not likely to reduce the viability of the shortnose sturgeon population in North Carolina rivers. By extension, PIT tagging is not likely to reduce the viability of shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the appropriate sizes of PIT tags are used and tagging protocols are closely followed.

Floy (T-bar Anchor) Tags. All shortnose sturgeon captured would also be marked with Floy tags to incorporate incidental recaptures by commercial and recreational fishermen and other researchers. This would help make collection of information useful for the assessment of the sturgeon population in the action area. In all captured 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 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 in NMFS annual reports.

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 that for the long-term, T-bar anchor tags were most effective (92%), but also noted that all of the insertion points healed slowly or not at all, and, in many cases, minor lesions developed.

Expected Response to Floy (T-bar Anchor) Tags. The use of Floy tags and PIT tags to mark shortnose sturgeon are duplicative means to identify captured fish. However, we believe that the practice is not expected to significantly impact sturgeon health. The attachment of tags may cause some discomfort and pain to shortnose sturgeon. Generally, there is little observable reaction to the injection of PIT tags. However, the injection of Floy tags may result in more noticeable reactions than the injection of PIT tags. There is also a greater potential for injury from the insertion of Floy tags than PIT tags because the tag is typically interlocked between interneural cartilage. Injury may result during attachment, although the potential for this is seriously reduced when tags are applied by experienced biologists and technicians. Mortality is unlikely for either tag type (PIT or Floy).

Injection of Floy tags into the dorsal musculature, however, may result in raw sores that may enlarge overtime with tag movement (Collins *et al.* 1994; Guy *et al.* 1996). Beyond the insertion site, it is unknown what effects the on fish the attachment of Floy tags may have. We know of no long-term studies evaluating the effect of these tags on the growth or mortality of tagged shortnose sturgeon. Anecdotal evidence recounted in NOAA's protocol (Moser *et al*. 2000) suggests that Floy tags have little impact on the fish because a number of shortnose were recovered about 10-years after tagging although no data are available to evaluate any effects on growth rate. Studies on other species suggest that the long-term effect of injecting anchor tags into the muscle may be variable. Researchers have observed reduced growth rates in lemon sharks and northern pike from tagging, whereas studies of largemouth bass did not depict changes in growth rates (Tranquilli and Childers 1982; Manire and Gruber 1991; Scheirer and Coble 1991).

To lessen known negative impacts described above using the Floy tag, sterile tagging technique would be used and methods would require to subsequently monitor dorsal fin tag sites of recaptured sturgeon for any lesions. Additionally, results of tag retention and fish health would be reported to NMFS in annual reports and as requested by NMFS. If impacts of the Floy tags are other than insignificant, NMFS would reevaluate their use in the permit.

Therefore, the Floy tagging methodology as proposed is not likely to reduce the viability of the shortnose sturgeon population in North Carolina rivers. By extension, Floy tagging is not likely to reduce the viability of shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the Floy tag protocols are closely followed.

Tissue Sampling. All shortnose sturgeon captured would be tissue-sampled (1.0 cm^2). The sample would be collected from the trailing margin of soft tissue of one of the pectoral fins using sharp sterilized scissors. Tissue sampling does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact. Many researchers have removed tissue samples according to this same protocol with no mortalities; therefore, we do not anticipate any long-term adverse effects to the sturgeon from this activity (Wydoski and Emery 1983).

Anesthetic. During the five years of research authorized by the proposed permit 14759, up to 5 shortnose sturgeon annually (up to 10 over five years) each in the Chowan River, Roanoke River, Cape Fear River, and Albemarle Sound would be anesthetized with MS-222 at concentrations up to 50 mg/L in order to sedate the fish for transmitter implantation. (The portion of fish anesthetized would be a subset of the group captured and would not increase capture numbers.) MS-222's mode of action prevents the generation and conduction of nerve impulses directly affecting the central nervous system, cardiovascular system, neuromuscular junctions, and ganglion synapses (Brown 1988). It is rapidly absorbed through the gills. However, because MS-222 is acidic and poorly absorbed, resulting in a prolonged induction time, Sodium bicarbonate (NaHCO3) would be used to buffer the water to a neutral pH.

MS-222 is a recommended anesthetic for sturgeon research when used at correct concentrations (Moser *et al.* 2000, USFWS 2008; *but see* Henyey *et al*. 2002, preferring electronarcosis to MS-222). It is rapidly absorbed through the gills and its mode of action is to prevent the generation and conduction of nerve impulses with direct actions on the central nervous system and cardiovascular system. Lower doses tranquilize and sedate fish while higher doses fully anesthetize them (Taylor and Roberts 1999). In 2002, MS-222 was FDA-approved for use in aquaculture as a sedative and anesthetic in food fish (FDA 2002).

One risk associated with employing MS-222 to anesthetize sturgeon is using concentrations at harmful or lethal levels. Studies show short-term risks of using MS-222 to anesthetize sturgeon other than shortnose, but show no evidence of irreversible damage when concentrations are used at precise recommended levels. A study on steelhead and white sturgeon revealed deleterious effects to gametes at concentrations of 2,250 to 22,500 mg/L MS-222, while no such effects occurred at 250 mg/L and below (Holcomb *et al.* 2004). Another study did not find MS-222 to cause irreversible damage in Siberian sturgeon, but found MS-222 to severely influence blood constituents when currently absorbed (Gomulka *et al*. 2008; *see also* Cataldi *et al.* 1998 for Adriatic sturgeon).

The above studies show use risks of MS-222 to other sturgeon species, but also show that irreversible damage could be avoided if researchers use proper concentrations. Pertaining to shortnose sturgeon specifically, studies conducted by Haley 1998, Moser *et al.* 2000, Collins *et al.* 2006, 2008 show success with MS-222 at recommended levels (concentrations up to 150 mg/L).

Effects of MS-222 would be short-term and only affect the target species. MS-222 is excreted in fish urine within 24 hours and tissue levels decline to near zero in the same amount of time (Coyle *et al*. 2004). To increase absorption time and ensure a fast anesthesia process, the applicant will add sodium bicarbonate to buffer the acidic MS-222 to a more neutral pH. Therefore, at the proposed rates of anesthesia, narcosis would take one minute and complete recovery time would range from three to five minutes (Brown 1988).

Studies show that recovery from anesthetic stress is more of a concern than the anesthetic itself, which leaves the body in 24 hours. Scientists have examined physiological responses of other fish species to MS-222. MS-222 has increased stress response in rainbow trout (Wagner *et al*. 2003), channel catfish (Small 2003), and steelhead trout (Pirhonen and Schreck 2003), as indicated by elevated plasma cortisol levels (Coyle et al. 2004). Additionally, a comparison of steelhead trout controls to MS-222-treated steelhead revealed an anesthetic stress response regarding feed. Steelhead sampled at 4, 24, and 48 hours after MS-222 exposure fed less than their controlled counterparts (Pirhonen and Schreck 2003). These studies indicate sublethal physiological concerns if duration of exposure is not limited.

Expected Response to Anesthetic. Due to the fact that the applicant aims to use a concentration up to 50 mg/L within the recommended limitations of MS-222 (which are up to 150 mg/L) and ensure that fish are anesthetized for a short period of time, NMFS believes that most shortnose sturgeon sedated by MS-222 would be exposed only to minimal short-term risk and should recover to normal. The applicant aims to avoid the possibility of irreversible effects by following concentration recommendations and recovery procedures used in successful shortnose sturgeon diet studies with similar methodologies (Haley 1998, Moser *et al.* 2000, Collins *et al.* 2006, 2008). Because MS-222 is acidic and poorly absorbed, resulting in a prolonged induction time, Sodium bicarbonate (NaHCO3) would be used to buffer the water to a neutral pH. At the proposed rate, induction time would be approximately three to five minutes and complete recovery times would range from five to six minutes (Brown 1988). MS-222 would be excreted in fish urine within 24 hours and tissue levels would decline to near zero in the same amount of time (Coyle *et al.* 2004). The applicant seems to address stress concerns by limiting duration of anesthesia and monitoring recovery in boat-side net pens before releasing fish.

Therefore, the anesthesia methodology as proposed is not likely to reduce the viability of the shortnose sturgeon population in North Carolina rivers. By extension, MS-222 anesthesia is not likely to reduce the viability of shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the appropriate concentrations of MS-222 are used and proposed duration exposure and procedures are closely followed.

Internal Sonic Transmitters. Up to 5 shortnose sturgeon annually (up to 10 over five years) each in the Chowan River, Roanoke River, Cape Fear River, and Albemarle Sound would be collected for surgical implantation of sonic transmitters using the protocol measures presented in Moser *et al.* (2000). Applicants would use Vemco V-7, V-9, V-13, or V-16 (see Table 3) sonic transmitter devices limited in size to no more than 2% of a given fish's body weight. These same fish will have also been tagged with PIT and Floy tags and will have undergone all of the procedures mentioned above. Although more invasive surgical procedures are required for this internal implantation, these tags provide greater retention rates than external attachment (Collins *et al*. 2002; Counihan and Frost 1999).

In general, adverse effects of these proposed tagging procedures 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. Choice of surgical procedure, fish size, morphology, behavior and environmental conditions can affect the success of telemetry transmitter implantation in fish (Jepsen *et al*. 2002).

Survival rates after implanting transmitters in shortnose sturgeon are high. Collins *et al*. (2002) evaluated four methods of radio transmitter attachment on shortnose sturgeon. They found 100% survival and retention over their study period for ventral implantation of a transmitter with internally-coiled antenna. Their necropsies indicated there were no effects on internal organs. Dr. Collins in South Carolina (M. Collins, *pers. comm., November 2006*) has also more recently reported no mortality due to surgical implantation of internal transmitters. 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 Delaware River. Eleven of these fish were relocated a total 115 times. 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 4 months. Periodic checks for an additional 2 months also showed no movement. Although there were no known mortalities directly attributable to the implantation procedure; the status of the 3 unrelocated individuals was unknown (Devries 2006).

Growth rates after transmitter implantation are reported to decrease for steelhead trout. Welch *et al.* (2007) report results from a study to examine the retention of surgically-implanted dummy acoustic tags over a 7 month period in steelhead trout pre-smolts and the effects of implantation on growth and survival. Although there was some influence in growth to week 12, survival was high for animals > 13 cm FL. In the following 16 week period growth of surgically implanted pre-smolts was the same as the control population and there was little tag loss from mortality or shedding. By 14 cm FL, combined rates of tag loss (mortality plus shedding) for surgically implanted tags dropped to < 15% and growth following surgery was close to that of the controls.

Tag weight relative to fish body weight is an important factor in determining the effects of a tag (Jepsen *et al.* 2002). The two factors directly affecting a tagged fish are tag weight in water (excess mass) and tag volume. Perry *et al.* (2001) studied buoyancy compensation of Chinook salmon smolts tagged with surgical implanted dummy tags. The results from their study showed that even fish with a tag representing 10% of the body weight were able to compensate for the transmitter by filling their air bladders, but the following increase in air bladder volume affected the ability of the fish to adjust buoyancy to changes in pressure. Winter (1996) recommended that the tag/body weight ratio in air should not exceed 2%. Tags of greater sized implants produced more mortality of juvenile Atlantic salmon. There was 60% mortality (3 of 5 fish) with a 32-mm implant and 20% mortality (1 of 5 fish) with a 28-mm implant and 20% mortality (1 of 5 fish) with a 24-mm implant (Lacroix *et al.* 2004). Fish with medium and large external transmitters exhibited lower growth than fish with small transmitters or the control group (Sutton and Benson 2003).

Implanted transmitters could affect fish swimming performance. Thorstad *et al.* (2000) studied the effects of telemetry transmitters on swimming performance of adult farmed Atlantic salmon. These researchers found that swimming performance and blood physiology of adult Atlantic salmon (1021-2338 g, total body length 45-59 cm) were not affected when equipped with external or implanted telemetry transmitters compared with untagged controls. There was no difference in endurance among untagged salmon, salmon with small external transmitters, large external transmitters and small body-implanted transmitters at any swimming speed. Authors cautioned that results of wild versus farmed salmon may be different (Peake *et al.* 1997). However, a similar study using sea-ranched Atlantic salmon found no difference in endurance, similar to the farmed salmon study (Thorstad *et al.* 2000). On the other hand, juvenile Chinook salmon < 120 mm FL with either gastrically or surgically implanted transmitters had significantly lower critical swimming speeds than control fish 1 and 19-23 days after tagging (Adams *et al.* 1998).

Implanted transmitters could effect fish growth. Juvenile Chinook salmon with transmitters in their stomachs (gastrically implanted) consistently grew more slowly than fish with surgically implanted transmitters, fish with surgery but no implanted transmitter, or fish exposed only to handling (Adams *et al.* 1998).

Water temperature has been shown to affect rainbow trout implanted with simulated transmitters. 80 rainbow trout were implanted with simulated transmitters and held at various temperatures for 50 days (10, 15, 20 degrees) (Bunnell and Isely 1999). Transmitter expulsion ranged from 12% to 27% and was significantly higher at 20 degrees C than at 10 degrees C. Mortality ranged from 7 – 25% and was not related to temperature.

Since implantation requires surgery, healing is frequently described in the relevant scientific literature. Several factors can affect obstacles to wound healing in fish including secondary infection and inflammation. Fish epidermal cells at all levels are capable of mitotic division, and during wound healing there is a loss of the intracellular attachments and cells migrate rapidly to cover the defect and provide some waterproof integrity (Wildgoose 2000). This leads to a reduction in the thickness of the surrounding epidermis and produces a thin layer of epidermis at least one cell thick over the wound, however the process can be inhibited by infection (Wildgoose 2000). Thorstad *et al*. (2000) state that incisions were not fully-healed in 13 of the farmed Atlantic salmon with implanted transmitters; two of these had signs of inflammation. Juvenile largemouth bass implanted with microradio transmitters exhibited short-term (5 days) inflammation around the incision and suture insertion points for both non-absorbable braided silk and non-absorbable polypropylene monofilament, but in the longer term (20 days) almost all sutures were shed and the incisions were completely healed (Cooke *et al*. 2003). Chapman and Park (2005) examined suture healing following a gonad biopsy of Gulf of Mexico sturgeon and found both the absorbable and nonabsorbable sutures to effectively sew the skin after biopsy with all sturgeons surviving surgery and incisions healing 30 days after the intervention. Dummy radio transmitters compounded the inflammatory effect silk sutures had on healing incisions compared with inflammation without transmitters (Wagner *et al*. 2000).

The expulsion or rejection of surgically implanted transmitters has been reported from a number of studies, therefore, expulsion could be an argument for using externally attached transmitters. It does not appear that expulsion causes further complications or death in fish that manifest this occurrence. Such expulsions often occur shortly after tagging and can lead to premature end of studies. Rates of tag shedding and ways of implant exits depend on species, fish condition, tag weight and environmental conditions (Jepsen *et al*. 2002). There are basically three ways for an implant to exit; through the incision, through an intact part of the body wall and through the intestine. Trans-intestinal expulsion is rare but has been occasionally reported in rainbow trout (Chisholm and Hubert 1985). Five months after tagging, 20% of juvenile Atlantic salmon had expelled their tags through the body wall, adjacent to the healed incision (Moore *et al*. 1990). No mortality or infection occurred as a result of tag expulsion, and fish continued to mature and behave like the control fish. Expulsion occurred in 13 of 22 rainbow trout tagged with dummy tags coated with paraffin wax within 42-175 days after tagging (Chisholm and Hubert 1985). In another study of rainbow trout, three of 21 fish expelled their tags via body wall without subsequent mortality (Lucas 1989). Tag expulsion by juvenile Atlantic salmon during Lacroix *et al.*'s study occurred but was not a cause of death (2004). Two surgically implanted transmitters were also apparently expelled by Atlantic sturgeon (Moser and Ross 1995). In Kieffer and Kynard's (1993) study, one shortnose sturgeon implanted with a sonic tag rejected its internal tag.

Coating the transmitters has been suggested to vary the rate of expulsion. It has been hypothesized that paraffin coating of the transmitter increases expulsion rate (Chisholm and Hubert 1985). Moser and Ross (1995) reported that retention of surgically implanted tags could be improved for Atlantic sturgeon when the transmitters were coated with a biologically inert polymer, Dupont Sylastic. Additionally, Kieffer and Kynard (*In press*) report that tag rejection internally is reduced by coating tags with an inert elastomer and by anchoring tags to the body wall with internal sutures. Kieffer and Kynard's fish retained tags for their operational life, and in most cases, lasted much longer (mean, 1,370.7 days).

Expected Response to Internal Sonic Transmitters. We expect that shortnose sturgeon exposed to internal sonic transmitter implantation would respond similar to the available information presented above. Survival rates are expected to be high with no ill effects on internal organs expected as a result of the transmitters. We do not expect mortality to occur as a result of this procedure, although a few tagged fish from studies reported above have disappeared and their fate is unknown. We expect that growth rates or swimming performance could be affected and that expulsion of the transmitter could occur. There have been no mortalities or infections reported to be associated with expulsion. We expect that the surgical wound would heal normally, but acknowledge that adverse effects of these proposed tagging procedures 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. The research methodologies will minimize these risks, as choice of surgical procedure, fish size, morphology, behavior and environmental conditions can affect the success of telemetry transmitter implantation in fish (Jepsen *et al*. 2002).

PR1 proposes to authorize the use of standardized protocols endorsed by NMFS (Moser *et al*. 2000) which aim to minimize the effects caused by internally implanting transmitter tags. To ensure the sturgeon can endure the weight of these tags, a condition would be imposed stating that the total weight of all transmitters and tags would not exceed 2% of the fish's body weight. Surgical implantation of internal tags would only be attempted when fish are in excellent condition, and would not be attempted on pre-spawning fish in spring or fish on the spawning ground, nor in water temperatures greater than 27^{o}C or less than 7^{o}C. By using proper anesthesia, sterilized conditions, precautions, and the surgical techniques described above, these procedures would not be expected to have a significant impact on the normal behavior, reproduction, numbers, distribution or survival of shortnose sturgeon.

VIII. Cumulative Effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered by this Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

NMFS expects the natural and human-induced phenomena in the action area will continue to influence shortnose sturgeon as described in the Environmental Baseline. However, it is the combination and extent to which these phenomena will affect shortnose sturgeon that remains unknown.

Future federal actions as well as scientific studies contributing to conservation or recovery of shortnose sturgeon will require consultation under the ESA and such studies are not included in the *Cumulative Effects* section of this Opinion. Sources queried for the information on non-federal activities include the U.S. Census Bureau and Lexis-Nexis news and law online search engine. On Nexis, we reviewed bills passed from 2008-2010 and pending bills under consideration were included as further evidence that actions are reasonably certain to occur. In addition, statutes already in place that continue to provide the authority of state agencies to regulate anthropogenic effects were reviewed. State regulation is critical for future anthropogenic impacts in a region. Pending and existing legislation for the states of North Carolina and Virginia address water supply and water quality concerns; riparian and coastal development; ecosystem, natural resource, and endangered species recovery and protection; soil conservation; and regulation of fisheries and invasive species.

IX. Integration and Synthesis of Effects

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Brandon 1978, Mills and Beatty 1979, Stearns 1992, Anderson 2000). As a result, if the assessment indicates that listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment.

The narrative that follows integrates and synthesizes the information contained in the *Status of the Species*, the *Environmental Baseline*, and the *Effects of the Action* sections of this Opinion to assess the risk the proposed activities pose to shortnose sturgeon. There are known cumulative effects (i.e., from future state, local, tribal, or private actions) that fold into our risk assessment for this species.

The proposed issuance by PR1 of scientific research Permit No. 14759 to Joseph Hightower, North Carolina Cooperative Fish and Wildlife Research Unit, would authorize directed take of shortnose sturgeon in the Chowan, Roanoke, and Cape Fear Rivers as well as Albemarle Sound. The proposed activities under this permit include capture, handling, PIT and Floy tagging, tissue sampling, anesthesia, and sonic transmitter implantation. The *Status of listed resources* section identified the construction of dams throughout the shortnose sturgeon's range as the main factor that probably reduced their reproductive success which, in turn, could be the primary reason for the reduction in population size for shortnose sturgeon. Other threats to the survival and recovery of shortnose sturgeon include habitat fragmentation and loss, siltation, water pollution, decreased water quality (low DO, salinity alterations), bridge construction, dredging and blasting, incidental capture in coastal fisheries, impingement on intake screens of power plant operations, and land use practices. Reasonably likely future actions described in the *Cumulative effects* section include state legislation to address water supply and water quality concerns; riparian and coastal development; ecosystem, natural resource, and endangered species recovery and protection; soil conservation; and regulation of fisheries and invasive species. Shortnose sturgeon population estimates are available for the Cape Fear River, but the other North Carolina populations remain unknown.

Permit 14759 would be valid for five years from the date of issuance and would authorize non-lethal sampling methods on up to 10 shortnose sturgeon annually each in the Chowan River, Cape Fear River, and Albemarle Sound (not to exceed 20 over 5 years); it would also authorize non-lethal sampling methods on up to 20 shortnose sturgeon annually in the Roanoke River (not to exceed 40 over 5 years). Each fish would be captured, handled, weighed, measured, Floy and PIT tagged, tissue sampled, allowed to recover and released. Additionally, a subset of 5 fish from those captured in each area would be anesthetized and surgically implanted with a sonic transmitter.

Although some degree of stress or pain is likely for individual fish captured, handled and tagged, and while tagging and tissue sampling will result in tissue injuries, none of the research procedures are expected to result in mortality or reduced fitness of individuals. Delayed or aborted spawning for some individual fish is a possibility, but the likelihood is remote given the mitigation measures proposed. The proposed permit is not expected to affect these population's reproduction, distribution, or numbers. Because the proposed action is not likely to reduce the these population's likelihood of surviving and recovering in the wild, it is not likely to reduce the species' likelihood of surviving and recovering in the wild.

IX. Conclusion

After reviewing the current status of endangered shortnose sturgeon, the environmental baseline for the action area, the effects of the proposed research program, and the cumulative effects, it is NMFS's biological opinion that the issuance of this permit to Joseph Hightower, North Carolina Cooperative Fish and Wildlife Research Unit is not likely to jeopardize the continued existence of the endangered shortnose sturgeon. Critical habitat has not been designated for shortnose sturgeon.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The following conservation recommendations would provide information that would improve the level of protections afforded in future consultations involving proposals to issue permits for research on the endangered shortnose sturgeon:

1. *Cumulative Impact Analysis.* Before authorizing any additional permits for activities similar to those contained in the proposed permits, F/PR1 should work with the shortnose sturgeon recovery team and the research community to develop protocols that would have sufficient power to determine the cumulative impacts (that is, includes the cumulative

lethal, sub-lethal, and behavioral consequences) of existing levels of research on individuals populations of shortnose sturgeon.

REINITIATION NOTICE

This concludes formal consultation on the proposed permit to Joseph Hightower, North Carolina Cooperative Fish and Wildlife Research Unit (Permit No. 14759) pursuant to the provisions of section 10 of the Endangered Species Act. Reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of allowable take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

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