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

Biological Opinion

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

Activity Considered: Biological Opinion on the Endangered Species Division section 6 Program's decision to award an Endangered Species Act section 6 grant to the Mississippi Department of Wildlife, Fisheries, and Parks (Award File NA10NMF4720034) to conduct research on Gulf sturgeon in the Pascagoula River Estuary.

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

Approved by: ______________________

Date: MAY 19 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 – Endangered Species Division section 6 Program. The consulting agency is NMFS' Office of Protected Resources – Endangered Species Division section 7 Program.

This document represents NMFS' Biological Opinion (Opinion) on the effects of the proposed section 6 grant award to fund studies on endangered and threatened species and critical habitat, and has been prepared in accordance with section 7 of the ESA as implemented by 50 CFR 402.14(g)-(j). This Opinion is based on our review of the Endangered Species Division's draft Environmental Assessment, grant application, the Gulf sturgeon recovery plan and 5-year Review, 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).

This consultation examines the NMFS Endangered Species Division section 6 Program's (PR3 section 6 Program) decision to award a grant (Award File No. NA10NMF4720034) which would fund scientific research activities on Gulf sturgeon in the Pascagoula River Estuary, Mississippi. The activities that would be funded through the proposed action have been authorized under delegated authorities granted to the Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) by the U.S. Fish and Wildlife Service under an ESA section 6 agreement for scientific collecting and handling permits for federally listed threatened species in Mississippi. MDWFP has delegated this responsibility to the Mississippi Museum of Natural Science.

CONSULTATION HISTORY

On February 4, 2010, the PR3 section 6 Program and the NMFS Endangered Species Division section 7 Program (PR3 section 7 Program) held a meeting to discuss the section 6 grants to be awarded for 2010. At that meeting, Award NA10NMF4720034 was discussed and a decision on how to move forward with consultation was reached. On March 13, 2010, the PR3 section 6 Program sent an initiation package to the PR3 section 7 Program for Award NA10NMF4720034, and on March 23, 2010, the PR3 section 7 Program initiated consultation.

BIOLOGICAL OPINION

I. DESCRIPTION OF THE PROPOSED ACTION

The proposed action addressed in this Opinion is the PR3 section 6 Program's decision to award a grant to the MDWFP, which would fund research on Gulf sturgeon in the Pascagoula River Estuary, Mississippi. The section 6 grant would provide 75 percent of the cost of the project and the State of Mississippi would provide 25 percent. The authority for the PR3 section 6 Program's grant award is section 6 of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq*.). The grant award would fund the purposeful harassment, harm, wounding, trapping, capture, or collection ("take[1]") of threatened Gulf sturgeon (*Acipenser oxyrinchus*) for scientific purposes. At present, take is not prohibited for threatened Gulf sturgeon, therefore, this Opinion did not analyze take authorizations. Instead, it analyzed whether the amount and extent of take would likely be enough to jeopardize the threatened Gulf sturgeon.

The activity proposed under Award NA10NMF4720034 is the award of grant money to fund 75 percent of MDWFP's Gulf sturgeon research activities. Award NA10NMF4720034 would fund MDWFP's Gulf sturgeon research for three years (June 2010 to May 2013) subject to semi-annual review by NMFS. The purpose of the research activities funded by the grant would be to identify feeding habitat for and movement of the juvenile/sub-adult cohort of Gulf sturgeon in the Pascagoula River Estuary. Activities slated to achieve this purpose include directed Gulf sturgeon capture; gill netting; genetic sampling; PIT and Floy tagging; radio transmitter

[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."

implantation with anesthesia; and acoustic telemetry of approximately 10 Gulf sturgeon per year (approximately 30 fish over three years). The activities that would be funded through the proposed action have been authorized under delegated authorities granted to the MDWFP by the U.S. Fish and Wildlife Service under an ESA section 6 agreement for scientific collecting and handling permits for federally listed threatened species in Mississippi. MDWFP has delegated this responsibility to the Mississippi Museum of Natural Science.

Capture/Gill Netting. Approximately 10 sturgeon (targeting juvenile and sub-adult, but could capture adults) per year for a total of 30 for the entire three-year grant will be captured by gill net and subject to all of the following procedures. Each gill net would consist of multifilament that is 5.0 or 6.3 cm bar mesh, 1.83 m deep, or a 10.2 cm bar mesh, 2.4 m deep, 61 m long. A majority of the gill nets will be set, however, a few may be drifted. Gill netting would take place from daylight to dusk up to 3 days per week (weather and gear dependent). Netting targeting juvenile and sub-adult sturgeon would occur in February-late April in 2011, 2012, and 2013 near the mouths of the West and East Pascagoula River. Netting targeting juveniles and sub-adults would also occur (May-September, 2011 and 2012 only) attempting to recapture previously tagged fish. Temperature, dissolved oxygen, salinity and water depth would also be measured. Sturgeon would be netted at temperatures 27 ^{O}C or below. Set nets would be attended regularly (checked at least every 2 hours) and would be removed if marine mammals were present. Drift nets would be monitored continuously and would also be removed if marine mammals were present. Once captured, sturgeon would be removed and placed in a live well on the boat, with continual water changes, while processing is occurring.

General Handling (e.g., holding, measuring, weighing). Fish handling and tagging operations would adhere to the animal care policies of the American Association of Ichthyologists and the American Fisheries Society (ASIH, AFS, AIFRB, 1988). All University Animal Care and Use (IACUC) protocols would be in place prior to initiation of the project.

To minimize handling stress, each fish would be moved and handled using latex gloves. Each fish, minimum size approximately 50 cm total length (TL), would be measured for TL and wet weight (WW) and checked for any external tags and any potential PIT tags (recaptures). Sturgeon would be weighed with a standard hanging scale or 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 fiberglass tape measure to the nearest centimeter. The time required to complete the standard sampling (i.e., removing from net, measuring, weighing, move to live well) would be 5 minutes per fish.

Following processing, all fish would be treated with slime coat restorative (Stress Coat, Aquarium Pharmaceuticals, Inc.) and released back to the water after full recovery. This portion of the handling would take an additional 10-15 minutes.

Genetic Tissue Sampling. Following USFWS standard operating procedures (1993), the applicant would remove a (1 cm^2 or less) non-deleterious tissue sample from the base of the dorsal (occasionally anal) fin for genetic work. These materials would be provided to Dr. Brian Kreiser at the University of Southern Mississippi for storage and ultimately for processing.

PIT and Floy (T-bar Anchor) Tagging. Each sturgeon would also be tagged with both PIT and Floy tags. AVID 134.2 kHz PIT tags would be applied with a sterile single use disposable syringe. The PIT tag would be loaded into the syringe and the needle inserted anterior and horizontally into the center of the fleshy base of the dorsal fin on the left side of the fish. The syringe plunger would then be depressed thereby inserting the tag. Finger pressure would be applied to the site of tag insertion as the syringe is withdrawn to prevent the PIT tag from backing out through the tagging wound. FLOY T-bar anchor tags would be attached with a Mark III scissor grip fish tagger in the fleshy portion of the pectoral fin proximal to the body. The tagger needle would then be pressed through the skin, the trigger is depressed, and the tagger is withdrawn. The T-bar tag would be lightly pulled to set the tag.

Transmitter Implantation and Anesthesia. Each Gulf sturgeon would also be anesthetized and surgically implanted with a transmitter. All of the fish selected for surgical implantation of tags would visually be in good overall health. All implanted sonic transmitters would also be limited in size to no more than 2% of a fish's body weight. Specifications of transmitters that would be used are as follows:

Model	Length (mm)	Diameter (mm)	Weight (H2O) (gm)	Weight (O2) (gm)
V7	22.5	7.0	1.0	1.8
V9	21.0	9.0	1.6	2.9
V13	36.0	13.0	6.0	11.0
V16	98.0	18.0	16.0	36.0

Surgeries would be performed in a rubber coated mesh sling held by a wooden table at a working height of 1.0 m. During surgery the sturgeon's body would be kept moist by flowing water from an adjustable, low-volume pump, and water would be delivered over the sturgeon's gills by placing a tube into the mouth. The pump would pull water from an open 75 liter cooler placed directly below the sturgeon; the cooler would also catch water as it drains away. The draining action of the water stream falling 0.8 m into the cooler serves to re-oxygenate the water as it re-circulates; the water in the cooler would also be replaced every 30 minutes. A 19 liter bucket with anesthesia would be placed inside the cooler, and when anesthesia is needed, the pump would be placed inside the bucket and the bucket would be placed under the fish to catch the draining "anesthesia water." When it is time to bring the fish out of anesthesia, the pump would be placed back into the freshwater in the cooler. To reduce stress, the sturgeon and crew would be shaded by a Bimini® top over the work area. To minimize handling stress, each fish would be moved and handled by researchers using latex gloves.

All sturgeons would be scanned for the presence of PIT tags and if none were recorded a PIT tag would be implanted at the base of the dorsal fin in accordance to standardized NMFS protocols (Moser et al. 2000). Additionally, each sturgeon would be scanned for the presence of a functional acoustic transmitter using a VEMCO receiver and hydrophone. Sturgeon with an operational transmitter would not be implanted with a new transmitter to avoid code collision between acoustic tags.

The following 3-5 minute transmitter implantation surgery under surgical anesthesia (Coyle et al. 2004) would be used. Gulf sturgeon selected for transmitter implantation would be netted at temperatures 27 ^O C or below. Each sturgeon would be anaesthetized as described above using a solution of 100-150 mg/L of tricaine methane sulfonate (MS-222) buffered to neutral pH with sodium bicarbonate or seawater. This solution would be administered until a state of anesthesia is reached (i.e., loss of equilibrium, little reaction to touch stimuli, cessation of movement, except for opercula movement). The anesthetic's induction and recovery time would vary but would be appropriate for sturgeon under the specific water temperature and oxygen conditions present (Fox et al. 2000). Just prior to the surgical procedure, the tube supplying the anesthetic would be removed and the sturgeon placed on the moist surgery 'rack'.

Respiration would be maintained by directing fresh ambient water pumped across the gills with tube inserted in the animals' mouth. The incision site (about 40 to 60 mm anterior to the pelvic fins) would be disinfected with Betadyne, and a sterile surgical scalpel would be used to make a 10 mm incision. Sterilized sonic transmitters, coated with an inert polymer compound, would be inserted into the surgical openings of sturgeon, and the incision would be closed with resorbable sutures. A thin layer of petroleum jelly mixed with Betadyne would then be spread over the incision areas to protect against infection (Fox et al. 2000).

Following processing, all fish would be placed in a separate net pen or recovery tank to ensure full recovery prior to release. Any fish not responding readily would be recovered further in the net pen by holding the fish upright and immersed in river water within a net pen and gently moving the fish front to back to aid freshwater passage over the gills to stimulate the fish. When showing signs of being able to swim away strongly, the fish would be released and a spotter would watch to make sure the fish stays down and is fully recovered.

Telemetry Receivers/Acoustic Arrays. Up to 40 Vemco telemetry receivers would be deployed from Interstate 10 south in the west and east Pascagoula River to the M.S. Sound and adjacent nearshore areas. Signals from the acoustic transmitters would be detected by an array of VEMCO VR2W units (submersible, single-channel hydrophone/receiver/ID detector/data logger/power source). While a number of VR2W units have been deployed in the past, new VR2W units coupled with the old ones would be placed throughout the study area to form an acoustic screen in the area described above. New VR2W units would be attached to buoys (see Peterson *et al*. 2008; Havrylkoff *et al*. 2009) or mounted on other stable structures. Coordination of placement of remote receivers would occur between MSDMR, the Pascagoula Port Authority, and the USCOE-Mobile District prior to deployment. The units (13 old and 15 new ones in year 1) would be deployed starting in late January 2011, and inspected and downloaded bi-weekly. Additional units would be put into service as in years 2 and 3. In addition to the anchored array, researchers would search for tagged fish (May-Sept 2011 and 2012) at least once per week with a directional hydrophone (Vemco VH110) and receiver (Vemco VR100) deployed from a boat similar to methods described by Ross *et al.* (2009). Development of spatial models using remote sensing data and management of the database would take place within a laboratory or office setting and do not involve the taking or handling of fish or samples. Data from the VR2W units would be a date/time stamped sequence of detections of individually identified Gulf sturgeon.

Benthic Sampling. Sampling for benthic resources and sediment characterization would occur in either January-February 2011 or August 2011 in areas covered by acoustic arrays. A total of 210 infaunal and sediment samples would be collected in a systematic grid across the entire sampling area in either January-February 2011 or August 2011 in areas covered by the acoustic arrays. Near surface (0-5 cm) benthic samples would be collected using a Wildco petite ponar dredge sampler (15 x 17 cm opening), including sediments from at least three independent samplings within a 2 m^2 radius of each station. Samples would be immediately transported to the laboratory for processing and analysis. Temperature, dissolved oxygen, salinity and water depth would also be measured.

II. SPECIAL AWARD AND PERMIT CONDITIONS

As stated previously, the activities that would be funded through the proposed action have been authorized under delegated authorities granted to the MDWFP by the U.S. Fish and Wildlife Service under an ESA section 6 agreement for scientific collecting and handling permits for federally listed threatened species in Mississippi. MDWFP has delegated this responsibility to the Mississippi Museum of Natural Science. The MDWFP currently has a permit for Gulf sturgeon research, Administrative Scientific Collecting Permit Number 0222101, from the Mississippi Museum of Natural Science. The permit conditions as stated in Permit Number 0222101 are reproduced below. In addition, the PR3 section 6 Program included Special Award Conditions (SACs), which are mitigation measures that MDWFP has agreed to and that appear within the permit conditions and restrictions below. These mitigation measures are part of the proposed action and must therefore be implemented by the recipient.

ADMINISTRATIVE SCIENTIFIC COLLECTING PERMIT NUMBER 0222101
Permit is valid from 1 March 2010 to 28 February 2011.

SPECIFIC CONDITIONS AND RESTRICTIONS:

1) All gill nets must be marked with the name of the institution, and the collecting permit number.
2) When targeting sturgeon, gill nets must be checked regularly (at least every two hours) to minimize harm to sturgeon captured in the nets.
3) Holding and processing time of captured sturgeon should be minimized when water temps are high ($\geq$ 27 C). At and above this temperature, total holding and processing time must not exceed 30 minutes.
4) All capture, holding, processing, and tagging of Gulf Sturgeon must be in accordance with USFWS and NOAA guidelines.
5) Any mortality of Gulf Sturgeon during capture or processing should be reported to MDWFP (Scott Peyton, Sherry Surrette, or Matt Roberts at 601-354-7303) within 48 hours.
6) This permit does not authorize taking any other state or federally listed species (see attached list).

GENERAL CONDITIONS AND RESTRICTIONS:

1) Specimens retained after collection must be placed in a public museum or collection where they will be available for examination by the scientific community. The Mississippi Museum of Natural Science (MMNS), 2148 Riverside Drive, Jackson, MS 39202-1353, ph: (601) 354-7303, is the principal repository of terrestrial and freshwater vertebrates, freshwater mollusks, and crayfish collected in Mississippi, and welcomes additional specimens. Unless alternative arrangements are made with the MMNS Collections manager (Scott Peyton, 601-354-7303) or curatorial staff at the MMNS, all collections of federally listed and state listed species will be deposited at the Mississippi Museum of Natural Science.

2) This permit does not authorize the taking of any federally threatened or endangered species or any state endangered species (list attached), unless otherwise specified in this permit.

REQUIRED COLLECTING PERMIT REPORTS

1) A collecting permit report using format described below must be filed within 15 days of the expiration of the permit. A new permit will not be issued until the report has been received. Collection reports should list taxa collected, number of individuals of each, exact collection locality and date of collection. Locality information must include the county of collection, and it is preferred that precise locality information be provided in latitude/longitude (GPS) or in the township, range, and section (TRS) system. If the TRS system is used, precise location within a section should be indicated (e.g.: NW4 of SE4 of Sec 11), if possible. If GPS or TRS information is not provided, include instead a clear and precise description of the location of the collection site relative to the nearest named or numbered road, town, intersection, and/or other feature(s) likely to be mapped on a USGS quad map. For aquatic species, provide the name of the stream in which collections were made.

   <u>Instructions for completing Scientific Collections Report</u>:
   Below is a list of information that should be included in scientific collecting reports, if it applies to the activities covered by the collecting permit. If you have any questions, please contact Scott Peyton at 601-354-7303 or collections.manager@mmns.state.ms.us.

   A. SPECIES - species name (scientific name), or lowest taxonomic description possible, for each collected taxon
   B. SACRIFICED - If specimens were killed for vouchers or other scientific purposes, indicate the number taken.
   C. NUMBER – total number of each species collected or handled. Include both the number taken and the number released in this total.
   D. DATE – specific date of each collection
   E. COUNTY – county where each collection occurred.
   F. COORDINATES (X) - latitude/longitude, UTM coordinates
   G. COORDINATES (Y) - latitude/longitude, UTM coordinates

H. UTM ZONE – UTM coordinates only
I. TRS - Township, Range and Section (optional, but please include if possible)
J. LOCALITY - brief description of locality, e.g. Chickasawhay River 100m upstream from HWY 84 bridge
K. COLLECTOR(S) – person or persons who made the collection.
L. TISSUE - Indicate the number of specimens from which tissue samples were taken for genetic analysis or other purposes. If no tissue samples were taken, this column can be omitted.
M. DISPOSITION - For sacrificed specimens or tissue samples, list institution(s) where specimens/samples were deposited. For specimens released, indicate where the specimens were released.
N. TEMP EXP or TEMP PROP - If specimens are held in captivity temporarily for experimental purposes or for propagation and later released, a field should be included to capture this information.
O. TAGGED - If specimens are marked or tagged and released, a field should be included to capture this information.

2) Those collecting federally listed species specified in this permit must submit an additional report to the state, due the first week of October, detailing collections of listed species made between 1 October of the previous year and 30 September of the current year.

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 Gulf 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.

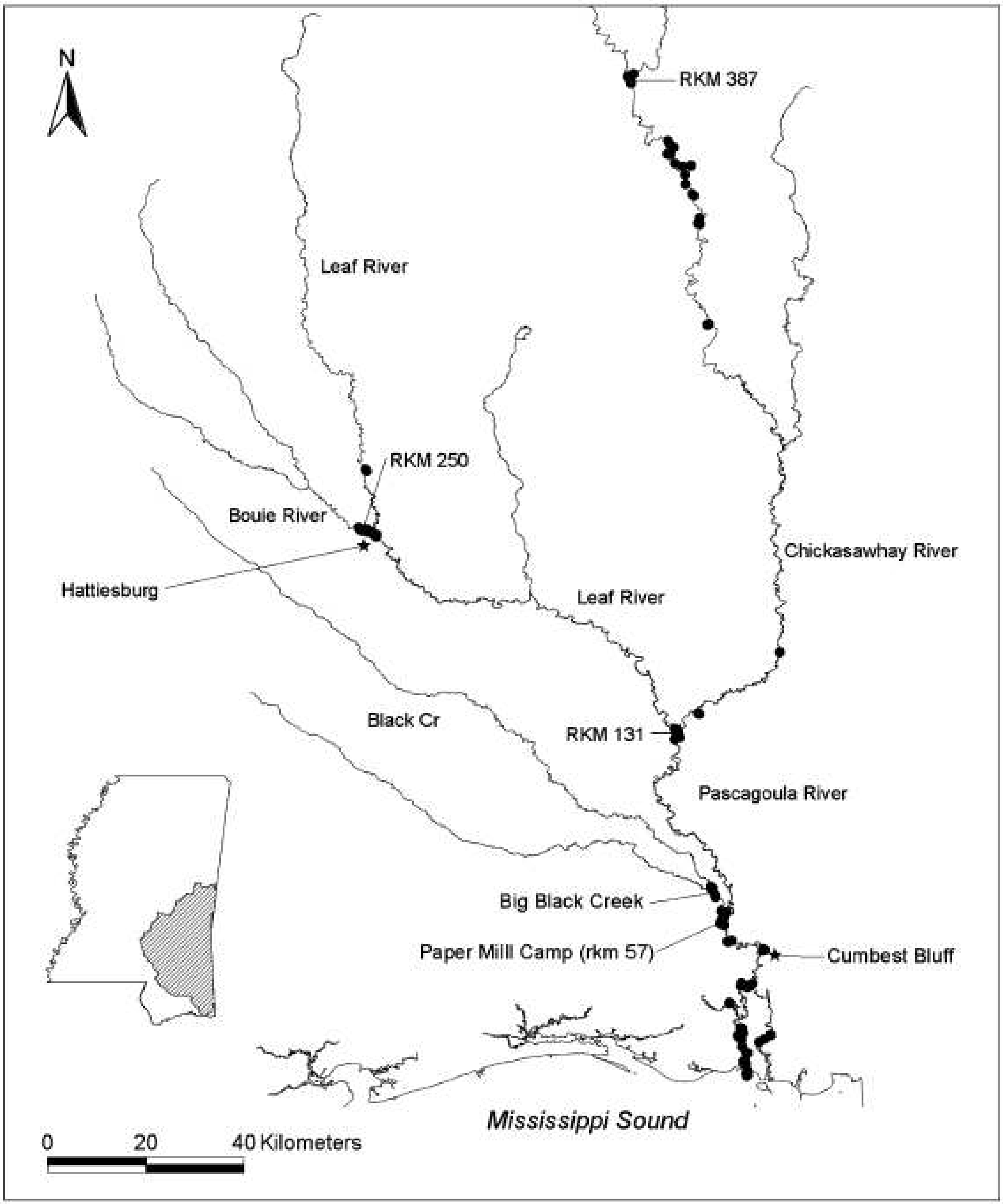
We rank the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. Carefully designed field experiments (for example, experiments that control potentially confounding variables) are rated higher than field 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 for section 7 consultation is defined as all the areas affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area is the Pascagoula River and Estuary, due to the fact that Gulf sturgeon from this population that utilize this entire habitat will be sampled. The proposed research under Award NA10NMF4720034 to MDWFP would take place in the waters of the Pascagoula River Estuary, Mississippi – beginning near the mouths of the West and East Pascagoula River (river kilometer (rkm) 0) to surrounding nearshore areas (from I-10 south to the Pascagoula rivermouth). Gill netting will take place at the mouth (rkm 0) of the east and west Pascagoula River. Acoustic telemetry will take place within the Pascagoula River estuary and surrounding nearshore areas.

The Pascagoula River Estuary is located in southeastern Mississippi with the Pascagoula River watershed draining about 25,123 km^2 - the last unimpeded major river system in the lower 48 states (MDEQ 2001). Of the 74 major river estuaries in North America, the Pascagoula River is the only one in the United States that remains unaffected by channel fragmentation and flow regulation. The land use of this watershed consists of primarily forestry and agriculture. The river splits into two distributaries 23 rkm north of its mouth. Chemise Bayou is a natural tributary that joins the two distributaries at rkm 5 on the east and rkm 3 on the west.

Figure 1. Map of the Pascagoula River Basin from Heise *et al*. 2005.
Note that circle and star marks denote sampling areas from the Heise study areas and have no significance when viewing the Figure for a visual representation of the action area.



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:

Gulf sturgeon	*Acipenser oxyrinchus desotoi*	Threatened

Critical habitat has been designated for Gulf sturgeon (March 19, 2003; 68 FR 13370). Their critical habitat includes 14 geographic areas (units) among the Gulf of Mexico rivers and tributaries encompassing approximately 2,783 rkm (1,730 river miles (rmi)) and 6,042 square kilometers (km2) (2,333 square miles (mi^2)) of estuarine and marine habitat. The proposed action would occur in Unit 2. The 14 total units include:

Unit 1 - the *Pearl River System* in St. Tammany and Washington Parishes in Louisiana and Walthall, Hancock, Pearl River, Marion, Lawrence, Simpson, Copiah, Hinds, Rankin, and Pike Counties in Mississippi;
Unit 2 - the *Pascagoula River System* in Forrest, Perry, Greene, George, Jackson, Clarke, Jones, and Wayne Counties, Mississippi;
Unit 3 - the *Escambia River System* in Santa Rosa and Escambia Counties, Florida and Escambia, Conecuh, and Covington Counties, Alabama;
Unit 4 - the *Yellow River System* in Santa Rosa and Okaloosa Counties, Florida and Covington County, Alabama;
Unit 5 - the *Choctawhatchee River System* in Holmes, Washington, and Walton Counties, Florida and Dale, Coffee, Geneva, and Houston Counties, Alabama;
Unit 6 - the *Apalachicola River System* in Franklin, Gulf, Liberty, Calhoun, Jackson, and Gadsen Counties, Florida;
Unit 7 - the *Suwannee River System* in Hamilton, Suwannee, Madison, Lafayette, Gilchrist, Levy, Dixie, and Columbia Counties, Florida;
Unit 8 - *Lake Pontchartrain, Lake St. Catherine, The Rigolets, Little Lake, Lake Borgne, and Mississippi Sound* in Jefferson, Orleans, St. Tammany, and St. Bernard Parish, Louisiana, Hancock, Jackson, and Harrison Counties in Mississippi, and in Mobile County, Alabama;
Unit 9 - the *Pensacola Bay System* in Escambia and Santa Rosa Counties, Florida;
Unit 10 - *Santa Rosa Sound* in Escambia, Santa Rosa, and Okaloosa Counties, Florida;
Unit 11 - *Florida Nearshore Gulf of Mexico Unit* in Escambia, Santa Rosa, Okaloosa, Walton, Bay, and Gulf Counties in Florida;
Unit 12 - the *Choctawhatchee Bay* in Okaloosa and Walton Counties, Florida;
Unit 13 – the *Apalachicola Bay* system in Gulf and Franklin Counties, Florida; and
Unit 14 - *Suwannee Sound* in Dixie and Levy Counties, Florida.

The critical habitat listing (68 FR 13370) contains the textual unit descriptions which are the definitive source for determining Gulf sturgeon critical habitat boundaries. The primary constituent elements (PCEs) of Gulf sturgeon critical habitat are abundant prey items; water quality and sediment quality necessary for normal behavior, growth, and viability of all life stages; and safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats.

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 Gulf sturgeon, refer to the Final Recovery Plan for Gulf Sturgeon (USFWS, GSMFC and NMFS 1995), and the 5-Year Status Review of Gulf Sturgeon (USFWS and NMFS 2009).

A. Listed Resources Not Considered Further in this Opinion

The following ESA listed resources occur in the action area, but we believe they are either not likely to be exposed to the proposed research or are not likely to be adversely affected.

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
Blue whale	*Balaenoptera musculus*	Endangered

Activities would include netting in freshwater-tidally mixed areas around rkm 0 at the mouths of the East and West Pascagoula River, and monitoring by boat of the acoustic array receivers established in the Pascagoula Estuary out to nearshore areas. It is known that sea turtles can frequently be found in the deeper waters of the adjacent Grand Bay National Estuarine Research Reserve (GNDNERR 2010). In addition, loggerhead turtles are known to nest on eastern Mississippi beaches with <25 crawls per year Dow *et al*. (2007). Furthermore, researchers targeting Gulf sturgeon in 1993 caught and released alive two juvenile sea turtles (unverified Kemp's ridleys) in the lower Pascagoula River (37,475 net-foot-hours, Murphy and Skaines 1994).

Although sea turtles and some listed whales occur within the action area, we believe that it is less likely that these animals would occur where nets will be set (rkm 0) than in the estuary where acoustic arrays will be located. Therefore, entanglement in nets is expected to be possible but unlikely. Since entanglement is possible, netting safeguards have been incorporated into the permit. These safeguards are similar to those for marine mammals and include: 1) continual, complete, and thorough visual net checks; 2) netting time restricted between 30 minutes after sunrise to 30 minutes before sunset; and 3) no deployment of nets if other listed species are found in the action area. Additionally, the grant recipients will be tending their drift gill nets continuously and checking their set gill nets every two hours. The acoustic array monitoring will take place by boat in the estuary and out to nearshore areas. The array monitoring would involve routine vessel maneuvers at the surface of the water and the boat would not be likely to strike any listed species.

The proposed grant award would fund research activities in Gulf sturgeon critical habitat Unit 2 – the Pascagoula River System. The primary constituent elements (PCEs) of Gulf sturgeon critical habitat are abundant prey items; water quality and sediment quality necessary for normal behavior, growth, and viability of all life stages; and safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats. The proposed activities consist of Gulf sturgeon capture, handling, tagging, acoustic array tracking, tissue sampling, and benthic sampling. Capture, handling, tagging, acoustic array tracking, and tissue sampling would have no effect on the PCEs. Benthic sampling would occur in areas covered by the acoustic arrays resulting in a total of 210 infaunal and sediment samples. Acoustic receivers will be placed remotely, as they are more effective in detecting more Gulf sturgeon over a wider variety of placement areas. The benthic samples would be near surface (0-5 cm) samples collected using a Wildco petite ponar dredge sampler (15 x 17 cm opening), including sediments from at least three independent samplings within a 2 m^2 radius of each array station. The grabbing of sediment in sites so remote from each other and in such a small amount would have an insignificant effect on the amount of Gulf sturgeon prey items that may be living within the sediment in the given sampling area. In addition, this benthic sampling technique would not impact the quality of the sediment, as it is merely grabbing up the benthos. As a result, the proposed grant award's activities are not likely to adversely affect the critical habitat for Gulf sturgeon, and their critical habitat is not addressed further in this Opinion**.**

B. Status of Species Considered in this Opinion

Species Description, Range-wide Distribution, and Population Structure. The Atlantic sturgeon, *Acipenser oxyrinchus*, is an andadromous species, migrating as adults into rivers during spring to spawn before returning to coastal waters to feed in the fall. The Florida peninsula separates this species into two subspecies. The northern subspecies, *A. o. oxyrinchus*, ranges from Labrador, throughout the Gulf of St. Lawrence drainage, southward at least to St. Johns River in Florida. The Gulf sturgeon, *A. o. desotoi*, had a historic range from the Mississippi River east to Tampa Bay, Florida. Sporadic occurrences were recorded as far west as the Rio Grande River in Texas and Mexico and as far east and south as Florida Bay (Wooley and Creteau 1985, Reynolds 1993). The Gulf sturgeon's present range extends from Lake Pontchartrain in Louisiana and the Pearl River system in Mississippi, east to the Suwanee River in Florida. Mark-recapture studies have confirmed the general fidelity of individual Gulf sturgeon returning to particular rivers (NOAA and USFWS 2003), presumably their natal rivers. Seven rivers are known to support reproducing populations of Gulf sturgeon: the Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicola, and Suwanee Rivers (Table 1). Gulf sturgeon reproduction is not known to currently occur in several basins (e.g., Mobile Basin) where it most likely occurred historically.

The Suwannee River supports the most viable population among coastal rivers of the Gulf of Mexico and was estimated at 7,650 individuals older than age two (Sulak and Clugston 1999). The subpopulation estimate for Gulf sturgeon older than age two in the Choctawhatchee River ranges from 1,700–3,000 fish, while subpopulation estimates in the Apalachicola, Pascagoula and Pearl rivers range from 50–350 fish (Lorio 2000). Although trends may not be statistically significant, the surveys presented in Table 1 indicate a roughly stable or a slowly increasing trend in number of individuals at a riverine population scale. Population size of Gulf sturgeon is variable across their range, but most populations appear to be relatively stable in number.

Given the variety in methods used, Gulf sturgeon population estimates are relatively imprecise, with more than half of the confidence intervals reported (Table 1) exceeding 65% of the value reported in the third column. This is perhaps owing to the low capture/recapture probabilities associated with sampling this species, which was estimated to be < 10% using closed-system models by Zehfuss *et al*. (1999).

Table 1. Estimated Gulf sturgeon population densities based on mark-recapture data (USFWS and NMFS 2009).

Abundance estimates listed refer to numbers of individuals greater than a specified size, which varies between studies depending on sampling gear, and in some cases, to numbers of individuals that use a particular portion of the river. Estimates are by researcher and then by year, since estimates are not necessarily comparable between researchers due to key differences in methods and assumptions.

River	Year of Data Collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
Pearl	1993	67	28	Not reported	Morrow *et al.* 1996
	1994	88	59	171	Morrow *et al.* 1996
	1995	124	85	236	Morrow *et al.* 1996
	1996	292	202	528	Morrow *et al.* 1998
	2001	430	323	605	Rogillio *et al.* 2001
Pascagoula	1999	162	34	290	Ross *et al*. 2001
	1999	193	117	363	Ross *et al*. 2001
	1999	200	120	381	Ross *et al*. 2001
	2000	181	38	323	Ross *et al*. 2001
	2000	206	120	403	Ross *et al*. 2001
	2000	216	124	429	Ross *et al*. 2001
Escambia	2003	558	83	1033	USFWS 2004
	2004	573	402	745	USFWS 2004
	2006	451	338	656	USFWS 2007
Yellow	2001	566	378	943	Berg *et al*. 2007
	2002 spring	500	319	816	Berg *et al*. 2007
	2002 fall	754	408	1428	Berg *et al*. 2007
	2003 spring	841	487	1507	Berg *et al*. 2007
	2003 fall	911	550	1550	Berg *et al*. 2007
Apalachicola	1983	282	181	645	Wooley and Crateau 1985
	1984	103	62	299	Barkuloo 1988
	1985	96	74	138	Barkuloo 1988
	1986	60	37	157	Barkuloo 1988
	1987	111	64	437	Barkuloo 1988
	1988	131	84	305	Barkuloo 1988
	1980	500	Not reported	Not reported	Pine and Martell 2009a
	2005	2000	Not reported	Not reported	Pine and Martell 2009a
	1990	108	75	196	USFWS 1990
	1998	270	135	1719	USFWS 1998
	1999	321	191	1010	USFWS 1999
	2004	350	221	648	USFWS 2004
	1983	149	115	208	Zehfuss *et al*. 1999
	1983	111	76	146	Zehfuss *et al*. 1999
	1984	87	59	150	Zehfuss *et al*. 1999
	1984	119	87	150	Zehfuss *et al*. 1999
	1985	101	87	127	Zehfuss *et al*. 1999
	1985	117	92	142	Zehfuss *et al*. 1999
	1986	65	47	105	Zehfuss *et al*. 1999
	1986	108	92	142	Zehfuss *et al*. 1999
	1987	116	70	225	Zehfuss *et al*. 1999
	1987	103	78	128	Zehfuss *et al*. 1999
	1988	109	81	164	Zehfuss *et al*. 1999
	1988	88	69	107	Zehfuss *et al*. 1999
	1989	62	37	131	Zehfuss *et al*. 1999
	1989	91	61	120	Zehfuss *et al*. 1999

River	Year of Data Collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
	1990	112	88	155	Zehfuss *et al*. 1999
	1990	218	114	321	Zehfuss *et al*. 1999
	1991	95	35	406	Zehfuss *et al*. 1999
	1991	144	83	205	Zehfuss *et al*. 1999
Suwannee	1992	2285	1887	2683	Carr *et al*. 1996
	1987	2473	2002	2944	Chapman *et al*. 1997
	1988	2144	1865	2423	Chapman *et al*. 1997
	1989	3055	2650	3460	Chapman *et al*. 1997
	1990	3049	2677	3421	Chapman *et al*. 1997
	1991	2097	1779	2415	Chapman *et al*. 1997
	1992	2832	2283	3381	Chapman *et al*. 1997
	1993	5312	3588	7036	Chapman *et al*. 1997
	1994	2898	2250	3546	Chapman *et al*. 1997
	1995	3370	1807	4933	Chapman *et al*. 1997
	1996	4295	1703	6887	Chapman *et al*. 1997
	1982	3000	Not reported	Not reported	Pine and Martell 2009a
	2004	10000	Not reported	Not reported	Pine and Martell 2009a
	1987	2059	1490	2890	Randall 2008
	1988	1895	1544	2349	Randall 2008
	1989	2118	1777	2543	Randall 2008
	1990	2473	2166	2839	Randall 2008
	1991	2923	2516	3409	Randall 2008
	1992	3379	2855	4011	Randall 2008
	1993	4273	3442	5321	Randall 2008
	1994	3508	2821	4376	Randall 2008
	1995	3579	3122	4119	Randall 2008
	1996	5525	3524	8684	Randall 2008
	1997	4061	3310	4998	Randall 2008
	1998	7606	5983	9702	Randall 2008
	1999	4944	4075	6017	Randall 2008
	2000	4217	3149	5660	Randall 2008
	2001	5021	3771	6706	Randall 2008
	2002	5220	3805	7185	Randall 2008
	2005	1817	1303	2544	Randall 2008
	2006	9728	6487	14664	Randall 2008
	1991	7650	Not reported	Not reported	Sulak and Clugston 1999
	1998	7650	Not reported	Not reported	Sulak and Clugston 1999
	2007	14000	Not reported	Not reported	Sulak 2008

a The primary author cited characterizes these as "preliminary estimates" in reviewing the document.

Life History Information. Gulf sturgeon are andadromous, feeding in the winter months in the marine waters of the Gulf of Mexico including bays and estuaries, migrating in the spring up freshwater rivers to spawn on hard substrates, and then spending summers in the lower rivers before emigrating back out into estuarine/marine waters in the fall. After spawning in the upper river reaches, both adult and subadult Gulf sturgeon migrate from the estuaries, bays, and the Gulf of Mexico to the coastal rivers in early spring (i.e., March through May) when river water temperatures range from 16°C to 23°C (Fox *et al.* 2000, Huff 1975; Carr 1983; Wooley and Crateau 1985; Odenkirk 1989; Clugston *et al.* 1995; Foster and Clugston 1997; Fox and Hightower 1998; and Sulak and Clugston 1999). Generally, fall downstream migration from the river into the estuary/Gulf of Mexico begins in September (at water temperatures around 23°C) and continues through November (Huff 1975; Wooley and Crateau 1985; Foster and Clugston 1997). Gulf sturgeon are known to congregate around passes during their migrations to saltwater and not likely to be found in high energy littoral zones.

Gulf sturgeon have been described as opportunistic and indiscriminate benthivores (bottom feeders); their guts generally contain benthic marine invertebrates including amphipods, lancelets, polychaetes, gastropods, shrimp, isopods, molluscs, and crustaceans (Huff 1975; Mason and Clugston,1993; Carr *et al.* 1996; Fox *et al.* 2000; Fox *et al.* 2002). These prey generally are burrowing species (e.g., annelids: polychaetes and oligochaetes, amphipods, isopods, and lancelets) that feed on detritus and/or suspended particles, and inhabit sandy substrate. They have also been observed feeding off plant surfaces and on fish bait (Dadswell *et al.* 1984).

Listing Status. Gulf sturgeon were listed as threatened on September 30, 1991 (56 FR 49653) pursuant to the Endangered Species Act of 1973 due to overfishing, dam construction, and habitat degradation. Gulf sturgeon were also listed on the International Union for Conservation of Nature and Natural Resources Red List as Vulnerable. The State of Mississippi has listed the Gulf sturgeon as endangered (MMNS 2001). Critical habitat has been designated for Gulf sturgeon which includes 14 geographic areas (units) among the Gulf of Mexico rivers and tributaries (March 19, 2003; 68 FR 13370).

Status and Trends of Gulf Sturgeon Populations. Using the mark-recapture data, general estimates of population size can be calculated. Although variable, most populations appear relatively stable with a few exceptions (Table 1). The number of Gulf sturgeon in the Escambia River system may have recently declined due to hurricane impacts, and the Suwannee River population appears to be slowly increasing. Due to lack of research since Hurricanes Ivan and Katrina, no data are available to determine the current size of the Gulf sturgeon populations within the Pearl and Pascagoula Rivers.

Research on Gulf sturgeon population characteristics in the past 5 years has been limited to the eastern five populations. The USFWS Panama City Field Office has annually monitored one or more of the four Florida Panhandle rivers (Escambia, Yellow, Choctawhatchee, and Apalachicola) since 2003 (fiscal year annual reports USFWS 2003-2008). USGS researchers completed the first assessment of the Yellow River population (Berg 2004, Berg *et al.* 2007). Advances in modeling population dynamics have been made, especially for the Apalachicola and Suwannee River populations (Flowers 2008, Pine and Martell 2009).

Gulf sturgeon reproduction is not known to currently occur in several basins (e.g., Mobile Basin) where it most likely occurred historically. A recent survey collected two Gulf sturgeon in Mobile Bay near Fairhope, AL (Mettee *et al.* 2009) after intensive netting. In addition to slowly recolonizing its former range, insights have emerged from population models in recent years suggesting that Gulf sturgeon life history characteristics also render the species slow to recover in abundance within its current range. Working with data from the Suwannee River population, Pine *et al.* (2001) identified three parameters (i.e., egg-to-age-1 mortality, the percentage of females that spawn annually, and adult mortality) as those most sensitive in determining the trajectory of population size. Pine *et al.* (2001) predicted that slight increases in estimated annual adult mortality (from 16% to 20%) would shift the population from an increasing trend into a decline. Flowers (2008) used an age-structured model to conclude that the Apalachicola population is probably slowly recovering, but still needs many years before returning to anywhere near its pre-exploitation abundance. Sulak (2008 Gulf sturgeon workshop) reported an analysis of mark-recapture data for the Suwannee River that suggests this population is regaining a semblance of its pre-exploitation age structure, with a shift from 10% mature individuals in 1996 to 40% in 2007. Morrow *et al.* (1999) recommends that, for the Pearl River, the population should be declared self-sustaining when long-term monitoring indicates that the population is stable or increasing with at least 100 individuals greater than 1.2 fork length and recruitment is equal to or greater than current levels.

Flowers (2008) describes the rapid decline in Gulf sturgeon landings as likely reflective of rapid erosion of the population age-structure of the large, older, highly fecund individuals being removed which led to a rapid change in the age-structure of the population and thereby reducing annual reproductive output and population recovery. Using several formulations (varying key input parameters, such as annual natural mortality) of an age-structured mark-recapture model (ASMR), Pine and Martell (2009) analyzed all available Gulf sturgeon sampling data collected since the late 1970's for the Apalachicola and Suwannee Rivers. For the Apalachicola River data, the models generally estimated population sizes (age 1+ Gulf sturgeon) of less than 500 individuals in the early 1980's, which increased to about 2,000 fish in 2005. These estimates are substantially higher than for other non-age-structured models. This is partly because estimates from Pine and Martell (2009) include younger age-classes than those included in Zehfuss *et al*. (1999). Despite key differences in input data and model assumptions, a general trend of gradually increasing abundance is apparent in the Apalachicola River. Similarly, for the Suwannee River data, the ASMR models estimated abundance in the early 1980's of about 3,000 age 1+ sturgeon, increasing to about 10,000 in 2004. These estimates are higher than the abundance estimates from Chapman or Sulak, for similar reasons as in the Apalachicola River analyses. Pine *et al*. (2001) found a positive population growth of about 5% annually for adults within the Suwannee River Gulf sturgeon population, and therefore in number to about 10,000 individuals in 2004.

Pascagoula River Gulf Sturgeon Population. A small population of Gulf sturgeon continues to persist in the Pascagoula drainage (Heise *et al*. 2004, 2005, Ross *et al*. 2004, Dugo *et al*. 2004). The Pascagoula supports an admixture of individuals, containing minimal genetic influence from drainages to the east (2%) and substantial interaction with the Pearl River (14.1%) (Dugo *et al.* 2004). The Pascagoula River has also been shown by Ross *et al.* (2004) to be utilized by multiple populations. Due to lack of research since hurricanes Ivan and Katrina, no data are available to determine the current size of the Gulf sturgeon populations within the Pearl and Pascagoula Rivers. Although, the Peterson *et al*. (2008) very low CPUE while targeting 2-3 year old Gulf sturgeon could mean that the hurricanes significantly affected survivorship of those two juvenile year classes in the Pascagoula. The USFWS and NMFS 5-year Review of Gulf sturgeon (2009) reported population estimates for Gulf sturgeon in the Pascagoula River based on a mark-recapture study by Ross *et al*. (2001) (Table 2).

Table 2. Pascagoula River Gulf sturgeon population estimates based on Ross *et al*. (2001) mark-recapture study.

River	Year of Data Collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
Pascagoula	1999	162	34	290	Ross *et al*. 2001
	1999	193	117	363	Ross *et al*. 2001
	1999	200	120	381	Ross *et al*. 2001
	2000	181	38	323	Ross *et al*. 2001
	2000	206	120	403	Ross *et al*. 2001
	2000	216	124	429	Ross *et al*. 2001

The Bouie River north of Hattiesburg, Mississippi (250 rkm upstream from the mouth of the Pascagoula River) is a spawning area (Heise *et al*. 2004). Additionally, radio telemetry suggests that spawning likely occurs in the Chickasawhay River, in areas isolated from the Bouie River spawning site by about 350 rkm (Dugo *et al.* 2004).

Heise *et al*. 2005 revealed the lower Pascagoula River to be a vital area for Gulf sturgeon. From May to November of each year, Gulf sturgeon congregate in a holding area in the lower portion of the Pascagoula River and Big Black Creek (rkm 57-68) and near Cumbest Buff (rkm 40). After that, they return to the Gulf of Mexico initiating their migration out of fresh water from late September to mid October, coincident with shorter day length, falling water temperature (range 21-26 Celsius), and elevated river flow.

In a multi-year study, Ross *et al*. (2009) found Gulf sturgeon from both the Pascagoula and Pearl Rivers broadly overlap and use the shallow water along the Gulf barrier islands as foraging grounds in the winter. These marine habitats utilized by the Gulf sturgeon were all less than 7 m deep, generally well oxygenated, and with relatively clear water; bottom substrates were mostly coarse sand and shell fragments or fine sand (Ross *et al*. 2009). Benthic samples taken at Gulf sturgeon telemetry location sites are dominated by Florida lancelets, sand dollars, annelids, haustoriid amphipods, and mollusks – all documented prey of Gulf sturgeon (Ross *et al*. 2009).

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 the Pascagoula River Estuary that are believed to affect the status and trends of threatened Gulf 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 Gulf sturgeon's range is probably the main factor (in addition to overfishing and habitat degradation) reducing their reproductive success which, in turn, could be the primary reason for the reduction in population size for Gulf sturgeon.

Although there are dams located on other rivers where other Gulf sturgeon populations are found, the Pascagoula River system is the last unimpeded major river system in the lower 48 states (MDEQ 2001).

Bycatch. All directed fisheries of Gulf sturgeon have been closed since 1972 in Alabama, 1974 in Mississippi, 1984 in Florida, and 1990 in Louisiana (USFWS 1995). Overutilization due to directed harvest is no longer a threat. Although confirmed reports are rare, it is still a common opinion among Gulf sturgeon researchers that possibly significant Gulf sturgeon mortality occurs as bycatch in fisheries directed at other species (NMFS 2009). Berg *et al.* (2004) noted finding a dead juvenile Gulf sturgeon on a trot line in the Blackwater River. The extent to which bycatch affects Gulf sturgeon is unknown.

Poaching. Poaching has 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). The extent to which poaching affects Gulf sturgeon is unknown.

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 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.

The extent to which dredging operations affect Gulf sturgeon is unknown.

Blasting. Bridge demolition, dredge, and other projects may include plans for blasting with powerful explosives. For example, some of the dredging referenced above includes blasting. 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 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).

The extent to which blasting affects Gulf sturgeon is unknown.

Bridge Construction/Demolition. Bridge construction and demolition projects may interfere with normal Gulf 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 Gulf 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 sturgeon and other swimbladder fish (Sonolysts 1994). Blast pressures below which negative impacts to 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.

Pollution from industrial, agricultural, and municipal activities is believed responsible for a suite of physical, behavioral, and physiological impacts to sturgeon worldwide (Karpinsky 1992, Barannikova 1995, Barannikova *et al.* 1995, Khodorevskaya *et al.* 1997, Bickham *et al.* 1998, Khodorevskaya and Krasikov 1999, Billard and Lecointre 2001, Kajiwara *et al.* 2003, Agusa *et al.*

2004). Life history of 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). Although little is known about contaminant effects on Gulf Sturgeon, a review estimating potential reactions has been performed (Berg 2006).

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. Juvenile Gulf sturgeon in the Suwannee River, Florida were found to hold concentrations of arsenic, copper, iron, mercury, lead, selenium, and zinc in their muscle (Alam *et al*. 2000). In addition, concentrations of arsenic, mercury, DDT metabolites, toxaphene, polycyclic aromatic hydrocarbons, and aliphatic hydrocarbons high enough to warrant concern were detected in Gulf sturgeon collected from northwest Florida areas (Bateman *et al*. 1994). A Gulf sturgeon caught in the Gulf of Mexico near Cape San Blas in December 1985 contained 14 ppm toxaphene in her ovaries (Bateman *et al*. 1994).

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).

The U.S. Environmental Protection Agency (EPA) published its third edition of the National Coastal Condition Report (NCCR III) in 2008, a "report card" summarizing the status of coastal environments along the coast of the United States (USEPA 2008; See Table 3 below). The report analyzes water quality, sediment, coastal habitat, benthos, and fish contaminant indices to determine status on a range from good to fair to poor. The northeast region of the U.S. (Virginia to Maine) was rated fair-poor. The Gulf of Mexico region (Texas to Florida) was rated fair-poor.

The southeast region of the U.S. (Florida to North Carolina) was rated good-fair, the best rating in the nation.

Table 3. Summary of the EPA NCCR III for the U.S. east coast published by the EPA (2008) grading coastal environments. (Northeast region=VA to ME; southeast region=FL to NC; and Gulf of Mexico=TX to FL)

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

The Mississippi Department of Environmental Quality (MDEQ) published a Pascagoula River Basin Status Report in 2001 that compiled and summarized many water quality issues in the basin. The Report summarized the 303(d) Clean Water Act "causes of impairment" for Pascagoula River Basin Streams and Lakes to be siltation (22%), nutrients (20%), pesticides (18%), pathogens (14%), low dissolved oxygen (12%), and others (14%). Monitored causes of impairment were pathogens, mercury, biological impairment, low dissolved oxygen, pH, and nutrients. In addition, Total Maximum Daily Load reports for the Pascagoula are available for fecal coliform, mercury, and pesticides.

Land Use Practices. In all, the Pascagoula River basin contains 9,600 square miles and is the second largest basin in Mississippi (MDEQ 2001). There are several urban areas in the basin near population centers such as Meridian, Laurel, Hattiesburg, and Pascagoula. The Pascagoula River Basin, with an estimated population of 716,925, encompasses roughly one-quarter of Mississippi's population. The 2008 census reported Meridian to have a population of 38,232, Laurel to have a population of 18,693, Hattiesburg to have a population of 51,993, and Pascagoula to have a population of 23,609 (U.S. Census 2008). Major land cover in the basin is as follows: forest (59%), pasture (19%), wetland (17%), crop (2%), urban (1%), water (1%), and barren (1%) (MDEQ 2001).

Power Plant Operations. 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 Gulf sturgeon. There are no nuclear power plants near the Pascagoula River estuary. The only nuclear power plant in the State of Mississippi is Grand Gulf nuclear power plant found in Vicksburg, on the border of Louisiana (USEIA 2008). Mississippi Power reports the following generating plants within the Pascagoula River basin land area:

Steam Plants	Nameplate capacity
Plant Daniel (Jackson County)	1,580,000 kW
Plant Sweatt (Lauderdale County)	80,000 kW
Plant Eaton (Forrest County)	67,500 kW
Combustion Turbines	
Chevron Cogenerating Plant (Jackson County)	147,292 kW
Plant Sweatt	39,400 kW
Plant Watson	40,000 kW

http://www.mississippipower.com/about/plants.asp

Research. Research activities could also pose a threat to Gulf sturgeon, causing future unknown or cumulative effects not immediately evident to researchers. Permits for Gulf sturgeon research in Mississippi are authorized under delegated authorities granted to the MDWFP by the U.S. Fish and Wildlife Service under an ESA section 6 agreement for scientific collecting and handling permits for federally listed threatened species in Mississippi. MDWFP has delegated this responsibility to the Mississippi Museum of Natural Science.

Hurricanes. Mortality of Gulf sturgeon as a result of hurricanes occurred in the Escambia River following Hurricane Ivan in 2004 (USFWS 2005) and in the northern Gulf of Mexico following Hurricane Katrina in 2005. The impacts of Katrina to the Pearl and Pascagoula Rivers are largely unknown, but it is thought that many fish were killed.

Red Tide. Red tide is the common name for a harmful algal bloom of marine algae known as *Karenia brevis,* which causes the ocean to appear red or brown. The algae produces a brevetoxin that is absorbed directly across the gill membranes of fish or through ingestion of algal cells. Fish mortalities associated with this algae are very common and widespread.

Since the 1990's the blooms of red tide have been increasing in frequency; the most recent outbreak occurred in 2007 and 2008. Red tide was the probable cause of death for at least 20 Gulf sturgeon in Choctawhatchee Bay in 1999 (USFWS 2000). Dead and dying Gulf sturgeon were reported to the Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute's Fish Kill Hotline in January 2006 attributed to post-bloom exposure (http://research.myfwc.com/features). More frequent or prolonged algal blooms may result from longer growing seasons predicted with climate change (FWC 2009). Red tides will likely continue to increase in frequency. Based on the best available information, toxins associated have likely killed Gulf sturgeon at both the juvenile and adult life stages. Because the loss of a small number of reproducing adults can have a significant overall effect on the status and trend of the population red tide is a threat to the Gulf sturgeon.

Climate Change. Climate change has potential implications for the status of the Gulf sturgeon through alteration of its habitat. The Intergovernmental Panel on Climate Change (IPCC 2007) concluded that it is very likely that heat waves, heat extremes, and heavy precipitation events over land will increase during this century. Warmer water, sea level rise and higher salinity levels could lead to accelerated changes in habitats utilized by Gulf sturgeon. Saltwater intrusion into freshwater systems could negatively impact freshwater fish and wildlife habitat (FWC 2009) resulting in more saline inland waters that may eventually lead to major changes in inland water ecosystems and a reduction in the amount of available freshwater. Changes in water temperature may alter the growth and life history of fishes, and even moderate changes can make a difference in distribution and number (FWC 2009). Freshwater habitats can be stressed by changes in both water quality and levels because of anticipated extreme weather periods as mean precipitation is expected to decrease along with an increase in precipitation intensity. Both droughts and floods could become more frequent and more severe, which would affect river flow, water temperature, water quality, channel morphology, estuarine salinity regimes, and many other habitat features important to the conservation of Gulf sturgeon.

A rise in water temperature may create conditions suitable for invasive and exotic species. Higher water temperatures combined with increased nutrients from storm runoff may also result in increased invasive submerged and emergent water plants and phytoplankton which are the foundation of the food chain (FWC 2009). New species of freshwater fishes may become established with warmer water temperatures (FWC 2009). The rate that climate change and corollary impacts are occurring may outpace the ability of the Gulf sturgeon to adapt given its limited geographic distribution and low dispersal rate.

Conservation. There are many state-administered management/assistance programs for the Pascagoula River Basin's water quality and wildlife issues. The Mississippi Department of Environmental Quality (MDEQ) manages several water quality management programs that are EPA-funded and provide technical assistance to the public and municipal entities including the Section 319 Non-point Source Pollution Grant Program, the Clean Water and Drinking Water Revolving Loan Program, and the Solid Waste Assistance Grant Program. There is also a Comprehensive Multimedia Pollution Prevention Assistance Program which is an outreach assistance program focused on helping businesses identify and reduce generated wastes and identifies and encourages recycling opportunities. The Mississippi Department of Agriculture and Commerce, Pesticide and Plant Protection Division licenses pesticide applicators and provides technical assistance to farmers experiencing pesticide application problems, as well as those needing assistance disposing of pesticides. The Mississippi State Department of Health enforces, develops, and implements on-site wastewater disposal. The Mississippi Forestry Commission provides technical assistance for non-point source pollution. The Mississippi Soil and Water Conservation Commission is designated as the management agency for agricultural non-point source pollution in the state. There are also Planning and Development Districts, Resource Conservation and Development Councils, and Soil and Water Conservation Districts that promote improvement of environmental conditions. The Mississippi Department of Wildlife, Fisheries, and Parks has a program to establish Scenic Stream Stewardships within the Pascagoula River Basin. Finally, the Mississippi Department of Marine Resources manages all marine life, public trust wetlands, adjacent uplands and waterfowl areas.

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. Section 305(b) also requires Mississippi (and all states) to produce a water quality assessment report which describes the status and quality of Mississippi's waters. The report lists causes and potential sources of pollution for those waters determined to be impaired and identifies and discusses water pollution control programs for point and non-point source pollution, documents environmental improvements for the previous years, notes special water quality concerns and problems, and describes each state's water quality monitoring program.

There are several ways that waste is managed in the Pascagoula River Basin. The CWA also requires National Pollutant Discharge Elimination System (NPDES) permits be issued for any facility discharging treated wastewater to state waters. Facilities in the Pascagoula River Basin that hold NPDES permits include industrial dischargers (143), municipal sewage dischargers (38), and commercial/private sewage dischargers (243) (MDEQ 2001). The Mississippi Department of Environmental Quality (MDEQ) has regulatory authority over hazardous waste operations within the Pascagoula Basin and reports that 232 of these sites exist in the basin (MDEQ 2001). There are also numerous solid waste facilities within the basin.

Integration of the Environmental Baseline. The above activities pose threats to its Gulf sturgeon population in the following ways. Many activities cause *death* – definite removal of individual fish from the population – at the adult, juvenile, and larval stages. Other activities cause *injury* to Gulf sturgeon, 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 Gulf sturgeon are potential 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. 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 sturgeon.

All of the activities identified in the Environmental Baseline section have the potential to injure individual Gulf sturgeon. Commercial and recreational fishing industries that catch Gulf 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 Gulf sturgeon.

Water quality changes from dredging, land use practices, point and non-point source pollution could also injure Gulf 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. Dredging operations may pose risks to Gulf sturgeon by destroying or adversely modifying their benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. Since Gulf 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 Gulf 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 Gulf 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). 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 permitted research activities could also injure Gulf sturgeon in the action area. The Mississippi Department of Wildlife, Fisheries, and Parks is currently operating under an existing permit granted by the Mississippi Museum of Natural Science in which they are authorized to capture, handle, weigh, measure, passive integrated transponder (PIT) tag, Floy-tag, and transmitter tag Gulf sturgeon. Thus far, mortality as a result of this permit has not been reported. However, fish captured may have been injured in a way that is not quantified.

Activities potentially altering the habitat of Gulf sturgeon are dredging and land use activities. Due to their benthic nature, dredging for shipping and other activities destroys sturgeon 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 Pascagoula River and Estuary.

In conclusion, there are no current reliable population estimates for both the Pascagoula and Pearl River populations due to lack of research since hurricanes Ivan and Katrina. A 1999 – 2000 mark-recapture study by Ross *et al*. (2001) reported mark-recapture estimates for Gulf sturgeon in the Pascagoula River to be 162 to 216 fish (Table 2). The Ross study aimed to describe movement and habitat use and was not meant to be an extensive population estimate.

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 Award NA10NMF4720034 would expose Gulf sturgeon to capture, handling, genetic tissue sampling, PIT and Floy tags, transmitter implantation with anesthesia, and acoustic monitoring. 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 six 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; and 6) sonic transmitter implantation with anesthesia and tracking. All captured Gulf sturgeon would be handled, weighed, measured, PIT tagged, Floy tagged, genetic tissue sampled, and would receive an transmitter implant with anesthesia. Activities are expected to occur in the Pascagoula River Estuary, Mississippi for three years - June 2010 to May 2013. Based on a review of available information, we determined that all of the possible stressors could pose a risk to Gulf sturgeon. Accordingly, the effects analysis of this consultation focused on all of the potential stressors.

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.

Under the proposed grant award, 10 Gulf sturgeon per year (30 over entire grant award study) would be subjected to all methods proposed. All captured Gulf sturgeon would be handled, weighed, measured, PIT and Floy tagged, genetic tissue sampled, and transmitter implantation with anesthesia. The time required to complete the standard sampling (i.e., removing from net, measuring, weighing, move to live well) would be 5 minutes per fish. The tagging portion of the handling would take an additional 10-15 minutes. Following processing, all fish would be treated with slime coat restorative (Stress Coat, Aquarium Pharmaceuticals, Inc.) and released back to the water after full recovery. Total holding time of Gulf sturgeon, after removal from the capture gear, holding, and scientific procedures would not exceed two hours.

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. Ten Gulf sturgeon annually (not exceeding 30 total for the entire 3-year grant award duration) would be captured using set gill nets and tended drift gill nets. 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). Historically, the majority of Gulf 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. 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.

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. To illustrate, we show shortnose sturgeon mortality resulting from six similar scientific research permits is summarized in Table 4 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 4: 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

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. 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 sturgeon could be done with lowered risk of direct mortality.

Expected Response to Capture. Sturgeon survival is effected by a relationship between temperature, DO, and salinity and this vulnerability may be increased by the research-related stress of capture, holding, and handling. Altinok *et al.* (1998), Sulak and Clugston (1998), Sulak and Clugston (1999), and Waldman *et al.* (2002) reported high temperatures, low DO, and high salinities result in significantly lower survival of Gulf sturgeon. Gulf sturgeon also appear dependent on temperature for optimal growth, fasting during the hot summer months and feasting during the winter when water temperatures and DO in the Gulf of Mexico and tributaries are more optimal (Sulak and Randall 2002). Although Gulf sturgeon reside in freshwater during summer months where water temperatures range from 28° to 32°C, there have been no studies estimating lethal temperature limits for Gulf sturgeon. It is worth noting, however, the healthiest population of Gulf sturgeon occurs in the Suwannee River, where temperatures are generally maintained at 28°C by springs in parts of the river.

Higher water temperatures are typically correlated with lower DO concentrations. Specific DO tolerance levels have not been established for Gulf sturgeon, although hypoxia for many *Acipenser* species has been documented to begin at 4 mg/L (Cech *et al.* 1984, Jenkins *et al.* 1993, Secor and Gunderson 1998).

As demonstrated above (Table 4), there is a chance that 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 utilize more conservative netting conditions than is suggested by the Moser *et al*. (2000) protocol. Researchers under the grant award would not net above temperatures of 27°C and would measure dissolved oxygen 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 mesh would be used which lessens chances of a thin line cutting into the fish causing injury. Based on the results of fish captures in recent years and the thorough mitigation measures included with these proposed activities, we expect the chances of a Gulf sturgeon being killed during capture to be very low.

Handling. Up to 10 Gulf sturgeon annually (not exceeding 30 total for the entire grant award duration) would be handled for length and weight measurements and the other proposed methods under this proposed authorization. Handling and restraining Gulf 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 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).

Improper handling can result in lethal or sub-lethal impacts to sturgeon. In some cases, sturgeon may display altered behavior after being released, for example, swimming towards the ocean rather than remaining in the river, or, in some instances, aborting spawning runs completely (Moser and Ross 1995, Schaffter 1997, Kelly *et al.* 2007, Benson *et al.* 2007, Moser and Lindley 2007). In a study of lake sturgeon (Axelsen and Mauger 1993 cited in Dick *et al.* 2006), tethered fish experienced greater stress and higher mortality than sturgeon kept in uncrowded cages.

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 short handling times, net pens, total holding time of less than 2 hours, and a slime coat restorative prior to release, should lessen the chance of injury or mortality during handling and restraint. To minimize capture and handling stress, the proposed research plans to hold Gulf 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. For most procedures planned, the total time required to complete routine handling and tagging would be no more than 15 minutes.

Passive Integrated Transponder (PIT) Tags. All Gulf sturgeon captured would be marked with PIT tags (up to 10 fish per year; no more than 30 fish over three years). Prior to PIT tagging, the entire dorsal surface of each fish would be scanned to detect previous PIT tags. Unmarked Gulf sturgeon would receive PIT tags via syringe. The needle would be inserted anterior and horizontally into the center of the fleshy base of the dorsal fin on the left side of the fish.

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). For retention rates, Clugston (1996) found that PIT tags implanted in Gulf sturgeon have a rate of approximately a 90%.

As with all research procedures, there is a risk of injury or mortality either directly or indirectly related to PIT tagging. 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. AVID 134.2 kHz PIT tags would be applied with a sterile single use disposable syringe. 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 Gulf sturgeon with PIT tags is unlikely to have significant impact on the reproduction, numbers, or distribution of Gulf 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. However, we expect that most Gulf sturgeon receiving PIT tags with proper insertion would not manifest ill effects from this tagging.

Floy (T-bar Anchor) Tags. All Gulf sturgeon captured would also be marked with Floy tags (up to 10 fish per year; no more than 30 fish over three years). In all captured sturgeon, Floy tags would be attached with Mark III scissor grip fish tagger in the fleshy portion of the pectoral fin proximal to the body. The tagger needle is pressed through the skin, the trigger is depressed, and the tagger is withdrawn. The Floy tag would be pulled slightly to set the tag.

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% for Gulf sturgeon. 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 Gulf 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 Gulf 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 Gulf sturgeon. 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).

Tissue Sampling. All Gulf sturgeon captured would be tissue-sampled. 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 (Wydoski and Emery 1983).

Expected Response to Tissue Sampling. There is no evidence that this procedure harms any species of sturgeon, therefore, we do not anticipate any long-term adverse effects to the sturgeon from this activity.

Transmitter Implantation. For the proposed activities, all Gulf sturgeon captured for the study would also undergo surgical implantation of sonic transmitters using the protocol measures presented in Moser *et al.* (2000). Applicants would use Vemco V7, V9, V13, or V16 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 have been 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. Three fish 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. There were no known mortalities directly attributable to the implantation procedure. However, the status of the 3 unrelocated individuals was unknown (Devries 2006), and delayed mortality could possibly be as high as 25%.

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 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 Transmitters. We expect that Gulf 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).

The grant recipients propose to use 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 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 Gulf sturgeon.

Anesthesia. All Gulf sturgeon will be anesthetized with MS-222 at concentrations up to 100-150 mg/L in order to sedate the fish for transmitter implantation. 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 2008b; *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, 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). Studies conducted on shortnose sturgeon 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 grant recipients 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 Anesthesia. Due to the fact that the applicant aims to use a concentration up to 100-150 mg/L within the recommended limitations of MS-222 and ensure that fish are anesthetized for a short period of time, NMFS believes that most Gulf 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 sturgeon 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).

Probable ill effects aside from mortality might be sublethal stress responses, however, the applicant is taking necessary precautions to shorten anesthetic time and monitor recovery in net pens. Therefore, the anesthesia methodology as proposed is not likely to reduce the viability of the Gulf sturgeon population in the Pascagoula River. By extension, MS-222 anesthesia is not likely to reduce the viability of Gulf 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.

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 Gulf sturgeon as described in the Environmental Baseline. However, it is the combination and extent to which these phenomena will affect Gulf sturgeon that remains unknown.

Future federal actions as well as scientific studies contributing to conservation or recovery of Gulf 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 state of Mississippi address oil spill prevention and response; water supply and water quality concerns; riparian and coastal development; ecosystem, natural resource, and endangered species recovery and protection; 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 Gulf 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 award grant by PR3 section 6 Program for Award NA10NMF4720034 to the Mississippi Department of Wildlife, Fisheries, and Parks, would fund research activities resulting in the directed take of Gulf sturgeon in the Pascagoula River Estuary. The proposed activities under this permit include capture, handling, PIT and Floy tagging, tissue sampling, transmitter implantation with anesthesia, and acoustic monitoring. The *Status of listed resources* section identified the construction of dams throughout the Gulf 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 Gulf sturgeon. However, dams are not the main factor reducing population size of the Pascagoula River population, due to the fact that it is unimpeded. Other threats to the survival and recovery of Gulf 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, hurricanes, red tide, climate change, possible 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 oil spill prevention and response; water supply and water quality concerns; riparian and coastal development; ecosystem, natural resource, and endangered species recovery and protection; and regulation of fisheries and invasive species. Due to lack of research since Hurricanes Ivan and Katrina, no data are available to determine the current size of the Gulf sturgeon populations within the Pearl and Pascagoula Rivers. However, The USFWS and NMFS 5-year Review of Gulf sturgeon (2009) reported population estimates for Gulf sturgeon in the Pascagoula River based on a mark-recapture study by Ross *et al*. (2001) (Table 5).

Table 5. Pascagoula River Gulf sturgeon population estimates based on Ross *et al*. (2001) mark-recapture study.

River	Year of Data Collection	Abundance Estimate	Lower Bound 95% CI	Upper Bound 95% CI	Source
Pascagoula	1999	162	34	290	Ross *et al*. 2001
	1999	193	117	363	Ross *et al*. 2001
	1999	200	120	381	Ross *et al*. 2001
	2000	181	38	323	Ross *et al*. 2001
	2000	206	120	403	Ross *et al*. 2001
	2000	216	124	429	Ross *et al*. 2001

In addition, although mark-recapture studies have revealed the general fidelity of individual Gulf sturgeon returning to particular rivers (NOAA and USFWS 2003), genetic studies have revealed that the Pascagoula River supports an admixture of individuals, containing minimal genetic influence from drainages to the east (2%) and substantial interaction with the Pearl River (14.1%) (Dugo *et al*. 2004). The Pascagoula River has also been shown by Ross *et al.* (2004) to be utilized by multiple populations.

Award NA10NMF4720034 would be valid for three years (June 2010 to May 2013) and would authorize non-lethal sampling methods on up to 10 Gulf sturgeon annually, but not to exceed 30 over the three-year award period. To accomplish these goals, methodologies propose to annually capture up to 10 Gulf sturgeon by set gill nets and tended drift gill nets. Gill netting would take place from daylight to dusk up to 3 days per week (weather and gear dependent). Netting targeting juvenile and sub-adult sturgeon would occur in February-late April in 2011, 2012, and 2013 near the mouths of the West and East Pascagoula River. Netting targeting juveniles and sub-adults would also occur (May-September, 2011 and 2012 only) attempting to recapture previously tagged fish. Each fish would be captured, handled, weighed, measured, Floy and PIT tagged, tissue sampled, anesthetized and implanted with a sonic transmitter, allowed to recover, and released. Ongoing acoustic monitoring would occur following tag and transmitter implants.

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 direct mortality or reduced fitness of individuals. However, results of studies that employed internal transmitters report that the fate of some implanted fish is unknown. Delayed or aborted spawning for some individual fish is a possibility, but the likelihood is remote given the mitigation measures proposed. The proposed Award is not expected to affect the population's reproduction, distribution, or numbers. Because the proposed action is not likely to reduce the Pascagoula River 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 threatened Gulf sturgeon, the environmental baseline for the action area, the effects of the proposed grant Award NA10NMF4720034, and the cumulative effects, it is NMFS's Biological Opinion that the issuance of this Award to the Mississippi Department of Wildlife, Fisheries, and Parks is not likely to jeopardize the continued existence of the threatened Gulf sturgeon. Critical habitat that has been designated within the action area is not affected by the proposed activity.

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 section 6 Awards for research on the threatened Gulf sturgeon:

1. *Compiling Data from Semi-Annual Reports and Sharing with PR1.* After receiving semi-annual reports from Award recipients, the PR3 section 6 Program should compile any data and results that can be obtained from the reports and coordinate this compilation with the Office of Protected Resources, Permits, Conservation and Education Division (PR1). PR1 currently compiles this information from the research permits it has the authority to authorize. Since PR1 does not have the authority to authorize permits for

Gulf sturgeon research, it would be beneficial to share this information which could be made available for further Gulf sturgeon consultations done by NMFS.

REINITIATION NOTICE

This concludes formal consultation on the proposed grant Award to the Mississippi Department of Wildlife, Fisheries, and Parks pursuant to the provisions of section 6 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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