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NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency: **Environmental Protection Agency (EPA), Region I**

Activity Considered: **Connecticut and Merrimack River Bioassessment Studies F/NER/2009/01913**

Conducted by: National Marine Fisheries Service
Northeast Region

Date Issued: July 30, 2009

Approved by: Pat Kurkul

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the effects of the US Environmental Protection Agency's funding and carrying out of proposed bioassessment studies in southern New England. This Opinion is based on information provided in the Biological Assessment dated March 2009, correspondence with EPA staff and contractors, scientific papers and other sources of information. A complete administrative record of this consultation will be kept at the NMFS Northeast Regional Office. Formal consultation was initiated on April 1, 2009.

INACTIVE

Consultation History
In 2008, EPA provided information to NMFS on proposed electrofishing surveys to be conducted throughout New England in 2009. Over the course of several conference calls, EPA and NMFS were able to identify rivers where NMFS listed species are known to be present. EPA informed NMFS that several studies were proposed for 2009 (as detailed below) and that one of these studies (REMAP, see below) would involve sampling in non-wadeable waters of each New England State.

On April 1, 2009, EPA requested formal consultation with NMFS on the effects of their proposed bioassessment projects in southern New England. As all of the information necessary to initiate consultation was received on this date, consultation was initiated on April 1, 2009. Throughout the consultation period, EPA and NMFS have held several conference calls to clarify the proposed action.

DESCRIPTION OF THE PROPOSED ACTION

Proposed Action
U.S. EPA, Region I is conducting three distinct, but interrelated bioassessment projects of southern New England rivers and streams that will take place in 2009; each includes a fish assemblage assessment based on a single gear electrofishing methodology. These projects include:

1) the National Rivers and Streams Assessment (NRSA);
2) a Regional Environmental Monitoring and Assessment Program (REMAP) survey of non-wadeable rivers; and,
3) an intensive survey of fish assemblages and habitat in the Connecticut River mainstem.
4)

The southern New England NRSA and REMAP studies will involve electrofishing in riverine waters in New Hampshire, Massachusetts, Connecticut and Rhode Island. However, as the only sampling sites where NMFS listed species are known to occur are the Merrimack and Connecticut Rivers, the description of the action presented herein will focus on the surveys being conducted in these rivers. EPA is also conducting several additional electrofishing surveys in Maine. However, as these are separate actions from those being considered in this consultation, a separate ESA section 7 consultation will be conducted on the effects of those actions as appropriate.

Both the REMAP and Connecticut River surveys will follow the Index of Biotic Integrity (IBI) study design (see below) which involves conducting electrofishing surveys in randomly selected 1-km reaches of the river, adjacent to the shoreline. The NRSA study uses a slightly different sampling methodology and sampling at these sites will involve electrofishing over a 4-km reach of river, again adjacent to the shoreline. EPA is currently proposing to provide funding to the Midwest Biodiversity Institute (MBI) to complete a contract to carry out these surveys.

INACTIVE

Connecticut River Fish and Habitat Assessment

This project entails a focused assessment of the fish assemblage and habitat of the Connecticut River mainstem. A survey of the mainstem downstream from Turners Falls to brackish tidewater is planned for 2009. In keeping with the methodology established by Yoder et al. (2006a; i.e., the IBI approach), boat electrofishing will be conducted once at each electrofishing site during a summer-fall (July 1 – September 30) index period. The 1-km long sample sites have been selected to occur in proximity to potential sources of pollution (e.g., permitted municipal and industrial discharges), key tributary confluences, and in reaches of contrasting habitat quality (e.g., free-flowing riverine, impoundments, other hydrologic modifications). These will be positioned at intervals of at least one site/4-5 mainstem miles. Sites from both the National Rivers and Streams Assessment (NRSA) are included as comparability sites. REMAP sites are accounted for with those Connecticut River sites that co-occur with the probabilistic design of REMAP.

National Rivers and Streams Assessment (NRSA)

The intention of the National Rivers and Streams Assessment project is to provide a comprehensive "State of the Flowing Waters" assessment for rivers and streams across the United States. In addition to rivers and streams, the national assessments will also include coastal waters, lakes, and wetlands in a revolving annual sequence (rivers and streams are scheduled for 2008-9). The purpose of these national assessments is to generate statistically-valid reports on the condition of the Nation's water resources and identify key stressors to these systems. The goal of the 2008-9 NRSA is to address two key questions about the quality of the Nation's rivers and streams:

- What percent of the Nation's rivers and streams are in good, fair, and poor condition for key indicators of water quality, ecological health, and recreation?

- What is the relative importance of key stressors such as nutrients and pathogens?

The NRSA is designed to be completed during an index period of late May through September 1[1]. Field crews will collect a variety of measurements and samples from predetermined sampling reaches (located with an assigned set of coordinates), and from randomized stations along the sampling reach. The field crews will also document the physical habitat conditions along the sampling reach. Candidate sampling locations are selected by U.S. EPA using a probability based survey design. Using this survey design allows data from the subset of sampled sites to be applied to the larger target population, and assessments with known confidence bounds to be made. Candidate sites are field verified and then sampled if they meet the target population criteria. For non-wadeable rivers sampling sites are configured to include 40 times the mean wetted width at the "X" point not to exceed a total length of 4 km (Figure 1). Because the sampling methods used by the NRSA are different from the Connecticut River and REMAP projects, each NRSA site will be sampled a second time using those protocols in order to conduct a comparability analysis of the results from each. NRSA sampling sites have been identified in both the Connecticut and Merrimack Rivers.

REMAP Study

The REMAP study will involve sampling sites in the Connecticut and Merrimack Rivers using the IBI methodology (1-km long sampling sites). The principal objectives of this project are:

1. provide a statistically valid estimate of the biological condition and associated stressors along a gradient of non-wadeable rivers and streams throughout New England;
2. compare assessment outcomes produced by different sampling designs in major mainstem rivers such as the Connecticut and Merrimac Rivers;
3. determine the transitional characteristics between wadeable and non-wadeable sites in New England;
4. describe a standardized protocol for sampling fish assemblages and habitat in non-wadeable rivers for multiple assessment purposes; and,
5. describe and initiate a process for biocriteria development including the development of reference condition, multimetric indices, and a template for tiered uses in non-wadeable rivers using the U.S. EPA Biological Condition Gradient as a foundation.

This project will focus primarily on fish assemblages and physical habitat because these resource features are the most commonly assessed among the various non-wadeable river research projects that are described herein, a working protocol has already been established in Maine (Yoder et al. 2006a), and this indicator is responsive to the physical (flow and habitat; Bain and Meixler 2008) and biological stressors (non-native species; Halliwell 2005; Yoder et al. 2006b) common to most New England rivers.

Field Sampling Methods

Methods for the collection of fish in the REMAP and Connecticut River surveys are based on those developed and used in Maine during 2002-7 (Yoder et al. 2006 a,b) and referred to as the IBI Methodology. IBI type sampling occurs over a 1-km long transect while the NRSA sampling at each site will occur over a 4-km reach. However, the sampling equipment is the

1 This applies to all chemical, physical, and biological indicators; fish assemblage sampling in non-wadeable rivers will conform to the July 1 - September 30 (October 15 in southern New England) seasonal index period.

INACTIVE

same as for all of the projects and is detailed below. All sampling is expected to occur in 2009; however, if weather or other conditions prevent the completion of the surveys in 2009, sampling could continue in 2010.

Merrimack River
A total of 4 NRSA sampling events and up to 5 REMAP sampling events will occur downstream from the Essex Dam in Lawrence, MA. The sites where REMAP sampling will occur are identical to the NRSA sampling sites, with the exception of one additional site. Therefore, four sites located between the Essex Dam and the lower islands near the I-95 bridge will be sampled twice within the July 1 – September 30 period and one additional site within this reach will be sampled once.

Connecticut River
A total of 20-25 sites will be sampled downstream from Turners Falls to the effective prohibition of electrofishing efficiency at tidewater in Connecticut. Of these sample sites, five will be sampled twice (once as NRSA sites and once as REMAP or Connecticut River survey sites). The remaining sites will be sampled once as REMAP and/or Connecticut River survey sites. The NRSA sites are expected to be sampled first, followed by the REMAP/Connecticut River sampling between August and September 30 or October 15. Of the Connecticut River sites, 5-6 of the sampling sites will occur upstream of the Holyoke Dam, with the remainder occurring in the lower river.

Electrofishing Methodology
Individual electrofishing sites are located along the shoreline with the most diverse habitat features in accordance with established methods (Yoder et al. 2006 a,b). This is generally along the gradual outside bends of larger rivers, but it is not invariable. Sampling distance is determined with a GPS unit and/or laser range finder.

Electrofishing entails passing an electric current in the water to capture or control fish. The electric current causes fish within the effective area of the electric field to become temporarily stunned or immobilized (referred to as electrotaxis) to facilitate capture by nets.

An electrofishing boat will make a single pass along each transect, traveling approximately 1 km along the shoreline (or 4km for the NRSA sampling). Electric currents will be applied to maintain power densities sufficient to generate electrotaxis in targeted fish (i.e., shad, salmon, and eels). Minimum settings will be estimated by measuring water conductivity and evaluating behavioral responses of fish prior to changing settings. Efforts to adjust settings will favor low frequency and pulse width to minimize any injuries to fish. Target electrical currents are 2 to 4 amps, 400 volts, and 60 pulses per second. Based upon these setting, the expected range of electrotaxis for fish in the electric field will be approximately 4.5 meters in diameter down to a depth of approximately 2.5 meters. During sampling the anode and cathode will be held as far apart as practical to generate a more diffuse field in order to minimize the risk of injury to fish. Stunned fish will be captured using hand held nets and removed from the water as rapidly as possible.

Captured fish will be immediately placed in aerated live wells containing ambient river water. Each transects typically takes 45 minutes to complete with an additional 45 minutes to process

INACTIVE

all of the fish captured. The total time held for each fish will vary; however, as fish are processed after each transect the maximum holding time for any one fish will be 90 minutes. Captured fish will be identified to species, measured, enumerated and released alive. In the event that any shortnose sturgeon are incidentally stunned and collected during sampling, the researchers have stated that sampling will be immediately suspended until sturgeon are processed and released.

Sampling Procedure

A boat-rigged, pulsed D.C. electrofishing apparatus is the single gear employed in the largest mainstem rivers where navigation with a john boat is feasible. This consists of a 16' john boat specifically constructed and modified for electrofishing. Electric current is converted, controlled, and regulated by Smith-Root 5.0 GPP alternator-pulsator that produces up to 1000 volts DC at 2-20 amperes depending on the relative conductivity. The pulse configuration consists of a fast rise, slow decay wave that can be adjusted to 30, 60, or 120 Hz (pulses per second). Generally, electrofishing is conducted at 60 or 120 Hz, depending on which selection is producing the optimum combination of voltage and amperage output and most effectively and safely stunning fish.

The voltage range is selected based on what percentage of the power range produces the highest amperage readings. Generally, the high range is used at conductivity readings less than 50-100 μS/cm2 and the low range is used at higher conductivities up to 1200 μS/cm2. Lower conductivities usually produce lower amperage readings. In 2005 a 14' raft mounted gear was tested and used to sample intermediate sized rivers where use of the 16' boat was not practical primarily due to navigational issues such as depth and fast flows. This method employs the same basic design as the 16' boat, but uses a Smith-Root 2.5 GPP unit. Electric current is converted, controlled, and regulated by Smith-Root 2.5 GPP alternator-pulsator that produces up to 1000 volts DC at 2-8 amperes depending on the relative conductivity. The principles of operation are the same as with the 5.0 unit.

The electrode array on the 16' boat consists of four 8' long cathodes (negative polarity; 1" diameter flexible steel conduit) which are suspended from the bow and 2-3 gangs of anodes (positive polarity) suspended from a retractable aluminum boom, the number used being dependent on the conductivity of the water. The raft configuration is similar except there are 6 cathodes in two gangs of 3 suspended from the sides of the raft. In both platforms the gangs of anodes consist of four 3/8" woven steel cable strands (each 4' in length) formed into a "gang" by binding them together near the attachment point on the boom. These gangs are added or detached as conditions change; anodes are increased at low conductivity (3 gangs) and reduced (2 gangs and/or fewer wires) at high conductivity. The anodes are suspended from a retractable aluminum boom that extends 2.75 meters in front of the bow on the 16' boat and 2.5 m on the 14' raft. The width of both arrays is 0.9 meters. Anodes and cathodes are replaced when they are lost, damaged, or become worn. For night sampling, 100-Watt floodlights are fixed on the guardrail and side rails on the netting platform located on the bow of the 16' boat; the 14' raft is not used at night. These are powered by the 12-volt DC output of the 5.0 GPP generator. Auxiliary lighting includes headlamps worn by the sampling crew and hand held lamps of 500,000 to 1,000,000 candle power. A 16' boat electrofishing crew consists of a boat driver and two netters; the 14' raft crew consists of a raft driver and one netter. Limited access to free-

INACTIVE

flowing segments may necessitate launching at an upstream location and recovering at a downstream location. Put-in and take-out sampling is conducted where navigational barriers preclude contiguous navigation.

For boat and raft electrofishing at individual sampling locations, the accepted procedure is to slowly and methodically maneuver the electrofishing boat in a down current direction along the shoreline maneuvering in and around submerged cover to advantageously position the netters to pick up stunned and immobilized fish. This may require frequent turning, backing, shifting between forward and reverse, changing speed, etc. depending on current velocity and cover density and variability. Although sampling effort is measured by distance, the time fished is an important indicator of adequate effort. Time fished can legitimately vary over the same distance as dictated by cover and current conditions and the number of fish encountered. In all cases, there is a minimum time that should be spent sampling each zone regardless of the catch. In our experience this is generally in the range of 2000-2500 seconds for 0.5 km, but could range upwards to 3500-4000 seconds where there is extensive instream cover and slack flows. For the 1.0 km standard distance, this was determined to be from 3000-4000 seconds for impounded and tidal sites and 3500-4500 seconds or more at riverine sites in 2002 and 2003.

Netters are required to wear polarized sunglasses to facilitate seeing stunned fish in the water during each daytime boat electrofishing run. A boat net with a 2.5m long handle and 7.62mm Atlas mesh knotless netting is used to capture stunned fish as they are attracted to the anode array and/or stunned. A concerted effort is made to capture every fish sighted by both the netters and driver. Since the ability of the netters to see stunned and immobilized fish is partly dependent on water clarity, sampling is conducted only during periods of "normal" water clarity and flows. Periods of high turbidity and high flows are avoided due to their negative influence on sampling efficiency. If high flow conditions prevail, sampling will be delayed until flows and water clarity return to seasonal, low flow norms.

Field Sample Processing Procedures

Captured fish are immediately placed in an on-board live well for processing. Water is replaced regularly in warm weather to maintain adequate dissolved oxygen levels in the water and to minimize mortality. Aeration will be provided to further minimize stress and mortality. Special handling procedures are employed for certain species. Adult Atlantic salmon and sturgeon, for example, would not be netted when sighted and the electric current would be turned off upon observation of these species. Any size estimates would be made visually. Fish that are not retained for voucher or other purposes are released back into the water after they are identified to species, examined for external anomalies, weighed and, if necessary, measured for total length. Every effort is made to minimize holding and handling times. Non-indigenous species may be kept and appropriately disposed of out of the water per the request of the state management agencies. The majority of captured fish are identified to species in the field; however, any uncertainty about the field identification of individual fish requires their preservation for later laboratory identification. Fish are preserved for future identification in borax buffered 10% formalin and labeled by date, river or stream, and geographic identifier (e.g., river mile). Fish weighing less than 1000 grams are weighed to the nearest gram on a spring dial scale (1000 g x 2g) or a 1000 g hand held spring scale. Fish weighing more than 1000 grams weighed to the nearest 25 grams on a 12 kg spring dial scale (12 kg x 50 g) or a 50 kg hand held spring scale.

INACTIVE

Samples that are comprised of two or more distinct size classes of fish (e.g., y-o-y, juveniles, and adults) are processed separately.

Electrofishing Effective Range
The electrofishing method as described generally produces an electric field of approximately 4.5-5.5 meters in diameter and depths of up to 2.5-3.5 meters. It is most effective along the shoreline and adjacent to hard structures such as bedrock ledges, woody debris, and hard substrates. The effective extent of the electric field is species dependent and based on the susceptibility of each to the electric field. The size of individual fish also affects their susceptibility to being influenced by the electric field. Generally larger fish are the most susceptible as the voltage gradient increases with length, but the method is generally effective for all sizes of fish >25 cm.

Sampling Site Configuration
The sampling sites are generally located immediately adjacent to the shoreline or submerged features such as bedrock ledges and gravel shoals. Generally, the "deepest side" of the river with the "best combination and heterogeneity of habitat, flow, and structural cover" is thoroughly sampled. A 1.0 km site typically requires between 3600 and 5400 seconds of "current time", i.e., the cumulative time that the electric field is activated within a site (the netters operate a foot pedal switch, current is applied intermittently). The variance in time fished is affected by site navigability, current velocity, current types, boat maneuverability, and the number of fish collected.

Special Precautions
EPA will employ the following special precautions while undertaking the proposed study. These precautions will be made conditions of any contract EPA enters into with Midwest Biodiversity Institute to carry out the proposed action.

1. Fish Handling and Disposition – Any shortnose sturgeon that are encountered and visibly identified as such while electrofishing will not be netted or otherwise handled. The electric current will be interrupted until it can be determined that a resumption of the electric current will not re-affect that individual fish. Juveniles that are inadvertently captured will be returned to the water and away from the subsequent sampling site.

2. Habitat Specific Considerations - A concern has been raised that smaller individuals such as young-of-year (y-o-y) could be collected along with other smaller species and y-o-y life stages. This could result in their being held in the aerated live well until the sample is processed at the end of each sampling zone. To avoid this occurrence, EPA will conduct some initial scoping samples of specific habitats that are likely to have y-o-y in order to determine the risk of this actually taking place. If shortnose sturgeon are collected, EPA will immediately consult with NMFS about necessary modifications of the sampling design, revised locations, or both.

3. On-site Consultations – EPA proposes to have sturgeon biologists accompany the electrofishing crew at the first set of sampling sites to make observations about the risks posed by the sampling method based on their local knowledge of shortnose sturgeon.

Action Area

INACTIVE

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." For purposes of this Section 7 consultation, the action area is defined as all areas where electrofishing sampling has the potential to affect listed species under the jurisdiction of NMFS. As discussed below, listed shortnose sturgeon are known to occur in the Merrimack and Connecticut Rivers. As explained above, the action will involve running multiple transects along the shoreline in the Connecticut and Merrimack Rivers. Each transect will result in an electric field 4.5-5.5 meters wide, 2.5-3.5 meters deep and 1-4 km long. Thus, the action area is defined as these stretches of the Merrimack and Connecticut Rivers being sampled by the proposed study. The proposed action is not expected to have any direct or indirect effects to listed species outside of the two areas where electric current will be experienced.

STATUS OF AFFECTED SPECIES

This section will focus on the status of the various species within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action. NMFS has determined that the action being considered in this biological opinion may affect the following endangered or threatened species under NMFS' jurisdiction:

Fish

Shortnose sturgeon (*Acipenser brevirostrum*) Endangered

Shortnose Sturgeon

Shortnose sturgeon are listed throughout their range. As such, the status of the species as a whole will be discussed below. Additionally, information specific to the Connecticut and Merrimack River populations of shortnose sturgeon, which occur in the action area, will be discussed in more detail.

Shortnose sturgeon life history

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans (amphipods, chironomids, isopods), and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell et al. 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)2 when the freshwater temperatures increase to 8-9°C. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse et al. 1987; Crowder et al. 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual

2 For purposes of this consultation, Northern rivers are considered to include tributaries of the Chesapeake Bay northward to the St. John River in Canada. Southern rivers are those south of the Chesapeake Bay.

INACTIVE

survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980b), and Pee Dee-Winyah River (0.08-0.12; Dadswell et al. 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell et al. 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female (Dadswell et al. 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Laboratory studies suggest that young sturgeon move downstream in a 2-step migration; a 2 to 3-day migration by larvae followed by a residency period by young of the year (YOY), then a resumption of migration by yearlings in the second summer of life (Kynard 1997). Juvenile shortnose sturgeon (3-10 years old) reside in the interface between saltwater and freshwater in most rivers (NMFS 1998).

In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures rise above 8°C, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996). In the Merrimack River, males returned to only one reach during a four year telemetry study (Kieffer and Kynard 1996). Squires (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam and Kieffer and Kynard (1996) found that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell et al. 1984; NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 12°, and bottom water velocities of 0.4 to 0.7 m/sec (Dadswell et al. 1984; NMFS 1998). For northern

INACTIVE

shortnose sturgeon, the temperature range for spawning is 6.5-18.0°C (Kieffer and Kynard in press). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell et al. 1984). Between 8° and 12°C, eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes. Juveniles move upstream in spring and feed mostly in freshwater reaches during summer.

Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell et al. 1984; Hall et al. 1991). Non-spawning movements include wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Adult sturgeon occurring in freshwater or freshwater/tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total length (Buckley and Kynard 1985). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adult and juvenile shortnose sturgeon congregate (Flourney et al. 1992; Rogers and Weber 1994; Rogers and Weber 1995; Weber 1996). While shortnose sturgeon are occasionally collected near the mouths of rivers and often spend time in estuaries, they are not known to participate in coastal migrations and are rarely documented in their non-natal river.

The temperature preference for shortnose sturgeon is not known (Dadswell et al. 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2 to 3°C (Dadswell et al. 1984) and as high as 34°C (Heidt and Gilbert 1978). However, temperatures above 28°C are thought to adversely affect shortnose sturgeon. In the Altamaha River, temperatures of 28-30°C during summer months create unsuitable conditions and shortnose sturgeon are found in deep cool water refuges.

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6m is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30m but are generally found in waters less than 20m (Dadswell et al. 1984; Dadswell 1979). Shortnose sturgeon have also demonstrated tolerance to a wide range of salinities. Shortnose sturgeon have been documented in freshwater (Taubert 1980; Taubert and Dadswell 1980) and in waters with salinity of 30 parts-per-thousand (ppt) (Holland and Yeverton 1973; Saunders and Smith 1978). Mcleave et al. (1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10ppt within a two hour period.

INACTIVE

The tolerance of shortnose sturgeon to increasing salinity is thought to increase with age (Kynard 1996). Shortnose sturgeon typically occur in the deepest parts of rivers or estuaries where suitable oxygen and salinity values are present (Gilbert 1989).

Status and Trends of Shortnose Sturgeon Rangewide

Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication, issued by the US Department of the Interior, stated that shortnose sturgeon were "in peril...gone in most of the rivers of its former range [but] probably not as yet extinct" (USDOI 1973). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon commonly were taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon (*Acipenser oxyrinchus*). More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (e.g., southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (see NMFS 1998). Shortnose sturgeon are listed as "vulnerable" on the IUCN Red List.

Although shortnose sturgeon are listed as endangered range-wide, in the 1998 recovery plan for this species, NMFS recognized 19 separate populations occurring throughout the range of the species. These populations are in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). NMFS has not formally recognized distinct population segments (DPS)[3] of shortnose sturgeon under the ESA. Although genetic information within and among shortnose sturgeon occurring in different river systems is largely unknown, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1997) and, therefore, should be considered discrete. The 1998 Recovery Plan indicates that while genetic information may reveal that interbreeding does not occur between rivers that drain into a common estuary, at this time, such river systems are considered a single population compromised of breeding subpopulations (NMFS 1998). A status review for this species is currently ongoing and no report is currently available.

Studies conducted since the issuance of the 1998 Recovery Plan have provided evidence that suggests that years of isolation between populations of shortnose sturgeon have led to morphological and genetic variation. Walsh et al. (2001) examined morphological and genetic variation of shortnose sturgeon in three rivers (Kennebec, Androscoggin, and Hudson). The

3 The definition of species under the ESA includes any subspecies of fish, wildlife, or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. To be considered a DPS, a population segment must meet two criteria under NMFS policy. First, it must be discrete, or separated, from other populations of its species or subspecies. Second, it must be significant, or essential, to the long-term conservation status of its species or subspecies. This formal legal procedure to designate DPSs for shortnose sturgeon has not been undertaken.

INACTIVE

study found that the Hudson River shortnose sturgeon population differed markedly from the other two rivers for most morphological features (total length, fork length, head and snout length, mouth width, interorbital width and dorsal scute count, left lateral scute count, right ventral scute count). Significant differences were found between fish from Androscoggin and Kennebec rivers for interorbital width and lateral scute counts which suggests that even though the Androscoggin and Kennebec rivers drain into a common estuary, these rivers support largely discrete populations of shortnose sturgeon. The study also found significant genetic differences among all three populations indicating substantial reproductive isolation among them and that the observed morphological differences may be partly or wholly genetic.

Grunwald et al. (2002) examined mitochondrial DNA (mtDNA) from shortnose sturgeon in eleven river populations. The analysis demonstrated that all shortnose sturgeon populations examined showed moderate to high levels of genetic diversity as measured by haplotypic diversity indices. The limited sharing of haplotypes and the high number of private haplotypes are indicative of high homing fidelity and low gene flow. The researchers determined that glaciation in the Pleistocene Era was likely the most significant factor in shaping the phylogeographic pattern of mtDNA diversity and population structure of shortnose sturgeon. The Northern glaciated region extended south to the Hudson River while the southern non-glaciated region begins with the Delaware River. There is a high prevalence of haplotypes restricted to either of these two regions and relatively few are shared; this represents a historical subdivision that is tied to an important geological phenomenon that reflects historical isolation. Analyses of haplotype frequencies at the level of individual rivers showed significant differences among all systems in which reproduction is known to occur. This implies that although higher level genetic stock relationships exist (i.e., southern vs. northern and other regional subdivisions), shortnose sturgeon appear to be discrete stocks, and low gene flow exists between the majority of populations.

Waldman et al. (2002) also conducted mtDNA analysis on shortnose sturgeon from 11 river systems and identified 29 haplotypes. Of these haplotypes, 11 were unique to northern, glaciated systems and 13 were unique to the southern non-glaciated systems. Only 5 were shared between them. This analysis suggests that shortnose sturgeon show high structuring and discreteness and that low gene flow rates indicated strong homing fidelity.

Wirgin et al. (2005), also conducted mtDNA analysis on shortnose sturgeon from 12 rivers (St. John, Kennebec, Androscoggin, Upper Connecticut, Lower Connecticut, Hudson, Delaware, Chesapeake Bay, Cooper, Peedee, Savannah, Ogeechee and Altamaha). This analysis suggested that most population segments are independent and that genetic variation among groups was high.

The best available information demonstrates differences in life history and habitat preferences between northern and southern river systems and given the species' anadromous breeding habits, the rare occurrence of migration between river systems, and the documented genetic differences between river populations, it is unlikely that populations in adjacent river systems interbreed with any regularity. This likely accounts for the failure of shortnose sturgeon to repopulate river systems from which they have been extirpated, despite the geographic closeness of persisting populations. This characteristic of shortnose sturgeon also complicates recovery and persistence

INACTIVE

of this species in the future because, if a river population is extirpated in the future, it is unlikely that this river will be recolonized. Consequently, this Opinion will treat the nineteen separate populations of shortnose sturgeon as subpopulations (one of which occurs in the action area) for the purposes of this analysis.

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. Shortnose sturgeon are large, long lived fish species. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. The species is anadromous in the southern portion of its range (i.e., south of Chesapeake Bay), while northern populations are amphidromous (NMFS 1998). Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) and Merrimack Rivers (~100 adults; M. Kieffer, United States Geological Survey, personal communication), while the largest populations are found in the Saint John (~100,000; Dadswell 1979) and Hudson Rivers (~61,000; Bain et al. 1998). As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. Kynard 1996 indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the St John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species or the shortnose sturgeon population in the Northeastern United States exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed.

Threats to shortnose sturgeon recovery

The Shortnose Sturgeon Recovery Plan (NMFS 1998) identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival.

Several natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon. Shortnose sturgeon continue to be taken incidentally in fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979; Dovel et al. 1992; Collins et al. 1996). Bridge construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb sturgeon concentration areas. Unless appropriate precautions are made, internal damage and/or death may result from blasting projects with powerful explosives. Hydroelectric dams may affect shortnose sturgeon by restricting habitat, altering river flows or temperatures necessary for successful spawning and/or migration and causing mortalities to fish that become entrained in turbines. Maintenance dredging of

INACTIVE

Federal navigation channels and other areas can adversely affect or jeopardize shortnose sturgeon populations. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. Mechanical dredges have also been documented to lethally take shortnose sturgeon. In addition to direct effects, dredging operations may also impact shortnose sturgeon by destroying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. Shortnose sturgeon are susceptible to impingement on cooling water intake screens at power plants. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. The operation of power plants can have unforeseen and extremely detrimental impacts to water quality which can affect shortnose sturgeon. For example, the St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June 1991 when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates. Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low dissolved oxygen water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that twenty shortnose sturgeon were killed during this low dissolved oxygen event.

Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sinderman 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long term effects are not yet known (Ruelle and Henry 1992; Ruelle and Kennlyne 1993). Available data suggests that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Although there is scant information available on the levels of contaminants in shortnose sturgeon tissues, some research on other related species indicates that concern about the effects of contaminants on the health of sturgeon populations is warranted. Detectible levels of chlordane, DDE (1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene), DDT (dichlorodiphenyl-trichloroethane), and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (Ruelle and Henry 1994). These compounds were found in high enough levels to suggest they may be causing reproductive failure and/or increased physiological stress (Ruelle and Henry 1994). In addition to compiling data on contaminant levels, Ruelle and Henry also determined that heavy metals and organochlorine compounds (i.e. PCBs) accumulate in fat tissues. Although the long term effects of the accumulation of contaminants in fat tissues is not yet known, some speculate that lipophilic toxins could be transferred to eggs and potentially inhibit egg viability. In other fish species, reproductive impairment, reduced egg viability, and reduced survival of larval fish are associated with elevated levels of environmental contaminants including chlorinated hydrocarbons. A strong correlation that has been made between fish weight, fish fork length, and DDE concentration in pallid sturgeon livers indicates that DDE increases proportionally with fish size (NMFS 1998).

INACTIVE

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002). Sixteen metals, two semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs, DDE (an organochlorine pesticide) were detected in the "adverse affect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. Contaminant analysis conducted in 2003 of tissues from a shortnose sturgeon from the Kennebec River revealed the presence of fourteen metals, one semivolatile compound, one PCB Aroclor, Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fish in the literature (ERC 2003). While no directed studies of chemical contamination in shortnose sturgeon have been undertaken, it is evident that the heavy industrialization of the rivers where shortnose sturgeon are found is likely adversely affecting this species.

During summer months, especially in southern areas, shortnose sturgeon must cope with the physiological stress of water temperatures that may exceed 28°C. Flourney et al.(1992) suspected that, during these periods, shortnose sturgeon congregate in river regions which support conditions that relieve physiological stress (i.e., in cool deep thermal refuges). In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flourney et al.1992; Rogers and Weber 1994; Weber 1996). The loss and/or manipulation of these discrete refuge habitats may limit or be limiting population survival, especially in southern river systems.

Pulp mill, silvicultural, agricultural, and sewer discharges, as well as a combination of non-point source discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. Shortnose sturgeon are known to be adversely affected by dissolved oxygen levels below 5 mg/L. Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28°C (Flourney et al. 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

Summary of status of shortnose sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard 1996), making the continued success of shortnose sturgeon in these rivers critical to the

INACTIVE

species as a whole.

Population sizes of the Delaware River population by three estimation procedures ranged from 6,408 to 14,080 adult sturgeon. This is the best available information on population size, but because the recruitment and migration rates between the population segment studied and the total population in the river are unknown, model assumptions may have been violated. Based on comparison to older population estimates, NMFS assumes that this population is increasing or at worst is stable.

While no reliable estimate of the size of either the shortnose sturgeon population in the Northeastern US or of the species throughout its range exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. Based on the best available information, NMFS believes that the status of shortnose sturgeon throughout their range is at best stable, with gains in populations such as the Hudson, Delaware and Kennebec, offsetting the continued decline of southern river populations, and at worst declining. The lack of information on the status of populations such as that in the Chesapeake Bay add uncertainty to determination on the status of this species as a whole.

INACTIVE

ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of the listed species in the action area. The activities that shape the environmental baseline in the action area of this consultation generally include: dredging operations, water quality, scientific research, shipping and other vessel traffic and fisheries, and recovery activities associated with reducing those impacts. The section below will discuss several threats that are global in nature and thus, impact shortnose sturgeon throughout the action area (i.e., climate change) as well as the impacts of localized actions that only affect shortnose sturgeon in specific river systems.

Global Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change induced by human activities - frequently referred to in layman's terms as "global warming." Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The Environmental Protection Agency's climate change webpage provides basic background information on these and other measured or anticipated effects (see www. epa.gov/climatechange/index.html). Activities in the action area that may have contributed to global warming include the combustion of fossil fuels by vessels.

The impact of climate change on shortnose sturgeon is likely to be related to changes in water temperatures, potential changes to salinity in rivers, and the potential decline of forage. These

changes may effect the distribution of species and the fitness of individuals and populations due to the potential loss of foraging opportunities, displacement from ideal habitats and potential increase in susceptibility to disease (Elliot and Simmonds 2007). A decline in reproductive fitness as a result of global climate change could have profound effects on the abundance and distribution of shortnose sturgeon in the action area, and throughout their range.

Connecticut River

The activities that shape the environmental baseline of this consultation include the effects of the past operation of the Holyoke Project, additional dams, up- and downstream hydropower and other electric generating facilities, coal tar deposits, fisheries, research projects, and water quality.

Impacts of Federal Actions that have Undergone Formal or Early Section 7 Consultation

On June 26, 1992, NMFS issued a Biological Opinion (Opinion) to the New England District Army Corps of Engineers (ACOE) for maintenance dredging of the Connecticut River Federal Navigation Project. The Opinion concluded that the proposed long-term maintenance dredging project was likely to jeopardize the continued existence of shortnose sturgeon in the Connecticut River due to the high number of shortnose sturgeon expected to be killed or otherwise affected by hopper dredging operations. In cooperation with the ACOE, NMFS developed a reasonable and prudent alternative which would avoid jeopardy to shortnose sturgeon in the Connecticut River. The RPA included a time of year restriction and a change in disposal location. The accompanying Incidental Take Statement indicated that NMFS believed up to 10 shortnose sturgeon were likely to be taken from dredging operations on an annual basis but due to difficulty in monitoring take, the ITS exempted the take of five shortnose sturgeon (mortalities due to entrainment in the hopper dredge) annually. This action has been ongoing since the 1960s and continues today. Dredging occurs nearly every year; however, no takes of shortnose sturgeon have been documented in recent years.

Impacts of the Operation and Maintenance of Holyoke Dam

Construction and operation of hydroelectric projects in the Connecticut River have significantly altered the natural characteristics of the river by altering the river flows and temperatures necessary for successful shortnose sturgeon spawning and/or migration. Hydroelectric projects also elevate the turbidity levels as a result of erosion generated by abnormal flow fluctuations and reduce the water velocity within the impoundment, making it difficult for sturgeon to find or effectively use the fishways. The most significant hindrance to shortnose sturgeon migration is the existence of the Holyoke Dam, a 150 year old barrier to normal upstream and downstream movement patterns of the Connecticut River shortnose sturgeon population. If the average shortnose sturgeon life span is 20 years, this represents almost 8 generations that have been affected by impaired migration. This long-term separation of the upriver and downriver shortnose sturgeon groups by Holyoke Dam likely has had significant effects on the Connecticut River population's likelihood of surviving and recovering in the wild.

The effects of the Holyoke Project on the shortnose sturgeon's ability to migrate in the Connecticut River have likely adversely affected the shortnose sturgeon's likelihood of surviving in the river. An extensive evaluation of shortnose sturgeon rangewide revealed that shortnose sturgeon above Holyoke Dam have the slowest growth rate of any surveyed (Taubert 1980 in

INACTIVE

Kynard 1997) while shortnose sturgeon in the lower Connecticut River have a high condition factor and general robustness (Savoy, in press). This suggests that there are growth advantages associated with foraging in the lower river or at the fresh- and salt-water interface. There are four documented foraging sites downstream of the Holyoke Dam, while only one exists upstream. The presence of the Holyoke Dam has likely resulted in depressed juvenile and adult growth due to inability to take advantage of the increased productivity of the fresh/salt water interface. This likely has negatively impacted the survival of the Connecticut River population of shortnose sturgeon and impeded recovery. This has also likely made the spawning periodicity of females greater.

The fishways at the Holyoke Dam provide limited upstream passage opportunities. While several shortnose sturgeon attempt to use the fish lift each year, currently these fish are returned downstream of the dam as safe downstream passage is not available. Upstream fish attempting to move downstream of the Dam can pass over the dam or through the turbines, both of which have a relatively high mortality rate. Shortnose sturgeon that are guided into the bypass can pass safely through the bypass pipe and are discharged below the dam.

The owners of the Holyoke project, in cooperation with NMFS and other partners, are in the process of making modifications to the existing fishway facilities to improve the likelihood of safe and successful passage for shortnose sturgeon. However, at this time, successful passage is limited. In 2005, NMFS completed section 7 consultation with the Federal Energy Regulatory Commission on the effects of the continued operation of the project pursuant to the terms of a multiparty Settlement Agreement and a proposed amended FERC operating license. The Settlement Agreement and amended license set forward measures necessary to provide safe and successful upstream and downstream passage for shortnose sturgeon and a timeline for implementation. This consultation concluded with a Biological Opinion dated January 27, 2005 in which NMFS concluded that the continued operation was likely to adversely affect but not likely to jeopardize the continued existence of shortnose sturgeon. a significant Managers have had to decide whether to pass shortnose sturgeon found in the fish lift upstream and whether to actively facilitate the passage of additional shortnose sturgeon located below Holyoke Dam.

Other past impacts of the Holyoke Dam include stranding shortnose sturgeon in pools below the dam. Ledges at the base of the spillway make it difficult for fish to pass upstream, especially in low flow conditions. In the past few years, attempts have been made to find and remove sturgeon stranded in pools when the fish lift ceased operating for the season. In 1990, 3 sturgeon were rescued from the pools, 4 sturgeon were rescued in 1996, 17 in 1998, and 37 in 1999. Without active efforts to remove these sturgeon and relocate them, they likely would have died due to increased temperatures and decreased dissolved oxygen. Many of the sturgeon rescued possessed heavy abrasions. Two shortnose sturgeon were stranded in the apron pool below the dam in 2002. These fish were removed and released into the mainstem river unharmed.

In addition to its effects on migration, the operation of the Holyoke Dam has other impacts. Shortnose sturgeon can be impacted by typical flow fluctuations as a result of past peaking and pulsing operations, elevated turbidity levels as a result of erosion generated by abnormal flow fluctuations, reduction of water velocity within the impoundment, and the degradation of riverine aquatic habitat both above and below the dam. These factors can also restrict effective migration

INACTIVE

by making the water conditions less suitable for shortnose sturgeon passage.

Impacts of Non-Federally Regulated Actions

Non-Federally Regulated Fishery Operations

Shortnose sturgeon are taken incidentally in anadromous fisheries along the East coast and may be targeted by poachers (NMFS 1998). It has been estimated that approximately 20 shortnose sturgeon are killed each year in the commercial shad fishery and an additional number are also likely taken in recreational fisheries (T. Savoy pers. comm. in NMFS 1998). Shortnose sturgeon have also been incidentally caught by recreational or commercial fishers, as seen in the Connecticut River shad fishery, and could be subject to poaching. Due to a lack of reporting, no information on the number of shortnose sturgeon caught and released or killed in commercial or recreational fisheries on the Connecticut River is available.

Impacts of Other Potential Sources of Impacts in the Action Area

Scientific Studies

Previous research projects conducted in the Connecticut River since 1976 may have influenced shortnose sturgeon survival, reproduction and/or migration. Research projects conducted in the action area included, but were not limited to, capturing, measuring, weighing, tagging (internal and external) and obtaining eggs from shortnose sturgeon. Currently, two ongoing research projects are permitted by NMFS. Both Dr. Boyd Kynard (USGS) and Mr. Tom Savoy (Connecticut Department of Environmental Protection) possess ESA Section 10(a)(1)(A) Permits to conduct scientific research on shortnose sturgeon in the Connecticut River. Both researchers have been conducting research in the Connecticut River for several years.

Dr. Kynard's current permit (No. 1239) authorizes him to take annually, for a period of five years, from the Connecticut River: 200 eggs, embryos and larvae (lethal take); 275 adult and large juveniles (capture, PIT tag and release); 25 adult and large juvenile (capture, PIT tag, internal radio tag and release); 1000 pre-spawned eggs (lethal take); 10 prespawning adults (capture, maintain in lab, release after experiments); and 20 pre-spawned adults (capture, radio tag, release). All of Dr. Kynard's work is to be conducted above the Holyoke Dam with the exception of the take of the 10 prespawning adults which are to be taken from below the Holyoke Dam. Dr. Kynard's permit specifies that indirect mortalities associated with research activities must not exceed five shortnose sturgeon within the five year period of the permit; and no more than two shortnose sturgeon in any one year. Dr. Kynard reported two mortalities in 2002.

Mr. Savoy's current permit (No. 1247) authorizes him to take annually, for a period of five years, from the Connecticut River: 100 juveniles (capture, tag, release); 400 adults (capture, tag, release, stomach sampling); 25 adult and large juveniles (capture, sonic/radio tag, release); 150 larvae (lethal take); 150 eggs (lethal take). Dr. Savoy's permit specifies that indirect mortalities associated with research activities must not exceed five shortnose sturgeon within the five year period of the permit; and no more than two shortnose sturgeon in any one year. Dr. Savoy's permit is only for activities below the Holyoke Dam. Under previous research permits, Dr. Savoy has had 13 mortalities, all due to mortality in gill nets.

Impacts of Contaminants and Water Quality

INACTIVE

Heavy usage of the Connecticut River and development along the waterfront has likely affected shortnose sturgeon throughout the action area. Coastal development and/or construction sites often result in excessive water turbidity, which could influence sturgeon spawning and/or foraging ability. Industries along the Connecticut River include or have included in the past, hydroelectric and other energy generating facilities, an armory, firearms factory, industrial mills and various other industrial pursuits. A 2004 cleanup of the river organized by the Connecticut River Watershed Council (CRWC) provides evidence of the highly polluted state of the Connecticut River. This cleanup collected approximately 42 tons of trash from the river including: propane tanks, car and boat parts, containers of motor oil and antifreeze as well as various other large and small items. The cleanup also observed but could not remove two heating oil tanks, three cars and three boats. Many of these items likely leak chemical waste into the river. The effect of trash and general pollution on shortnose sturgeon in the Connecticut River is unknown. While water quality has improved in the Connecticut River, previous pollution levels have led to historic dissolved oxygen levels as low as 2-4mg/L and the designation of the river by some environmental groups as "the best landscaped sewer in America" (Savoy, in press).

Pulp mill, silvicultural, agricultural, and sewer discharges, as well as a combination of non-point source discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. Shortnose sturgeon are known to be adversely affected by low oxygen levels (below 5 mg/L). Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28°C (Flourney *et al.* 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal. Point source discharge (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may also impact the health of sturgeon populations. The compounds associated with discharges can alter the pH of receiving waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival.

The New England Interstate Water Pollution Control Commission issued a report in early 1998 on water quality threats. This report indicated that the Connecticut River had several major water quality issues. These included: toxins, such as PCBs; combined sewer overflows (CSOs) which can cause poor water quality conditions in urban areas after storm events; and non-point source pollution. All four of the states with Connecticut River waters have public health advisories regarding the consumption of fish caught in the river (MA: PCBs, CT: mercury and PCBs). The Connecticut River Watershed Council (CRWC) has also identified acid rain and atmospheric deposition of mercury and other contaminants as a problem throughout the watershed.

Coal tar deposits released in the Connecticut River have likely affected spawning success, egg survival and/or larval development. Coal tar contains toxic Polycyclic Aromatic Hydrocarbons (PAHs) that are known to be carcinogenic. Other pollutants in the Connecticut River, such as polychlorinated biphenyls (PCBs), could affect shortnose sturgeon reproduction as well. In the Connecticut River, coal tar leachate was suspected of impairing sturgeon reproductive success. Kocan (1993) conducted a laboratory study to investigate the survival of sturgeon eggs and

INACTIVE

larvae exposed to PAHs, a by-product of coal distillation. Only approximately 5% of sturgeon embryos and larvae survived after 18 days of exposure to Connecticut River coal-tar (i.e., PAH) demonstrating that contaminated sediment is toxic to shortnose sturgeon embryos and larvae under laboratory exposure conditions (NMFS 1998). There are several known coal tar contaminated sites below the Holyoke Dam that have only recently begun to be cleaned up. It is likely that these sites as well as any others have had adverse effects on any shortnose sturgeon present in the action area over the years.

Impacts of Invasive Species
A number of invasive species are known to exist in the watershed. These species have been inadvertently and purposefully introduced to the Connecticut River watershed by humans. These include common reed, purple loosestrife, Eurasian milfoil, water chestnut, mute swans, Asiatic clams, and wooly adelgids. The potential for these species to affect shortnose sturgeon is currently unknown.

Impacts of Dams, Hydroelectric and Other Power Plants
The presence of other dams in addition to the Holyoke Project on the Connecticut River could effect shortnose sturgeon migration. There are 16 dams upstream of the Holyoke Dam on the river's mainstem, and one breached structure downstream of Holyoke. The Enfield Dam was constructed in 1902 and is located at rkm 110, downstream from the Holyoke Dam. It is a 1.7 meter canal wing dam which may impede the movement of upstream migrating shortnose sturgeon during periods of extreme low water (Buckley 1982; Buckley and Kynard 1983). The dam was breached in 1977 and is currently passable to fish in at least four locations. Historical information documents the migration of adult shortnose sturgeon upstream past the Enfield Rapids and the dam as far back as 1912, well before the breaches occurred (Eastman 1912). Historical information also suggests that the Enfield Dam never functioned as a permanent barrier, but rather as a seasonal impediment to the upstream movement of shortnose sturgeon. The Holyoke Dam is the first barrier to migratory fish on the mainstem Connecticut River.

The presence of a dam, alone, alters the natural flow fluctuations of a river. Changes in the natural flows and natural flow fluctuations are a result of how a dam is operated. The upstream Turners Falls and Deerfield River Projects are peaking projects[4] and control flows to the Holyoke impoundment to some extent. Turners Falls is located approximately 35 miles upstream of the Holyoke Dam on the mainstem Connecticut River and has a hydraulic capacity of up to 15,000 cfs. The present Turners Falls Dam, canal and a small power station were licensed in 1889. The dam diverts the mainstem into a 3.5-km long power canal that supplies water to Cabot Station, a hydroelectric generating facility built in 1920. Cabot Station has six Francis turbines with a generation capacity of 51 MW at 368 m^3/s flow, a 50-m wide spillway, a modified Ice Harbor fish ladder, and a bypass flume. During periods of high discharge that exceed Cabot Station's generating capacity (about 400m^3/s), water spills over Turners Falls Dam into the natural river bed that leads to the Rock Dam. In spring, as discharge decreases, most river flow is diverted into the power canal and spillage ceases at Turners Falls Dam. When the dam controls all river flow, Cabot Station generates in peaking mode with low generation during

4 A peaking facility is a power-generating plant that only operates during the maximum load periods (i.e., the times when energy demand is at its peak). This results in greater fluctuations in daily and seasonal dam operation and flow rates.

INACTIVE

hours of low demand and high generation and discharge during peak demand. Flows passing through Turners Falls from the pump storage operations at Northfield Mountain are responsible for most of the flows to the Holyoke Project. Located 30 miles upstream of the Holyoke Dam on the Deerfield River, the Deerfield River Project also contributes to the variations in daily and hourly inflows to the Holyoke Project, although to a lesser extent than the other projects.

As a result of fluctuating downstream flows, the Holyoke, Turner Falls, and Deerfield River Projects likely have influenced shortnose sturgeon spawning patterns, degraded reproductive habitat or elevated turbidity levels, impairing shortnose sturgeon movement in the Connecticut River. High river flows during the normal shortnose sturgeon spawning period can cause unacceptably fast bottom water velocities and prevent females from spawning. This situation was observed in the Connecticut River in early May of 1983 and 1992 when flows were higher than normal and temperatures were lower than normal, but still adequate for spawning (Buckley and Kynard 1985, Kynard 1997). Buckley and Kynard (1985) and Kieffer and Kynard (in press) speculated that the reproductive rhythm of females may be under endogenous control and suitable river conditions must be available or endogenous factors prevent females from spawning. Thus, reproductive success depends on suitable river conditions during the spawning season, and human interactions causing habitat flow modifications could alter these natural river conditions, thus affecting spawning success. Dewatering events while females are spawning at Rock Dam have been documented to terminate spawning (Kieffer and Kynard in press) and flow regulation at Rock Dam makes spawning of shortnose sturgeon at this site impossible in most years. Regular operation of Turners Falls Dam and Cabot Station introduce shifts in discharge and velocity that have deleterious effects on shortnose sturgeon spawning success. Operations at Cabot Station during years of low discharge may significantly reduce survival of eggs and embryos. When there is a no-flow period, spawning substrate can be de-watered, probably killing eggs and embryos.

Regulation of the Connecticut River creates unnatural discharge regimes that affect the spawning of females and survival of early life stages. There are a series of Army Corps of Engineer's (ACOE) dams on tributaries located upstream of Montague. These dams are used to control floods and as spring river discharge decrease, the ponded waters in the dams is released. This extends the cool, high-discharge period beyond natural conditions. The extension of this discharge for even a week is likely sufficient to close the discharge window and cause spawning failure (Kieffer and Kynard in press).

Impingement of shortnose sturgeon on power plant cooling water intake screens may also have contributed to sturgeon mortality in the Connecticut River. This is likely to be a problem at facilities with screens with larger mesh sizes and high water velocities. Mortalities were thought to be high at the Connecticut Yankee nuclear power plant; however, this plant has not been operational since 1996 and decommissioning was completed in 2003.

Merrimack River

Impacts of Federal Actions that have Undergone Formal or Early Section 7 Consultation
To date, NMFS has not conducted any formal or early section 7 consultations for actions proposed for the Merrimack River.

INACTIVE

Impacts of Non-Federally Regulated Actions

Non-Federally Regulated Fishery Operations

As noted in the "Connecticut River" section above, shortnose sturgeon are taken incidentally in anadromous fisheries along the East coast and may be targeted by poachers (NMFS 1998). While NMFS has received reports of recreational fishermen capturing Atlantic sturgeon at the mouth of the Merrimack River, there is currently no information on the number of shortnose sturgeon caught and released or killed in commercial or recreational fisheries on the Merrimack River.

Other Potential Sources of Impacts in the Action Area

Scientific Studies

Previous research projects conducted in the Merrimack River since the 1980s may have influenced shortnose sturgeon survival, reproduction and/or migration. Research projects conducted in the action area included, but were not limited to, capturing, measuring, weighing, and tagging (internal and external) shortnose sturgeon. Currently, one ongoing research projects are permitted by NMFS. Dr. Boyd Kynard (USGS) possesses a permit issued pursuant to ESA Section 10(a)(1)(A) to conduct scientific research on shortnose sturgeon in the Merrimack River.

Dr. Kynard's current permit (No. 1549) authorizes him to take annually, for a period of five years, from the Merrimack River: 10 eggs, embryos and larvae (lethal take); 85 adult and large juveniles (capture, PIT tag and release); and 15 adult and large juvenile (capture, PIT tag, internal radio tag and release. Dr. Kynard's permit specifies that indirect mortalities associated with research activities must not exceed two shortnose sturgeon in any one year. Dr. Kynard has not reported any mortalities in the Merrimack River.

Impacts of Hydroelectric Projects

The first mainstem dam (Essex Dam) on the Merrimack River is located at river km 46 in Lawrence, Massachusetts, and operates as a run-of-the-river facility. In three years of telemetry and gillnetting, however, no shortnose sturgeon was ever detected upstream of river km 35, even though habitat suitable to complete the entire life history appeared abundant in this reach just below the dam, suggesting the Merrimack River shortnose sturgeon's present life history is genetically predisposed to exist in a shorter reach of river. As such, based on the best available information, the Essex Dam does not appear to be preventing shortnose sturgeon from accessing preferred habitat.

Water quality and contaminants

Pathogens from combined sewer overflows and urban runoff are the major causes of water quality problems for the river according to a 2001 watershed assessment. Additionally, nutrients and ammonia are listed as problems, particularly around urban areas (Dunn 2001). Water quality of the Merrimack River was assessed by the MA DEP (Carr and Kennedy 2003). Reaches from Lowell to Newburyport were consistently determined impaired for fish consumption due to PCB and mercury contamination and for primary recreational contact (swimming) due to fecal coliform bacteria. In addition, the report cited advisories for shellfishing in the lower river.

INACTIVE

Status of Shortnose Sturgeon in the Action Area
As noted above, shortnose sturgeon are listed throughout their range and exist as 19 populations. The proposed action will take place in two rivers supporting shortnose sturgeon populations. The section below will discuss the status of shortnose sturgeon in the Connecticut and Merrimack Rivers

Connecticut River
Natural mortality is a factor that should be considered when estimating the impacts to species recovery. Taubert (1980) estimated the total instantaneous mortality rate to be 0.12 for adult shortnose sturgeon in the Holyoke Pool portion of the Connecticut River. It is likely that the fishing mortality rate is very low in this population, so the natural mortality rate is probably very close to the instantaneous mortality rate (NMFS 1998). Using catch curves and Hoenig's technique, total instantaneous natural mortality for shortnose sturgeon in the Connecticut River estuary was estimated to be 0.13 (T. Savoy personal communication, in NMFS 1998).

The best available scientific data indicates that historically, shortnose sturgeon ranged above Hadley Falls to Turners Falls. Spring high water events afforded upstream migrating shortnose sturgeon the opportunity to navigate the Hadley Falls area. The Holyoke Dam and associated lock and pool were built in 1849, for the most part blocking downriver fish from the 58 km reach of river between Holyoke and Turners Falls. It is also possible that shortnose sturgeon were able to use the Hadley Boat Lock to gain access to upriver habitat. The first successful fishway, an elevator, was installed at the tailrace in 1955 to pass fish attracted to the hydroelectric turbine discharge. Consequently from 1849 to 1955, shortnose sturgeon above the dam were isolated from shortnose sturgeon below the dam, with the possible exception of some members of the upriver population passing downriver over the crest of the dam or through the lock, canal system or turbines. Another fishway, the spillway lift, was built in 1976 at the base of the dam to pass fish attracted to spillage water.

The Holyoke Dam separates shortnose sturgeon in the Connecticut River into an upriver group (above Holyoke Dam) and a lower river group that occurs below Holyoke Dam to Long Island Sound. The abundance of the upriver group has been estimated by mark-recapture techniques using Carlin tagging (Taubert 1980) and PIT tagging (Kynard unpublished data). No information exists on the historical numbers of shortnose sturgeon in the Connecticut River prior to the late 1970s. Estimates of total adult abundance calculated in the early 1980s range from 297 to 516 in the upriver population to 800 in the lower river population. Population estimates conducted in the 1990's indicated populations in the same range. The total upriver population estimates ranged from 297 to 714 adult shortnose sturgeon, and the size of the spawning population was estimated at 47 and 98 for the years 1992 and 1993 respectively. The lower Connecticut River population estimate for sturgeon >50 cm TL was based on a Carlin and PIT tag study from 1991 to 1993. A mean value of 875 adult shortnose sturgeon was estimated by these studies. Savoy (in press) estimates that the lower river population may be as high as 1000 individuals, based on tagging studies from 1988-2002. It has been cautioned that these numbers may overestimate the abundance of the lower river group because the sampled area is not completely closed to downstream migration of upriver fish (Kynard 1997). Other estimates of the total adult population in the Connecticut River have reached 1200 (Kynard 1998) and based on Savoy's recent numbers the total population may be as high as 1400 fish. Regardless of the

INACTIVE

actual number of fish present in the river, the effective breeding population, consisting of the upriver population as no lower river fish are currently passed upstream, totals only approximately 400 fish.

Talbert (1980b) reported that Connecticut River shortnose sturgeon exhibited relatively good growth until 8 to 10 years after which it declined rapidly. The average length of shortnose sturgeon at age 10 was 70.1cm, but shortnose sturgeon at age 25 were only 90cm in length. The largest shortnose sturgeon recorded by Talbert was 111cm in length. While the majority of shortnose sturgeon captured in this study were between 8 and 18 years of age, shortnose sturgeon in excess of 25 years were not uncommon.

Shortnose sturgeon in the Connecticut River reach sexual maturity at approximately age 8. In the Connecticut River, Buckley and Kynard (1985) found that spawning lasted 2-5 days in 1980-1992, and Kynard (1997) noted that spawning lasted 7-13 days in 1989-1993. A more recent study (Kieffer and Kynard in press), notes a spawning period of 5-17 days during the same 26 day period each year (April 27 – May 22). Shortnose sturgeon spawn in the Connecticut River from the last week of April to mid-May; after peak spring flows and in moderate, decreasing river discharge (Taubert 1980; Buckley and Kynard 1985; Kynard 1997). In the lower Connecticut River, most of the ripening shortnose sturgeon migrate to their spawning grounds in August-October and remain near the spawning areas (i.e., overwinter) until spring (Dadswell 1979; Buckley and Kynard 1985).

Several areas of the river have been identified as concentration areas. In the downriver segment, a concentration area is located in Agawam, MA which is thought to provide summer feeding and over wintering habitat. Other concentration areas for foraging and over wintering is located in Hartford, Connecticut, at the Head of Tide (Buckley and Kynard 1985) and in the vicinity of Portland, Connecticut (CTDEP 1992). Shortnose sturgeon also make seasonal movements into the estuary, presumably to forage (Buckley and Kynard 1985; Savoy in press). Above the dam, there are also several concentration areas. During summer, shortnose sturgeon congregate near Deerfield. Many overwinter at Whitmore. Successful spawning has been documented at two sites in Montague and this is thought to be the primary spawning site for shortnose sturgeon in the Connecticut River (see below).

In the Connecticut River, foraging occurs in the summer in both freshwater and saline reaches of the river (Buckley and Kynard 1985; Savoy and Shake 1992). One foraging area is located above Holyoke Dam and four others are located below Holyoke Dam. There is also an overwintering area located approximately 25 km downstream of the upriver (Montague) spawning area. These upriver sites are probably preferred by pre-spawning shortnose sturgeon that will reproduce the following spring (Kieffer and Kynard, in press). Shortnose sturgeon in the lower river appear to migrate upstream to the area of the Holyoke Dam throughout the summer foraging season. It is possible that these fish seek to reach the upstream foraging and overwintering areas to await the spring spawning season. The migration of juvenile and adult shortnose sturgeon to points downstream of the Holyoke Dam appears to be a natural event coincidental with increased river discharges (Seibel 1991; Kynard 1997).

Adult shortnose sturgeon remain in freshwater all year in the Connecticut River, but some adults

INACTIVE

briefly enter low salinity river reaches in May to June and then return upriver (Buckley and Kynard 1985; Savoy in press). The concentration area used by adult fish in the Connecticut River is in reaches where natural or artificial features cause a decrease in river flow, possibly creating suitable substrate conditions for freshwater mussels (Kieffer and Kynard 1993), a major prey item for adult sturgeon (Dadswell et al. 1984). Both adults and juveniles have been found to use the same river reaches in the Connecticut River and have summer home ranges of about 10 km (Savoy 1991; Seibel 1991). The wintering range is usually less than 2 km, with fish congregating in deep areas, usually within or near the summer range (Seibel 1991). Foraging adults prefer curved or island reaches in the summer, not straight runs, and appear to prefer gravel and rubble substrate in the summer, but sand in the winter. Fish foraging activity is almost equal during day and night, but most adult sturgeon occur in slightly deeper water during the day than at night.

In 1983, Buckley and Kynard identified a shortnose sturgeon spawning site below Holyoke Dam. This area was initially determined to be a spawning area based on the relatively high numbers of telemetered sturgeon concentrating in the region during the spring spawning season. Investigation of this site, however, has provided evidence of successful spawning in very few years. In 1985, 4 eggs and 4 embryos were recovered (Buckley and Kynard 1985). In 1998, one egg was collected at Holyoke and during 1999 seven eggs were collected at Holyoke (4 of the eggs were dead and the remaining 3 were in an early stage of development). This suggests that a limited amount of spawning may occur below the Holyoke Dam, but given the numbers of eggs and larvae captured at the upstream versus the downstream spawning sites it is clear that spawning at Montague (the upriver site) is significantly more successful.

Two areas above Holyoke Dam, near Montague, have more consistently been found to provide spawning habitat for shortnose sturgeon. This spawning habitat is located at river km 190-192 and is the most upstream area of use. It is located just downstream of the species' historical limit in the Connecticut River at Turners Falls (river km 198). Across the latitudinal range of the species, spawning adults typically travel to approximately river km 200 or further upstream where spawning generally occurs at the uppermost point of migration within a river (Kynard 1997; NMFS 1998). The Montague sites have been verified as spawning areas based on successful capture of sturgeon eggs and larvae in 1993, 1994, and 1995, that were 190 times the number of fertilized eggs and 10 times the number of embryos found in the Holyoke site (Vinogradov 1997). In seven years of study (1993-1999), limited successful spawning, as indicated by capture of embryos or late stage eggs, occurred only once (1995) at Holyoke Dam (Vinogradov 1997; Kynard et al. 1999c). Using this same measure, successful spawning occurred at Montague during 4 of 7 years. Both Montague and Holyoke sites have been altered by hydroelectric dam activities, but all information suggests that females spawn successfully at Montague, not at Holyoke Dam. Thus, it appears that most, if not all, recruitment to the population comes from spawning in the upriver segment.

The Montague area is the 1.4-km reach from the Rock Dam to 200m downstream of Cabot Station. In this area, river depths are less than 10m and all common types of river habitat are present. Much of the river bottom in the natural river bed and in the tailrace of Cabot Station is rock and rubble. The 0.5-km long tailrace downstream of Cabot Station contains rubble/boulder shoals that can be exposed briefly in spring during low river discharge and low Cabot Station

INACTIVE

generation.

Kieffer and Kynard (in press), conducted a multiyear study (1993-2003) on the pre-spawning migration and spawning of Connecticut River shortnose sturgeon. Seventy-two adults were tracked from the four wintering sites, with 54 adults tracked during two or more spring periods. During this ten year period, only eighteen (25%) of the adults initiated a pre-spawning migration. The study observed 27 (26 males, 1 female) pre-spawning migrations from wintering areas. Twenty-four of the pre-spawning adults wintered at Whitmore and initiated a pre-spawning migration from there. Three males wintered and initiated migration from other winter sites (Second Island, Hatfield, and Elwell Island). While river discharge, day length and moon phase differed when migration began, males left Whitmore each year during similar temperatures (7.0-9.2°C). Fifty-one non-spawning adults were also tracked as they left Whitmore. Adults left Whitmore on similar dates to the spawning adults. Most non-spawning adults left Whitmore at the same time or within a week of pre-spawning migrants (i.e., by the first week in May). However, during all years, some adults remained at the winter site through early June, suggesting that they were foraging at the winter site.

Tracking also occurred at the Deerfield Confluence Area, many of the fish radio-tagged at Deerfield migrated to Montague, with several of the males moving back and forth between Deerfield and Montague at least once. A group of nonspawners was also located at Deerfield. Some of these fish stayed at Deerfield until at least November, suggesting that the Deerfield area is used by adults in all reproductive stages during spring and summer.

A total of 450 males and 55 females were captured and measured at Montague during 1993-2003. While both sexes showed a significant and similar length/weight relationship, females were significantly greater in total length and weight than males. Abundance estimates at the Montague site during spawning ranged from 14 to 360 adults. Spawning was documented to have succeeded in 1993, 1994, 1995, 1998-2000 and 2003 and spawning failed in 1996, 1997, 2001 and 2002. The mean abundance of adults for the years when spawning succeeded was significantly higher (198) than in years when spawning failed (50). Spawning succeeded more often at Cabot Station (7 years) than at Rock Dam. For the 11 years of the study, successful spawning only occurred for 7 years. In all years, spawning occurred from April 27-May 22, lasting from 5-17 days (mean 8.3 days). Even during years when spawning occurred, tracking indicated that some females did not spawn. While females spawned at either Cabot Station or Rock Dam, some males likely spawned at both locations. In 2002, spawning failed because the pre-spawning migration failed (no females and only two males were captured at Montague).

During spawning, the daily mean temperatures at Cabot Station were 6.5-14.7°C and the mean temperatures when spawning occurred at Rock Dam were 9.1-14.5°C. Females spawned in water depths of 1-5m with a peak at 1.5-1.9m. Bottom water velocity at spawning site was a mean of 70cm/s with the greatest usage of 75-125 cm/s. The only substrate type females used was cobble/rubble (101-300 mm diameter).

Suitable spawning windows were determined to be based on day length, water temperature and water discharge. Endogenous physiological factors controlled by day length set the duration of the potential spawning window. For the Connecticut River, this period is from April 27 – May

INACTIVE

22. Within this window, temperature and discharge must overlap for spawning to occur. Kieffer and Kynard estimated that during the period of 1904 and 1991, 33 years had unsuitable discharge and 7 years likely had failed pre-spawning migrations. Thus, of these years, spawning likely failed for 40 years and was unknown for 2 years (due to unusual discharge patterns). The longest period of suitable discharge at Cabot Station was 5 consecutive years (1948-1952 and 1964-1968) and the longest period of unsuitable discharge was 4 consecutive years (1969-1972). The results of this analysis clearly indicate that shortnose sturgeon spawning in the Connecticut River does not occur every year. The cause of these failures has not yet been identified.

Pre-spawning males moved at a mean ground speed of 4 km/day and females moved 3-10 km/day. This is significantly slower than ground speeds recorded during summer and fall (16-20 km/day; Buckley and Kynard 1985). This suggests that pre-spawning adults, who have not foraged since November, may be conserving energy for spawning. The migration route for all adults leaving the winter site was the channel.

Two wintering and migration strategies appear to be used by Connecticut River pre-spawning females. Most females downstream of the Holyoke Dam that could spawn the next spring, attempt to migrate upstream to Deerfield during the summer or early fall preceding spawning (Kynard et al. in press). When displaced over the dam, most were disoriented and returned downstream before spawning, but two remained upstream, summered at Deerfield, wintered at Whitmore and migrated to spawn at Montague. The migration and behavior of these two fish likely shows the natural movement pattern of downstream segment females if upstream passage was available over Holyoke Dam. The choice by pre-spawning females to winter at Whitmore, closest to Montague, strongly suggests that this choice is adaptive and likely has energetic benefits from a shorter spring spawning migration.

Many males spawned during several conservative years, but no male spawned every year. Trusov (1991) found difference in the maturation rates of testes of male stellate sturgeons (*Acipenser stellatus*) and suggested feeding success likely influenced stage of maturity. The interval of spawning for females was 6 years or more and highly variable. It should be noted that these males and females were from the upstream population segment and that unlike the downstream population segment, these fish do not have access to the mineral and forage resources in the estuary. Kieffer and Kynard (in press) suggest that female spawning periodicity in a reunited Connecticut River population would likely show a shorter time interval between spawning of females.

Vinogradov (1997) conducted a detailed comparison study of the Holyoke and Montague spawning sites, but did not detect significant differences in habitat parameters (substrate quality, bottom velocity, water temperature). The researchers hypothesized that sturgeon are spawning site specific and that there is a strong behavioral drive to move upriver. The investigators argued that Holyoke Dam may have less of an effect on the potential population size (by limiting the number of spawners) than on the compromise to gene flow, which is extremely significant in a population where high levels of demographic stochasticity may determine the population's long-term viability.

Monitoring of spawner abundance in the Connecticut River indicated that abundance varies

INACTIVE

greatly from year to year: in 1992 there were 47 spawners, while in 1993, 98 spawners were detected (Kieffer and Kynard unpublished data). Sampling in 1998 revealed that spawning at both locations was mainly unsuccessful, except for a rare female at Montague and Holyoke. In fact, all evidence indicates that, until 1999, there had been limited or no significant reproduction since 1995 (Kynard et al. 1999c). Further, it appears that not every mature female spawns successfully. In the Connecticut River, one of four female shortnose sturgeon removed for egg culture in 1988 could not spawn due to a tumor (Kynard personal observation), suggested to be due to exposure to coal tar leachate in the river.

In 1997, an ecological risk analysis was conducted for shortnose sturgeon in the Connecticut River by Applied Biomathematics (Root and Akcakaya 1997). The analysis concluded that the stability observed in upriver and downriver populations of shortnose sturgeon in the Connecticut River would be possible under two conditions: reproduction in both upper and lower populations and small to moderate rates of dispersal between them; or no fecundity in the lower population, very high fecundity in the upper population and a high rate of net downstream dispersal.

Merrimack River

The first detailed study of shortnose sturgeon in the Merrimack River was conducted by Dr. Boyd Kynard and Micah Kieffer (Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts, Amherst) between 1987 and 1991. A total of 630 overnight gill nets were set between April–November throughout the study (approximately 11,524 sampling hours) and only 24 adults were captured with few recaptures. Tracking data indicated that the majority of the population resided within river km 7–32 (Kieffer and Kynard 1993). Only a rare individual was observed outside of this range (one tagged fish made a brief movement upstream to river km 35 in the summer of 1989). Because telemetry data indicated fish remain in the river (no/low emigration) and there is low annual adult mortality, mark-recapture results from three years when ranges of residence were known, were combined in a Schnabel abundance estimate: 32 adults (20–79; 95% confidence interval; B. Kynard and M. Kieffer unpublished information).

Adult spawning behavior was studied for three years (1988 – 1990) at the spawning ground in Haverhill, Massachusetts (rkm 30–32; Figure 1). Spawning success was confirmed by the capture of two live embryos in 1990 at rkm 32 (Kieffer and Kynard 1996). Tagged pre-spawning adults arrived at the spawning grounds no earlier than 12 April and departed no later than 30 April. Between acoustic tracking and gillnet captures, a total of 10 individual fish were observed during the three full years of study at the spawning grounds in Haverhill. Additionally, a one-day tracking effort in April 1991 showed three tagged males had again moved to the spawning area. Males appeared to outnumber females at the spawning site. Of 10 total individuals observed, eight were males (all were observed running sperm at least once) and the sex of two were unknown. Among the 10 individuals, five were observed at the spawning area multiple years (females are not known to spawn annually).

The specific timing and location of spawning was determined by observing mature adults in likely spawning activity and by back-calculating the estimated age of the captured embryos. In 1989, spawning occurred at approximately rkm 31 between 26–30 April within an approximately 10.5 ha site. In 1990, spawning occurred between 22–29 April within a similarly sized site, approximately 13.5 ha, but was located upstream of the 1989 site by less than 1 km (rkm 32). As

INACTIVE

stated earlier, spawning in 1990 was confirmed by capturing viable early life stages (ELS) but sampling for ELS was not conducted in any other year.

During the estimated spawning periods in 1989 and 1990, decreasing river discharge ranged between 390–240 m^3/s and increasing temperature ranged between 9.6–14.0°C. Spawning micro-habitat data were collected in 1989 and 1990. In both years, spawning occurred over boulder-rubble substrate. In 1989, mean depth was 2.3 m and ranged from 1.8–3.0 m; bottom velocity averaged 0.48 m/s with a range of 0.3–0.7 m/s. In 1990 mean depth was 3.8 m and ranged from 2.7–5.5 m and bottom velocity averaged 0.33 m/s, with a range; 0.3–0.4 m/s.

Immediately following spawning, in the first week of May, a portion of post-spawning as well as non-spawning fish moved downstream to the salt/fresh water interface (river km 7–12). Here fish remained for up to six weeks (through mid-June) in an area that experienced wide shifts in temperature, salinity, turbidity, and velocity. This was also the time and place that sub-adult Atlantic sturgeons were observed, and the only period when the two species inhabited the same reach. Although the reason for this behavior was unknown, it has been observed in other temperate shortnose sturgeon populations, such as the Delaware River (O'Herron et al. 1993) and the Connecticut River (Buckley and Kynard 1985, Savoy 1991), and researchers in the Merrimack River speculated that movement to this area provided post-spawning and post-wintering fish with an essential mineral or dietary element following an energetic depletion (Kieffer and Kynard 1993).

The remainder of the year, shortnose sturgeon occupied an 11-km reach (river km 13–23 (from approximately Haverhill to Amesbury) that experienced reversing currents during flooding tides and maximum salinity penetration as far upstream as river km 16. During this time, researchers examined habitat selections throughout daily and seasonal cycles based on a hierarchical categorization of habitats. Shortnose sturgeon used three geomorphological regions (curve, island, and run) equally during foraging (summer-fall). Fish used channel and shoal habitats equally during summer, but favored channel in fall. For micro-habitat categories, fish used a depth range of 2–6 m that changed little through the foraging season. Although substrate use varied among four categories, fish were found most often over sand. Most fish were documented in daylight illumination levels of < 2,500 lx, but illumination ranged as high as 20,000 lx (Kynard et al. 2000).

As the river discharge decreased in late-spring and summer, tidal salinity during high tide traveled farther upstream. During a six-week period between the end of spawning and mid June, some shortnose sturgeon occupied the same reach as the Atlantic sturgeon (river km 12–7). For the remainder of the foraging year, the maximum upriver penetration of tidal salinity (1–10 ppt) occurred between river km 14–9. Most shortnose sturgeon locations occurred upstream of this reach, and most Atlantic sturgeon locations occurred downstream (Kieffer and Kynard 1993). Tracking during winter months was infrequent, however, tagged shortnose sturgeon tracked between late November–March remained within an 11-km reach (river km 12–23) (Kieffer and Kynard 1993). Although no temperature loggers were placed in the river through the winter, temperatures could be expected to follow a typical New England profile, approaching minimums of 0°C, indicating fish would likely adopt the energy-conserving behavior of minimal movements and foraging as observed by Kieffer and Kynard (In review) in the Connecticut

INACTIVE

River.

Researchers observed two seasonal migrations. In mid-April, tagged fish moved the 10 km from wintering areas to the spawning sites at Haverhill. Following spawning, fish departed Haverhill by early May. Some moved the 10 km back to the foraging area used by all adults in the summer and fall (rkm 13–23), while some continued to move farther downstream to the lower islands (rkm 7–12), an area used by both post- and non-spawning shortnose sturgeon only during the period following the spawning season (April 29–June 22), when fish were beginning to resume feeding following winter inactivity.. After a maximum of 6 weeks, the fish at the lower islands returned to the summer-fall foraging area (river km 13–23; Kieffer and Kynard 1993).

A recent NMFS-funded survey effort (M. Kieffer unpublished data) resulted in the capture of 22 adults (mostly ripe males) in six overnight gill nets set in late April 2008 at the spawning area identified at Haverhill, MA during earlier studies (river km 32; Kieffer and Kynard 1996). Catch-per-unit-effort (CPUE) results during spring in 2008 (0.305; M. Kieffer unpublished data) were in stark contrast to earlier spring CPUE results (1989; 0.005 and 1990; 0.018; Kieffer and Kynard 1996). However, as sampling was limited to this one event, there is currently insufficient information from which to make any determinations on any change in abundance.

Summary and synthesis of the Status of Species, Environmental Baseline, and Cumulative Effects sections

The Status of the Species, Environmental Baseline, and Cumulative Effects Sections, taken together, establish a "baseline" against which the effects of the proposed action are analyzed to determine whether the action—the proposed electrofishing survey - is likely to jeopardize the continued existence of the species. To the extent available information allows, this "baseline" (which does not include the future effects of the proposed action) would be compared to the backdrop plus the effects of the proposed action. The difference in the two trajectories would be reviewed to determine whether the proposed action is likely to jeopardize the continued existence of the species. This section synthesizes the Status of the Species, the Environmental Baseline, and Cumulative Effects sections as best as possible given that some information on shortnose sturgeon is quantified, yet much remains qualitative or unknown.

Summary of status of shortnose sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard 1996), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

INACTIVE

Population size of the Merrimack River population is estimated at 33 fish. This is the best available information on population size, but because this estimate is several years old and a recent sampling event captured over 20 adults in one net, the validity of this estimate is unknown. However, based on the best available information, NMFS estimates that this population is stable, and recognizes that it may be increasing. The total population size in the Connecticut River is estimated at approximately 1,400 shortnose sturgeon, with about 400 of these fish located upstream of the Holyoke Dam. Based on comparison to older population estimates, NMFS assumes that this population is increasing or at worst is stable.

While no reliable estimate of the size of either the shortnose sturgeon population in the Northeastern US or of the species throughout its range exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of populations such as that in the Chesapeake Bay add uncertainty to determination on the status of this species as a whole. Based on the best available information, NMFS believes that the status of shortnose sturgeon throughout their range is at best stable, with gains in populations such as the Hudson, Delaware and Kennebec, offsetting the continued decline of southern river populations, and at worst declining.

EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR 402.02). Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). This Opinion examines the likely effects (direct and indirect) of the proposed action on shortnose sturgeon in the action area and their habitat within the context of the species' current status, the environmental baseline and cumulative effects.

As explained in the "Description of the Action" section above, the proposed action will involve electrofishing at 20-25 sampling sites in the Connecticut River and 5 sites in the Merrimack River with some of these sites being sampled twice. All sampling will take place between July 1 and October 15. Sampling is proposed to be completed in 2009; however, if not, it will be completed in 2010. This section of the Opinion analyzes the effects of the proposed sampling events on shortnose sturgeon present within the action area of this consultation.

Based upon the best available data for the Merrimack River, shortnose sturgeon could be present in any of the river reaches identified for sampling. Similarly, shortnose sturgeon could be present in any of the river reaches identified for sampling in the Connecticut River. Due to the time of year when sampling will occur, no spawning or overwintering fish will be affected; similarly no shortnose sturgeon eggs would be present in either river system during this time of year. Additionally, shortnose sturgeon larvae are extremely unlikely to be affected by the proposed action. This is due to the location of the electrofishing survey outside of the channel where shortnose sturgeon larvae are known to occur and the depth at which larvae normally

INACTIVE

occur. These factors make it extremely unlikely that any larvae will be exposed to the electric current from the electrofishing boat. Therefore, the only life stages likely to be exposed to effects of the action are juveniles and adults.

Electrofishing can cause mortality or injury to fish. Fish encountering the electric current typically undertake an involuntary movement toward the positive electrode. Harmful effects to fish during electrofishing can include spinal injuries, bleeding at gills or vent, hemorrhaging, and excessive physiological stress (Snyder 2004). Snyder (2004), however, states that injuries heal and seldom result in delayed mortality if electrofishing is conducted carefully. Handling and anesthesia associated with electrofishing surveys can also cause harm to fish. Snyder (2004), in a review of the effects of electrofishing on fish, notes that electrofishing mortalities related to asphyxiation are often the result of poor handling.

Based upon the best available information on the distribution of shortnose sturgeon in the Connecticut and Merrimack Rivers where electrofishing will occur, sampling sites are expected to overlap with the distribution of all shortnose sturgeon within these rivers. As noted above, the population estimate for the Merrimack River, where 9 sampling events will take place (4 sites sampled twice, 1 additional site), is approximately 33 fish. Population estimates for the upper Connecticut River where 5-6 sampling sites will take place are 400 fish and population estimates for the lower river where 14-20 sampling sites will take place are approximately 1,000 fish.

For the Merrimack River, the approximate river area between the documented upstream occurrence of shortnose sturgeon in the river and the lower islands near Newbury, between which the sampling will take place, is approximately 5.6 sq km. Of this area, shoreline electrofishing transects will occur in approximately 0.1155 sq km. (length of the 9 transects x 5.5 m width), or approximately 2.06% of the overall area. During the months when sampling will take place (July – early October), shortnose sturgeon are not known to form aggregations such as those that occur during spawning and overwintering. Shortnose sturgeon are likely to be well distributed throughout the action area and to be mobile within the area as they are actively foraging and moving throughout the action area. As such, it is difficult to predict the exact location of individual shortnose sturgeon at the time of the electrofishing. As such, for purposes of determining the number of shortnose sturgeon likely to be exposed to the electric current generated by the electrofishing boat, NMFS has assumed a uniform distribution of shortnose sturgeon throughout the action area during sampling activities. Assuming this uniform distribution, it is likely that no more than one shortnose shortnose sturgeon (1.7% of 33 fish) will be present along the transects to be sampled. As explained above, the effective depth of the electric current is 2.5-3.5m from the surface. Shortnose sturgeon are known to spend the majority of time in the bottom meter of the water column. Therefore, depending on the depth of the waters being sampled and the location of an individual shortnose sturgeon in the water column, it is possible that a shortnose sturgeon could be within the sampling transect but due to its presence below the effective depth, not be affected by the electric current. However, as information on the depths at the sampling sites is not available and it is impossible to predict the exact location of an individual fish in the water column at the time of sampling, NMFS will assume that any shortnose sturgeon present within the sampling transect could be exposed to electric current. As such, NMFS expects that not more than one shortnose sturgeon will be exposed to electric current during the electrofishing survey in the Merrimack River.

INACTIVE

For the upper Connecticut River, the approximate river area between the Turners Falls Dam and the Holyoke Dam, between which 5-6 sampling sites are located, is approximately 16.5 sq km. Of this area, shoreline electrofishing transects will occur in approximately 0.077 sq km (total length of transects x 5.5 m width), or approximately 0.47% of the overall area. Assuming a uniform distribution of sturgeon throughout this area during sampling activities (see explanation above), it is likely that no more than two shortnose shortnose sturgeon (0.47% of 400 fish) are likely to be present along the transects to be sampled in the upper Connecticut River. As explained above, the effective depth of the electric current is 2.5m from the surface. Shortnose sturgeon are known to spend the majority of time in the bottom meter of the water column. Therefore, depending on the depth of the waters being sampled and the location of an individual shortnose sturgeon in the water column, it is possible that a shortnose sturgeon could be within the sampling transect but due to its presence below the effective depth, not be affected by the electric current. However, as information on the depths at the sampling sites is not available and it is impossible to predict the exact location of an individual fish in the water column at the time of sampling, NMFS will assume that any shortnose sturgeon present within the sampling transect could be exposed to electric current. As such, NMFS expects that not more than two shortnose sturgeon will be exposed to electric current during the electrofishing survey in the upper Connecticut River.

For the lower Connecticut River, the approximate river area between the Holyoke Dam and the lowermost sample site, between which 17-20 sampling sites are located, is approximately 54.5 sq km. Of this area, shoreline electrofishing transects will occur in approximately 0.187 sq km (total length of transects x 5.5 m width), or approximately 0.34% of the overall area. Assuming a uniform distribution of sturgeon throughout this area (see explanation above) during sampling activities, it is likely that no more than four shortnose shortnose sturgeon (0.34% of 1000 fish) are likely to be present along the transects to be sampled in the upper Connecticut River. As explained above, the effective depth of the electric current is 2.5-3.5m from the surface. Shortnose sturgeon are known to spend the majority of time in the bottom meter of the water column. Therefore, depending on the depth of the waters being sampled and the location of an individual shortnose sturgeon in the water column, it is possible that a shortnose sturgeon could be within the sampling transect but due to its presence below the effective depth, not be affected by the electric current. However, as information on the depths at the sampling sites is not available and it is impossible to predict the exact location of an individual fish in the water column at the time of sampling, NMFS will assume that any shortnose sturgeon present within the sampling transect could be exposed to electric current. As such, NMFS expects that not more than four shortnose sturgeon will be exposed to electric current during the electrofishing survey in the upper Connecticut River.

Based on the information presented above, NMFS expects that no more than 7 shortnose sturgeon will be exposed to electric current during the electrofishing sampling on the Connecticut and Merrimack Rivers.

Electrofishing can cause mortality or injury to fish. Limited information is available regarding effects to shortnose sturgeon. Moser (2000) conducted limited laboratory experiments on the effects of electrofishing on shortnose sturgeon. Shortnose sturgeon were exposed to electrical

INACTIVE

current for up to 60 seconds at a time, four to five minutes a day. Despite this extensive level of exposure, no mortality occurred. Shortnose sturgeon recovered very quickly from exposures and no difference in growth was seen in control and exposed subjects suggesting that feeding behaviors were not affected. Sturgeon were initially more responsive to the electroshocking treatment than catfish; however, they recovered quickly and moved to avoid the stimulus. More sturgeon than catfish rolled onto their side or completely rolled upside-down within the first 15 seconds. They also exhibited more twitching, rigor and avoidance behaviors than did catfish. But, sturgeon generally recovered immediately after the experiment. Over 75% of the sturgeon recovered immediately, with maximum recovery times of 5 minutes. Sturgeon were exposed repeatedly over a 32 day period and no long term mortality was seen.

Electrofishing injury rates for shovelnose sturgeon (*Scaphirhynchus platorynchus)* were documented to be 0% according to Snyder (2003). Lab studies conducted on juvenile white sturgeon (*Acipenser transmontanus*) showed higher injury rates for pulsed DC current compared to DC current (68% vs. 10%) with no mortality (Holliman and Reynolds 2002).

The available mortality data for shortnose sturgeon indicates that mortality resulting from exposure to electrofishing current is likely to be zero. This is supported by mortality data for other sampling methods as well. Most researchers utilize gill nets to capture shortnose sturgeon as electrofishing is not an effective method for capturing shortnose sturgeon. Gill net mortality rates for adult shortnose sturgeon have been reported to range from 0 to 1.22% (NMFS 2008), and mortality rates for electrofishing can be expected to be much lower than that reported for gill nets.

Based upon this information, of the shortnose sturgeon that are likely to be present within the effective zone for the electrofishing boat (1 in the Merrimack, 2 in the upper Connecticut and 4 in the lower Connecticut), none are expected to die. Exposed sturgeon are likely to be stunned and may roll or twitch. The available information indicates that most shortnose sturgeon will recover immediately, with all exposed sturgeon recovering within 5 minutes. It is likely that most shortnose sturgeon will recover and swim away before they are netted. However, as shortnose sturgeon adults are large fish and may be vulnerable to injury during capture in hand nets, no adult sturgeon will be netted or handled during the study. If encountered, an attempt will be made to net juvenile shortnose sturgeon. These fish will be processed immediately (i.e., measured, weighed, and photographed) and released alive downstream of the sampling area.

In summary, based on the limited size of the effective area of the electrofishing boat and the likely distribution of shortnose sturgeon within the action area, no more than 7 shortnose sturgeon are expected to be affected by each late summer sampling event. Exposed sturgeon may be temporarily stunned and exhibit rolling or twitching behavior, but no injuries or mortalities are expected and any effects will be temporary. As no sampling will occur during shortnose sturgeon spawning activities and any adults encountered during sampling will have months to recover prior to any subsequent spawning activities, no significant effects to spawning shortnose sturgeon are expected. It is important to note that these estimates are based on several assumptions, including that shortnose sturgeon will be distributed evenly throughout the portion of each river where sampling will occur and that shortnose sturgeon distribution will be constant throughout the study period. These assumptions are reasonable because: (1) during the months

INACTIVE

when sampling will take place (July – early October), shortnose sturgeon are not known to form aggregations such as those that occur during spawning and overwintering, (2) as they are not aggregated, shortnose sturgeon are likely to be well distributed throughout the action area, (3) shortnose sturgeon in the action area are likely to be mobile within the area as they are actively foraging and moving throughout the action area, and (4) the time period for sampling overlaps with only one season (i.e., summer and early fall foraging, and not overwintering or spawning). It is important to note that the low number of expected encounters is supported by the available information for other electrofishing surveys in rivers where shortnose sturgeon are known to occur. For example, electrofishing was conducted in the Penobscot River in 2008 in areas where shortnose sturgeon are known to occur and no shortnose sturgeon were observed to be affected. Similarly, the State of New York conducts electrofishing surveys in the Hudson River each spring. Despite reportedly observing shortnose sturgeon throughout the project area, no shortnose sturgeon have been rolled or otherwise affected during this multi-year sampling program. Further, EPA has reported that only 3 sturgeon (1 Atlantic and 2 presumed shortnose) have been observed to be stunned during at least five years of electrofishing effort in various rivers throughout New England where sturgeon are known to occur.

CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR §402.02 as those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation.

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

Impacts to shortnose sturgeon from non-federal activities are largely unknown in the action area. It is possible that occasional recreational and commercial fishing for anadromous fish species may result in incidental takes of shortnose sturgeon. However, positive identification and distinction between Atlantic sturgeon and shortnose sturgeon are difficult and therefore, historically, takes have not been quantified. Pollution from point and non-point sources has been a major problem in the action area. Contaminants introduced into the water column or through the food chain, eventually become associated with the benthos where bottom dwelling species like shortnose sturgeon are particularly vulnerable.

Scientific Studies

It is likely that additional scientific studies will be conducted on shortnose sturgeon in the action area. Continued capturing, handling, tagging, and tracking of shortnose sturgeon may affect their migration, reproduction, foraging, and survival.

Contaminants and Water Quality

Contaminants associated with the action area are directly linked to industrial development along the waterfront. PCB's, heavy metals, and waste associated with point source discharges and

INACTIVE

refineries are likely to be present in the future due to continued operation of industrial facilities. In addition many contaminants such as PCB's remain present in the environment for prolonged periods of time and thus would not disappear even if contaminant input were to decrease. It is likely that shortnose sturgeon will continue to be affected by contaminants in the action area in the future.

Industrialized waterfront development will continue to impact the water quality in and around the action area. Refineries, sewage treatment facilities, manufacturing plants, and generating facilities present in the action area are likely to continue to operate. Excessive water turbidity, water temperature variations and increased shipping traffic are likely with continued future operation of these facilities. As a result, shortnose sturgeon foraging and/or distribution in the action area may be adversely affected.

Excessive turbidity due to coastal development and/or construction sites (e.g., bridge construction or demolition) could influence sturgeon spawning. Shortnose sturgeon require a clean rock or cobble substrate to deposit their eggs and unfavorable substrates could make it impossible for eggs to adhere to critical interstitial areas. Additionally, excessive turbidity could impair sturgeon foraging by making it difficult to locate prey.

Sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from coastal development, groundwater discharges, and industrial development. Chemical contamination may have an effect on listed species reproduction and survival. While the effects of contaminants on shortnose sturgeon are relatively unclear, pollution may also make shortnose sturgeon more susceptible to disease by weakening their immune systems. While dependent upon environmental stewardship and clean up efforts, impacts from marine pollution, excessive turbidity, and chemical contamination on marine resources and the ecosystem of the action area are expected to continue in the future.

Fisheries
Incidental take of shortnose sturgeon is likely with the continued operation of hook and line and commercial fisheries in the action area. There have been no documented takes in the action area, however, there is always the potential for this to occur when fisheries are known to operate in the presence of shortnose sturgeon. Thus, the operation of these hook and line fisheries and commercial fisheries could result in future shortnose sturgeon mortality and/or injury.

As noted above, impacts to listed species from all of these activities are largely unknown. However, NMFS has no information to suggest that the effects of future activities in the action area will be any different from effects of activities that have occurred in the past.

□SEQ CHAPTER \h \r 1□**INTEGRATION AND SYNTHESIS OF EFFECTS**
Shortnose sturgeon are endangered throughout their entire range. This species exists as nineteen separate populations that show no evidence of interbreeding. The shortnose sturgeon residing in the Connecticut and Merrimack rivers form two of these nineteen populations.

INACTIVE

NMFS has estimated that the proposed electrofishing survey has the potential to result in the exposure of no more than seven shortnose sturgeon to electric current from the electrofishing boat. However, this exposure will result in no mortality of shortnose sturgeon.

This action will not reduce reproduction of shortnose sturgeon in the Merrimack or Connecticut River populations because it will (1) not result in the mortality of any shortnose sturgeon and therefore will not effect any potential reproduction of that individual; (2) not affect any spawning adults; (3) not affect spawning habitat; and (4) as recovery from exposure is expected to be rapid and complete, will not affect the reproductive fitness of any individual by reducing fecundity or increasing the interval between spawning.

This action will not reduce the numbers of shortnose sturgeon in the Penobscot River because it will not result in the mortality of any shortnose sturgeon. The proposed action will not reduce distribution because the action will not impede shortnose sturgeon from accessing spawning, foraging or overwintering grounds in the Merrimack or Connecticut River. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon.

For these reasons, NMFS believes that there is not likely to be any reduction in reproduction, numbers or distribution of shortnose sturgeon in the Connecticut or Merrimack River populations or the species as a whole. As there will not be a reduction in reproduction or numbers of shortnose sturgeon in these populations and no reduction in the rangewide distribution of shortnose sturgeon, this action is not likely to impede the ability of the species to recover. As such, there is not likely to be an appreciable reduction in the likelihood of survival and recovery in the wild of these populations or the species as a whole.

□SEQ CHAPTER \h \r 1□**CONCLUSION**

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is NMFS' biological opinion that the proposed action may adversely affect but is not likely to jeopardize the continued existence of the shortnose sturgeon. Because no critical habitat is designated in the action area, none will be affected by the proposed action.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. NMFS interprets the term "harm" as an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR §222.102). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

INACTIVE

Amount or Extent of Incidental Take

The proposed action has the potential to directly affect shortnose sturgeon by causing them to be stunned by the electric current and then be captured and handled. As explained in the "Effects of the Action" section of this consultation, no mortalities are likely and all shortnose sturgeon exposed to the current are expected to recover quickly. While shortnose sturgeon may exhibit behaviors such as rolling or twitching, no injuries are likely to be sustained. Based on available population estimates, the known distribution of the species within the Merrimack and Connecticut Rivers, the location of the sampling sites, and the effective range of the electrofishing boat, NMFS has determined that no more than 1 shortnose sturgeon from the Merrimack River, 2 shortnose sturgeon from the upper Connecticut and 4 shortnose sturgeon from the lower Connecticut are likely to be effected by the electrofishing survey. While no injuries or mortalities to any shortnose sturgeon are expected, the anticipated interaction of 7 shortnose sturgeon with sampling gear would be considered harassment under Section 9 of the ESA. In the accompanying biological opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to the species.

Reasonable and prudent measures

Reasonable and prudent measures are those measures necessary and appropriate to minimize incidental take of a listed species. NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize and monitor impacts of incidental take of shortnose sturgeon:

1. EPA must ensure that the contractor contact NMFS before sampling commences and again upon completion of the sampling activity.
2. EPA must ensure that the contractor promptly report all interactions with shortnose sturgeon to NMFS.

Terms and conditions

In order to be exempt from prohibitions of section 9 of the ESA, EPA must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and which outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. These terms and conditions must be included as part of the contractual and assistance agreements between EPA and MBI and their subcontractors.

1. To implement RPM #1, EPA must contact NMFS within 3 days of beginning and ending sampling occurring below the Turners Falls Dam in the Connecticut River and below the Essex Dam in the Merrimack River (Julie Crocker: by email (Julie.Crocker@noaa.gov) or phone (978-282-8480) or the Section 7 Coordinator by phone (978-281-9328) or fax (978-281-9394)).
2. To implement RPM #2, EPA must contact NMFS within 24 hours of any interactions with shortnose sturgeon, including non-lethal and lethal takes (Julie Crocker: by email (Julie.Crocker@noaa.gov) or phone (978-282-8480) or the Section 7 Coordinator by phone (978-281-9328) or fax (978-281-9394)).
3. To implement RPM #2, EPA must instruct the contractor to not net any adult shortnose sturgeon over 2 feet in length. Any sub-adult sturgeon netted during sampling must be

INACTIVE

photographed and measured. The corresponding incident report form (Appendix A) must be completed and submitted to NMFS **within 24 hours** by fax (978-281-9394 or e-mail (Julie.Crocker@Noaa.gov)) of any interaction with shortnose sturgeon (juvenile or adult).

4. To implement RPM #2, EPA must instruct the contractor that in the event adult sturgeon come in contact with sampling gear, all electrofishing must cease for 5 minutes or until the fish is observed to recover and leave the sampling area.

5. To implement RPM #2, the EPA must instruct the contractor that in the event of any lethal takes, any dead specimens or body parts must be netted, photographed, measured, and preserved (refrigerate or freeze) until disposal procedures are discussed with NMFS. The Sturgeon Salvage form included as Appendix B must be completed and submitted to NMFS as noted above.

6. To implement RPM #2, the EPA must instruct the contractor that if any lethal take occurs, the contractor must take fin clips (according to the procedure outlined in Appendix C) to be returned to NMFS's NER for ongoing analysis of the genetic composition of shortnose sturgeon populations.

7. To implement RPM #2, the EPA must submit a final report at the end of each calendar year summarizing the results of sampling activities and any takes of listed species to NMFS by mail (to the attention of the Section 7 Coordinator, NMFS Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930).

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that might otherwise result from the proposed action. Specifically, these RPMs and Terms and Conditions will keep NMFS informed of when sampling activities are taking place and will require EPA to report any take in a reasonable amount of time, as well as avoid additional sources of injury and mortality to adult fish that may result from handling associated with netting. Term and Condition #1, #2 and #6 are specifically designed to monitor take. As shortnose sturgeon adults may be vulnerable to additional injury and/or mortality if captured in a hand held net, Term and Condition #3 is necessary and appropriate to prevent the occurrence of this additional source of injury and mortality. In order to effectively monitor and report the effects of this action, Term and Condition #3 permits collecting data from juvenile shortnose sturgeon. Netting and collecting data from juvenile shortnose sturgeon will enable NMFS to better monitor the take associated with this project. Term and Condition #4 will further reduce any impacts to the species by allowing any adult shortnose sturgeon interacting with sampling gear to recover and move outside of the sampling area. As NMFS does not anticipate any lethal take, the implementation of Term and Condition #5 and #6 are necessary and appropriate to preserve any dead shortnose sturgeon so that they may be salvaged and examined to determine the cause of death. Genetic information is important to document, if possible, whether the fish killed belongs to the Connecticut or the Merrimack population as well as whether the fish contains any unique genetic haplotypes.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the

INACTIVE

sturgeon. To further reduce the adverse effects of fisheries sampling on listed species, NMFS recommends that NEFSC implement the following conservation recommendations.

(1) If any lethal take occurs, the EPA should arrange for contaminant analysis of the specimen. If this recommendation is to be implemented, the fish should be immediately frozen and NMFS's NER should be contacted within 24 hours to provide instructions on shipping and preparation

REINITIATION OF CONSULTATION

This concludes formal consultation on the proposal by the EPA to fund and/or carry out the New England fish assemblage projects in the Connecticut and Merrimack Rivers. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, Section 7 consultation must be reinitiated immediately.

INACTIVE