U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT

# A SUPPLEMENTAL BIOLOGICAL ASSESSMENT FOR POTENTIAL IMPACTS TO THE NEW YORK BIGHT DISTINCT POPULATION SEGMENT OF ATLANTIC STURGEON (*Acipenser oxyrinchus oxyrinchus*) WHICH IS PROPOSED FOR FEDERAL ENDANGERED SPECIES LISTING RESULTING FROM THE DELAWARE RIVER MAIN STEM AND CHANNEL DEEPENING PROJECT

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# TABLE OF CONTENTS

List of Figures

## 1.0 INTRODUCTION

### 1.1 PURPOSE

Section 7 of the Endangered Species Act, as amended November 10, 1978, requires that a Biological Assessment be prepared for all major Federal actions involving construction when Federally listed or proposed endangered or threatened species may be affected. The purpose of this assessment is to update the original biological assessment completed by the Philadelphia District of the US Army Corps of Engineers (USACE) in January 2009 that focused exclusively on the District's Delaware River Main Stem and Channel Deepening project and its potential impacts to the right, humpback, and fin whales; loggerhead, leatherback, Kemp's ridley, hawksbill and green sea turtles; and shortnose sturgeon. All of these species are endangered, except for the loggerhead sea turtle, which is listed as threatened. The current biological assessment will address potential impacts to the Atlantic sturgeon which was recently proposed for listing as an endangered species (Federal Register Vol 75, No. 193, Wednesday October 6, 2010; 50 CFR Parts 223 and 224). This assessment will also address any changes to the Main Channel Deepening project since the 2009 biological assessment.

### 1.2 ENDANGERED SPECIES ACT

This "biological assessment" is part of the process provided under Section 7(a)(4) of the Endangered Species Act. Section 7(a)(4) was added to the Act to provide the National Marine Fisheries Service (NMFS) and other Federal agencies a mechanism for identifying and resolving potential conflicts between a proposed action and proposed species at an early planning stage. Detailed procedures for the consultation process required under the Endangered Species Act are defined in 50CFR402.

### 1.3 JEOPARDIZED SPECIES

The primary concern with the Atlantic sturgeon is whether or not impacts associated with the Delaware River Deepening Project "jeopardizes the continued existence" of the species. Federal regulation defines this term as "engaging in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of that species."

### 1.4 CHRONOLOGY OF EVENTS LEADING UP TO THIS ASSESSMENT

In September 1986 the Philadelphia District initiated formal consultation under Section 7 of the Endangered Species Act of 1973 (16 U.S. C. 1531 *et seq*.), with regard to maintenance dredging of Delaware River Federal Navigation Projects from Trenton to the Sea, and potential impacts to the Federally endangered shortnose sturgeon (*Acipenser brevirostrum*). "A Biological Assessment of Shortnose Sturgeon (*Acipenser brevirostrum*) Population in the Upper Tidal Delaware River: Potential Impacts of Maintenance Dredging" was forwarded to NMFS for their review.

It was determined by the Corps that maintenance dredging activities in the southern reaches of the Delaware River, specifically from Philadelphia to the Sea, were not of concern with respect to impacting shortnose sturgeon. The area, between Philadelphia and Wilmington, was considered the "pollution zone" and was only utilized as a migratory route by adults during the early spring and late fall. This area is no longer considered a pollution zone and is utilized by shortnose sturgeons (ERC 2004, 2005, 2006a, 2006b, 2007). South of Wilmington the shortnose sturgeon population is limited to adults due to increased salinity.

In September 1995, the Philadelphia District again initiated formal consultation under the Endangered Species Act with regard to potential impacts associated with dredging projects permitted, funded or conducted by the Philadelphia District. "A Biological Assessment of Federally Listed Threatened and Endangered Species of Sea Turtles, Whales, and the Shortnose Sturgeon within Philadelphia District Boundaries: Potential Impacts of Dredging Activities" was forwarded to NMFS for their review. A Biological Opinion was issued by NMFS on November 26, 1996 (Montanio, 1996) for all dredging projects carried out by the District. The Opinion stated that dredging projects within the Philadelphia District may adversely affect sea turtles and shortnose sturgeon, but are not likely to jeopardize the continued existence of any threatened or endangered species under the jurisdiction of NMFS. For projects within the Philadelphia District, the anticipated incidental take by injury or mortality is three (3) shortnose sturgeon. This Opinion was amended with a revised Incidental Take Statement (ITS) on May 25, 1999.

In letters dated 14 February 1997 and 29 December 1997, the United States Department of Commerce, the parent agency of the NMFS, stated that the Biological Opinion issued by the NMFS in 1996 does not cover blasting. They further stated that sea turtles and marine mammals are not likely to be found in the Marcus Hook area where blasting will occur for the deepening project, but shortnose sturgeon may be found in the area. This is due in part to the fact that the Chester – Philadelphia "pollution zone no longer exists" (Fruchter, 1997). They requested that the Corps continue to coordinate with NMFS to ensure compliance with the requirements of the Endangered Species Act. In May 2000 the Philadelphia District submitted a Biological Assessment of the required rock blasting in the Marcus Hook navigational range of the main channel deepening project. On January 31, 2001 NMFS issued their Biological Opinion which concluded that rock blasting conducted from December 1 to March 15 may adversely affect, but is not likely to jeopardize the continued existence of listed species under NMFS' jurisdiction.

Since that time, the project was delayed for several years due to sponsorship uncertainties and permit processing delays. In May 2007, the Philadelphia Regional Port Authority (PRPA) took over sponsorship of this project from the Delaware River Port Authority. In June 2008, the Corps and the PRPA executed a Project Partnership Agreement for construction of the Delaware Main Stem and Channel Deepening Project from 40 feet to 45 feet. In December 2008, NMFS requested that the Corps reinitiate consultation for the Delaware deepening project in light of new information available regarding shortnose sturgeon and their use of the Delaware River. In response, the Corps prepared a biological assessment entitled "A Biological Assessment for Potential Impacts to Federally Listed Threatened and Endangered Species of Sea Turtles, Whales and the Shortnose Sturgeon Resulting from the Delaware River Main Stem and Channel Deepening Project" in January 2009 (USACE, 2009). On July 17, 2009 NMFS issued their Biological Opinion which concluded that the proposed action is likely to adversely affect but is not likely to jeopardize the continued existence of the loggerhead or Kemp's ridley sea turtle or shortnose sturgeon. Additionally, NMFS concluded that the proposed action is not likely to affect leatherback or green sea turtles and, therefore, is not likely to jeopardize the continued existence of these species. Also, because no critical habitat is designated within the action area, NMFS concluded that none will be affected by the proposed action.

In March 2010, the Corps initiated construction in Reach C of the project. The next phase of initial construction is scheduled to begin in August 2011. On October 6, 2010, NMFS published a Notice in the Federal Register proposing to list three Distinct Population Segments of Atlantic sturgeon in the Northeast Region of NMFS. The New York Bight Distinct Population Segment, which includes all Atlantic sturgeon whose range occurs in watersheds that drain into coastal waters, including Long Island Sound, the New York Bight, and the Delaware Bay, from Chatham, MA to the Delaware-Maryland border on Fenwick Island, as well as wherever these fish occur in coastal bays, estuaries, and the marine environment from Bay of Fundy, Canada, to the Saint Johns River, FL, is proposed for listing as endangered (Atlantic Sturgeon Status Review Team, 2007). In response to this proposed listing, the Corps participated in a conference call with NMFS to discuss the proposed listing and the potential impact of the listing on on-going Corps projects, including the Delaware River Main Stem and Channel Deepening Project. On November 15, 2010 the Corps sent a letter to NMFS initiating coordination regarding this proposal relative to the deepening project. In a subsequent conference call with NMFS on January 20, 2011, it was decided that the Corps would prepare a Biological Assessment outlining potential impacts to the Atlantic sturgeon. NMFS will then issue a Conference Report containing recommendations for reducing adverse impacts so that upcoming construction can take place as planned. If the species is listed, NMFS will adopt the Conference Report to act as a final Biological Opinion.

## 1.5 PROJECT BACKGROUND

Established in 1866, the Philadelphia District is responsible for the Federal role in water resource development projects in the Delaware River Basin, and for Federal navigation projects in the Delaware, Schuylkill, Salem and Christina Rivers, the Intracoastal Waterway (IWW) of New Jersey from Manasquan Inlet to Cape May, and the IWW Delaware River to Chesapeake Bay – Chesapeake and Delaware Canal. The Delaware River has three major sub-basins: the Schuylkill, Lehigh, and Lackawaxen in Pennsylvania. Other basin rivers include the Neversink, Cooper, and Assiscunk in New Jersey, and the Brandywine in Pennsylvania.

The Philadelphia District keeps the Delaware River ports, which include Philadelphia, Camden, and Wilmington, economically viable by maintaining an authorized 40-foot depth in the Delaware River navigation channel from Newbold Island in Bucks County north of Philadelphia, to deepwater in the Delaware Bay. Another project is a six-mile reach of the Schuylkill River in Philadelphia. Other projects include federally authorized navigation channels in waterways and inlets in New Jersey, Delaware, and Maryland, including the Chesapeake & Delaware Canal connecting the Delaware River and Upper Chesapeake Bay, Salem River and the Manasquan, Barnegat and Cape May Inlets in New Jersey, and Wilmington Harbor and Indian River Inlet in Delaware.

The existing Delaware River, Philadelphia to the Sea, Federal navigation project was adopted by Congress in 1910 and modified in 1930, ’35, ’38, ’45, ’54 and ’58. The existing project provides for a channel from deep water in Delaware Bay to a point in the bay, near Ship John Light, 40 feet deep and 1,000 feet wide; thence to the Philadelphia Naval Base, 40 feet deep and 800 feet wide, with a l,200-foot width at Bulkhead Bar and a 1,000-foot width at other channel bends; thence to Allegheny Avenue Philadelphia, PA; 40 feet deep and 500 feet wide through Horseshoe Bend and 40 feet deep and 400 feet wide through Philadelphia Harbor along the west side of the channel. The east side of the channel in Philadelphia Harbor has a depth of 37 feet and a width of 600 feet. All depths refer to mean low water. The 40-foot channel from the former Naval Base to the sea was completed in 1942. The channel from the former Naval Base to Allegheny Avenue was completed in 1962.

There are 19 anchorages on the Delaware River. The Mantua Creek, Marcus Hook, Deepwater Point, Reedy Point, Gloucester and Port Richmond anchorages are authorized under the Philadelphia to the sea project. The remaining 13 are natural, deep-water anchorages. The authorized anchorage dimensions are as follows:

| | |
|---|---|
| Mantua Creek: | 40’ X 2,300’ X 11,500’ (mean) |
| Marcus Hook: | 40’ X 2,300’ X 13,650’ (mean) |
| Deepwater Point: | 40’ X 2,300’ X 5,200’ (mean) |
| Reedy Point: | 40’ X 2,300’ X 8,000’ (mean) |
| Port Richmond: | 37’ X 500’ (mean) X 6,400’ |
| Gloucester: | 30’ X 400’ (mean) X 3,500’ |

Mantua Creek anchorage is currently maintained to about 60% of the authorized width and a 37-foot depth. The Marcus Hook anchorage, enlarged in 1964, is maintained to authorized dimensions. The anchorage at Port Richmond is about 35 feet deep, as are the Reedy Point and Deepwater Point anchorages. The Gloucester anchorage requires no dredging and is currently deeper than authorized.

There are wide variations in the amount of dredging required to maintain the Philadelphia to the sea project. Some ranges are nearly self maintaining and others experience rapid shoaling. The 40-foot channel requires annual maintenance dredging in the amount of 3,455,000 cy. Of this amount, the majority of material is removed from the Marcus Hook (44%), Deepwater Point (18%) and New Castle (23%) ranges. The remaining 15 percent of material is spread throughout the other 37 channel ranges. The historic annual maintenance quantities for the Marcus Hook and Mantua Creek anchorages are 487,000 and 157,000 cy, respectively.

The Federal government has the responsibility for providing the necessary dredged material disposal areas for placement of material dredged for project maintenance. There are currently seven upland sites in the riverine portion of the project and one open-water site, located in Delaware Bay, that are used for this purpose. The seven confined upland sites are National Park, Oldmans, Pedricktown North, Pedricktown South, Penns Neck, Killcohook and Artificial Island. The open water site in Delaware Bay is located in the vicinity of Buoy 10. This site is only approved for placement of sand.

## 2.0 UPDATE OF THE PROJECT STATUS AND SCHEDULE FROM THAT PRESENTED IN THE JANUARY 2009 BIOLOGICAL ASSESSMENT

The Delaware River Main Stem and Channel Deepening Project, as depicted in Figure 1, was described in great detail in the January 2009 biological assessment and is incorporated here by reference. This section discusses the changes to the project since the 2009 description.

## 2.1 STATUS OF INITIAL CONSTRUCTION

Initial construction for the project began on March 1, 2010 and concluded on September 18, 2010 with the dredging of Reach C of the channel. Reach C extends from the Delaware Memorial Bridge to just below the Chesapeake and Delaware Canal (Figure 2). The work was completed by the Norfolk Dredging Company using two 24-inch hydraulic cutterhead suction dredges (the Pullen and the Charleston). Approximately 3,594,963 cy of material was removed from Reach C and placed in the Federally owned Killcohook upland confined disposal facility (CDF). In accordance with the Terms and Conditions outlined in the 2009 Biological Opinion, daily monitoring of the disposal area was conducted. Corps' construction inspectors were on-site every day and daily inspections of the ponded areas around the weir structures were made. No shortnose or Atlantic sturgeon were observed during construction.

## 2.2 BROADKILL BEACH CONSTRUCTION WINDOW

As stated in the 2009 EA, in order to best meet the competing hopper dredging restrictions recommended by the Cooperative for the Atlantic sturgeon, sandbar shark and overwintering blue crabs, the Broadkill Beach portion of the project was scheduled to take place between 1 April and 30 June. To protect sandbar shark during this period, the plan was to float the dredge pipe to avoid disruption of sandbar shark movements and to stockpile sand above mean high water from 15 April to 15 September. After 15 September, sand was to be graded below mean high water to widen the beach. However, during the May 13, 2010 project coordination meeting between the Corps, DNREC, and Dr. Dewayne Fox, an Atlantic sturgeon researcher with Delaware State University, it was decided that a more acceptable time of year for construction of the Broadkill Beach project is from 15 September to 15 December. Dredging and shoreline work during this time would avoid any impacts to the sandbar shark, the sand tiger shark, the horseshoe crab, and local residents and vacationers using the beach during the summer months. According to Dr. Fox, dredging at this time would not impact Atlantic sturgeon, as his data show they are not using this area at this time of year. The Corps will work with DNREC to develop a dredging plan that minimizes impacts to overwintering blue crab during the month of December (*i.e*. schedule dredging in December in areas least utilized by blue crab). The attached updated project schedule incorporates this change (Appendix A).

## 2.3 BEND WIDENING AREAS

USACE (2009) indicated that the project includes 11 bend widenings at various ranges. It noted that the Miah Maull - Cross Ledge bend would not be widened. The Miah Maull –

Figure 1. Delaware River Main Channel Deepening Project

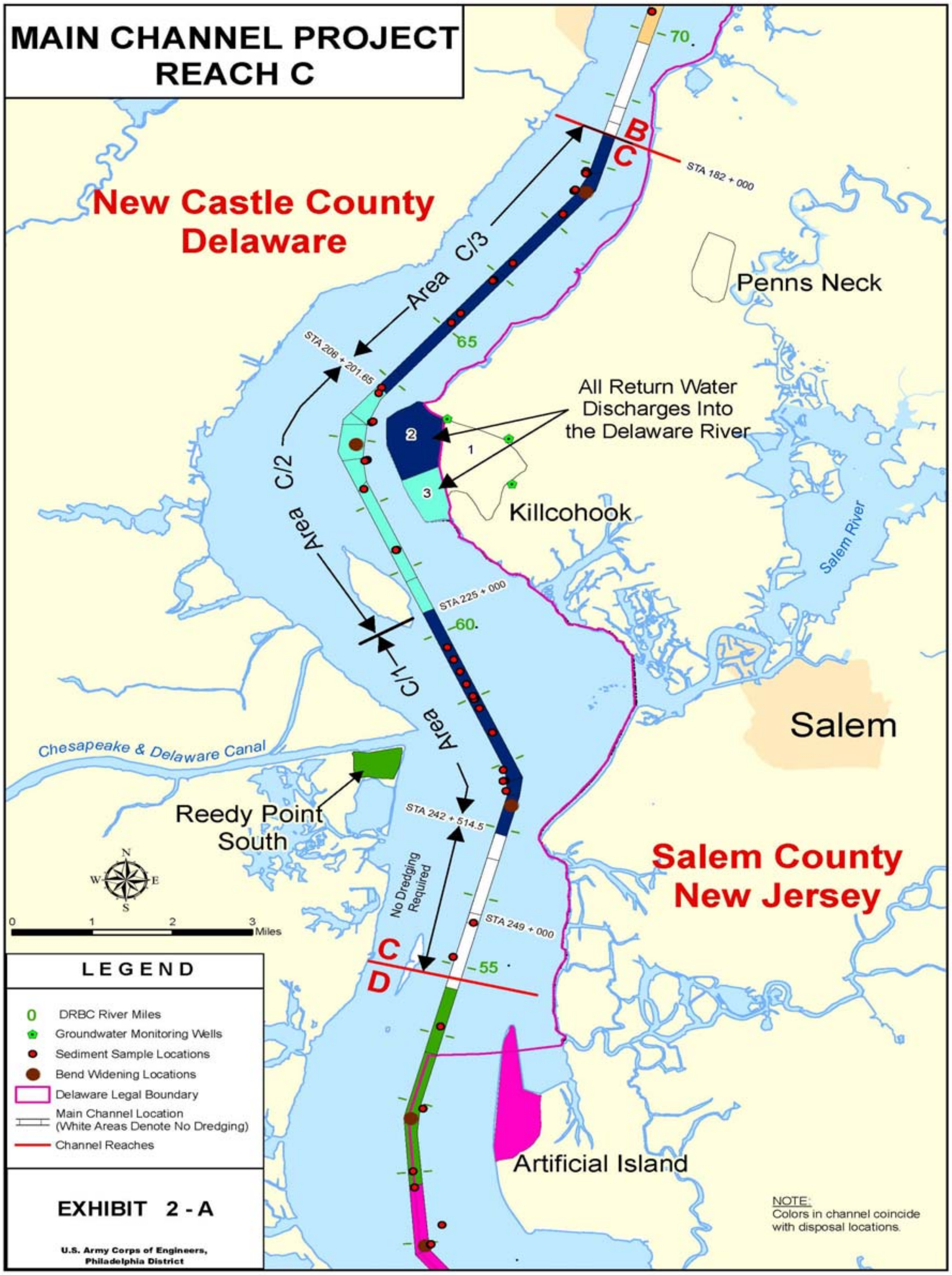

Figure 2. Reach C of Main Channel Deepening Project

Cross Ledge bend will be widened as part of the project, however no dredging is required at this location. The Miah Maull – Cross Ledge bend is sufficiently deep and will only require repositioning of navigation buoys to effect the widening.

## 2.4 CONSTRUCTION SCHEDULE FOR REMAINING WORK

The next phase of the project, which will include dredging in Reach B, (stations 137+000 to 176+000) is scheduled to begin in August 2011. An updated proposed schedule can be found in Appendix A. While this is our best estimate based on available information, it should be noted that all contracts are subject to the availability of project funds. For this reason, a given contract may slide to another calendar year, but the time of year the work will be conducted will not change in order to adhere to environmental dredging windows.

## 2.5 OPERATION AND MAINTENANCE

The required maintenance dredging of the 45-foot channel will increase by 862,000 cubic yards per year (cy/yr) from the current 3,455,000 average cy/yr for the 40-foot channel for a total of 4,317,000 cy/yr. Only areas shallower than 45 feet will be dredged during maintenance activities. Maintenance dredging in the river usually takes place over an approximately 2 month period between August and December using a hydraulic cutterhead dredge. All material excavated from the river portion of the project will continue to be placed in existing approved upland disposal areas. The timing and duration of maintenance dredging in the bay varies. Dredging in this area is done using a hopper dredge with open water disposal. Maintenance dredging is expected to be conducted yearly on an as needed basis for the 50 year project life.

## 2.6 ROCK BLASTING

Approximately 77,000 cubic yards of bedrock from the Delaware River near Marcus Hook, PA (River Mile 76.4 to River Mile 84.6) would be removed to deepen the navigation channel to a depth of 47 ft below mean lower low water. Rock will be placed in the Fort Mifflin dredged material disposal site located in Philadelphia, PA (Figure 1). In order to remove the rock by blasting, holes drilled into the rock are packed with explosive and inert stemming material at the surface in order to direct the force of the blast into the rock. The depth and placement of the holes along with the size and blast timing delays of the charges control the amount of rock that is broken and energy levels released during the blasting operations. The project would be conducted by repeatedly drilling, blasting, and excavating relatively small areas until the required cross section of bedrock is removed. Rock blasting and mechanical removal of rock from the river would occur between 1 December and 15 March. It is now anticipated that rock removal can be completed over one winter season rather than two as stated in the 2009 Biological Assessment (USACE, 2009). There have been no other changes to the rock blasting portion of the project since the issuance of the 2009 Biological Opinion regarding blasting impacts to sturgeon.

## 3.0 SPECIES OF CONCERN

Proposed and listed species that may occur within the Delaware River Deepening Project area include the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and the shortnose sturgeon (*Acipenser brevirostrum*), as well as loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys* *kempi*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*) sea turtles; and the right(*Eubalaena glacialis*), humpback (*Megaptera novaeangliae*), and fin (*Balaenoptera physalus*) whales. All of these species are endangered, except for the loggerhead sea turtle, which is threatened, and the Atlantic sturgeon which is currently proposed for Federal endangered species listing.

## 3.1 ATLANTIC STURGEON (*Acipenser oxyrinchus oxyrinchus*)

### 3.1.1 GENERAL ATLANTIC STURGEON INFORMATION

Since the 1970s, Atlantic sturgeon have been studied intensely but many important aspects of the species life history are still unknown (Murawski and Pacheco 1977; Van den Avyle 1983; Smith and Dingley 1984; Smith and Clugston 1997; Bain 1997; Bemis and Kynard 1997; Kynard and Horgan 2002; as cited by ASSRT, 2007). Historically, the species was present in approximately 38 rivers in the United States from St. Croix, ME to Saint Johns River, FL, most of which supported historical spawning populations. Currently, Atlantic sturgeon are still present in 35 rivers, and spawning occurs in at least 20 of these rivers. Atlantic sturgeon spawn in freshwater but move to coastal waters as subadults (ASSRT, 2007). Subadult Atlantic sturgeon travel throughout coastal and estuarine habitats, undergoing rapid growth. Coastal regions where migratory Atlantic sturgeon are commonly found include Bay of Fundy, Massachusetts Bay, Rhode Island, New Jersey, Delaware, Delaware Bay, Chesapeake Bay and North Carolina (Dovel and Berggren, 1983; Johnson *et al.*, 1997; Rochard *et al.*, 1997; Kynard *et al.*, 2000; Eyler *et al.*,2004; Stein *et al.*, 2004a; Dadswell 2006; as cited in ASSRT, 2007). Spawning adults in the mid-Atlantic systems generally migrate back upriver in April-May to spawn in their natal river (ASSRT, 2007).

Atlantic sturgeon are distinguished by armor-like plates and a long snout with a ventrally located protruding mouth. Four barbells in front of the mouth help the sturgeon to locate prey. Sturgeons are omnivorous benthic feeders and filter quantities of mud along with their food. The diet of adult sturgeon includes mollusks, gastropods, amphipods, isopods and fish, while juveniles generally feed on aquatic insects and other invertebrates (ASSRT, 2007).

The Atlantic sturgeon population has been divided into 5 distinct population segments (DPSs) (Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic). These DPSs were configured to account for the marked difference in physical, genetic, and physiological factors within the species, as well as the unique ecological settings and unique genetic characteristics that would leave a significant gap in the range of the taxon if one of them were to become extinct (ASSRT, 2007). Currently, the Northeast Region of NMFS is proposing to list the Gulf of Maine population as threatened and the New York Bight (NYB) and Chesapeake Bay (CB) DPSs as endangered. The Delaware River Main Channel Deepening Project falls within the boundaries of the NYB population.

### 3.1.2 DESCRIPTION

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is one of 27 sturgeon species (family: Acipenseridae) and one of nine species/subspecies native to North America (Cech and Doroshov, 2004). Atlantic sturgeon can attain lengths of up to 14 feet (425 cm) and weights of more than 800 pounds (363 kg). Their dorsal coloration ranges from olive brown to bluish black with paler sides and white ventral surface (NMFS, 2010). Sturgeon are an ancient fish with a cartilaginous skeleton and an ancestral fossil record dating back more than 200 million years (Bemis and Kynard, 1997). Their distinctive features include five major rows of dermal scutes or bony external plates derived from the epidermis, not scales. The scutes can have a razor sharp barb, or spur that curves towards the tail, typically present in younger fish. In older fish the scutes are generally flat. Scutes serve as the sturgeon's main defense against predators.

When feeding along the river bottom, sturgeon use their protractile extendable mouth much like a vacuum while searching for food. Silt, gravel and other inedible substances are expelled through the gills or back out the mouth. Sturgeon also possess barbells, soft tactile organs that resemble whiskers near the mouth. These act as taste buds and are used to search for food in sediments. The sturgeon tail is heterocercal in which the upper lobe is longer than the lower lobe, similar to a shark's tail.

Atlantic sturgeon have been known to live up to 60 years (Mangin, 1964 as cited by Grunwald *et al.,* 2007) although age validation studies show a variation of ±5 years (Stevenson and Secor, 1999). Sexual maturity occurs from 7-28 years, depending on geographic location and gender (Collins *et al*., 2000). The minimum size for a sexually mature adult sturgeon is roughly 133 cm fork length (FL) (Van Eenennaam *et al.,* 1996). Atlantic sturgeon show latitudinal variation in growth and maturation, exhibiting faster growth and earlier age at maturation in more southern areas. In South Carolina, maturity occurs between 5 to 19 years of age (Smith *et al*., 1982), in the Hudson River at 11 to 21 years (Young *et al*., 1988), and in the Saint Lawrence River between 22 to 34 years (Scott and Crossman, 1973).

Atlantic sturgeon are anadromous, spending the majority of their adult phase in marine waters, migrating up rivers to spawn in freshwater and migrating to brackish waters in juvenile growth phases. Adults return to their natal freshwater rivers to spawn (Dovel and Berggren, 1983). Southern populations typically spawn earlier (April-May) than mid-Atlantic region Atlantic sturgeon (May-July), and fish occupying the northernmost rivers spawn from June-August (Smith and Clugston 1997).

Adult Atlantic sturgeon return to their natal river to spawn (Collins *et al*., 2000; Grunwald *et al*., 2007). Although spawning locations within the Delaware River have not been ascertained, a small specimen (128 mm) was taken near Pea Patch Island, DE (rkm 101) (river kilometer references are based on DRBC, 1969), an area historically described by Borodin (1925) as a principal spawning area, although historic data on spawning may no longer be applicable due to changes in the present-day location of the salinity transition zone. Research conducted in nearby Hudson River provides some valuable insight regarding critical riverine spawning habitat (Dovel and Berggren 1983, Van Eenennaam *et al*., 1996). Atlantic sturgeon populations natal to the Delaware and Hudson Rivers are considered genetically closely related (King *et al.,* 2001) and spawning activity is believed to take place in the upper freshwater regions of these rivers. Simpson (2008) concluded that based on telemetry results, salinity profiles, and available hard-bottom substrate, the lower limit of Atlantic sturgeon spawning in the Delaware River may be near Tinicum Island (rkm 136) while the upper limit is likely to be above the fall line near Trenton, NJ (rkm 211).

Atlantic sturgeon eggs are highly adhesive and are deposited primarily on gravel, rocky hard-bottom substrates and fertilized externally (Borodin, 1925, Smith *et al*., 1980). Periods between spawning can range from 2-6 years (Vladykov and Greeley, 1963; Van Eenennaam *et al.*, 1996; Stevenson and Secor, 1999). Spawning is believed to occur in water temperatures up to 24.3° C (Dovel and Berggren, 1983). Egg incubation periods vary with water temperature. Larval Atlantic sturgeon emerge from the egg in roughly 4-6 days (based on hatching temperatures of approximately 18° C-20° C). Newly hatched larvae exhibit negative phototactic behavior to avoid predation (Kynard and Horgan, 2002) and show a preference to migrate downstream towards more brackish waters (Smith *et al.*, 1980; Kynard and Horgan, 2002). Yolk sac absorption occurs within 8-12 days. At the end of their first summer the majority of young-of-the-year (YOY) Atlantic sturgeon remain in their natal river while older subadults begin to migrate offshore (Dovel and Berggren, 1983).

The following spring returning subadults, as well as the overwintering river Young-of-Year (YOY), are thought to gradually move into summer foraging areas where they remain until the fall (Dovel and Berggren, 1983; Kieffer and Kynard, 1993; Shirey *et al.,*1997; Savoy and Pacileo, 2003). By Year 2, a larger proportion of subadult Atlantic sturgeon are believed to migrate offshore (Dovel and Berggren, 1983). Older subadult Atlantic sturgeon are known to undertake extensive marine migrations and occupy non-natal estuaries during the late spring, summer, and early fall months (Dovel and Berggren, 1983), presumably for feeding (Dadswell, 1979) or perhaps for thermal or salinity refuge (Savoy and Pacileo, 2003).

Brundage and Meadows (1982) reported that no Atlantic sturgeon in spawning condition had been recorded from the Delaware Estuary and that most were likely immature as the majority were smaller than the minimum 112 cm TL for mature males and a minimum of 200 cm TL for females (Dovel, 1979). Van Eenennaam *et al*. (1996) reports the transition to adult phase differing in males and females but in most instances, have attained maturity at 133 cm TL. Atlantic sturgeon as young as age 2 have been observed in the lower Delaware Bay or possibly leaving the system (Brundage and O'Herron in Calvo *et al*., 2010). Research in the Delaware River has shown that up to 40% of tagged subadult Atlantic sturgeon in the Delaware River left the estuary after reaching age 2 (pers. Comm. H. Brundage 2011). Year 1 juveniles, however, are thought to occupy the upper tidal Delaware River to develop physiologically to tolerate salinity (McEnroe and Cech, 1987). Research on 2009 year class juveniles (both age 0+ and 1+) in the Delaware River showed more rapid growth and greater lengths achieved by Atlantic sturgeon juveniles than by those of similar age in other river systems as well as previous studies within the Delaware River (pers. comm. H. Brundage, 2011).

### 3.1.3 GENERAL DISTRIBUTION WITHIN THE NEW YORK BIGHT DISTINCT POPULATION SEGMENT

The New York Bight (NYB) DPS includes all Atlantic sturgeon whose range occurs in watersheds that drain into coastal waters, including Long Island Sound, the New York Bight, and Delaware Bay, from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon have been documented from the Hudson and Delaware rivers as well as at the mouth of the Connecticut and Taunton rivers, and throughout Long Island Sound, with evidence to support that spawning occurs in the Hudson and Delaware rivers (ASSRT, 2007). Historically, the Delaware River may have supported the largest stock of Atlantic sturgeon of any Atlantic coastal river system (Kahnle *et al.*, 1998; Secor and Waldman 1999; Secor 2002; as cited in ASSRT, 2007). The current abundance of all Atlantic sturgeon life stages in the Delaware River has been greatly reduced from reported historical levels.

Several studies have shown that Atlantic sturgeon distribution within the Delaware Estuary is seasonally dependent, utilizing different regions within the river and bay dependent upon time of year and life history stage. In early spring, juvenile Atlantic sturgeon occur in the shallow waters of the Delaware Bay, and by late spring, abundance increases in the lower tidal river. Upstream movement continues through early summer as water temperatures rise and begin a reverse migration in fall. Juvenile Atlantic sturgeon are believed to overwinter in the deeper waters of the lower estuary. Some subadults and adults are believed to exit the estuary in late fall and overwinter in the ocean. Seasonal utilization of different reaches of the river allows for scheduling dredging and construction activities around known habitat utilization periods.

### 3.1.4 DISTRIBUTION IN PROJECT AREA

The area of scientific research covering Delaware River Atlantic sturgeon encompasses the tidal Delaware River, extending from the fall line at Trenton, New Jersey (rkm 214.5) to the head of Delaware Bay (rkm 77.6). The river above Philadelphia, PA is fresh water (salinities of 0–0.5‰) year round. Below Philadelphia the river salinities vary on seasonal and daily scales from an oligohaline to mesohaline gradient (salinities of 0.5–18‰), with freshwater inflow, tidal stage, and meteorological conditions providing contributing factors (Cronin *et al*., 1962). Water temperatures vary from 0ºC in mid-winter to over 30ºC in summer (Polis *et al*., 1973). Tides in the Delaware River are semidiurnal with a period of 12.42 hours and average amplitude of about 1.9 m.

Information in the literature on Atlantic sturgeon is limited for most river systems including the Delaware. Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) were once abundant in all major estuaries along the Atlantic coast. By the late 1800’s, the Delaware River Atlantic sturgeon fishery was the largest in the United States producing 75% of the total US harvest from 1890-1899 (Townsend, 1900). Factors contributing to the precipitous decline of Atlantic sturgeon during the latter part of the 19th century include overharvesting, reduced water quality, and anthropogenic influences. In 1888 total catch in the Delaware River approached 3000 metric tons (Smith, 1985). By 1900 the total catch was less than 10% of the peak harvest years (Ryder, 1890; Cobb 1900).

Most populations of Atlantic sturgeon in east coast river systems are poorly understood (ASSRT, 2007), including the Delaware Estuary. Brundage and Meadows (1982) evaluated records of Atlantic sturgeon captured in the Delaware Estuary from 1958 through 1980 from literature, unpublished data, and logs maintained by commercial fishermen who took Atlantic sturgeon incidental to their operational catch for other species. Just 130 Atlantic sturgeon; 64 commercially fished with gill nets and 66 incidental to fishery and ecological studies, were reported captured over this 22 year period.

The majority of research on Atlantic sturgeon within the Delaware Estuary has occurred in the 1980s through to the present. Dovel and Berggren (1983) identified water temperature as a migratory key for larger subadults in the Hudson River. They concluded that as water temperatures fell below $20^{o}$ C, subadult Atlantic sturgeon begin to move out of the estuary. However, they also noted that salinity may also play a role in subadult migratory behavior. Once water temperatures dropped below $9^{o}$ C, remaining riverine YOY and early stage subadults (<6 years of age) seek winter habitat based on substrate type. As water temperatures began to exceed $9^{o}$ C in the spring, subadults resumed migration upriver towards summer occupation areas.

Habitat selection by subadult Atlantic sturgeon is likely driven by a combination of factors, including water temperature, salinity, dissolved oxygen, depth, substrate type, and available prey resources. Subadult Atlantic sturgeon are thought to occupy specific concentration zones within estuaries due to the presence of prey resources which, in part, are dependent on the aforementioned specific physiochemical characteristics (ECS, 1993 as reported in Simpson, 2008).

A number of studies on subadult Atlantic sturgeon in different riverine systems identify preferred habitat as oligohaline. In the Hudson River low salinity areas serve as nursery habitat (Dovel and Berggren, 1983; Bain *et al*., 2000). In the Chesapeake Estuary, hatchery-raised telemetered Atlantic sturgeon YOY, within one week after release, relocated (>90%) in oligohaline waters (Secor *et al*., 2000). In the Merrimack River sub-adults occupied oligo-mesohaline habitats (Kiefer and Kynard, 1993; Moser and Ross, 1995). Likewise within the Delaware River, concentration zones are typically found in the oligohaline and mesohaline reaches (Shirey *et al*., 1997).

In their evaluation of capture records from 1958 to 1980, Brundage and Meadows (1982) found Atlantic sturgeon to be most abundant in Delaware Bay (rkm 0-55) in spring and in the lower tidal river (rkm 56-127) during summer. The researchers noted that this seasonal distribution appeared similar to that described for the Hudson River. Larger Atlantic sturgeon (800 to 1,300 mm TL) were relatively more abundant in the Delaware Estuary than had been reported in other estuaries. Acknowledging the limitations imposed by relying on incidental catch records, Brundage and Meadows (1982) offer several generalizations of Atlantic sturgeon captured within the Delaware Estuary. The data suggests that a viable population exists within the Delaware Estuary utilizing different regions of the river and bay, depending on season and life history stage. A seasonal pattern of movement is apparent. In early spring juvenile Atlantic sturgeon occur in the shallow waters of Delaware Bay, and in late spring, abundance increases in the lower tidal river. This upstream movement continued through early summer. A similar pattern has been described by Dovel (1979) for the Hudson River.

Juvenile Atlantic sturgeon are believed to overwinter in the deeper waters of the lower estuary and move upstream and inshore in spring in response to increasing water temperatures. However, in the Delaware River, juvenile Atlantic sturgeon ranged as far north as the fall line at Trenton, whereas in the Hudson River, juveniles were found only to river km 145 (Kingston, NY), some 100 km below the limit of tidal intrusion. Juvenile Atlantic sturgeon were most abundant in summer in the lower tidal portion of the Delaware River, most likely utilizing this area for foraging grounds. Numbers in August decreased in this area, the month of maximum water temperatures. Dovel (1979) reported that Hudson River Atlantic sturgeon seek cooler waters in summer. Numbers of Atlantic sturgeon in the Delaware Bay increased slightly in September, while abundance decreased in the upper and lower tidal river the same month, suggesting a return to overwintering areas in late summer.

From interviews with commercial trawl fishermen in 1978-79 operating out of Ocean City, MD, Brundage and Meadows (1982) reported that Atlantic sturgeon are commonly taken near the mouth of the Delaware Bay in fall. Most were recorded as small (0.6 to 1.5 m long), with occasional captures of larger individuals (2.5-3.5 m long). Dovel (1979) reported that fish emigrate from the Hudson River once they reach 800 mm-1,300 mm TL and were rare in the Hudson River, inferring that they remain at sea. However in the Delaware system, Atlantic sturgeon this size were common and composed 62% of measured specimens in the Delaware Bay and 48% of those from the lower tidal Delaware River. It is important to note that a compilation of incidental catch records and a substantial amount of anecdotal information does not take into consideration catch per unit effort, particularly in comparisons of abundance records across different estuaries.

An acoustic telemetry and netting survey was conducted in the lower tidal Delaware River from May 2005 through December 2006 by Brundage and O'Herron (2009) to investigate relative abundance, distribution, and movements of both shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon. Six juvenile Atlantic sturgeon were fitted with external tags. Although only one Atlantic sturgeon was acoustically tagged, the fish exhibited directed movement from the lower tidal river to Delaware Bay in fall and showed a preference for deeper waters. This fish ranged over a 111 km reach of the estuary between Marcus Hook and lower Delaware Bay, spending most of its time in the vicinity of Artificial Island (rkm 83).

In early November, this fish moved rapidly from the lower tidal river (rkm 110) to lower Delaware Bay (rkm 19), where telemetry detection ceased. Depth records for this sturgeon ranged from 2.6 to 16.0 m and averaged 11.7 m. This apparent affinity of juvenile Atlantic sturgeon for deeper water within the Delaware River is consistent with earlier studies (Lazzari *et al*., 1986; Shirey, 1997) and for other rivers (Haley *et al*., 1996; Bain, 1997; Sweka *et al*., 2007). Shirey (1997) identified two important concentration areas of Atlantic sturgeon during the spring and summer within the Delaware River (rkm 80-90 and rkm 115-125). Hatin *et al*. (2007) reported that age 2 Atlantic sturgeon used deep water (6-10m) near a channel, but did not use the deepest areas available. Moser and Ross (1995) found juvenile Atlantic sturgeon in >30 m deep water in the lower Cape Fear River but also observed telemetered fish within < 2 m of the surface.

The Brundage and O'Herron (2009) study suggests that juvenile shortnose sturgeon and Atlantic sturgeon co-occur in the same tidal Delaware River regions and do not segregate based on salinity. Their study also showed a generalized pattern of juvenile sturgeon movement into seasonally brackish and tidal freshwater regions of the river in spring-summer and downstream movement to overwintering areas in the lower estuary or nearshore ocean in fall-winter. This pattern has also been inferred from other Delaware Estuary sturgeon studies (Brundage and Meadows, 1982 ; Lazzari *et al*., 1986; Shirey *et al*., 1997) as well as movements of juvenile sturgeon tracked in the Hudson River (Dovel and Berggren, 1983; Bain, 1997). Some juveniles may remain in the tidal freshwater reaches of the river to overwinter, as evidenced by the capture of an early juvenile in the lower tidal river in February by Burton *et al*. (2005) and the capture of several juveniles in the upper tidal river during December through February by Lazzari *et al*. (1986) and O'Herron (unpublished data). These captured fish were identified as subadults between the ages of 2-6, based on age/length data collected by Dovel and Berggren (1983), Lazzari *et al*. (1986), and Shirey (1996). Dovel and Berggren (1983) reported that Atlantic sturgeon remain in the Hudson River for up to 6 years, but some may leave the estuary as young as age 2. Results from more recent acoustic tagging studies in the Delaware Estuary of 2009 year class Atlantic sturgeon showed 27% (3 of 11 fish tagged in the fall of 2010) went to the ocean in December 2010 when they were technically still age 1+ (almost age 2). Fish of this year class seemed to grow very rapidly, and perhaps matured physiologically at a much younger age, thus allowing them to live in ocean water at a somewhat younger age (pers. comm. H. Brundage, 2011).

Another telemetry study was conducted in the Delaware Estuary between 2005-2007 (Simpson, 2008). Thirty-two Atlantic sturgeon were implanted with telemetry tags and monitored to study habitat use. The study showed Atlantic sturgeon entering the Delaware Estuary in early spring (mid-March through mid-May) and then gradually moving up into the river. Tagged subadults tended to reduce their movements in the summer as compared to spring and fall, where movements occasionally exceeded 100 km/day. The subadults concentrated in deep water (>8m) and demonstrated a preference for gravel/hard-bottom substrates. Nine of the 32 tagged fish were histologically confirmed as reproductively mature fish. Movement of tagged adults was highly varied, with only two adults entering the freshwater region of the river (>rkm 130). Simpson's (2008) study results showed substrate type and depth playing important factors in habitat selection by Atlantic sturgeon in the Delaware Estuary, coinciding with the characteristics of areas within the Delaware River where telemetered subadults were most likely to occur.

Directional upriver movements were observed between early May and late June, with concentrations of fish in the Philadelphia, PA (rkm 163–186) and Trenton, NJ (rkm 199–211) regions. Coupled with substrate and water quality data, sturgeon movements suggest the existence of a relict spawning population within the Delaware River. A few Young-of-Year fish (342 mm TL) have been caught sporadically within the Delaware River during the 1970s/80s, (and one in 2005) with a total of 66 Age 0 juveniles captured in 2009 (pers. comm. H. Brundage, 2011). This conclusion is supported by genetic evidence of an extant Delaware River distinct population (King *et al*., 2001; Wirgin *et al*., 2007; Grunwald *et al*., 2007) although subadult Atlantic sturgeon natal to other estuaries also occupy the Delaware Estuary (Dovel and Berggren, 1983; Wirgin *et al*., 2007).

Migrations of subadult Atlantic sturgeon upriver during spring and summer months are likely driven by foraging opportunities (Dadswell, 1979). In both the Hudson River and Delaware River, subadult Atlantic sturgeon will occasionally congregate and overwinter within brackish river waters (Bain, 1997; Brundage and Meadows, 1982). Shirey *et al.* (1999) also reported substrate type, water depth and salinity as determining factors in subadult Atlantic sturgeon habitat utilization in the Delaware Estuary. Artificial Island (rkm 80-90), Cherry Island Flats (rkm 110-115) Marcus Hook Anchorage (rkm 125-130) are areas where preferred water depths and substrate types occur (i.e. predominately mixed gravel and sand sediments with areas of non-depositional substrate (Sommerfield and Madsen 2003; Wilson, 2007). Moser and Ross (1995) reported subadult Atlantic sturgeon occupied depths of greater than 10 m throughout the year and moved very little during summer in the Delaware Estuary. Subadult Atlantic sturgeon in the Delaware River tended to occupy deepwater habitats outside of the main shipping channel where depths were maximized during the summer months (Simpson, 2008). Atlantic sturgeon movements were minimal during peak summer water temperatures (mid-July/early-September).

Each of these three concentration areas offer relatively deepwater habitat outside of the main shipping channel. Salinity is thought to play a significant factor in Atlantic sturgeon distribution (Dovel and Berggren, 1983; *Bain et al.*, 2000). Previous studies have noted that subadult Atlantic sturgeon typically occupy both the oligohaline and moderately mesohaline

(<10ppt) environments (Dovel and Berggren, 1983; Kiefer and Kynard, 1993; Moser and Ross, 1995; Simpson, 2008).

Brundage and O’Herron (ERC, Inc. in Calvo *et al.*, 2010 for the USACE, Philadelphia District) conducted gill net surveys and acoustic tagging of Atlantic sturgeon between October-November 2008 and again in May-November 2009 in the lower tidal Delaware River from the lower Cherry Island Flats near Wilmington, DE (110 rkm) to the upper Marcus Hook, PA anchorage (rkm 130). Of 57 juvenile Atlantic sturgeon captured (and 6 obtained from the Delaware Department of Natural Resources and Environmental Control (DNREC)), 26 were telemetered, 6 of which were YOY. Acoustically tagged subadults (i.e. juveniles older than Year 1), ranged from the nearshore ocean off of Ocean City, NJ to Philadelphia, PA (rkm 148), while predominately detected in the lower tidal Delaware River from Liston Range (rkm 70) to Tinicum Island (rkm 141).

Subadult movements were generally localized during summer and early fall, with higher concentrations located in the Marcus Hook vicinity (rkm 123-129) and Cherry Island Flats (rkm 112-118). In late fall, movement increased with three separate notable patterns: nineteen fish (47%) exhibited rapid directed movements to the lower Delaware Bay or the ocean; 4 fish (21%) moved towards the bay but were not detected below the Liston Range (where the bay widens considerably and receiver detection is porous), and it is likely these 4 fish may have likewise continued to the lower bay or ocean. Six fish (32%) appeared to have remained in the tidal river into the winter. The Brundage and O’Herron (Calvo *et al.*, 2010) study supports previous studies that suggested a relationship between fish length and movement pattern in subadult Atlantic sturgeon, with smaller, presumably younger juveniles remaining in the tidal river to overwinter. The six acoustically-tagged YOY fish captured in late fall 2009 from the Marcus Hook anchorage (rkm 127) ranged from Deepwater, NJ (rkm 105) to Roebling, NJ (rkm 199). Two of these YOY remained in the Marcus Hook to Chester reach of the river (rkm 123-130). Another tagged YOY was detected over a wider range of the lower tidal river between Deepwater (rkm 105) to Tinicum Island (rkm 141). Three tagged YOY made more extensive movements, moving progressively upriver to the Torresdale (rkm 176) to Roebling (rkm 199) reach of the upper tidal river in winter 2010.

The movement patterns of subadult Atlantic sturgeon observed in this study were consistent with those observed in other Delaware Estuary studies (Brundage and Meadows, 1982; Brundage and O’Herron, 2009; Lazzari *et al.*, 1986; DNREC, 2009) as well as studies of subadult Atlantic sturgeon in the Hudson River (Dovel and Berggren, 1983; Bain, 1997). Subadults move upriver in the Delaware River into seasonally brackish and tidal freshwater reaches during the summer and may move downriver to overwintering areas in the lower estuary and nearshore ocean in fall-early winter. Younger juveniles are not all likely to move down bay, and may overwinter in the lower tidal river. The collection of 32 YOY Atlantic sturgeon (Brundage and O’Herron in Calvo *et al*., 2010) and an additional 34 YOY captured by DNREC (2009) is evidence of a successful spawn of Atlantic sturgeon in the Delaware River in 2009. Previous YOY Atlantic sturgeon captures within the Delaware River have been sporadic. Burton *et al*., (2005) captured one in the Marcus Hook anchorage in February 2005. Previously, 5 YOY captures occurred in the 1970s (Brundage and O’Herron in Calvo et al., 2010).

The use of marine habitat by Atlantic sturgeon larger subadults and adults is not fully known. Dovel and Berggren (1983) state that growth rates appear to accelerate. By-catch records suggest a preference for relatively shallow (<60m) habitat composed of a gravel and sand substrate (Stein *et al*., 2004). Two of 6 externally-tagged Atlantic sturgeon from the Delaware River were recaptured in eastern Long Island Sound, more than 560 km from their original capture location (Savoy and Pacileo, 2003; Brundage and O'Herron, 2009).

### 3.1.5 FOOD RESOURCES

Although sturgeons generally occupy North American waters where temperatures range to 30° C, activity and growth are more optimal in cooler (<25° C) waters (Cech and Doroshov 2004). Atlantic sturgeon are believed to seek thermal refuge in deepwater habitat and exhibit limited movement during periods of elevated temperatures (>25° C). As water temperatures peak during the summer months the ability of water to hold dissolved oxygen decreases, which may potentially drive subadult Atlantic sturgeon to cooler, deepwater habitat where dissolved oxygen levels are generally higher (Dovel and Berggren, 1983; Moser and Ross, 1995; Cech and Doroshov, 2004; Niklitschek and Secor, 2005).

These physiochemical parameters also determine the availability of prey resources, possibly driving subadult Atlantic sturgeon estuarine habitat occupation (Dadswell, 1979). Some important prey organisms for Atlantic sturgeon include polychaetes, oligochaetes, amphipods and isopods, and mollusks (Johnson *et al*., 1997; Haley, 1998). In the Delaware River, the Asiatic river clam (*Corbicula manilensis*) is considered a primary food source for the shortnose sturgeon, a species thought to overlap in habitat use with Atlantic sturgeon within the Delaware Estuary (Brundage and O'Herron, 2009*)*. *Corbicula* is widely distributed at all depths in the upper tidal Delaware River, although it is considerably more numerous in shallows on both sides of the river than in the channel (Hastings, 1985). Aquatic worms and insects (*Oligochaetes* and *Tendipedidae*) are also abundant. Additional taxa include *Hirudinea, Odonata, Anguilla rostrata Amphipoda, Polychaetes, Nematoda,* and *Ferrissia*. Dadswell (1979) and Marchette and Smiley (1982) studied feeding habits of shortnose sturgeon. They reported freshwater feeding occurs during portions of the year when water temperature is greater than 10° C. Feeding during colder months occurs at a depth of 15-25 m. Feeding activity in saline water occurs year-round, although an analysis of stomach contents suggests that feeding is less frequent during the winter. Substrate types associated with important prey items for subadult Atlantic sturgeon include clay and silt in the Hudson River (Bain *et al*., 2000), organic mud substrates in Albemarle Sound (Armstrong, 1999), and sandy mud and clay mud in the Savannah River (Hall *et al*., 1991)

## 3.2. OTHER SPECIES OF CONCERN

### 3.2.1 SEA TURTLES

There are five listed turtle species that may occur within the Delaware River Deepening Project area. They include loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempi*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*) sea turtles. All of these species are endangered, except for the loggerhead sea turtle, which is threatened.

Sea turtles spend most of their lives in an aquatic environment, and males of many species may never leave the water (Hopkins and Richardson 1984, Nelson 1988). The recognized life stages for these turtles are egg, hatchling, juvenile/subadult, and adult (Hirth, 1971).

Reproductive cycles in adults of all species involve some degree of migration in which the animals return to nest at the same beach year after year (Hopkins and Richardson, 1984). Nesting generally begins about the middle of April and continues into September (Hopkins and Richardson, 1984; Nelson, 1988; Carr, 1952). Mating and copulation occur just off the nesting beach. A nesting female moved shoreward by the surf lands on the beach, and if suitable crawls to a point above the high water mark (Carr, 1952). She then proceeds to excavate a shallow body pit by twisting her body in the sand (Bustard, 1972). After digging the body pit she proceeds to lay her eggs, size and egg shape is species specific (Bustard, 1972). Incubation periods for loggerheads and green turtles average 55 days, but range from 45 to 65 days depending on local conditions (Nelson, 1988).

Hatchlings emerge from the nest at night, breaking the egg shell and digging their way out of the nest (Carr, 1952). They find their way across the beach to the surf by orienting to light reflecting off the breaking surf (Hopkins and Richardson, 1984). Once in the surf, hatchlings exhibit behavior known as "swim frenzy," during which they swim in a straight line for many hours (Carr, 1986). Once into the waters off the nesting beach, hatchlings enter a period known as the "lost year". It is not known where this time is spent, what habitat this age prefers, or mortality rates during this period. It is currently believed the period encompassed by the "lost year" may actually turn out to be several years. Various hypotheses have been put forth about the "lost year." One is that hatchlings may become associated with floating sargassum rafts offshore. These rafts provide shelter and are dispersed randomly by the currents (Carr, 1986). Another hypothesis is that the "lost year" for some species may be spent in a salt marsh/estuarine system (Garmon, 1981).

The functional ecology of sea turtles in the marine and/or estuarine ecosystem is varied. The loggerhead is primarily carnivorous and has jaws well-adapted to crushing mollusks and crustaceans, and grazing on encrusted organisms attached to reefs, pilings and wrecks. The Kemp's ridley is omnivorous and feeds on swimming crabs and crustaceans. The green turtle is a herbivore and grazes on marine grasses and algae while the leatherback is a specialized feeder preying primarily upon jellyfish. Until recently, sea turtle populations were large and subsequently played a significant role in the marine ecosystem. This role has been greatly reduced in most locations as a result of declining turtle populations. These population declines are a result of natural factors such as disease and predation, habitat loss, commercial overutilization, and inadequate regulatory mechanisms for their protection. This has led to several species being in danger, or threatened with extinction.

However, due to changes in habitat use during different life history stages and seasons, sea turtle populations are difficult to census (Meylan, 1982). Because of these problems, estimates of population numbers have been derived from various indices such as numbers of nesting females, numbers of hatchlings per kilometer of nesting beach, and number of subadult carcasses (strandings) washed ashore (Hopkins and Richardson, 1984).

Each turtle species within the project area was described in great detail in USACE, 2009, and is incorporated here by reference. There have been no significant changes to the distribution, population size, food or nesting requirements of the species since that time.

### 3.2.2 WHALES

Three species of endangered whales may also occur within the Delaware River Deepening project area. These species include the right (*Eubalaena glacialis*), humpback (*Megaptera novaeangliae*), and fin (*Balaenoptera physalus*) whales.

A former resource of the Delaware Estuary, the presence of whales convinced Dutch settlers to establish their first permanent settlement in Delaware on Cape Henlopen, in 1631. Since then the numbers of whales off of the New Jersey and Delaware coast have decreased. Records indicate that the endangered humpback whales, fin whales and right whales were occasionally sighted in the Delaware Estuary. However, since the introduction of the Endangered Species Act in 1973, whales have been sighted with increasing frequency along the New Jersey and Delaware Coast, and have become the subject of a growing whale watch industry in the mid-Atlantic.

Information concerning distribution, life history and population size for these species was discussed in detail in USACE, 2009 and is incorporated here by reference. There have been no significant changes to the status of these whales within the Delaware River since that time.

### 3.2.3 SHORTNOSE STURGEON

The shortnose sturgeon (*Acipenser brevirostrum*) is an endangered species of fish found in major rivers of eastern North America, from the Saint John's River in Florida to the Saint John River in New Brunswick, Canada, including the Delaware River. This species may also be found in estuaries and in ocean regions adjacent to river mouths. Although typically an anadromous species, landlocked populations of shortnose sturgeon are known to exist. Like Atlantic sturgeon, shortnose sturgeon spawn in freshwater, usually above tidal influence. In northern latitude river systems, spawning grounds are generally characterized by fast flows (40-60 cm/sec) and gravel or rubble bottoms. Spawning occurs in the spring. In the Delaware River, spawning normally occurs during the middle 2 weeks of April (Hoff, 1965; Brundage and Meadows, 1982a).

Detailed information regarding the shortnose sturgeon was presented in USACE, 2009 and is incorporated here by reference. There have been no significant changes to the species since that time.

## 4.0 FACTORS AFFECTING THE NEW YORK BIGHT DISTINCT POPULATION SEGMENT OF ATLANTIC STURGEON

Like all anadromous fish, Atlantic sturgeon are vulnerable to many habitat impacts because of their varied use of rivers, estuaries, bays, and the ocean throughout the phases of their life. Habitat alterations that may be affecting Atlantic sturgeon include dam construction and operation, dredging and disposal, and water quality modifications such as changes in levels of DO, water temperature and contaminants (ASSRT, 2007). Other threats to the species include vessel strikes and fisheries impacts.

Dredging in riverine, nearshore and offshore areas has the potential to impact aquatic ecosystems by removal/burial of benthic organisms, increased turbidity, alterations to the hydrodynamic regime and the loss of shallow water or riparian habitat. According to Smith and Clugston (1997), dredging and filling impact important habitat features of Atlantic sturgeon as they disturb benthic fauna, eliminate deep holes, and alter rock substrates. Indirect impacts to sturgeon from either mechanical or hydraulic dredging include the disruption of benthic feeding areas, spawning migration, and resuspension of sediments in spawning areas. In addition, hydraulic dredges can directly impact sturgeon and other fish by entrainment in the dredge (ASSRT, 2007). Dickerson (2006) summarized sturgeon takes from hopper dredging activities conducted by the USACE between 1990 and 2005, resulting in impacts to 24 sturgeon (2 – Gulf, 11- Shortnose, and 11-Atlantic). Fifteen of these sturgeon were reported as dead. Seasonal dredging restrictions help to reduce impacts to Atlantic sturgeon and other anadromous fish by restricting dredging activities during sensitive time periods.

Atlantic sturgeon may be particularly susceptible to impacts from environmental contamination and poor water quality due to their benthic foraging behavior and long-life span. Sturgeon utilizing habitats in urbanized areas may be exposed to numerous suites of contaminants within the substrate (ASSRT, 2007). Secor (1995) noted a correlation between low abundances of sturgeon during periods of decreased water quality caused by increased nutrient loading and increased spatial and temporal frequency of hypoxic conditions.

Atlantic sturgeon have been directly harvested for years. Many authors have cited commercial over-harvesting as the single greatest cause of the decline in abundance of Atlantic sturgeon (Ryder, 1890; Vladykov and Greely, 1963; Hoff, 1980; ASMFC, 1990; Smith and Clugston, 1997; as cited in ASSRT 2007). Harvest records indicate that sturgeon fisheries were established in every major coastal river along the Atlantic Coast at one time and were concentrated during the spawning migration (Smith, 1985). The majority of the sturgeon fishery between 1870 and 1920 was in the Delaware River and Chesapeake Bay System with New Jersey and Delaware reporting the greatest landings. Landings reported until 1967 most likely included both Atlantic and shortnose sturgeon (ASSRT, 2007). Despite the fact that the fishery has been closed coastwide since 1995, poaching of Atlantic sturgeon continues and is a potentially significant threat to the species, but the magnitude of the impact is unknown (ASSRT, 2007). Impacts to sturgeon through bycatch is also a significant concern, but one that is hard to quantify due to limited available data.

According to ASSRT, 2007, “The recovery of Atlantic sturgeon along the Atlantic Coast, especially in areas where habitat and water quality is severely degraded, will require improvements in the following areas: 1) elimination of barriers to spawning habitat either through dam removal, breaching, or installation of successful fish passage options; 2) operation of water control structures to provide flows compatible with Atlantic sturgeon use in the lower portion of the river (especially during spawning season); 3) imposition of restrictions on dredging, including seasonal restrictions and avoidance of spawning/nursery habitat; and 4)

mitigation of water quality parameters that are restricting sturgeon use of a river (*i.e.,* DO). Additional data regarding sturgeon use of riverine and estuarine environments is needed.”

## 4.1 FACTORS AFFECTING THE DELAWARE RIVER POPULATION OF THE ATLANTIC STURGEON

The portion of the Delaware River and Bay that is available to Atlantic sturgeon extends from the Delaware Bay to Trenton, NJ; a distance of 140rkm. There are no dams within this reach of the river, leaving all of the potential habitat accessible to the species. Until recently, poor water quality has been a significant factor for fish utilizing the upper tidal portion of the Delaware estuary. Chemicals and untreated sewage have been making their way into the river and surrounding estuary for at least the past 200 years. Coal silt in the upper Delaware River was one of the major contributors to the pollution problem from 1820-1940 (ASSRT, 2007). Borodin (1925) and Horn (1957) suggest that pollution from oil and dyes was a factor in the decline of Atlantic sturgeon in the estuary. As late as the early 1970's, levels of DO between Wilmington and Philadelphia regularly dropped below levels that could support aquatic life from late spring through early fall. Since 1990, DO levels have remained above minimum state standards throughout the entire year (R. Greene, DNREC, Pers. Comm. 1998, as cited in ASSRT, 2007). The restoration of other anadromous species within the system suggests that environmental conditions are now adequate to support growth of the Atlantic sturgeon subpopulation if the fish are allowed to reach maturity and spawn (C. Shirey, DNREC, Pers. Comm. 2005, as cited by ASSRT, 2007).

It is believed that overfishing was the most likely cause of the dramatic decline in the fishery market and presumably in abundance of the Delaware River sturgeon population in the early 1900s. No landings were reported after 1993 however, and the direct fishery was officially closed on April 1, 1998 (ASSRT, 2007). Atlantic sturgeon are still caught as bycatch of commercial fisheries operation in the Delaware Bay gill net fishery, posing a moderate risk to this subpopulation's viability. The majority of these landings occur in March and April, but bycatch mortality during this period is typically low (C. Shirey, DNREC, Pers. Comm., 2005 as cited in ASSRT, 2007).

As presented in ASSRT (2007), the Status Review Team (SRT) for the proposed listing of the Atlantic sturgeon found that the Delaware River subpopulation had a moderately high risk of becoming endangered in the next 20 years, due to the loss of adults from ship strikes. Dredging was considered a moderate risk as maintenance dredging takes place annually from the Delaware Bay to Trenton, NJ. Dredging in the upper portions of the river near Philadelphia were considered detrimental to successful Atlantic sturgeon spawning since this area may be historic spawning grounds for the species. Recommended dredging restrictions that are in place during the spawning season help to minimize risk, but it is suspected that the continued degradation of the spawning habitat through dredging is likely to increase the instability of the subpopulation (ASSRT, 2007).

## 5.0 POTENTIAL IMPACTS FOR THE DELAWARE RIVER DEEPENING PROJECT

### 5.1 ATLANTIC STURGEON

Examination of the potential impact of destruction, modification or curtailment of habitat on Atlantic sturgeon is presented in this section. If information was not available specific to Atlantic sturgeon, information relevant to other sturgeon species (particularly the shortnose sturgeon, as it is the only other sturgeon species that inhabits the Delaware Estuary), is presented. Similarities in sturgeon life history and physiology makes these data and analyses applicable, with qualification, to Atlantic sturgeon. The Brundage and O'Herron (2009) study suggests that juvenile shortnose sturgeon and Atlantic sturgeon co-occur in the same tidal Delaware River regions and do not segregate based on salinity. Different aspects of the Main Channel

Deepening project have the potential to impact Atlantic sturgeon. This section also discusses the potential impacts to Atlantic sturgeon both during construction and after, including both physical effects on the fish, their food sources, as well as their spawning and overwintering habitat.

### 5.1.1 PHYSICAL INJURY DURING CONSTRUCTION

The most recent studies conducted within the Delaware Estuary on Atlantic sturgeon have focused on 1) their current population status; 2) critical subadult habitats; and 3) the spatial and temporal extent of spawning areas. Acoustic telemetry results indicate that Atlantic sturgeon undergo a late spring/early summer upriver migration, followed by a period of dampened movement during the warmest summer months, and then a downriver migration in the fall. Within the Delaware Estuary, three main concentration areas of juvenile Atlantic surgeon have been identified: Artifical Island (rkm 80-90), Cherry Island Flats (rkm 110-115), and the Marcus Hook Anchorage (rkm 125-130). These three concentration areas offer relatively deepwater habitat outside of the main channel closer to the shore where the sturgeon have been observed. Studies show that gravelly, cobble bottom substrate type, moderately deep water and oligohaline salinity levels are present within these preferred congregation areas (Dovel and Berggren, 1983; Simpson, 2008; Baine *et al*., 2000; Kiefer and Kynard, 1993; Moser and Ross, 1995; Shirey *et al.*, 1997; Brundage and Meadows, 1982; Dovel, 1979; and Lazzari *et al.*, 1986). This apparent affinity of juvenile Atlantic sturgeon for deeper water within the Delaware River is consistent with earlier studies (Lazzari *et al*., 1986; Shirey *et al.*, 1997) and for other rivers (Haley *et al*., 1996; Bain, 1997; Sweka *et al*., 2007). Shirey *et al.* (1997) identified two important concentration areas of Atlantic sturgeon during the spring and summer within the Delaware River (rkm 80-90 and rkm 115-125). Hatin *et al*. (2007) reported that age 2 Atlantic sturgeon used deep water (6-10m) near a channel, but did not use the deepest areas available.

The existing 40-foot Federal navigation channel from Philadelphia to the Sea is routinely maintained by the U.S. Army Corps of Engineers. Approximately 3,455,000 cubic yards of material are dredged annually to maintain the 40-foot depth. Sediment and water quality of the dredged sediments and placement area effluent are analyzed in accordance with the NJDEP water quality certification process. Inlet slurry samples, a mixture of dredged sediment from the weir, discharge plume, and background locations are analyzed for inorganics, semi-volatile organic compounds, pesticides, and high resolution or arochlor polychlorinated biphenyls (PCBs).

A total of 71 water samples have been collected at the point of CDF discharge and analyzed between 2000 and 2009 for the Delaware River dredging. Based on the results of the chemical analysis, water quality impacts associated with the operation of CDFs, where riverine maintenance material has been placed, was determined to be minimal. Water quality was also modeled to determine the potential levels of exposure for aquatic organisms to contaminants mobilized at either the point of dredging or at the point of weir discharge into the water column (Versar, 2001). Once mixing is considered at the point of discharge, it was concluded that at flood and ebb tides, all water quality criteria would be met within 2 meters of the weir.
The Philadelphia District evaluated the near-field concentrations of metals and PCBs released during dredging operations (Versar, 2001a). These evaluations were conducted for cutterhead hydraulic dredging in the shipping channel and for bucket dredging in berthing areas. Conclusions drawn from the water quality near-field (i.e. within a 200-foot mixing zone) evaluation model were that metals and PCBs would not exceed the DRBC's water quality criteria

in the vicinity of a working cutterhead hydraulic dredge or a bucket dredge during dredging. Since dredging and dredged material disposal operations are short-term events, comparison of sample data to acute water quality criteria is more accurate than a comparison to chronic (or long-term) water quality standards. The potential for PCB mobilization during dredging operations and sequestered within the CDF were also evaluated (Versar, 2001b). The conclusions drawn from this study were: 1) PCB concentrations tend to be higher in shallow areas outside of the navigation channel; 2) PCB concentrations are lower in Delaware Bay than in the Delaware River; 3) the majority of PCBs present in dredged sediments are retained in CDFs; and 4) PCB concentrations in CDF weir discharges are not vastly greater than background river PCB concentrations. A more detailed discussion of these chemical analyses is provided in the Environmental Assessment (USACE, 2009a).

Dredging for the Delaware River Main Channel Deepening Project began on March 1, 2010. The first construction contract was for Reach C, which extends from the Delaware Memorial Bridge to just below the C&D Canal. In conjunction with the dredging, environmental monitoring for potential water quality impacts was conducted at the Federally-owned Killcohook CDF as well as at the point of active dredging (Versar, unpublished data). Samples were analyzed for metals, pesticides, PCBs, and semi-volatile organics. Sample results were compared to DNREC freshwater acute and chronic water quality criteria for protection of aquatic life. Acute criteria were considered to assess short duration, higher concentration exposures in the Delaware River near the discharge points (*i.e.* near-field assessment). With the exception of aluminum, and one instance each for arsenic, chromium, and selenium most of the parameters did not exceed acute criteria, and when a chronic criteria was exceeded, the exceedance was only slightly over the criterion and short-lived.

A CORMIX water quality model for a similar discharge configuration was applied to the few acute exceedances observed in the monitoring samples (considering average concentrations found in the background water). The exceedances were predicted to fall below criteria between 10 and 25 meters away from the discharge point. A mass balance evaluation of the contaminant load entering and leaving the Killcohook CDF indicated that for most contaminants detected in the material entering the site, 99% was retained by the CDF and not released back to the Delaware River (Versar, unpublished data).

Water quality was also monitored at the point of active dredging. One concern with respect to impacts to sturgeon due to dredging is that it causes a disruption of benthic sediments which may increase levels of suspended sediments and contaminants in the water and negatively impact benthic fauna (Smith and Clugston, 1997). The lack of exceedances of both acute and chronic water quality criteria, and data demonstrating that TSS levels down-current of the cutterhead are similar to background levels indicate that water quality was not impacted at the point of dredging. Similar results would be expected for the remainder of the dredging, indicating that the project should not affect the Atlantic sturgeon through the degradation of water quality or through the introduction of contaminants.

With regard to potential physical injuries to Atlantic sturgeon, the potential exists for them to become entrained during dredging operations. Dickerson (2006, as cited by ASSRT, 2007) believes that direct physical impacts to sturgeon is associated with dredging machinery (*i.e*. drag arms, pumps). It is expected, however, that most adult sturgeon would actively avoid a working dredge. O'Herron *et al.* (1985) did a study of shortnose sturgeon in the upper tidal

Delaware River to assess potential impacts of maintenance dredging of the Duck Island and Perriwig ranges between June and November 1983. They found no evidence of sturgeon killed or injured by the dredging operation. They also observed that adult shortnose sturgeon had a tendency to move away from the dredge and returned only after the dredge had left the area.

In March 1996 two sturgeon carcasses were found in the Money Island Upland Placement Site. Mortality may have resulted two weeks prior in the Newbold Range dredging. In January 1998 three sturgeon carcasses were discovered in the Money Island CDF while the Kinkora and Florence ranges were being dredged.

Deepening of Reach C of the project began on March 1, 2010 and concluded on September 18, 2010. The required terms and conditions specified in the January 2009 Biological Opinion include daily inspections of the dredged material disposal area to document any entrainment of shortnose sturgeon. Corps' construction inspectors were on-site every day and daily inspections of the ponded areas around the weir structures were made. No Atlantic or shortnose sturgeon were observed.

Another potential direct physical injury to sturgeon may result from blasting operations. Surveys for the presence of Atlantic and shortnose sturgeon were conducted in March 2005 using a Video Ray® Explorer submersible remotely operated vehicle (ROV) to determine if these species were present in the Marcus Hook to Tinicum reach of the Delaware River during winter (Burton *et al.*, 2005). A total of 39 survey miles of bottom habitat were recorded. Of the 411 fish camera encounters, three sturgeon were observed: two in the Marcus Hook range and one in the Tinicum range. Although it could not be determined from the video which sturgeon species were observed, gillnetting in the Marcus Hook anchorage produced one juvenile Atlantic sturgeon with a total length of 396 mm. The ROV results confirmed that sturgeon are using the Marcus Hook area in the winter months, although relative densities were much lower than those observed near Trenton, NJ, where concentrations of sturgeon occur in several large aggregations.

Unlike shortnose sturgeon, which are known to overwinter in the upper reaches of the river, juvenile Atlantic sturgeon overwinter in the deeper waters of the lower estuary and older subadults and adults may leave the estuary for oceanic waters in fall and winter. Blasting operations to remove bedrock in the Marcus Hook range are scheduled to be performed between December 1 and March 15 to minimize potential impact to migrating Atlantic sturgeon moving to the lower reaches of the estuary in fall to overwinter and when lower numbers of Atlantic sturgeon are expected to be in the Marcus Hook range. Approximately 77,000 cubic yards of bedrock over 18 acres near Marcus Hook, PA (rm 76.4 to rm 84.6) would be removed to deepen the navigation channel to a depth of 47 ft mean low water. Blasting operations would occur for a brief period each day, five days/week between December 1 and March 15. Several studies have demonstrated that underwater blasting can cause fish mortality (Teleki and Chamberlain, 1978; Wiley *et al*., 1981; and Burton, 1994). Size of charge and distance from detonation are factors determining fish mortality. Water depth, substrate type, and the size and species of fish also influence the number of fish killed by underwater explosions.

Several studies have demonstrated that underwater blasting can cause fish mortality. Size of the charge, distance from detonation, depth of water, substrate type and size and species of fish are all factors that determine mortality. Teleki and Chamberlain (1978) monitored fish mortality on 13 species in blasting experiments in Nanticoke, Lake Erie and found that fish were killed in radii ranging from 65.6 to 164 feet (20-50 m) for 50 lbs (22.7 kg) per charge and from 147.6 to 360.9 feet (45-110 m) for 600.5 lbs (272.4 kg) per charge. Mortality differed by species at identical pressure. No sturgeon were tested. Common blast-induced injuries included swimbladder rupturing and hemorrhaging in the coelomic and pericardial cavities.

Wiley *et al.* (1981) measured swim bladder movement in caged fish at varying depths in Chesapeake Bay to estimate mortality at the mouth of the Patuxent River. Pressure gages were placed in cages containing spot (*Leiostomus xanthurus*) and white perch (*Morone americana*). Using data collected during 16 blasts, Wiley *et al.* (1981) predicted the distances at which 10%, 5%, and 90% mortality of white perch occurred. For 32kg charges, the pressure wave was propagated horizontally most strongly at the depth at which the explosion occurred. Their analyses showed that fish mortality is strongly dependent on the depth of the fish. For larger fish at shallower depths (23-36 ft), the swimbladder does not have time to fully respond to the positive portion of the explosion wave. Thus, at shallow depth the larger fish are in effect protected from harm by their swimbladders, while at the resonance depth their swimbladders are burst.

Burton (1994) conducted experiments on the Delaware River to estimate the effects of blasting 1,600 cubic yards of bedrock near Easton, PA with juvenile American shad (*Alosa sapidissim*) and smallmouth bass (*Micropterus dolomieu*) juveniles. All fish in cages positioned farther than 78.7 ft (24 m) from the blast survived.

The effects of blasting on shortnose sturgeon were examined in Wilmington Harbor, NC in 1998/1999. Test blasts consisted of 52.9 to 61.7 lbs (24 to 28 kg). During test blasting 50 hatchery reared juvenile striped bass and shortnose sturgeon were placed in mesh cylinder cages three feet from the bottom. Test blasts were conducted with and without air curtains (i.e. stream of air bubbles) 50 feet from the blast. Survival rates just after the blast and 24 hours later were similar. Survival beyond 140 feet (with or without the air curtain) were not significantly different. This 140-foot distance equaled 2.1 acres and was the edge of the LD1 (i.e. the lethal distance from the blast where 1% of the fish died).

Post-blast fish condition and their potential for future survival for 70 shortnose sturgeon were evaluated. Most fish were caged 35 feet from the blast and one cage was located 70 feet from the blast. There was no clear reduction in injury observed with air curtains in place, and shortnose sturgeon generally suffered a less significant degree of injury than striped bass. While sturgeon had relatively little swimbladder damage, they more often exhibited distended intestines with gas bubbles inside and hemorrhage to the body wall lining. There was no sign of hemorrhage or swimbladder damage in the shortnose sturgeon caged 70 feet away from the blast, but these fish exhibited distended intestines, which may have been caused by the blast. Moser (1999) speculated that sturgeon fared better than striped bass because their swimbladder has a free connection to the esophagus, allowing gas to be expelled rapidly without damage. Many fish exhibited no outward signs of stress or physical damage but had extensive evidence of internal damage. Sturgeon placed in holding tanks exhibited no greater long-term mortality (two months) than fish not exposed to blasting.

Blasting operations can also cause indirect impacts to sturgeon through the destruction of benthic habitat and foraging resources. However, Atlantic sturgeon only engage in light foraging during the winter and while most younger juveniles may remain in the estuary during winter, older juveniles (> Year 2) and adults are known to migrate to the lower estuary our leave the estuary for oceanic waters to overwinter.

### 5.1.2 PHYSICAL INJURY POST CONSTRUCTION

The Delaware Estuary is classified as a well-mixed system due to the predominance of tidal influence over freshwater inflow. Tidal mixing inhibits the formation of significant vertical salinity stratification. The distribution of salinity in the estuary determines habitat suitability for living resources and human water uses (*i.e*. industrial and municipal water supply withdrawals, groundwater recharge, *etc*.). Estuarine salinity exhibits significant variability on both spatial and temporal scales, and at any given time reflects the competing influences of freshwater inflow from tributaries (and groundwater) versus saltwater inflow from the Atlantic Ocean. A longitudinal gradient is a permanent but dynamic feature of salt distribution in the Delaware Estuary; higher at the mouth and decreasing in the upstream direction. There is also a lateral gradient in the bay. Tidal currents in the bay also advect higher salinity in the upstream direction during flood flow, with lower salinity water advected in the downstream direction during ebb. In essence, the salinity at any given location varies in response to many forcing functions, including seasonal changes in freshwater flow, wind forcing, and water levels.

Atlantic sturgeon are anadromous, spending the majority of their adult phase in higher saline marine waters and migrating upriver to spawn in freshwater, then returning to brackish waters in juvenile growth phases. One issue of concern raised with respect to the Main Channel project is the impact a deepened channel may have on the salinity distribution of the river. DiLorenzo *et al.* (1993) concluded that deepening efforts were projected to have a negligible effect on tidal regime and saltwater intrusion within the Delaware Estuary. In order to estimate the potential for the proposed deepening project to affect salinity, a 3-dimensional hydrodynamic computer model (CH3D-WES) was developed (Kim and Johnson, 1998).

Physical processes affecting estuarine-wide hydrodynamics that were modeled included tides, wind, density effects (salinity and temperature), freshwater inflows, turbulence, and the effect of the earth’s rotation. Kim and Johnson (2007) used the numerical model to assess the effect on salinity within the Delaware River with a sea level rise of 0.547 ft, representing the assumed increase that may occur between 1996 and 2040. Johnson (2010) modeled the impact of much greater sea level rises and projected increased consumptive water uses, under both existing conditions (with a 40-foot navigation channel) as well as a deepened 45-foot channel, to assess salinity changes at 15 locations within the Delaware Estuary.

The fundamental conclusion drawn from the modeling studies is that deepening the existing navigation channel from 40 to 45 feet will result in minimal salinity increases in the Philadelphia area under a worst-case scenario of a recurrence of the drought of record (1965). The DRBC drought management plan in place maintains flow objectives, with reservoir storage, to prevent the intrusion of ocean salinity into the Philadelphia area in excess of existing standards. Computed salinity at Chester, PA for the 5-foot channel deepening, had a maximum increase of about 0.10 ppt. At the Delaware Memorial Bridge, maximum increases of about 0.25 ppt occur with the 5-foot channel deepening.

The Johnson (2010) modeling study showed the impact of sea level rises at 15 stations within the Delaware Estuary. Salinity increases were higher at stations in the Delaware Bay and salinity differences progressively decreased upriver. Model runs addressed impacts of the channel deepening on salinity with increased consumptive use of Delaware River water and potential sea level rise under the worst case scenario (the drought of record). Results showed that all three system changes (*i.e*. channel deepening, increased consumptive use, and sea level rise) individually cause small but finite increases in salinity in the reach between Philadelphia and Wilmington during a recurrence of the drought of record. A 7-day average demonstrated that even if a drought of record were to recur with a projected 2040 sea level rise and with projected 2040 consumptive uses, and the channel deepened to 45 feet, the salinity at River Mile 98 would not exceed the chlorinity standard. A more detailed discussion on the model results can be found in the USACE, 2009 Environmental Assessment.

In the Delaware River, subadult Atlantic sturgeon are known to congregate and overwinter within brackish river waters (Brundage and Meadows, 1982), however, spawning locations within the Delaware River are currently unknown. Previous studies have noted that subadult Atlantic sturgeon typically occupy both the oligohaline and moderately mesohaline (<10ppt) environments (Dovel and Berggren, 1983; Kiefer and Kynard, 1993; Moser and Ross, 1995; Simpson, 2008). Based on available information within the Delaware Estuary, conclusions regarding the potential impact to Atlantic sturgeon as a result of a small increase in salinity in the Delaware River cannot be drawn at this time.

Dredging provides safe passage for commercial shipping and recreational boat traffic. The Delaware Estuary hosts one of the largest petrochemical port complexes in the United States, with 17 ports between Salem, NJ (rkm 97) to the ports of southern Bucks County, PA (rkm 203). Over 3,000 ocean-going vessels visit the Philadelphia Port Complex annually, making it the fifth busiest port complex in the United States. The long distance that vessels transit through the Delaware Estuary up through the narrowing upriver reaches allows for the possibility of ship encounters with sturgeon. Three carcasses of mature Atlantic sturgeon have been documented from the lower river and upper bay during spawning season, including two gravid mature females and one male (NOAA, 1998). An eight-foot female Atlantic sturgeon was found dead in June 1994, adjacent to Port Penn, aged to approximately 25 years old. A second female was found in late spring 1997 adjacent to Port Penn, just south of the eastern end of the C&D Canal. The third sturgeon, a male, was located just north of the mouth of the Cohansey River, on Beechwood Beach in May 1997. This fish appeared to be cut in half by the propeller of a large vessel. Between 2005 and 2008, a total of 28 Atlantic sturgeon mortalities were reported in the Delaware Estuary (Brown and Murphy, 2010). Sixty-one percent were of adult size and 50% of the mortalities were attributed to apparent vessel strikes. The remaining carcasses were too badly decomposed to ascertain the cause of death. Although Atlantic sturgeon mortalities from encounters with commercial vessels occur in the Delaware Estuary, the Main Channel Deepening Project will not increase the frequency of ship strikes since an increase in the number of ships traversing the river is not anticipated. The Main Channel 45-foot deepening will primarily reduce the lightering of crude oil tankers in the lower Delaware Bay, allowing vessels to off-load more of their crude oil directly at upriver port facilities. The distance between vessel keel and the deeper navigation channel bottom will essentially be the same as the current 40-foot depth within the channel.

### 5.1.3 HABITAT IMPACTS

As discussed previously, three major concentration areas of Atlantic sturgeon are known within the Delaware Estuary along with their known migratory patterns. However, very little is known of Atlantic sturgeon spawning habitat. Simpson (2008) concluded that based on telemetry results, salinity profiles, and available hard-bottom substrate, the lower limit of Atlantic sturgeon spawning in the Delaware River may be near Tinicum Island (rkm 136) while the upper limit is likely to be above the fall line near Trenton, NJ (rkm 211). Dredging may also pose an adverse impact on egg survival through a temporary localized increase in suspended sediments, depending on what months dredging was scheduled. Demersal sturgeon eggs may adhere to suspended sediments and suffocate (Simpson, 2008). Additionally, contaminant loads have been known to alter development, growth and reproductive performance (Cooper, 1989; Sinderman, 1994; as cited by ASSRT, 2007). Dredging for the deepening project within this portion of the river is scheduled to occur between August and November outside the spring spawning period. Studies on both near-field TSS levels, metals and PCBs at the cutterhead in the shipping channel and for bucket dredging in berthing areas showed no exceedances of DRBC water quality criteria for the protection of aquatic life within a 200-foot mixing zone of the working dredge (Versar, 2001a). At the point of weir discharge from the CDF, with mixing, all water quality criteria would be met within 2 meters of the weir at ebb and flood tides. At slack tide, which lasts for a half hour, acute water quality criteria was met for copper at a distance of 44 meters. The slack tide plume reached a depth of 0.2 meters from the surface.

In their 1982 study, Brundage and Meadows reported that no Atlantic sturgeon in spawning condition had been recorded from the Delaware Estuary. A few Young-of-Year fish (342 mm TL) have been caught sporadically within the Delaware River during the 1970s/80s, (and one in 2005), but a total of 66 Age 0 juveniles were captured in 2009 (pers. comm. H. Brundage, 2011). Dissolved oxygen levels have increased dramatically in the river between 1970 and 1990 and anoxic conditions during summer months no longer occur. Coupled with this improved water quality data, studies suggest the existence of a relict spawning population within the Delaware River. This conclusion is supported by genetic evidence of an extant Delaware River distinct population (King *et al*., 2001; Wirgin *et al*., 2007; Grunwald *et al*., 2007).

### 5.1.4 IMPACTS TO FOOD RESOURCES

Atlantic sturgeon are primarily benthic feeders and any change in bottom habitat will alter the benthic faunal community causing a subsequent reduction in prey resources and thereby negatively impact feeding adults and to a much greater extent, young and subadult Atlantic sturgeon. Sturgeon generally feed when the water temperature is greater than 10$^{o}$C (Dadswell, 1979 and Marchette and Smiley, 1982) and in general, feeding is heavy immediately after spawning in the spring and during the summer and fall, and lighter in the winter. Since blasting in the Marcus Hook navigational range is planned for the winter months, when benthic productivity is low and sturgeon feeding activity is light, there should be minimal impact on sturgeon foraging. Additionally, Atlantic sturgeon congregate primarily in moderately deep water and not the deepest adjacent waters within the navigation channel in the Delaware Estuary as other river systems (Hatin *et al.*, 2007). Subadult Atlantic sturgeon are thought to occupy specific concentration zones within estuaries due to the presence of prey resources (ECS, 1993 as reported in Simpson, 2008).

The Asiatic river clam (*Corbicula manilensis,* or *Corbicula fluminea*) is considered to be the primary food source for the shortnose sturgeon (O'Herron and Hastings, 1985). Fine clean sand, clay, and coarse sand are preferred substrates for this clam, although this species may be found in lower numbers on most any substrate (Gottfried, and Osborne, 1982; Belanger et al., 1985; Blalock and Herod, 1999). Gottfried and Osborne (1982) reported density as lowest on bottoms composed of silty organic sediments. Rocky bottom is not considered prime habitat for the Asiatic clam; however, Scott (1992) found high numbers (2596.14 per square meter) of *Corbicula* below Conowingo Dam on gravel and bedrock substrates in the Susquehanna River. The high densities may be the result of the high oxygen concentrations immediately below the dam.

Between Tinicum and Wilmington, non-contiguous outcroppings of bedrock will be removed by blasting as part of the Deepening Project. This area of bedrock comprises less than 1% of the total project area. The presence of any benthic organisms on the rock would be removed by blasting. The impact should not extend beyond the area of immediate impact since previous studies indicate that invertebrates are not sensitive to pressure related damage from underwater explosions, which may be due to the fact that all the invertebrate species tested lack gas-containing organs which have been implicated in internal damage and mortality in vertebrates (Keevin and Hempen, 1997). Although there is no known information about invertebrate recovery time after blasting, data from other disturbances indicates that the benthic communities should become reestablished on the underlying rock within 2 years or less (USACE, 1999). It is unlikely that the blasting of rock to deepen the navigation channel will have a significant impact on the food source of sturgeons since the fish do minimal foraging during the time period when blasting would occur (winter) and since *Corbicula*, their predominant food source, is widespread in the fresh water shallower portions of the Delaware Estuary in more preferred habitats.

Removal of benthic organisms within the remaining sections of the project where dredging will take place may also impact the available food resources for sturgeon. Benthic sampling by O'Herron and Hastings (1985), in association with past USACE maintenance dredging in the Delaware River, found that *Corbicula* recolonized dredged areas in the subsequent growing season. However, the post-dredging specimens collected were smaller than pre-dredge clams, and provided less biomass, even though total numbers of individuals were commonly higher. As stated above, however, *Corbicula* is widespread throughout other portions of the river so any reduction in biomass should not have a significant impact on sturgeon feeding.

## 5.2 OTHER SPECIES OF CONCERN

### 5.2.1 SEA TURTLES

In NMFS' September 1995 Biological Opinion regarding all Philadelphia District dredging activities (including the Delaware River deepening) NMFS determined that pipeline dredges are unlikely to adversely affect sea turtles. Pipeline dredges are relatively stationary and only influence small areas at any given time. For a turtle to be taken with a pipeline dredge, it would have to approach the cutterhead and be caught in the suction. This type of behavior would appear unlikely, but may be possible. This position, of course, could change if new information suggests that sea turtle/pipeline dredge interactions occur.

Clamshell dredges are least likely to adversely affect sea turtles because they are stationary and impact very small areas at a given time. Any sea turtles injured or killed by a clamshell dredge would have to be directly beneath the bucket. The chances of this are extremely low, although a take of a live turtle by a clamshell was documented at Canaveral.

Only the hopper dredge has been implicated in the mortality of endangered and threatened sea turtles. Thus, this biological assessment concentrates on adverse impacts of hopper dredges that will be used for the main channel deepening project.

Among the several possible causes of death to sea turtles is the potential entrainment of individuals in hopper dredging apparatus. Incidental mortality of sea turtles due to channel dredging with hopper dredges became evident as a result of dredging in the Port Canaveral Channel, Florida in 1980 (Dickerson *et al.,* 1991). This sheltered, low energy area is prone to shoaling and requires regular dredging to maintain the channel depth (Studt, 1987). Initial investigations revealed an unusually high concentration of loggerhead turtles in the channel, possibly due to the physical characteristics of the channel (soft bottom, low energy, deeper water). These factors may make the ship channel an ideal resting area for adult and sub-adult turtles, and as a refuge from predators and an overwintering site for smaller turtles (Byles and Dodd 1989; Meylan *et al.,* 1983; Carr *et al.,* 1980). At the same time, however, the characteristics that make the Canaveral area favorable to sea turtles also make it a high maintenance area in terms of dredging. Thus, the potential for turtle/dredge interactions is high.

Impacts from dredging in the Delaware Estuary to listed species of sea turtles are dependent on the timing of the operations and the type of equipment employed. No impacts to any listed species of sea turtle would be expected if dredging were to be completed between 16 November and 30 April, or if equipment other than hopper dredges were employed to complete the work. However, there are potential impacts associated with hopper dredging conducted between 1 May and 15 November, when sea turtles may be present in the Delaware Estuary. Any of the five species of sea turtles could transit the channel during the warmer months, but only loggerhead and Kemp's ridley turtles are likely to be foraging in the channel, near the channel bottom. The leatherback turtle is a pelagic feeder, with minimal bottom exposure. The number of loggerheads and Kemp's ridleys foraging in the Delaware Estuary is unknown, and it is not understood what percentage of the population within this area will avoid entrainment.

In the Delaware Estuary, dredging the channel will take crabs and other benthic organisms from the area. Hence, the food resource values of these areas might be temporarily reduced for sea turtles. Because of the mobility of crabs and rapid recolonization of disturbed benthic communities in estuarine environments, resource values will begin to recover immediately.

Other threats to sea turtles in the Delaware Estuary and nearshore areas include drowning in trawl nets, entanglement and drowning in crab pot lines and pound net leader hedging, wounding from boat propellers, incidental capture at the Salem Generating Station, and entanglement, ingestion, and other complications from contact with marine debris, including petroleum products.

The destruction and/or modification of habitat from coastal development, and losses due to incidental capture during commercial fishing are likely the two major factors impacting sea turtle populations along the Atlantic Coast of the United States.

Incidental capture (take) is defined as the capture of species other than those towards which a particular fishery is directed. As implied by this definition, the commercial fishing industry has been implicated in many of the carcass strandings on southeast U.S. beaches. The annual catch of endangered leatherback, loggerhead, Kemp’s ridley, and green sea turtles by shrimp trawlers in the Gulf of Mexico and the southeast has been estimated at 962,000 turtles, primarily Kemp’s ridley. The average mortality rate was estimated to be about 86,000 turtle deaths per year (Epperly *et al.*, 2002).

However, not all beach carcasses are the result of drowning in fish nets. Other human-related causes of mortality include damage from boating, plastic ingestion, *etc*. More research needs to be conducted to determine the precise cause of death of these animals. The unintentional capture of species during non-fishery related processes may also be considered as incidental capture. In New Jersey and New York, boat damage is a commonly observed injury in stranded turtles.

The loggerhead is the most numerous turtle in U.S. coastal waters, and therefore would be encountered most frequently by fishermen and recreational boaters.

Even though any loss of an endangered or threatened species is important, the magnitude of the losses of loggerhead and Kemp's ridley sea turtles from hopper dredging for the Delaware River deepening would not be expected to significantly impact the U.S. Atlantic coast populations of these sea turtle species.

### 5.2.2 WHALES

Impacts to listed species of whales are unlikely with any type of dredging equipment. During operation, a dredge moves very slowly. Only during dredge transit to and from a work area or disposal site does the speed increase. The only means of potential impact is thought to be by collisions between vessels and whales during transit. Based on existing vessel traffic, this potential is considered insignificant. The Delaware River deepening is not anticipated to increase the vessel traffic to Delaware and Philadelphia ports. The primary purpose of the deepening project is to increase the efficiency of the vessels currently using the river. The increase in channel depth will reduce the need to lighter oil tankers in Delaware Bay before traversing up the Delaware River and allow more dry cargo to be carried by other vessels. This has the potential to decrease shipping traffic by reducing barge traffic and allowing goods to reach the ports with fewer vessel trips.

### 5.2.3 SHORTNOSE STURGEON

Potential impacts to shortnose sturgeon resulting from the deepening project would be similar to those for Atlantic sturgeon and were discussed in great detail in USACE 2009. Potential impacts include entrainment into a working dredge, impacts resulting from rock blasting, habitat alteration and loss of food resources. Studies have documented that major Delaware River shortnose sturgeon aggregation sites occur within the Trenton to Newbold Island area, which is above the deepening project area. However, some individuals may be present in deepening work areas. NMFS approved observers will be onboard hopper and mechanical dredges to monitor for take of shortnose sturgeon. Confined disposal facilities will be monitored for work utilizing hydraulic cutterhead suction dredges. A NMFS approved plan will be in place prior to any blasting to insure that no shortnose sturgeon are within 500 feet of a blast site. Habitat destruction and loss of food resources are expected to be of minimal impact as a large percentage of new construction and all maintenance dredging would occur within the existing navigation channel, which comprises a small portion of the river. A primary food resource for shortnose sturgeon is the Asiatic river clam (*Corbicula manilensis*), which is abundant within freshwater portions of the Delaware River.

## 6.0 REASONABLE AND PRUDENT MEASURES TO MINIMIZE IMPACTS

### 6.1 ATLANTIC STURGEON

Potential impacts to both the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*Acipenser brevirostrum*), as a result of the main channel deepening project, were most recently presented in the 2009 Environmental Assessment (USACE, 2009a) and for the shortnose sturgeon in the 2009 Biological Assessment (USACE, 2009). Although there are life history differences between shortnose and Atlantic sturgeon (most notably: shortnose sturgeon remain in the estuary to overwinter whereas Atlantic sturgeon adults and older subadults are known to leave the estuary for oceanic waters), the two species are known to occupy the same salinity regions within the Delaware Estuary (Brundage and O'Herron, 2009). For this reason, the protection measures previously identified for the shortnose sturgeon will also be implemented for the Atlantic sturgeon. These measures are discussed in detail below.

There may be a potential impact to overwintering juvenile Atlantic sturgeon because rock blasting will be required to remove bedrock in the Marcus Hook range performed between 1 December and 15 March. The measures listed below focus on preventing physical injury to juveniles that may be near the blasting area, but would likely protect the larger adult fish if any were present since there is evidence that smaller fish are more vulnerable to injury than larger fish (USACE, 1997). Studies have shown that the size of charge and distance from detonation are the two most important factors in determining fish mortality from blasting (Teleki and Chamberlain, 1978; Wiley *et al.*, 1981; and Burton, 1994). In addition, the measures listed below were used in North Carolina to successfully minimize impacts to sturgeon and have been coordinated with the NMFS for use with this project:

- Scare charges will be used for each blast. A scare charge is a small charge of explosives detonated immediately prior to a blast for the purpose of scaring aquatic organisms away from the location of an impending blast. Two scare charges will be used for each blast. The detonation of the first scare charge will be at 45 seconds prior to the blast, with the second scare charge detonated 30 seconds prior to the blast. Some fish may not locate the origin of the first scare charge. The second scare charge allows these creatures to better locate the source of the charge and maneuver away from the source.

- Average pressure shall not exceed 70 pounds per square inch (psi) at a distance of 140 feet.

- Maximum peak pressure shall not exceed 120 psi at a distance of 140 feet.

- Pressure will be monitored for each blast only at a distance of 140 feet.

- Surveillance for schools of fish will be conducted by vessels with sonar fish finders before each blast, and if fish schools are detected, blasting will be delayed until they leave. The surveillance zone will be approximately circular with a radius of about 500 feet extending outward from each blast set.

Adverse impacts to fish will be further minimized by conducting blasting between December 1 and March 15 as recommended by the Delaware River Basin Fish and Wildlife Management Cooperative, and using controlled blasting methods such as delayed blasting and “stemming” to reduce the amount of energy that would impact fish. In addition, fish avoidance techniques will be utilized to drive fish away from the proposed blasting area to reduce the detrimental impact to fish. Monitoring impacts to fish from the blasting will also be conducted to verify that impacts are minimal.

The pre- and post-blast monitoring for fish including Atlantic sturgeon shall be conducted under the supervision of a principal biologist that has at least a Master of Science degree in fisheries biology or similar fields and must have obtained in their name any required approvals/permits to work with Atlantic sturgeon.

In addition to the protection measures associated with blasting activities, NMFS approved observers will be onboard hopper and mechanical dredges to monitor for take of shortnose sturgeon. Confined disposal facilities will be monitored for work utilizing hydraulic cutterhead suction dredges. The discovery of any sturgeon will be reported to NMFS as outlined in the July 2009 Biological Opinion.

## 6.2 SEA TURTLES

The Philadelphia District is concerned with the possible negative impacts that dredging may exert on threatened and endangered populations of sea turtles in the Delaware Estuary. We also recognize the need to monitor activities which may present a genuine threat to species of concern. It is the intention of the Philadelphia District to continue monitoring for sea turtles during dredging projects, when warranted. Sea turtle observer(s) shall be on board any hopper dredge working in areas of concern (below the Delaware Memorial Bridge) from May 1 through November 15. The observer shall be on board the dredge continually during this window. While on board the dredge the observer shall provide the required inspection coverage on a rotating, six/eight hours on and six/eight hours off, basis. In addition, these rotating six/eight hour periods should vary from week to week. In addition, hopper dredging that occurs in the Bay (*i.e.,* reached D and E) from May 1 through November 15 will include sea turtle deflectors on the hopper dragarms to minimize sea turtle impacts. All such dredging and monitoring will be conducted in a manner consistent with the Incidental Take Statement issued by NMFS for this project. The District will continue to coordinate monitoring results with NMFS, and work to develop appropriate measures to minimize impacts.

## 6.3 WHALES

Due to the slow nature of whales it is the District's intention to slow down to 3 - 5 mph operating speed after sun set or when visibility is low when a whale is known to be in the project area. Contract plans and specifications will require the hopper dredge operator to monitor and record the presence of any whale within the project vicinity.

## 6.4 SHORTNOSE STURGEON

There may be a potential impact to overwintering juvenile shortnose sturgeon because rock blasting will be required to remove bedrock in the Marcus Hook range performed between 1 December and 15 March. The measures listed below focus on preventing physical injury to juveniles that may be near the blasting area, but would likely protect the larger adult fish if any were present since there is evidence that smaller fish are more vulnerable to injury than larger fish (USACE, 1997). Studies have shown that the size of charge and distance from detonation are the two most important factors in determining fish mortality from blasting (Teleki and Chamberlain, 1978; Wiley *et al.*, 1981; and Burton, 1994). In addition, the measures listed below were used in North Carolina to successfully minimize impacts to shortnose sturgeon and have been coordinated with the NMFS for use with this project:

- Scare charges will be used for each blast. A scare charge is a small charge of explosives detonated immediately prior to a blast for the purpose of scaring aquatic organisms away from the location of an impending blast. Two scare charges will be used for each blast. The detonation of the first scare charge will be at 45 seconds prior to the blast, with the second scare charge detonated 30 seconds prior to the blast. Some fish may not locate the origin of the first scare charge. The second scare charge allows these creatures to better locate the source of the charge and maneuver away from the source.

- Average pressure shall not exceed 70 pounds per square inch (psi) at a distance of 140 feet.

- Maximum peak pressure shall not exceed 120 psi at a distance of 140 feet.

- Pressure will be monitored for each blast only at a distance of 140 feet.

- Surveillance for schools of fish will be conducted by vessels with sonar fish finders before each blast, and if fish schools are detected, blasting will be delayed until they leave. The surveillance zone will be approximately circular with a radius of about 500 feet extending outward from each blast set.

Adverse impacts to fish will be further minimized by conducting blasting between December 1 and March 15 as recommended by the Delaware River Basin Fish and Wildlife Management Cooperative, and using controlled blasting methods such as delayed blasting and “stemming” to reduce the amount of energy that would impact fish. In addition, fish avoidance techniques will be utilized to drive fish away from the proposed blasting area to reduce the detrimental impact to fish. Monitoring impacts to fish from the blasting will also be conducted to verify that impacts are minimal.

The pre- and post-blast monitoring for fish including shortnose sturgeon shall be conducted under the supervision of a principal biologist that has at least a Master of Science degree in fisheries biology or similar fields and must have obtained in their name the appropriate ESA permits to work with shortnose sturgeon.

In addition to the protection measures associated with blasting activities, NMFS approved observers will be onboard hopper and mechanical dredges to monitor for take of shortnose sturgeon. Confined disposal facilities will be monitored for work utilizing hydraulic cutterhead suction dredges. The discovery of any sturgeon will be reported to NMFS as outlined in the July 2009 Biological Opinion.

## 7.0 DISCUSSION/CONCLUSIONS

While the Corps plans to construct the majority of the deepening project within the dredging windows to protect threatened and endangered species, some portions of the project will need to be completed when species may be present in the project area. With regard to the protection of sea turtles, monitors are required to be on all hopper dredges working between May 1 and November 15 downstream of the Delaware Memorial Bridge. As shown in Appendix A, hopper dredging is scheduled to occur below the Delaware Memorial Bridge from 1 September to 30 November for Reach E deepening with placement at Broadkill Beach; from 1 April to 31 August for Reach E deepening with placement at Kelly Island; and from 1 December to 30 June for Reach D deepening with placement at the Reedy Point South and Artificial Island confined disposal facilities. NMFS approved sea turtle monitors will be onboard all hopper dredges operating between 1 May and 15 November.

While it is possible for Atlantic and shortnose sturgeon to become entrained in the dredge during dredging operations, the majority of potential impacts would be related to blasting activities. In order to minimize these potential impacts, blasting is only scheduled to take place between December 1 and March 15. Further measures being taken to minimize impacts to Atlantic and shortnose sturgeon were outlined above. The complete blasting plan was previously included in the 2000/2001 NMFS coordination and Biological Opinion which concluded that rock blasting conducted from December 1 to March 15 may adversely affect, but is not likely to jeopardize the continued existence of listed species under NMFS' jurisdiction.

Maintenance dredging of the project following the deepening will continue on a yearly basis as is currently done. It is expected that maintenance dredging will take place in the same channel ranges as it does now but that the quantity of material to be removed may increase by approximately 25%.

Through the implementation of the features described in this assessment to protect Atlantic sturgeon, sea turtles, whales and the shortnose sturgeon, the Corps believes it will be possible to minimize and in some cases eliminate any impacts to these species. The Corps will continue to actively work with the NMFS, the states of Delaware, Pennsylvania, and New Jersey, and the local communities to ensure that the planned activities will not negatively impact the populations' chances for survival.

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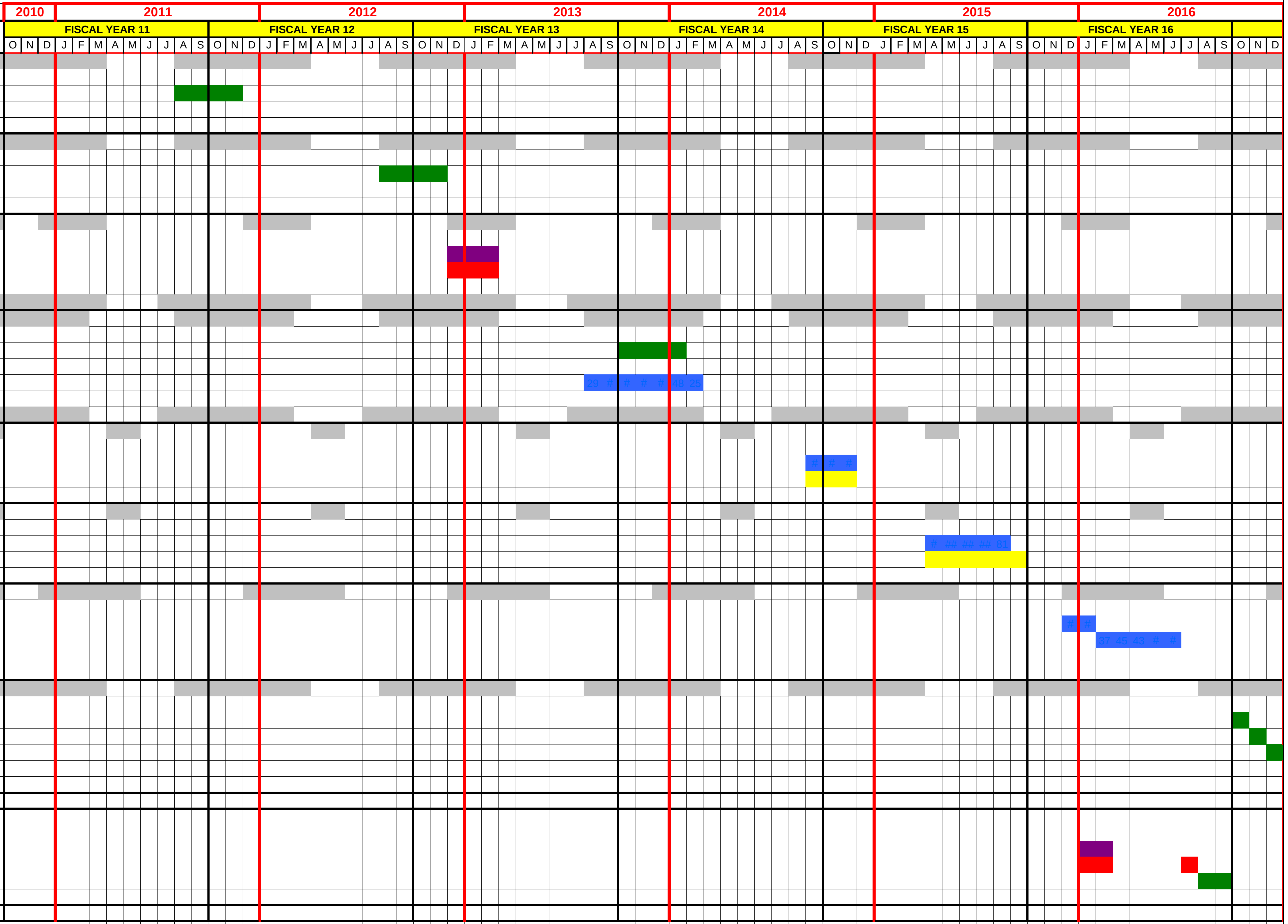
# APPENDIX A
# UPDATED PROJECT SCHEDULE

# DRAFT

# DELAWARE RIVER MAIN CHANNEL DEEPENING

## PROPOSED PROJECT SCHEDULE - DECEMBER 2010

| DREDGING CONTRACTS | Duration (Mo) | Estimated Quantity (cy) | Dredging Window & Type |
|---|---|---|---|
| **Contract No. 2** | | | hyd |
| **Reach B** | | | |
| 137+000 to 176+000 - Pedricktown South | 2.68 | 1,357,774 | HYD |
| **Contract Total** | | **1,357,774** | |
| | | | |
| **Contract No. 3A** | | | hyd |
| **Reach B** | | | |
| 090+000 to 124+000 - Pedricktown North | 3.51 | 1,050,700 | HYD |
| **Contract Total** | | **1,050,700** | |
| | | | |
| **Contract No. 3B** | | | bla |
| **Rock Removal** | | | |
| Blasting | 3.17 | | BLA |
| Dredging - Fort Mifflin | 3.17 | 77,000 | MEC |
| **Contract Total** | | **77,000** | |
| | | | mec |
| **Contract No. 4** | | | hyd |
| Reach AA | | | |
| 19+700 to 32+756 - National Park | 2.88 | 994,000 | HYD |
| Reach A | | | |
| 32+756 to 90+000 - Pedricktown North | 6.10 | 1,666,600 | HOP |
| **Contract Total** | | **2,660,600** | |
| | | | hop |
| **Contract No. 5** | | | hop |
| **Reach E** | | | |
| 461+300 to 512+000 - Broadkill Beach | 3.00 | **1,598,700** | HOP |
| **Contract Total** | | **1,598,700** | |
| | | | |
| **Contract No. 6** | | | hop |
| Reach E | | | |
| 351+300 to 461+300 - Kelly Island | 4.50 | 2,483,000 | HOP |
| **Contract Total** | | **2,483,000** | |
| | | | |
| **Contract No. 7** | | | hop |
| Reach D - | | | HOP |
| 249+000 to 270+000 - Reedy Point South | 1.13 | 396,300 | |
| 270+000 to 324+000 - Artificial Island | 4.63 | 1,654,800 | |
| **Contract Total** | | **2,051,100** | |
| | | | |
| **Contract No. 8** | | | hyd |
| **Reach B** | | | |
| Marcus Hook Anchorage - Oldmans | 0.89 | 1,671,400 | HYD |
| 124+000 to 137+000 - Pedricktown South | 0.45 | 499,300 | HYD |
| 137+000 to 155+000 - Pedricktown South | | 85,726 | HYD |
| **Contract Total** | | **2,256,426** | |
| | | | |
| **Total Channel** | **41.9** | **16,038,100** | |
| | | | |
| **Berth Deepenings** | | | |
| Berth Deepenings Drill/Blast | | | |
| Berth Deepenings Clamshell | | | |
| Berth Deepenings CSD Rehandling WP | | | |
| | | | |
| **Total Berth Deepenings** | | **460,437** | |



**Legend:**

| | | |
|---|---|---|
| 🟦 | HOP | HOPPER DREDGE |
| 🟩 | HYD | CUTTER SUCTION DREDGE |
| 🟨 | | LANDSIDE CONSTRUCTION |
| 🟥 | MEC | CLAMSHELL DREDGE |
| 🟪 | BLA | DRILLBOAT (BLASTING) |
| ▨ | | DREDGING WINDOW |

**Revised December 2010**