United States Department of the Interior

FISH AND WILDLIFE SERVICE
646 Cajundome Blvd.
Suite 400
Lafayette, Louisiana 70506

May 1, 2015

Colonel Richard L. Hansen
District Commander
U.S. Army Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160-0267

Dear Colonel Hansen:

Please find attached the Fish and Wildlife Service's (Service) Biological Evaluation (BE) for the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Bayou Bonfouca Marsh Creation Project (PO-104). That BE addresses impacts to threatened and endangered species and their critical habitat that would result from project construction. That project is funded as part of CWPPRA's 20th Priority Project List and its primary purpose is to re-create low salinity brackish marsh in the open water areas immediately behind the northern Lake Pontchartrain shoreline in the vicinity of Bayou Bonfouca and Bayou Liberty. Most of the marsh creation will be on the Service's Big Branch National Wildlife Refuge.

Our BE addresses impacts to the endangered West Indian manatee (*Trichechus manatus*) and the threatened Atlantic sturgeon (*Acipenser oxyrhynchus desotoi*) and its critical habitat. Based on incorporation of impact avoidance and minimization measures the Service has determined that the proposed project is not likely to adversely impact neither the manatee nor the Atlantic sturgeon. Based on avoidance of critical habitat constituent elements and minimization of impacts to Atlantic sturgeon habitat we have also determined that the proposed project is not likely to adversely impact designated critical habitat for the Atlantic sturgeon.

Please consider use of our BE for any Endangered Species Act consultations needed with the National Marine Fisheries Service for issuance of federal permits (i.e., Section 10, Section 404) for this project. If your staff has any questions or comments regarding our BE, please have them contact David Walther at (337) 291-3122.

Sincerely,

For

Jeffrey D. Weller
Supervisor
Louisiana Field Office

Attachment

cc: Southeast Louisiana Refuge Complex, Bayou Lacomb, LA
NMFS, St. Petersburg, FL
OCPR, Baton Rouge, LA

BIOLOGICAL EVALUATION

BAYOU BONFOUCA MARSH CREATION
PO-104

ST. TAMMANY PARISH, LOUISIANA

FISH AND WILDLIFE SERVICE

ECOLOGICAL SERVICES

LAFAYETTE, LOUISIANA

May 2015

BIOLOGICAL EVALUATION

BAYOU BONFOUCA MARSH CREATION
PO-104

ST. TAMMANY PARISH, LOUISIANA

May 2015

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BIOLOGICAL EVALUATION

PURPOSE

The purpose of this Biological Evaluation (BE) is to determine the effects of implementing the Bayou Bonfouca Marsh Creation Project (PO-104) in St. Tammany Parish, Louisiana on Federally listed threatened and endangered species and their critical habitat. Funding is provided through the Coastal Wetlands Planning, Protection and Restoration Act of 1990. The U.S. Fish and Wildlife Service (Service) serves as the Federal sponsor with the State of Louisiana (i.e., Coastal Protection and Restoration Authority) serving as the local sponsor.

The primary goal of the PO-104 project is to create and/or nourish up to 638 acres of marsh habitat in the open water areas immediately behind the Lake Pontchartrain shoreline in the vicinity of Bayou Bonfouca and restore portions of the Lake Pontchartrain shoreline (Figure 1). This will maintain the lake-rim function (i.e., reduced erosion rate) along this section of shoreline, especially east of Bayou Bonfouca where very little land and shoreline remains. Much of the marsh creation portion of this project is located within the Big Branch Marsh National Wildlife Refuge, with the rest being located on private lands.

The major cause of wetland loss in the project area was due to Hurricane Katrina in August of 2005. Although the shoreline erosion rates are relatively low, only a narrow strip of land currently exists between Lake Pontchartrain and interior ponds, with several breaches along the shoreline both east and west of Bayou Bonfouca.

LOCATION OF THE PROPOSED PROJECT

The Bayou Bonfouca Marsh Creation Project is located in the Lake Pontchartrain Basin in southeastern Louisiana along the northeastern shore of Lake Pontchartrain as shown in Figure 1. Lake Pontchartrain is a 621 square mile lake located on the northern edge of the Mississippi River Deltaic Plain and south of the Pleistocene Terraces.

Lake Pontchartrain has an average salinity of 4 parts per thousand and the project area has an average salinity of 3.5 parts per thousand with salinities being affected by the freshwater discharges from the Amite, Tangipahoa and Pearl Rivers and saltwater primarily through the tidal connection of the Rigolets (Sikora and Sikora, 1982). Operation of the Bonnet Carre Spillway (a project feature of the Mississippi River and Tributaries Flood Control Project) infrequently (approximately every 10 years) maintains freshwater in the lake for extended periods of time (e.g., January through late June).

PROJECT DESCRIPTION

Project features include marsh creation and nourishment and shoreline restoration to fill open water and broken marsh areas, respectively, along the northeastern rim of Lake Pontchartrain (Figure 1). The proposed marsh creation/nourishment will be achieved by a one-time mining of sediment from a borrow site located in northeastern Lake Pontchartrain. It is anticipated that the borrow pit would be dredged to an average maximum depth of 10 feet below the lake bottom.

To avoid digging borrow sites too deep, dredging contractors will often attempt to maintain an approximate 1 to 2 feet buffer above of the maximum allowable depth; therefore to achieve a 10-foot depth, the maximum dredging depth will be set at 12 feet. Therefore, this BE will examined the impacts of the proposed borrow sites as if they were dredged to a depth of 10 feet below the lake bottom. Because the elevation of the lake bottom varies the anticipated depth of the northern and southern borrow portions of the borrow pit would be approximately -19 and -21 feet North America Vertical Datum (NAVD) 88. The borrow pit is orientated in a northwest to southeast direction basically parallel to the adjacent shoreline and is rectangular in shape. The borrow pit would cover approximately 648 acres. The peninsula extending into the northwest corner of the borrow pit is designed to avoid sandier substrate. Additional information concerning the design of the borrow pit is presented in the following section.

Dredged material will be pumped into the marsh creation sites to a maximum elevation range of +2.5 - +3.0 feet NAVD 88, with the goal of having the maximum amount of marsh within the intertidal range within the 20 year project life. These sites generally include some broken marsh and are relatively well contained by surrounding marsh. The project has been designed so that the dredged slurry would not flow directly into Lake Pontchartrain or Bayou's Liberty and Bonfouca and effluent from the dredging operation will be contained within the interior marsh. The marsh creation sites are also designed so that they will de-water into the adjacent marsh (i.e., marsh nourishment) and containment dikes are located on each marsh creation cell to prevent the dredged material from flowing into adjacent ponds and other open water areas. Breaches along the Lake Pontchartrain shoreline and the banks of Bayou's Liberty and Bonfouca will be plugged so that the dredged slurry does not flow into the lake or bayous.

BORROW PIT INVESTIGATIONS AND DESIGN CONSIDERATIONS

Geotechnical investigations were conducted on the proposed borrow site and the four (4) marsh creation areas. A total of eleven (11) borings were drilled in the Lake Pontchartrain borrow site (see Figure 2A and B.) to a depth of twenty (20) feet and a total of nine (9) borings were taken within the 4 proposed fill areas. Laboratory analysis preformed on the soil samples were soil compressive strength tests, moisture content tests, organic content tests, grain size determinations, specific gravity tests, consolidation tests with rebound, Atterberg's limit determinations, soil classifications, settling column tests and self-weight consolidation tests of which the results are on file with the Louisiana Ecological Services Field Office (LFO). The results of the 11 boring logs taken within the proposed borrow site can be found in Appendix A.

To further investigate sediment composition within the proposed borrow site, 100 grab samples were collected from the top few inches of sediment across the entire proposed borrow area (see Figure 3A and 3B). Figure 4 presents a graphical representation of the distribution of sand content in the borrow area based on the sampling. Sand content shown in the figures refers only to the material passing the U.S. No. 10 sieve and retained on the U.S. No. 200 sieve.

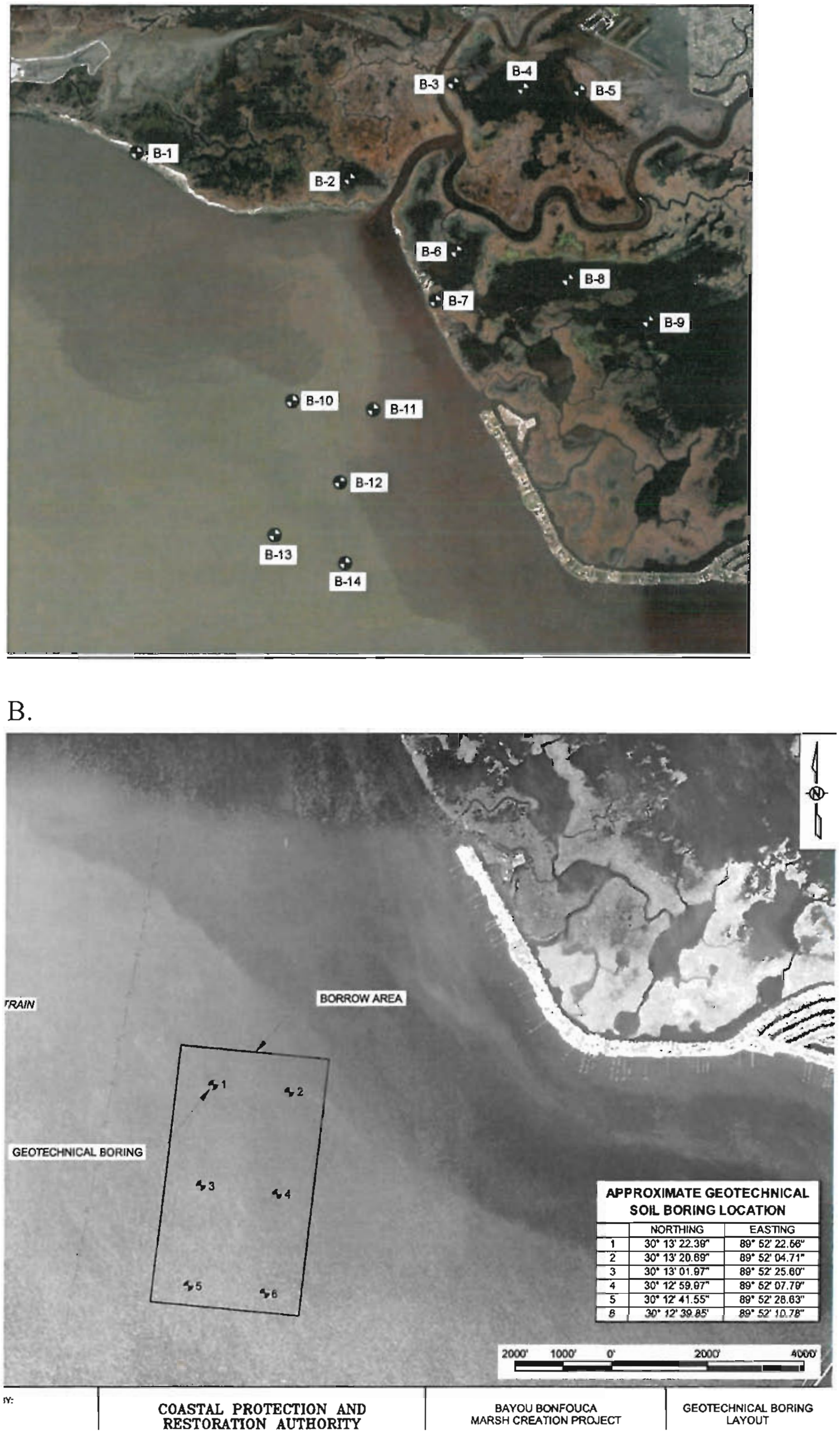
The controlling engineering factors concerning borrow site design include the location and the size of the borrow site (acreage and depth). The initial size of the borrow area was determined by the volume of material necessary to fill the marsh creation cells. The borrow volume is

Figure 1. Project Features

Figure 2. Project area geotechnical soil boring locations; A) original borrow area, B) expanded borrow area.

A.

B.



APPROXIMATE GEOTECHNICAL SOIL BORING LOCATION

	NORTHING	EASTING
1	30° 13' 22.38"	89° 52' 22.56"
2	30° 13' 20.69"	89° 52' 04.71"
3	30° 13' 01.97"	89° 52' 25.60"
4	30° 12' 59.97"	89° 52' 07.79"
5	30° 12' 41.55"	89° 52' 28.63"
6	30° 12' 39.85'	89° 52' 10.78"

Figure 3. Sediment grab sample locations; A) original borrow area, B) original and expanded borrow area.

Figure 4. Graphical representation of the distribution of surface sand content within the proposed borrow areas.

Notes
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference. Aerial image was taken from Google Earth Pro., Licensed to GeoEngineers, Inc.. Imagery dated. 11/29/2011

computed by multiplying the fill volume by the cut to fill ratio of 1.3 for hydraulically dredged material. The borrow site acreage can be calculated by dividing the borrow volume by the maximum dredge depth. A safety factor of 1.5 was applied to the borrow site to ensure that adequate area and borrow material would be available. Because of the safety factor the proposed acreage (approximately 400 acres) represents a maximum area that would be utilized, however, it is probable that less acreage would be needed. Cross-sections of the borrow site design and typical marsh creation areas are shown in Appendix B.

Another governing factor in the determination of the borrow site location was the presence of submerged aquatic vegetation (SAV) which often occurs in vast beds along the north shore of Lake Pontchartrain. Common species include *Ruppia maritima, Vallisneria americana, and Myriophyllum spicatum*. SAV beds have been documented in Lake Pontchartrain to extend from the shoreline to a depth of approximately 6.5 feet (Cho and Poirrier 2001). Based on the extent of the SAV beds near Bayou Bonfouca , the project team decided to place the borrow sites in waters equal-to or greater than 10 feet in depth and beyond the zone of SAV growth to avoid any impacts. The Bayou Bonfouca borrow site was placed directly southwest of the marsh creation site and along an oil and gas pipeline, leaving a minimum 500-foot buffer.

The original borrow site was proposed offshore of Bayou Bonfouca. The Service was concerned that sandy bottoms in this area could be an important feeding area for the threatened Atlantic sturgeon (*Acipenser oxyrhynchus Desotoi)*, a bottom-feeding fish that is believed to use sandy substrates as feeding habitat (Fox *et al.* 2002, Harris *et al.* 2005, Parauka *et al.* 2010, Ross *et al.* 2001a). Peterson *et al.*, (2013), however, found that juvenile and sub-adult Atlantic sturgeon in the western portion of their range did not utilize sandy substrate like sturgeon in the eastern portion of their range. Because adult sturgeon may use Lake Pontchartrain and adults in the western portion have been associated with sandy substrate (Ross *et al*, 2009) avoidance of this sediment type was determined to be prudent. Sediment surveys revealed appreciable amounts of sand in the original borrow site. While sand substrate is found within Lake Pontchartrain it is not the dominant substrate type (Flocks, *et al.*, 2002). Therefore, it decided that the original borrow site needed to be expanded further offshore (i.e., southwesterly direction) to avoid areas with sand concentrations greater than 75 percent. This percentage was based upon a report that sturgeon are often located in areas where sand comprised eighty percent or more of the substrate (Fox *et al.* 2000).

The depth of the borrow site, which is often associated with a decrease in dissolved oxygen (DO) levels, was also a factor considered in designing the borrow site. This is important because a decrease in DO levels has been associated with a decrease in benthic organisms, a food source for Atlantic sturgeon (Flocks and Frazer 2002, Reine *et al.*, 2014). To minimize the creation of hypoxic zones (less than or equal to 2 parts per million of DO) and or anoxic zones (less than or equal to 0 parts per million of DO) the Service examined data from existing borrow sites located on the south shore of Lake Pontchartrain (Flocks and Frazer 2002). Data indicated that at a depth of 50-feet below the lake surface (35 feet below the lake bottom), anoxic conditions could persist for most of a year; while at depth of 30 feet (15 feet below the lake bottom), anoxic conditions occurred 27 percent of the year and at a 20 foot depth (5 feet below the lake bottom), anoxic conditions could occur for approximately 15 percent of the year. The Service also used information taken from a presentation on the Borrow Area Monitoring and Management (BAMM) Program for Coastal Restoration in Louisiana (Khalil, 2014). Data was obtained from the 9-feet deep (below lake bottom) Goose Point and Pointe Platte borrow sites, approximately 4,000 feet northwest of the proposed borrow site from June to October 2013. Data presented indicated that the Goose Point borrow site experienced 3 hypoxic events. The control site located outside but adjacent to the borrow site experienced similar hypoxic conditions (duration and DO levels) during two of those events. During the third hypoxic event the control site did not experience any hypoxia. During one of the hypoxic events, anoxic conditions were also documented in the borrow site. Early during this anoxic event the control site experienced hypoxic conditions but recovered, however, the borrow site remained anoxic and/or hypoxic for an estimated additional 10 days. Poirrier *et al.*, (2009) has documented hypoxic and anoxic conditions in Lake Pontchartrain, especially in the southeastern area where the Inner Harbor Navigational Channel (IHNC) allows high saline waters to flow into the lake. Hypoxic conditions can extend up to 6 miles from the IHNC and encompass up to approximately 100 square miles. Wind driven currents can move this area of poor water quality into adjacent areas (McCorquodale et al., 2002). The proposed borrow area as well as the Goose Point and Pointe Platte are located far enough away from the IHNC as to not be directly influenced by the stratification and resulting hypoxic conditions but are close enough to have that stratified water wind blown into the area. Poirrier (2012) determined that the 2009 closure of a major navigation channel that allowed salt water intrusion through the IHNC has significantly reduced the stratification and hypoxia associated with that channel. However, the hypoxic events documented by Khalil (2014) indicate that normal stratification or other factors may still result in hypoxia because no known weather events that are typically associated with hypoxic conditions (e.g., large rainfall, tropical storm. etc.) could be identified during those recorded events.

Modeled wind driven water currents within Lake Pontchartrain indicate that the project area would have greater velocities within the project area as compared to the south shore dredge holes or other parts of the lake. However, certain combinations of wind direction and speed occurring with specific tidal events could result in minimal circulation. Modeled tidal currents within the project area could be approximately twice the magnitude of those occurring at the south shore borrow sites (List and Signell 2002). Modeling of the Bayou Bonfouca borrow site (Coast and Harbor Engineering 2014) dredged to –25 feet North American Vertical Datum 1988 (NAVD88)(15 feet below the lake bottom) and having 1 horizontal:5 vertical side slopes indicated that the residence time of water within the pit would increase from approximately 1 day to between approximately 1.5 to 2.1 days based upon conservative tidal and wind estimates (e.g., low tidal amplitudes and low wind velocities) however, the modeling did not account for any type of stratification (e.g., saline, temperature) that could reduce mixing and increase residence time.

To help determine the impact of borrow sites on potential Atlantic sturgeon prey twelve benthic/sediment samples were collected using a three-inch diameter core from different water depths (10 to 19 feet below water surface) within the Point Platte and Goose Point borrow sites (dredged in 2009) and at two adjacent control sites (natural bottom). Analysis of that data indicated that number of organisms were not significantly different between the control site and the borrow site and within the borrow sites regardless of depth (BEM 2014). The Service examined the data to see if any easily discernable relationship existed between the number of species and/or organisms collected and depth, sediment oxygen demand (SOD), or amount of recent deposition (i.e. fluff); no relationship was readily apparent.

Other factors that contribute to the anoxic conditions associated with borrow sites along Lake Pontchartrain's south shore include salt water stratification, urban discharge, and relatively low current velocities; consideration of how those factors may or may not be prevalent in the project area was also considered when the borrow site depth was determined. Lake Pontchartrain's benthic community was found to be highly variable probably due to a combination of those factors affecting water quality (Macauley *et al.*, 2007). Operation of the Bonnet Carre, (typically once every 10 years) and the run-off from tributary rivers may also impact the lake by the formation of freshwater lenses over denser saltwater. Probably one of the most significant natural factors contributing to salt water stratification is associated with hurricanes and/or large tropical storms which not only affect the project area borrow site, but Lake Pontchartrain as a whole (Poirrier *et al.*, 2008, Poirrier *et al.*, 2009). Hurricanes can also cause hypoxic and anoxic conditions usually through the increased biological oxygen demand (BOD) of affected waterways from an increase in the amount of organic material associated with rainfall runoff and storm surge inundation. (Mallin *et al.* 2002, Poirrier *et al.*, 2008). Macauley *et al.*, (2007) reported that following Hurricane Katrina DO levels increased within Lake Pontchartrain; however, their sampling occurred 52 days after landfall. Recovery of DO levels following hurricanes can vary within estuaries and between hurricane events with some recovery times occurring within one month (Mallin *et al.*, 1999, Mallin *et al.*, 2002. Stevens *et al.*, 2006).

Periodic anoxic and/or hypoxic events, regardless of their source can result in benthic communities having a lower abundance and diversity (Reine, *et al.*, 2014).

Rainwater pump stations for the New Orleans metropolitan area discharge low dissolved oxygen waters and other material (e.g., fine organic particulates) along the south shore which can further contribute to poor water quality and can possibly contribute to depressed dissolved oxygen levels in that area and in the borrow pits on the south shore of Lake Pontchartrain. There are no similar pump stations on the eastern shore, however, discharge from Bayou Bonfouca, just north of the borrow during rain events likely contains organic matter and urban runoff similar to the south shore pump stations.

SPECIES DESCRIPTIONS

Although the endangered red-cockaded woodpecker (RCW, *Picoides borealis*), may occur in the vicinity of the proposed project area, the proposed activities would not be located within suitable habitat for those species. Any suitable habitats for that species would be located outside the region of influence for the proposed action. No effects are expected to occur either during project planning or implementation; therefore, the proposed action would not adversely affect the RCW.

FISH

Atlantic sturgeon (*Acipenser oxyrhynchus desotoi*)

Status

On September 30, 1991, the Atlantic sturgeon (formerly the Gulf sturgeon or Gulf of Mexico sturgeon) was listed as a threatened species under the ESA, and the Service and National Marine Fisheries Service designated critical habitat for this species in Louisiana, Mississippi, Alabama, and Florida on April 18, 2003. In Louisiana, Atlantic sturgeon critical habitat includes the Pearl River System in Washington and St. Tammany Parishes, the Bogue Chitto River (i.e., identified as Unit 1), as well as Lake Pontchartrain east of the Lake Pontchartrain Causeway, all of Little Lake, The Rigolets, Lake St. Catherine, and Lake Borgne (i.e., identified as Unit 8).

Species and Habitat Description

The Atlantic sturgeon is an anadromous fish (breeds in fresh water after migrating up rivers from marine and estuarine environments). That fish inhabits coastal rivers from Louisiana to Florida during spring and summer, and the estuaries, bays, and marine environments of the Gulf of Mexico during fall and winter. It is a nearly cylindrical, primitive fish embedded with bony plates or scutes. The head ends in a hard, extended snout; the mouth is inferior and protrusible and is preceded by four conspicuous barbels. The tail (caudal fin) is distinctly asymmetrical; the upper lobe is longer than the lower lobe (heterocercal). Adults range from 4 to 8 feet in length with adult females larger than adult males.

Atlantic sturgeon are long-lived, with some individuals reaching at least 42 years of age (Huff 1975). Age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years (Huff 1975). In the spring (from late February to mid-April) when the river surface temperatures are 17 to 21° C, sexually mature, ripe males and females migrate into the rivers (Carr, *et al.* 1996) to spawn. It is believed that Atlantic sturgeon in the Gulf of Me exhibit a spawning periodicity similar to those on the Atlantic coast, which have a long inter-spawning period, with females spawning at intervals ranging from every 3 to 5 years, and males every 1 to 5 years (Smith 1985).

Atlantic sturgeon eggs are demersal (they sink to the bottom), adhesive, and vary in color from gray to brown to black (Vladykov and Greeley 1963, Huff 1975, Parauka *et al.* 1991). During their early life history stages, sturgeon require hard substrates for eggs to adhere to, and shelter for developing larvae (Sulak and Clugston 1999). Egg collection sites have consisted of limestone bluffs and outcroppings, cobble, limestone bedrock covered with gravel, and small cobble, gravel, and sand (Sulak and Clugston 1999, Fox *et al.* 2000, Craft *et al.* 2001). Water depths at egg collection sites have ranged from 4.6 to 26 feet, with temperatures ranging from 64.8 to 75.0 degrees Fahrenheit (°F) (Fox *et al.* 2000, Ross *et al.* 2000, Craft *et al.* 2001). Laboratory experiments indicate that optimal water temperature for survival of Atlantic sturgeon larvae is between 59 and 68°F, with low tolerance to temperatures above 77°F (Chapman and Carr 1995). Young-of-the-year Atlantic sturgeon appear to disperse widely, using extensive portions of the river as nursery habitat. They are typically found on sandbars and sand shoals over rippled bottom and in shallow, relatively open, unstructured areas.

Feeding Habits

The Atlantic sturgeon is a benthic (bottom dwelling) suction feeder. Its hydrodynamic body form is adapted for holding position on the bottom where it feeds mostly upon small invertebrates in the substrate using its protrusible tubular mouth. The type of invertebrates ingested vary by habitat, which ranges from riverine, to estuarine, to marine waters of the Gulf, and by the age of the fish, but are mostly soft-bodied animals that occur in sandy substrates.

Atlantic sturgeon feeding habits in fresh water vary depending on the fish's life history stage. Young-of-the-year Atlantic sturgeon remain in fresh water feeding on aquatic invertebrates, mostly insect larvae, and detritus approximately 10 to 12 months after spawning occurs (Mason and Clugston 1993, Sulak and Clugston 1999). Juveniles (less than 5 kg (11 lbs), ages 1 to 6 years) are believed to forage extensively and exploit scarce food resources throughout the river, including aquatic insects (*e.g.*, mayflies and caddisflies), worms (oligochaetes), and bivalve mollusks (Huff 1975; Mason and Clugston 1993). Juvenile sturgeon collected in the Suwannee River are trophically active (foraging) near the river mouth at the estuary, but trophically dormant (not foraging) in summer holding areas upriver; however, a portion of the juvenile population reside and feed year round near the river mouth (K. Sulak, U.S. Geological Survey [USGS], pers. comm. 2002). Brooks (2004) determined the principal, secondary and minor foods of juvenile sturgeon found in the Suwannee River Estuary (Table 1). In the Choctawhatchee River, juvenile Atlantic sturgeon did not remain near the estuary at the river mouth for the entire year; instead, they were located during winter months in Choctawhatchee

Bay and moved to riverine aggregation areas in the spring (F. Parauka, Service, pers. comm. 2002).

Many reports indicate that adult (sexually mature) and subadult (age 6 to sexual maturity) Atlantic sturgeon lose a substantial percentage of their body weight while in freshwater (Wooley and Crateau 1985; Mason and Clugston 1993; Clugston *et al.* 1995) and then compensate the loss during winter feeding in the estuarine and marine environments (Wooley and Crateau 1985; Clugston *et al.* 1995). Gu *et al.* (2001) tested the hypothesis that subadult and adult Atlantic sturgeon do not feed significantly during their annual residence in freshwater by comparing stable carbon isotope ratios of tissue samples from subadult and adult Suwannee River Atlantic sturgeon with their potential freshwater and marine food sources. A large difference in isotope ratios between freshwater food sources and fish muscle tissue suggests that subadult and adult Adult Atlantic sturgeon do not feed significantly in freshwater. The isotope similarity between Atlantic sturgeon and marine food resources strongly indicates that this species relies almost entirely on the marine food web for its growth once they begin to mature and leave their natal river (Gu *et al.* 2001).

Table 1. Principal food categories for juvenile Atlantic sturgeon erected from the macrofauna found in the Suwannee River Estuary (Brooks 2004).

Principal Foods	Secondary Foods	Minor Foods
Brachiopods	Anthozoans	Bivalves
Free-living Amphipods	Cumaceans	Decapods
Insect Larvae	Nematodes	Gastropods
Isopods	Nemerteans	Ophiuroids
Oligochaetes	Ostracods	
Shrimp	Polychaetes	
	Tube-building Amphipods	
	Hirudinea	

Having spent at least 6 months in the river fasting, it is presumed that adult and subadult sturgeon begin feeding immediately upon leaving the river of summer residency. If so, the lakes and bays at the mouths of the river systems where Atlantic sturgeon occur are especially important because they offer the first opportunity for feeding. To regain the weight they lose while in the river system and to maintain positive growth on a yearly basis, adults and subadults need to consume sufficient quantities of prey while in estuarine and marine waters. Reproductively active Atlantic sturgeon require yet additional food resources (Fox *et al.* 2002; D. Murie and D. Parkyn, University of Florida [UF], pers. comm. 2002).

Adult and subadult Atlantic sturgeon, while in marine and estuarine habitat, are thought to forage opportunistically (Huff 1975), primarily on benthic invertebrates. Gut content analyses have indicated that the Atlantic sturgeon's diet is predominantly amphipods, lancelets, polychaetes, gastropod mollusks, shrimp, isopods, bivalve mollusks, and crustaceans (Huff 1975; Mason and Clugston 1993; Carr *et al.* 1996; Fox *et al.* 2000; Fox *et al.* 2002). Atlantic sturgeon from the Suwannee River subpopulation, are known to forage on brachiopods (D. Murie and D. Parkyn, UF pers. comm. 2002); however, this is not a documented prey item of other subpopulations. Ghost shrimp (*Lepidophthalmus louisianensis*) and haustoriid amphipods (*e.g.*, *Lepidactylus* spp.) are strongly suspected to be important prey for adult Atlantic sturgeon over 1 m (3.3 feet) (Heard *et al.* 2000; Fox *et al.* 2002). This hypothesis is based on the following evidence:

- Atlantic sturgeon have been consistently located and observed actively feeding in areas where numerous burrows similar to those occupied by ghost shrimp exist (Fox *et al.* 2000) and in areas having a high density of ghost shrimp and haustoriid amphipods (Heard *et al.* 2000);
- the digestive tracts of two adult Atlantic sturgeon that died during netting operations contained numerous ghost shrimp (Fox *et al.* 2000);
- stomach contents of a 30 kg (67 lb) sturgeon taken in the upper portion of Choctawhatchee Bay contained more than 100 individual haustoriid amphipods and 67 ghost shrimp (Heard *et al.* 2000); and
- approximately one-third of 157 sturgeon guts analyzed by Carr *et al.* (1996) contained exclusively brachiopods and ghost shrimp.

When river temperatures drop in the fall to about 17 to 22° C, Atlantic sturgeon return to the coastal shelf areas of the Gulf of Mexico (Carr *et al.* 1996). Most subadult and adult Atlantic sturgeon spend the cooler months (October or November through March or April) in estuarine areas, bays, or the Gulf of Mexico (Odenkirk 1989, Foster 1993, Clugston *et al.* 1995, Fox *et al.* 2002) feeding. Winter habitats used by Atlantic sturgeon coincide with the habitats of their prey. Along the Mississippi Sound barrier islands, Atlantic sturgeon habitat typically consists of sandy substrates with a range in depth between 6.2 to 19.4 feet. Gulf of Mexico near shore (less than 1 mile) where Atlantic sturgeon are found consists of unconsolidated, fine-medium grain sand habitats, near natural inlets and passes between the Gulf and adjacent estuaries that support crustaceans such as mole crabs, sand fleas, various amphipod species, and lancelets (Menzel 1971, Abele and Kim 1986, American Fisheries Society 1989). Estuary and bay unvegetated habitats have a preponderance of sandy substrates that support burrowing crustaceans, such as ghost shrimp, small crabs, various polychaete worms, and small bivalve mollusks (Menzel 1971, Abele and Kim 1986, American Fisheries Society 1989) which are prey for Atlantic sturgeon.

Estuarine and Marine Habitat

Most subadult and adult Atlantic sturgeon spend cool months (October or November through March or April) in estuarine areas, bays, or in the Gulf of Mexico (Odenkirk 1989; Foster 1993; Clugston *et al.* 1995; Fox *et al.* 2002). Studies of subadult Atlantic sturgeon (ages 4 to 7) in Choctawhatchee Bay found that 78 percent of tagged fish remained in the bay the entire winter, while 13 percent ventured into a connecting bay. Possibly the remaining 9 percent overwintered in the Gulf of Mexico (Service 1998). Adult Atlantic sturgeon are more likely to overwinter in the Gulf of Mexico, with 45 percent of the tagged adults presumed to have left Choctawhatchee Bay and spent extended periods of time in the Gulf of Mexico (Fox *et al.* 2002). In contrast, Atlantic sturgeon from the Suwannee River subpopulation are known to migrate into the nearshore waters, where they remain for up to two months and then depart to unknown feeding locations in the open Gulf of Mexico (Carr *et al.* 1996; Edwards *et al.* 2003).

Research in Choctawhatchee Bay indicates that subadult Atlantic sturgeon show a preference for sandy shoreline habitats with water depths less than 3.5 m (11.5 feet) and salinity less than 6.3 parts per thousand (Parauka *et al.* 2001). Fox and Hightower (1998) found that adult Atlantic sturgeon monitored in Choctawhatchee Bay use some of the same habitats as subadults. The majority of tagged fish have been located in areas lacking seagrass (Fox *et al.* 2002; Parauka *et al.* 2001). Craft *et al.* (2001) found that Atlantic sturgeon in Pensacola Bay appear to prefer shallow shoals 1.5 to 2.1 m (5 to 7 feet) and deep holes near passes. Estuary and bay unvegetated habitats with sandy substrate support a variety of burrowing crustaceans, such as ghost shrimp and small crabs, amphipods, polychaete worms, and small bivalve mollusks (Menzel 1971; Abele and Kim 1986; American Fisheries Society 1989). Atlantic sturgeon are often located in these areas, and because their known prey items are present, it is assumed they are foraging. Telemetered Atlantic sturgeon tracked in Mississippi Sound were frequently located over sandy substrates at the passes between barrier islands (Ross *et al.* 2001a). Bottom samples at these sites all contained lancelets (*Branchiostoma*), a documented prey item of Atlantic sturgeon. Nearshore areas of the Gulf of Mexico (less than 1.6 km [1 mi] from land) with unconsolidated, fine-to-medium-grain sand substrates, typically support crustaceans such as mole crabs, sand fleas, various amphipod species, and lancelets (Menzel 1971; Abele and Kim 1986; American Fisheries Society 1989), all of which are sturgeon prey items.

Range and Population Dynamics

Historically, the Atlantic sturgeon occurred from the Mississippi River east to Tampa Bay. Its present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida, with infrequent sightings occurring west of the Mississippi River. In the late 19th century and early 20th century, the Atlantic sturgeon supported an important commercial fishery, providing eggs for caviar, flesh for smoked fish, and swim bladders for isinglass, a gelatin used in food products and glues (Huff 1975, Carr 1983). Atlantic sturgeon numbers declined due to over fishing throughout most of the 20th century. The decline was exacerbated by habitat loss associated with the construction of water control structures, such as dams and sills (submerged vertical wall of relatively shallow depth separating two bodies of water), mostly after 1950. In several rivers throughout the species' range, dams have severely restricted sturgeon access to historic migration routes and spawning areas (Boschung 1976, Wooley and Crateau 1985, McDowall 1988).

The majority of recent Atlantic sturgeon sightings in the Pearl River drainage have occurred downstream of the Pools Bluff Sill on the Pearl River, near Bogalusa, Louisiana, and downstream of the Bogue Chitto Sill on the Bogue Chitto River in St. Tammany Parish, Louisiana. Between 1992 and 1996, 257 Atlantic sturgeon were captured from the Pearl River system (West Middle River, Bogue Chitto River, East Pearl River, and West Pearl River). The subpopulation in that system was estimated at 292 fish, of which only 2 to 3 percent were adults (Morrow *et al.* 1998b). The annual mortality rate was calculated to be 25 percent.

Preliminary results from captures between 1992 and 2001 suggest a stable subpopulation in the Pearl River of 430 fish, with approximately 300 adults (Rogillio *et al.* 2002). Morrow *et al.* (1998) suggested that the Pearl River Atlantic sturgeon population would be self-sustaining if the number of adults was at least 100, recruitment was satisfactory, and annual mortality was less than about 15 percent (i.e., instantaneous mortality (*Z)* of 0.16). Based on those criteria and from data gathered during 2000 and 2001, it appeared that the population was at least self-sustaining and may even been recovering and that there may have been as many as 300 adults. Depressed dissolved oxygen levels and other factors associated with the passage of Hurricane Katrina and Rita in 2005 are expected to have caused Atlantic sturgeon mortality in this area; similar mortality resulted in Florida following the passage of Hurricane Ivan. The immediate post-hurricane Katrina and Rita instantaneous mortality (i.e., *Z*) estimate for the Pearl River population is 0.38, with fewer large adults being captured. The degree of dispersal following a hurricane is not known, therefore, that population estimate should be considered preliminary. An increase in the number of large adults captured was experienced two years following the passage of those hurricanes; however, a population estimate has not been recalculated (James Kirk, Corps of Engineers pers. comm. with David Walther, Service). The extent of impacts to adult wintering habitat (e.g., estuarine and Gulf water) or sturgeon in those habitats following the release of oil from the Deepwater Horizon well is not known at this time. Following an August 2011 chemical spill in the Pearl River 28 dead sturgeon were recovered; the impact of this event to the Pearl River population was not assessed.

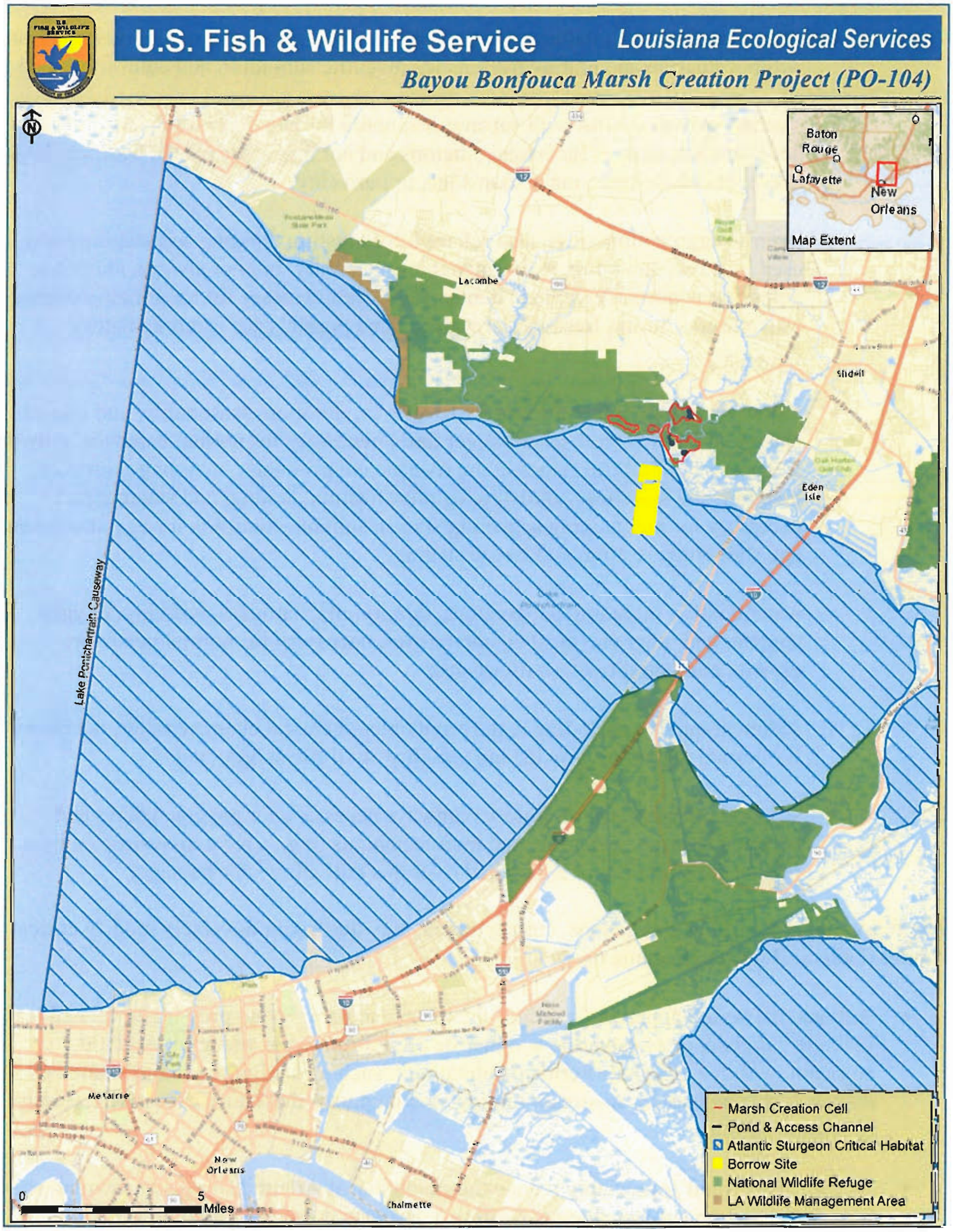
Management and Protection

Life history characteristics of Atlantic sturgeon may complicate and protract recovery efforts. Atlantic sturgeon cannot establish a breeding population rapidly because of amount of time it takes them to reach sexual maturity. Further, Atlantic sturgeon appear to be river-specific spawners, although immature Atlantic sturgeon occasionally exhibit plasticity in movement from one river to another. Therefore, natural repopulation by Atlantic sturgeon migrating from other rivers may be very low (Dugo 2004, Paruka *et al.*, 2011).

The take of Atlantic sturgeon is prohibited in the state waters of Louisiana, Mississippi, Alabama, and Florida. Section 6(a) of the ESA provides for extended cooperation with states for the purpose of conserving threatened and endangered species. Federal funding is provided to states under those agreements to implement the approved programs. All four of the above mentioned states have entered into Section 6 agreements with the Service.

On March 19, 2003, the Fish and Wildlife Service and NOAA Fisheries published a final rule in the Federal Register (Volume 68, No. 53) designating critical habitat for the Atlantic sturgeon in Louisiana, Mississippi, Alabama, and Florida. Portions of the Pearl and Bogue Chitto Rivers (i.e., Unit 1) Lake Pontchartrain east of the Lake Pontchartrain Causeway, all of Little Lake, The Rigolets, Lake St. Catherine, and Lake Borgne (Unit 8) within Louisiana were included in that designation (Figure 5). Designation of critical habitat included the identification of constituent elements. The primary constituent elements (PCE) essential for the conservation of Atlantic sturgeon are those habitat components that support feeding, resting, sheltering, reproduction, migration, and physical features necessary for maintaining the natural processes that support

Figure 5. Atlantic sturgeon Critical Habitat and project location.



those habitat components; those elements should be considered when determining potential project impacts. The PCE for Atlantic sturgeon critical habitat include:

- abundant prey items within riverine habitats for larval and juvenile life stages, and within estuarine and marine habitats for juvenile, sub-adult, and adult life stages;
- riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone, or hard clay;
- riverine aggregation areas, also referred to as resting, holding and staging areas, used by adult, sub-adult, and/or juveniles, generally, but not always, located in holes below normal riverbend depths, believed necessary for minimizing energy expenditures during freshwater residency and possibly for osmoregulatory functions;
- a flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging; and necessary for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larvae staging;
- water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;
- sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and
- safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g., a river unobstructed by a permanent structure, or a dammed river that still allows for passage).

The following types of Federal actions, among others, may destroy or adversely modify critical habitat (Federal Register [Volume 68, No. 53]):

- Actions that would appreciably reduce the abundance of riverine prey for larval and juvenile sturgeon, or of estuarine and marine prey for juvenile and adult Atlantic sturgeon, within a designated critical habitat unit, such as dredging; dredged material disposal; channelization; in-stream mining; and land uses that cause excessive turbidity or sedimentation;
- Actions that would appreciably reduce the suitability of Atlantic sturgeon spawning sites for egg deposition and development within a designated critical habitat unit, such as impoundment; hard-bottom removal for navigation channel deepening; dredged material

disposal; in-stream mining; and land uses that cause excessive sedimentation;

- Actions that would appreciably reduce the suitability of Atlantic sturgeon riverine aggregation areas, (also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, believed necessary for minimizing energy expenditures and possibly for osmoregulatory functions), such as dredged material disposal upstream or directly within such areas; and other land uses that cause excessive sedimentation;

- Actions that would alter the flow regime (the magnitude, frequency, duration, seasonality, and rate-of -change of fresh water discharge over time) of a riverine critical habitat unit such that it is appreciably impaired for the purposes of Atlantic sturgeon migration, resting, staging, breeding site selection, courtship, egg fertilization, egg deposition, and egg development, such as impoundment; water diversion; and dam operations;

- Actions that would alter water quality within a designated critical habitat unit: including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, such that it is appreciably impaired for normal Atlantic sturgeon behavior, reproduction, growth, or viability, such as dredging; dredged material disposal; channelization; impoundment; in-stream mining; water diversion; dam operations; land uses that cause excessive turbidity; and release of chemicals, biological pollutants, or heated effluents into surface water or connected groundwater via point sources or dispersed non-point sources;

- Actions that would alter sediment quality within a designated critical habitat unit such that it is appreciably impaired for normal Atlantic sturgeon behavior, reproduction, growth, or viability, such as dredged material disposal; channelization; impoundment; instream mining; land uses that cause excessive sedimentation; and release of chemical or biological pollutants that accumulate in sediments;

- Actions that would obstruct migratory pathways within and between adjacent riverine, estuarine, and marine critical habitat units, such as dams, dredging, point-source-pollutant discharges, and other physical or chemical alterations of channels and passes that restrict Atlantic sturgeon movement.

MAMMALS

West Indian Manatee (*Trichechus manatus*)

Status

The West Indian manatee was listed as endangered throughout its range for both the Florida and Antillean subspecies in 1967, and received Federal protection with the passage of the ESA in 1973. Critical habitat was designated in 1976, 1994, 1998, 2002, and 2003 for the Florida subspecies.

Species and Habitat Description

The West Indian manatee is a large gray or brown aquatic mammal. Adults average approximately 10 feet in length and weigh up to 2,200 pounds. They have no hind limbs, and their forelimbs are modified as flippers. Manatee tails are flattened horizontally and rounded. Their body is covered with sparse hairs and their muzzles with stiff whiskers (Service 2001). The nostrils, located on the upper snout, open and close by means of muscular valves as the animal surfaces and dives (Husar 1977, Hartman 1979). Manatees will consume any aquatic vegetation (i.e., submerged, floating, and emergent) available to them and sometimes even shoreline vegetation. Although primarily herbivorous, they will occasionally feed on fish. Manatees may spend about 5 hours a day feeding, and may consume 4 to 9 percent of their body weight per day.

Observations of mating herds indicate that females mate with a number of males during their 2- to 4-week estrus period, and then they go through a pregnancy estimated to last 12 to 14 months (O'Shea *et al.* 1992). Births occur during all months of the year with a slight drop during winter months. Manatee cows usually bear a single calf, but 1.5 percent of births are twins. Calves reach sexual maturity at 3 to 6 years of age. Mature females may give birth every 2 to 5 years (Service 2001).

Manatees inhabit both salt and freshwater of sufficient depth (5 feet to usually less than 20 feet) throughout their range. Shallow grassbeds with ready access to deep channels are preferred feeding areas in coastal and riverine habitats (Service 2001). They may also be encountered in canals, rivers, estuarine habitats, saltwater bays, and have been observed as much as 3.7 miles off the Florida Gulf Coast. Between October and April, Florida manatees concentrate in areas of warmer water. Severe cold fronts have been known to kill manatees when the animals did not have access to warm water refuges. During warmer months they appear to choose areas based on an adequate food supply, water depth, and proximity to fresh water. Manatees may not need fresh water, but they are frequently observed drinking water from hoses, sewage outfalls, and culverts.

Range and Population Dynamics

During winter months, the United States' manatee population confines itself to the coastal waters of the southern half of peninsular Florida and to springs and warm water outfalls as far north as southeast Georgia. Power plant and paper mill outfalls created most of the artificial warm water refuges utilized by manatees. During summer months, they migrate as far north as coastal Virginia on the east coast and the Louisiana coast in the Gulf of Mexico.

During summer months, manatees disperse from winter aggregation areas, and are commonly found almost anywhere in Florida where water depths and access channels are greater than 3.3 to 6.6 feet (O'Shea 1988). In the warmer months, manatees usually occur alone or in pairs, although interacting groups of 5 to 10 animals are not unusual (Service 2001). A few individuals have been known to stray as far north as the northern Georgia coast and as far west as the coastal waters of Louisiana.

Manatees are known to regularly occur in Lakes Pontchartrain and Maurepas and their associated coastal waters and streams. It also can be found less regularly in other Louisiana coastal areas, most likely while the average water temperature is warm. Based on data maintained by the Louisiana Natural Heritage Program (LNHP), over 80 percent of reported manatee sightings (1999-2011) in Louisiana have occurred from the months of June through December. Manatee occurrences in Louisiana appear to be increasing and they have been regularly reported in the Amite, Blind, Tchefuncte, and Tickfaw Rivers, and in canals within the adjacent coastal marshes of southeastern Louisiana. Manatees may also infrequently be observed in the Mississippi River and coastal areas of southwestern Louisiana.

In the early 1980s, scientists tried to develop procedures for estimating the overall manatee population in the southeastern United States (Service 2001). The best estimate throughout the State of Florida was 1,200 manatees (Reynolds and Wilcox 1987). In the early 1990s, the State of Florida initiated a statewide aerial survey in potential winter habitats during periods of severe cold weather (Ackerman 1995), and the highest count of 3,276 manatees was recorded in January 2001. A more recent population survey was conducted in 2012 as part of the Marine Mammal Protection Act. That Stock Assessment Report (SAR) reported a population of 4,834 individuals within the Florida manatee stock (Federal Register 78 FR 19002). Large numbers of manatees were reported in Lake Pontchartrain prior to the landfall of Hurricane Katrina, however, there were no reports of manatee mortality following the hurricane.

Management and Protection

The most significant problems faced by manatees is death or injury from boat strikes and failure to return to Florida during the winter months. Minimum flows and levels for warm water refuges need to be established to ensure their long-term availability for manatees. Their survival will depend on maintaining the ecosystems and habitat sufficient to support a viable manatee population (Service 2001). The focus of recovery is on implementing, monitoring, and addressing the effectiveness of conservation measures to reduce or remove threats that will lead to a healthy and self-sustaining population (Service 2001).

The West Indian manatee is also protected under the Marine Mammal Protection Act (MMPA) of 1972. The MMPA establishes a national policy for the maintenance of health and stability of marine ecosystems and for obtaining and maintaining optimum sustainable populations of marine mammals. It includes a moratorium on the taking of marine mammals. The recovery planning under the ESA includes conservation planning under the MMPA (Service 2001).

EFFECTS OF PROPOSED ACTION

FISH

Atlantic sturgeon

Previously documented effects of dredging on Atlantic sturgeon, other sturgeon species, or other anadromous species that may be applicable to the proposed action include the following:

1) Entrainment in dredging equipment (NMFS 1998; Hastings 1983; Veshchev 1982);
2) Burial during disposal (Savoy 1991; NMFS 1992);
3) Disruption of migratory movements (Hastings 1983; NMFS 1992);
4) Release of contaminated material from sediments (Varanasi 1992);
5) Turbidity effects and decreased water quality (Secor and Gunderson 1998; Secor 1995; Jenkins *et al.* 1993);
6) Destruction of habitat and food resources (NMFS 1992; Carr 1983; Service 1996); and
7) Effects on habitat geomorphology due to channel geometry alterations (Kanehl and Lyons 1993; Hubbard *et al.* 1994).

Of these potential effects, numbers 2, 4, 5, and 7, are discountable for the proposed project. Burial during disposal (Number 2) is unlikely because the proposed disposal sites will be within the enclosed shallow water area (i.e., the wetlands creation area) adjacent to the lake. Examination of sediment samples collected from Lake Pontchartrain revealed that dredging and disposal operations should not pose a contamination problem (Number 4) (Goatcher 2005). In addition, the Service would comply with Louisiana's water quality standards and again, disposal is in an area that is probably not inhabited (due to substrate, water depth, and access routes) and will become closed to sturgeon utilization (Numbers 4 and 5). Turbidity effects on water quality (Number 5) are likely to be minor, localized, and short-term, due to the use of hydraulic pipeline dredging equipment and the selection of disposal sites. Because the borrow site is located within a lake there should be no channel geometry alterations (Number 7) resulting from the proposed dredging (see "Description of the Proposed Action"). Alterations of the lake bottom would involve a maximum depth increase of approximately 10 feet below the lake bottom (i.e., 20 to 25 feet total depth from the water surface), however, the borrow site and the marsh creation areas should not affect the lakes overall geomorphology due to their small size relative to the size of Lake Pontchartrain and the fact that the deeper (deeper than 50 feet below the lake bottom) and older holes (dug as early as 1930's) along the south shore of Lake Pontchartrain do not appear to have significantly altered the surrounding lake bottom (Flocks and Franze, 2002).

The potential direct effects of the project on Atlantic sturgeon survival and essential behavior include potential entrainment in the dredging equipment (Number 1) and disruption of migratory movements (Number 3). Both are probably not likely to occur in the lake, since sturgeon are less likely to encounter the dredge in the broader lake environment and if they do encounter the dredge, they may easily navigate around it. The remaining potential effect (Number 6) is a form of habitat modification and is evaluated in this section through an analysis of the project's effects on the applicable PCEs (see pages 16 and 17) of sturgeon critical habitat. The disruption of migratory movements (Number 3) as a habitat modification relative to the PCE of safe and unobstructed migratory pathways was not undertaken because the proposed project would not result in permanent habitat modifications that would block fish movement. It may instead deter fish from passing the dredge while it operates, and possibly kill or injure fish that are not wary of the dredge, which are both impacts that are more appropriately addressed as direct effects to the species.

Effects to Species

Hydraulic dredges, such as the pipeline dredge proposed for this project, can lethally harm sturgeon by entraining sturgeon (NMFS 1998). NMFS observers documented the take of one Atlantic sturgeon entrained in a hopper dredge operating in King's Bay, Georgia (NMFS 1998). Atlantic sturgeon have been killed in both hydraulic pipeline and bucket-and-barge operations in the Cape Fear River, North Carolina (NMFS 1998). Endangered species observers in South Carolina in 1990 documented the lethal take of two Atlantic sturgeon 27 inches (69 cm) in length from hopper dredging in the Georgetown Entrance Channel (NMFS 1998). Hastings (1983) reported anecdotal accounts of adult sturgeon expelled from dredge spoil pipes in a study on the Atlantic coast. Two shortnose sturgeon *(A. brevirostrum)* carcasses were discovered in a dredge spoil near Tullytown, Pennsylvania, and were apparently killed by a hydraulic pipeline dredge operating in the Delaware River in March 1996 (NMFS, 1998). In 1998, three shortnose sturgeon were killed by a hydraulic pipeline dredge operating in the Florence-to-Trenton section of the upper Delaware River (NMFS 1998). Veshchev (1982) reported that hydraulic dredging operations caused mortality of Russian sturgeon *(A. gueldenstaedti)* and stellate sturgeon *(A. stellatus)* in the Caspian Basin. Two Atlantic sturgeon were killed by hopper dredge operations in December 2004, one near Gulf Port, Mississippi, and the other near Dauphin Island, Alabama (C. Slay, pers. comm. 2004). These were the first reported Atlantic sturgeon mortalities by dredging operations on the Gulf coast. The proposed project is not going to utilize a hopper dredge but a pipeline dredge. As evidenced above, most entrainments by hydraulic pipeline dredges has occurred in riverine areas where there is possibly a greater chance of sturgeon encountering the intake flow fields around the cutterhead.

The potential for migratory movement and entrainment impacts would depend upon the timing and location of the project. Because the borrow site is not located in small water body the potential for dredging to disrupt any migratory movement is highly unlikely. Avoidance of areas having a higher sand content would help reduce the risk of any sturgeon that may utilize that area. If a sturgeon would swim into site the likelihood of entrainment would depend on many factors including the size of the fish, its' swimming ability and the velocity of the dredge's intake.

There are no known studies of Atlantic sturgeon swimming speeds however, lake sturgeon which are morphologically similar (asymmetrically forked caudal fin and a short muscular, naked peduncle) have undergone swimming speed studies. Hoover *et al.* (2005) determined that the risk of entraining juvenile lake sturgeon (size range 5 – 8 inches, 30 – 200 millimeters) was low for intake velocities of 1.6 feet/second (ft/s, 50 centimeters/second [cm/s]) which were reported to extend up to 4.9 feet (1.5 meters [m]) from the cutterhead. Entrainment is also related to a species behavior to increasing velocities and it is not known if Atlantic sturgeon would behave similarly to lake sturgeon. The area to which the dredge would pose an entrainment hazard to sturgeon is a function of the size of the dredge, its pumping velocity, the size of the fish encountering the dredge, and perhaps other variables. Larger dredges have a broader intake flow field and larger fish have a greater ability to overcome the suction velocity of the pipeline and avoid entrainment. A conservative assumption is that a hazard zone 6.6 feet (2 m) wide was applicable to all sturgeon; the actual hazard zone is probably smaller. For dredges up to 36 inches (in, 91 centimeters [cm]) (in diameter with a typical pipe velocity of 15 ft/sec (4.6

meters/second [m/s]), the water velocity towards the cutter head at a distance 6.6 feet (2 m) away from the cutter head is less than 0.8 ft/sec (25 cm/s) (Hoover *et al.* 2004). The burst velocity of all species of sturgeons beyond the fingerling stage of growth probably well exceeds 0.8 ft/sec (25 cm/s) (Hoover *et al.* 2004). Thus at a distance of 3.7 feet (1.12 meters) from the dredge pipeline the entrainment of a juvenile sturgeon is unlikely (Hoover 2011). The likelihood of entraining an adult sturgeon is believed to be even less. The smallest sturgeon in the project area would probably be juveniles and young subadults arriving from north-shore rivers in the late fall/early winter. The size range of sturgeon captured in the project vicinity ranges from approximately 19 inches (48.5 cm) to 39 feet (1.2 m). A review of data from an ongoing telemetry study in Lake Pontchartrain did not indicate that the proposed borrow area is an area where Atlantic sturgeon were not found to remain for extended periods of time or concentrate (Glenn Constant personal communication, 2014); based on the above information no dredging window is proposed for this event.

Proposed construction should span approximately 148 days including 12 weather days. (Shannon Haynes CPRA, per. comm. with Robert Dubois Service, 2014). To further reduce the risk of entrainment the following protective measures would be incorporated into the proposed project plans:

1. The cutter/suction head shall remain completely buried in the bottom material during dredging operations.
2. If pumping water through the cutter/suction head is necessary to dislodge material, clean pumps or cutter/suction head, etc., the pumping rate shall be slowed to the lowest rate possible until the cutter/suction head is at mid-depth, where the pumping rate can then be increased. Pumping rates shall be reduced to the slowest speed feasible during the cutter/suction head's return to the water bottom.

Considering the large expanse of water surrounding the proposed borrow areas where sturgeon could avoid any dredge, their potential ability to avoid entrainment via burst swimming speeds, and incorporation of the above protective measures the Service has determined that the proposed project is not likely to adversely affect the Atlantic sturgeon or the PCE that addresses disruption of migratory pathways.

Effects to/on Habitat

Four PCEs of critical habitat are present in the project area (see Status of the Critical Habitat in the project area): food items, water quality, sediment quality, and migratory pathways. As discussed above, the nature of the proposed action necessitates the evaluation of effects on migration as a species effect and not as a habitat effect. Water and sediment quality impacts are discountable (see the introduction to Effects of the Action). The project may affect the ability of estuarine critical habitat unit to provide abundant food items by removing substrate from the lake bottom that support those food items.

Because the project area salinities range between freshwater and estuarine, the feeding habitats of both juvenile fish, which feed near river mouths, and of adult/subadult fish, which feed exclusively in saltwater habitats (see Life History – Food Habits) could be affected. However, the great distance of the project area from the mouth of the Pearl River (the only known spawning river in the watershed) indicates there are probably other important feeding areas closer to the Pearl River for adult/sub-adult fish returning to the relatively prey-rich estuary following months of fasting in riverine summer resting areas. Younger fish have a lower tolerance for salt water and the river/bay interface is where greater benthic prey density (compared to the river) and lower salinity regimes intersect. Tracking studies in Lake Pontchartrain during 2001 failed to locate any sturgeon in the lake (Granger, 2002). The reasons for the apparent decrease in utilization of this area are not known. As previously mentioned a review of data from an ongoing telemetry study in Lake Pontchartrain did not indicate that the proposed borrow area is an area where Atlantic sturgeon were not found to remain for extended periods of time or concentrate (Glenn Constant personal communication, 2014). Effects to the PCE food items, which are dependent on sediment composition and effects to critical habitat area are addressed below.

Effect to food/sediment

Atlantic sturgeon generally feed in sandy substrates (see Species Description – Food Habits). Sediment samples have been taken from Lake Pontchartrain since the early 1970's. However, no previous sediment sampling occurred within the proposed borrow sites. Other samples in the vicinity of the sites were judged to be too far (i.e., greater than 2,000 feet) from the borrow sites to provide data that would reflect site conditions.

For project planning, eleven (11) borings were taken within the proposed borrow site. Borings B10-B14, had very soft dark sandy clay or clayey sand or silt at the lake-bottom surface (10 feet.) The depth of the proposed borrow site (i.e., -23 feet) indicated that the surface sediments following excavation would be composed of medium to stiff green and gray clay or silt with some sand pockets ferrous nodules and lenses. Therefore, utilizing the proposed Bayou Bonfouca borrow area would not result in a significant change in substrate composition.

Because sand could be considered a PCE and some sandy areas were located within the borrow site during preliminary sampling, the planning team employed GeoEngineers, Inc. to collect two hundred (200) evenly spaced surface sediment samples from the proposed borrow site; graphic results can be seen in Figure 4. It was decided that within the proposed borrow area all areas in which the surface sediments were shown to consist of seventy percent (75%) sand or greater would be excluded from dredging (i.e. no dredge zone). This was based on Fox et al., (2002) determination that sturgeon were typically located where sediment consisted of approximately 80 percent or more of sand and other researchers also finding sturgeon associated with sandy substrate (Harris et al., 2005, Ross et al., 2009) .

The filling rate of the IHNC borrow site on the south shore of Lake Pontchartrain was determined to be approximately 0.59 inches (1.5 cm) per year. The filing rate of the Goose Point borrow site was determined to range between 0 and 5.3 feet per year with an average of 0.3 feet per year (Khalil et al., 2014). That filling rate would refill the borrow site in approximately 33 years. However, those filling rates were determined from hydrographic surveys of the borrow site, thus any sloughing of the pits sides may have been included as part of the infilling rate thus potentially skewing the averaged rate towards a much faster rate than is actually occurring.

Coring of sediment accumulations in the IHNC borrow site showed occasional layers of sandy material being deposited (approximately 8 percent of the total accumulation) which could offer periodic and temporary increases in sandy substrate, if such sand lenses would occur. Using the infilling rate of 0.59 inches per year the proposed borrow pit could theoretically refill in approximately 203 years. Currently, the Goose Point and Pointe Platte borrow sites have accumulated an average of about 4.5 inches (11.25 cm) of flocculent at the bottom of the borrow sites since excavation based on 6 sediment cores taken from each of those sites. This accumulation equates to an infilling rate of approximately 0.8 inches per year (1.9 cm) meaning that the borrow pit could refill in approximately 150 years. It is not known if the flocculent will eventually consolidate into a firm substrate. This infilling rate is slightly higher than that determined from the IHNC pit, however since the Goose Point pits construction there have been two opening of the Bonnet Carre Spillway which introduces Mississippi River sediment into the lake and some tropical storm events (e.g., Hurricane Katrina) which can also redistribute sediments; thus the longer term average from the IHNC borrow sites are believed to reflect a more realistic long-term refill rate.

Dredged holes on the south shore of Lake Pontchartrain experience stratification and periods of anoxic conditions (Flocks and Franze, 2002). However, benthic organisms that were present were secondary prey items as defined by Brooks (2004). A literature review on the impacts of dredge holes was undertaken by Pisapia (1974). In that review, several studies documented lower dissolved oxygen levels and decreased abundance of benthic and finfish species within dredge holes. However, some holes appeared to provide good water quality and benthic and finfish species were present but in decreased abundance in comparison to un-dredged areas. Areas that experienced flushing did not exhibit stratification which often leads to lower dissolved oxygen levels and decreased abundance of benthic organisms and finfish. In a study assessing the habitat value of 11 dredge holes in Tampa Bay only 3 were recommend for filling to restore habitat and one was recommended for refilling to reduce shoreline erosion. The remaining dredge holes were recommended to remain unfilled because they provided good water quality and had levels of benthic organisms and finfish equal to or greater than adjacent areas of similar depth (Tampa Bay Estuary Program 2005). An evaluation of dredge holes in Lake Worth Lagoon, Florida, determined that not all dredged holes were candidates for depth modification because some still provided good water quality and good habitat quality for benthic organisms and finfish. The location of a dredged hole to ocean inlets and a canal had a major influence on the benthic fauna within the dredge hole (Vose, *et al.,* 2005). Pits that were believed to experience more current (i.e., flushing) were thought to provide better habitat. Reine *et al.*, (2014) documented improved DO levels and benthic community in partially re-filled dredged holes in Mobile Bay. However, the benthic community still differed from the natural bay bottom community. Decreasing the proposed borrow pits depth from 15 feet to 10 feet below the lake bottom is anticipated to help reduce hypoxic and anoxic events. As previously presented sampling results from the borrow site north of this area indicate colonization by benthic species found outside of the pit (see Borrow Pit Investigation and Design Considerations).

A comparison of the ten most abundant benthic organisms in Lake Pontchartrain as identified by various reports is presented in Table 1 of Appendix C. Two of the studies were done post Hurricane Katrina and indicated that the benthic communities apparently still had not recovered from the effect of that storm (Poirrier et al., 2008, Macaulaey et al., 2007). As previously mentioned Lake Pontchartrain's benthic community exhibits variations (Tables 3 through 6 of Appendix C) that are probably related to the changes in salinity both across the lake and between years, and reoccurring hypoxic/anoxic conditions (Macaulaey et al., 2007). The nine most common taxa reported from those studies include, *Rangia, cuneata*, Nemertea, *Texadina sphinctostoma*, *Parandalia americana*, *Steblospio benediciti*, *Amphicteis floridus*, *Cerapus benthophilus*, and Chironomids. Comparison of Ray's (2007) benthic samples from Lake Borgne (Table 2 in Appendix C) indicates that over five years the eight most abundant benthic taxa in Lake Borgne include four of the most abundant species found in Lake Pontchartrain. All eight species have also been reported at least once as one of the ten most abundant species in Lake Pontchartrain. Lake Borgne is more directly influenced via saline coastal water, thus some differences in the benthic community should exist, but there is similarity between the two areas benthic communities.

Based upon food habitat studies of the Atlantic sturgeon it does not appear that the proposed borrow site provide a large abundance of primary food items (Table 1), however, many of the reported benthic taxa listed as secondary food items are found in the proposed borrow site. However, these species can also be found throughout most of the lake as well as in adjacent estuarine areas (e.g., Lake Borgne) as previously mentioned. In addition, some recolonization of the borrow pit with prey items will occur even following anoxic events (BEM 2014). Limiting the depth of the proposed borrow pits and locating the proposed borrow pits in areas having higher current velocities reduces the potential for the borrow pits to develop hypoxic and/or anoxic conditions which could limit prey availability. Considering the above factors the Service has determined that the proposed project is not likely to adversely affect the PCE addressing food and sediment.

Effects to Critical Habitat Estuarine Unit 8

The Service anticipates that dredging within the lake will occur from approximately 1,700 to 23,000 feet from the shore. Water depths at the proposed borrow site range from approximately 10 to 14 feet.

Critical habitat within Lake Pontchartrain (188,675 acres) comprises about 47 percent of lake (total area of 403,200 acres) and 21 percent of Unit 8 (i.e., Lake Pontchartrain, Lake, St. Catherine, Lake Borgne, Mississippi Sound); Unit 8 extends over 883,323 acres. The total area of the borrow site (i.e., a maximum of 648 acres) comprises approximately 0.3 percent and 0.07 percent of critical habitat in Lake Pontchartrain and Unit 8, respectively. The borrow site has been configured to avoid areas that are predominated by sand (i.e., 75% or greater sand content) thus avoiding areas that potentially have primary food items (Fox et al., 2002), however, other studies (Brooks 2004) indicate that the proposed borrow site locations may provide prey species for Atlantic sturgeon. Prey associated with the less sandy substrate have been found within the existing borrow site and in most of Lake Pontchartrain and Lake Borgne (BEM 2014, Ray 2009). Recolonization of borrow pits with prey species does occur (BEM 2014) but borrow pits may exacerbate natural hypoxic conditions that re-occur in Lake Pontchartrain thus limiting full recovery of the benthic community (Flocks and Franze, 2002, Khalil, 2014). Only two borrow pits have been dug since the designation of critical habitat; the total area of those borrow sites (i.e., a maximum of 298 acres) comprises approximately 0.2 percent and 0.03 percent of critical habitat in Lake Pontchartrain and Unit 8, respectively. Combined with the proposed borrow sites the total area impacted by both projects comprises approximately 0.5 percent and 0.1 percent of critical habitat in Lake Pontchartrain and Unit 8, respectively. Since most of the designated critical habitat is composed of similar substrate (Flocks, et al., 2002) or substrate that supports possible non-sandy substrate prey, the Service has determined that the proposed borrow pit is not likely to adversely affect designated Atlantic sturgeon critical habitat.

MAMMALS

West Indian Manatee

Sightings of the West Indian manatee in Louisiana have occurred in Lakes Pontchartrain and Maurepas, and associated coastal waters and streams (i.e., Amite, Blind, Tchefuncte, and Tickfaw Rivers) during the summer months (i.e., June through September); however, there is no known resident population in the State. The borrow sites were located at a distance from the shoreline to prevent impacts to sea grass beds on which manatees feed; in addition, effluent from the marsh creation sites would be filtered across the marsh to further reduce suspended sediments that could also impact sea grass beds.

During in-water work in areas that potentially support manatees all personnel associated with the project should be instructed about the potential presence of manatees, manatee speed zones, and the need to avoid collisions with and injury to manatees. All personnel should be advised that there are civil and criminal penalties for harming, harassing, or killing manatees which are protected under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Additionally, personnel should be instructed not to attempt to feed or otherwise interact with the animal, although passively taking pictures or video would be acceptable. The following standard protective measures should be implemented;

- All on-site personnel are responsible for observing water-related activities for the presence of manatee(s). We recommend the following to minimize potential impacts to manatees in areas of their potential presence:

- All work, equipment, and vessel operation should cease if a manatee is spotted within a 50-foot radius (buffer zone) of the active work area. Once the manatee has left the buffer zone on its own accord (manatees must not be herded or harassed into leaving), or after 30 minutes have passed without additional sightings of manatee(s) in the buffer zone, in-water work can resume under careful observation for manatee(s).

- If a manatee(s) is sighted in or near the project area, all vessels associated with the project should operate at "no wake/idle" speeds within the construction area and at all times while in waters where the draft of the vessel provides less than a four-foot clearance from the bottom. Vessels should follow routes of deep water whenever possible.

- If used, siltation or turbidity barriers should be properly secured, made of material in which manatees cannot become entangled, and be monitored to avoid manatee entrapment or impeding their movement.

- Temporary signs concerning manatees should be posted prior to and during all in-water project activities and removed upon completion. Each vessel involved in construction activities should display at the vessel control station or in a prominent location, visible to all employees operating the vessel, a temporary sign at least 8½ " X 11" reading language similar to the following: "CAUTION BOATERS: MANATEE AREA/ IDLE SPEED IS REQUIRED IN CONSRUCTION AREA AND WHERE THERE IS LESS THAN FOUR FOOT BOTTOM CLEARANCE WHEN MANATEE IS PRESENT". A second temporary sign measuring 8½ " X 11" should be posted at a location prominently visible to all personnel engaged in water-related activities and should read language similar to the following: "CAUTION: MANATEE AREA/ EQUIPMENT MUST BE SHUTDOWN IMMEDIATELY IF A MANATEE COMES WITHIN 50 FEET OF OPERATION".

- Collisions with, injury to, or sightings of manatees should be immediately reported to the Service's Louisiana Ecological Services Office (337/291-3100) and the Louisiana Department of Wildlife and Fisheries, Natural Heritage Program (225/765-2821). Please provide the nature of the call (i.e., report of an incident, manatee sighting, etc.); time of incident/sighting; and the approximate location, including the latitude and longitude coordinates, if possible.

Furthermore, the disturbance to that species would only be temporary during project construction, and would result in temporary displacement. The manatees would likely move to another area for foraging or resting purposes, and there would be other available areas to which the animals may relocate.

SUMMARY OF DETERMINATIONS

The proposed action would not be located within suitable habitat for the RCW nor will it indirectly affect areas inhabited by that species. The proposed action, therefore, would have no effect on that species.

FISH

Effects to three of the four PCEs that are present in the project area would not occur or are discountable. The Service determined that the effects are discountable because effluent from the marsh creation areas would flow through adjacent marsh areas, thus removing their potential to affect water and sediment quality. Turbidity associated with dredging would be temporary in nature and there are no know contaminants in the proposed borrow sites. Effects to the fourth PCE, abundant food items, are small in scale relative to the potential feeding area in Critical Habitat Unit 8 as a whole. Lake Pontchartrain comprises about 21 percent of the designated critical habitat in Unit 8 (i.e., Lake Pontchartrain, Lake, St. Catherine, Lake Borgne, Mississippi Sound). The total area of the borrow site (i.e., a maximum of 648 acres) comprises approximately 0.3 percent and .07 percent of critical habitat in Lake Pontchartrain and Unit 8, respectively. The above analysis indicates that the proposed project would have a negligible impact on the ability of the estuarine critical habitat unit to function for the conservation of the Atlantic sturgeon especially when avoidance of areas having higher sand concentration thus potentially greater preferred food abundance is considered and when viewed in the more limited context of the estuarine unit, which serves as winter feeding habitat of juvenile and sub-adult fish. Limiting the depth of the proposed borrow pits and locating the proposed borrow pits in areas having higher current velocities substantially reduces the potential for the borrow pits to develop hypoxic and/or anoxic conditions which could limit prey availability.

In summary, the borrow sites are not located within areas that are predominated by sand, therefore, the borrow areas are not believed to be highly utilized by Atlantic sturgeon for feeding nor provide constituent elements of critical habitat, furthermore any areas that contain 75% sand or greater would be avoided. Considering the above factors the Service has determined that the project's effect on food resources in the project area would not significantly impair essential behavioral patterns and result in death or injury of Atlantic sturgeon; therefore, the Service has determined that the proposed project is not likely to adversely affect designated Atlantic sturgeon critical habitat.

Considering the large expanse of water surrounding the proposed borrow areas where sturgeon could avoid any dredge, their potential ability to avoid entrainment via burst swimming speeds, the reduced potential of entrainment by conducting dredging operations only during time periods when there are fewer sturgeon present, avoidance of areas having high sand concentrations, and incorporation of protective measures the Service has determined that the proposed project is not likely to adversely affect the Atlantic sturgeon as a species or the PCE that addresses disruption of migratory pathways.

Post construction surveys of the actual borrow site configuration will be undertaken along with water quality monitoring in the borrow pit. Collection of this information will be coordinated with and made available to interested resource agencies.

MAMMALS

The West Indian manatee is known to occur periodically in the coastal waters of Louisiana. If a manatee were to stray into the project area, it may be attracted to noise from any proposed activities. Consequently, an on-board observer would be present to alert the proper personnel, and harmful activities (e.g., dredging) would be temporarily suspended until the animal can move to safety. Should a manatee be sighted within any work areas, the Service's Louisiana Ecological Services, Field Office (646 Cajundome Blvd. Suite 400, Lafayette, LA, 70506) would be contacted immediately. Therefore, the proposed action is not likely to adversely affect the West Indian manatee.

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Appendix A

Results of Proposed Borrow Site Soil Borings

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	○	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
			●	GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	●	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	⁘	SW	WELL-GRADED SANDS, GRAVELLY SANDS
			⁘	SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	◇	SM	SILTY SANDS, SAND - SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▥	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY
			▨	OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS			∿	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS		TYPICAL DESCRIPTIONS
GRAPH	LETTER	
▤	CC	Cement Concrete
■	AC	Asphalt Concrete
▩	CR	Crushed Rock/ Quarry Spalls
▩	TS	Topsoil/ Forest Duff/Sod

▽	**Measured groundwater level at time noted on log**
▼	**Initial groundwater level observed at time of exploration**
≡	**Perched water observed at time of exploration**

Graphic Log Contact

—	**Distinct contact between soil strata or geologic units**
/	**Approximate location of soil strata change within a geologic soil unit**

Material Description Contact

—	**Distinct contact between soil strata or geologic units**
- - -	**Approximate location of soil strata change within a geologic soil unit**

Sampler Symbol Descriptions

☒	**Standard Penetration Test (SPT)**
■	**Shelby tube**
▤	**Piston**
◧	**Direct-Push**
◫	**Bulk or grab**

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	**Percent fines**
AL	**Atterberg limits**
CA	**Chemical analysis**
CP	**Laboratory compaction test**
CS	**Consolidation test**
DS	**Direct shear**
HA	**Hydrometer analysis**
MC	**Moisture content**
MD	**Moisture content and dry density**
OC	**Organic content**
PM	**Permeability or hydraulic conductivity**
PP	**Pocket penetrometer**
SA	**Sieve analysis**
UU	**Triaxial compression**
UC	**Unconfined compression**
VS	**Vane shear**

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GEOENGINEERS

FIGURE A-1

Drilled	Start 9/12/2011	End 9/12/2011	Total Depth (ft) 31.5	Logged By SM Checked By VT	Driller Specialized Environmental Resources, LLC	Drilling Method Wet Rotary
Surface Elevation (ft) Vertical Datum	Undetermined		Hammer Data	N/A	Drilling Equipment	Pontoon Barge-Mounted Drill Rig
Latitude Longitude	N30° 14' 13.0" W89° 52' 20.0"		System Datum	Geographic NAD83 (feet)	Groundwater	
Notes: See Figure A-1 for explanation of symbols.						

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
9/12/2011	1.0	

		FIELD DATA									LABORATORY DATA								
Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)¹	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0						▽			Zero (0) feet top of deck Water line									
	5																		
	10									Mudline									
		■	3			1		▨	CL	Very soft dark gray clay with silt	30					44	27		
		■	12			2		▨		Medium gray silty clay with ferrous nodules								0.284	
	15	■	13			3		▨		Soft gray very silty clay with ferrous nodules	25					26	12		
		■	8			4		▨		Stiff gray silty clay with ferrous nodules									
	20	■	11			5		▨		Stiff gray silty clay with ferrous nodules	24					40	22		
		■	13			6		▨		Stiff gray silty clay with ferrous nodules									
		■	3			7		▩	CH	Medium gray clay with ferrous nodules	38					53	34		
	25	■	9			8		▨	CL	Medium gray silty clay with ferrous nodules									
		■	19			9		▩	CH	Medium gray clay with ferrous nodules	34					84	55		
	30	■	13			10		▨	CL	Medium gray silty clay with ferrous nodules									

*Indicates a remold was used for strength testing.
¹FV = Field Vane shear strength corrected for material characteristics.

Baton Rouge: Date:3/21/12 Path:P:\16\16715023\GINT\BAYOU BONFOUCA MARSH CREATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Log of Boring B-10

GEOENGINEERS

Project: Bayou Bonfouca Marsh Creation Project (PO-104)
Project Location: St. Tammany Parish, Louisiana
Project Number: 16715-023-00

Figure A-11
Sheet 1 of 1

Drilled	Start 9/12/2011	End 9/12/2011	Total Depth (ft) 30	Logged By SM Checked By VT	Driller Specialized Environmental Resources, LLC
Drilling Method	Wet Rotary				
Surface Elevation (ft) Vertical Datum	Undetermined	Hammer Data	N/A	Drilling Equipment	Pontoon Barge-Mounted Drill Rig
Latitude Longitude	N30° 14' 10.6" W89° 51' 56.1"	System Datum	Geographic NAD83 (feet)		

Notes: See Figure A-1 for explanation of symbols.

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
9/12/2011	1.0	

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)¹	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0									Zero (0) feet top of deck									
							∇			Water line									
	5																		
										Mudline									
	10		7			1			CL	Very soft gray silty clay with ferrous nodules									
			9			2				Soft gray very silty clay with ferrous nodules	24					31	17		
			8.5			3				Medium gray sandy clay with ferrous nodules									
	15																		
			13			4				Medium gray very sandy clay with ferrous nodules	24					28	14		
			9			5			CH	Medium brown and gray clay with ferrous nodules									
	20		11			6				Medium green and gray clay with calcareous and ferrous nodules	25					70	49		
			6			7				Stiff green and gray clay with ferrous nodules									
			12			8				Stiff green and gray clay with ferrous nodules	27					69	49		
	25																		
			5			9				Stiff green and gray clay with ferrous nodules									
			6			10			CL	Stiff green and gray clay with silt, sand pockets and ferrous nodules	28					47	33		
	30																		

¹Indicates a remold was used for strength testing.
¹FV = Field Vane shear strength corrected for material characteristics.

Baton Rouge: Date:3/21/12 Path:P:\16\16715023\GINT\BAYOU BONFOUCA MARSH CREATION BORING LOGS.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_LAB

Log of Boring B-11

GEOENGINEERS

Project: Bayou Bonfouca Marsh Creation Project (PO-104)
Project Location: St. Tammany Parish, Louisiana
Project Number: 16715-023-00

Figure A-12
Sheet 1 of 1

Drilled	Start 9/12/2011	End 9/12/2011	Total Depth (ft) 31	Logged By SM Checked By VT	Driller Specialized Environmental Resources, LLC	Drilling Method Wet Rotary

Surface Elevation (ft) Vertical Datum	Undetermined	Hammer Data	N/A	Drilling Equipment	Pontoon Barge-Mounted Drill Rig
Latitude Longitude	N30° 13' 52.0" W89° 52' 06.0"	System Datum	Geographic NAD83 (feet)	Groundwater	

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
9/12/2011	1.0	

Notes: See Figure A-1 for explanation of symbols.

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	LABORATORY DATA Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)[1]	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0						∇			Zero (0) feet top of deck Water line									
	5																		
	10									Mudline									
			7			1			SC	Very soft dark gray clayey sand with shells	22					29	10		21
			9			2			CL	Very soft dark gray sandy clay with shells									
	15		10			3				Medium gray clay with silt, ferrous nodules and sand pockets	25					44	26		
			11			4				Medium gray silty clay with calcareous and ferrous nodules									
	20		12			5			CH	Medium gray clay with calcareous and ferrous nodules	23					54	34		
			2.5			6			CL	Medium gray silty clay with calcareous and ferrous nodules									
			11			7			CL-ML	Medium gray clayey silt with calcareous nodules	25					25	6		
	25		10			8			CL	Medium brown and gray silty clay with sand pockets and ferrous nodules									
			6.5			9				Medium tan and gray clay with silt pockets, lenses and ferrous nodules	34					49	29		
	30		9			10				Medium gray silty clay with silt pockets and ferrous nodules									

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*Indicates a remold was used for strength testing.

[1] FV = Field Vane shear strength corrected for material characteristics.

Log of Boring B-12

GeoEngineers

Project: Bayou Bonfouca Marsh Creation Project (PO-104)
Project Location: St. Tammany Parish, Louisiana
Project Number: 16715-023-00

Figure A-13
Sheet 1 of 1

Drilled	Start 9/12/2011	End 9/12/2011	Total Depth (ft) 31	Logged By SM Checked By VT	Driller Specialized Environmental Resources, LLC	Drilling Method Wet Rotary
Surface Elevation (ft) Vertical Datum	Undetermined		Hammer Data N/A		Drilling Equipment Pontoon Barge-Mounted Drill Rig	
Latitude Longitude	N30° 13' 39.0" W89° 52' 25.0"		System Datum Geographic NAD83 (feet)		Groundwater Date Measured 9/12/2011	Depth to Water (ft) 1.0	Elevation (ft)

Notes: See Figure A-1 for explanation of symbols.

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)¹	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0						∇			Zero (0) feet top of deck Water line									
	5																		
	10									Mudline									
			9			1			CL	Very soft dark gray very sandy clay with sand pockets	33					31	14		
			10			2				Loose dark gray sandy clay with shells									
	15		11			3				Soft gray very sandy clay with ferrous nodules	17					23	11		
			4			4				Soft gray very sandy clay with ferrous nodules									
			12			5				Medium gray very silty clay with ferrous nodules	18					30	18		
	20																		
			13			6				Medium gray silty clay with ferrous nodules									
			13			7			CH	Medium gray clay with ferrous nodules, sand pockets and lenses	35					70	47		
	25		12			8				Medium gray clay with ferrous nodules									
			9			9				Medium gray clay with ferrous nodules	31					67	47		
			12			10			CL	Medium gray clay with silt pockets, lenses and ferrous nodules	22					42	25		
	30																		

¹Indicates a remold was used for strength testing.
²FV = Field Vane shear strength corrected for material characteristics.

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Log of Boring B-13

GEOENGINEERS

Project: Bayou Bonfouca Marsh Creation Project (PO-104)
Project Location: St. Tammany Parish, Louisiana
Project Number: 16715-023-00

Figure A-14
Sheet 1 of 1

Drilled	Start 9/12/2011	End 9/12/2011	Total Depth (ft)	31	Logged By SM Checked By VT	Driller Specialized Environmental Resources, LLC	Drilling Method Wet Rotary
Surface Elevation (ft) Vertical Datum	Undetermined		Hammer Data	N/A		Drilling Equipment	Pontoon Barge-Mounted Drill Rig
Latitude Longitude	N30° 13' 31.6" W89° 52' 04.5"		System Datum	Geographic NAD83 (feet)		Groundwater	

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
9/12/2011	1.0	

Notes: See Figure A-1 for explanation of symbols.

		FIELD DATA									LABORATORY DATA								
Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Water Content, %	Dry Density, (pcf)	Compressive Strength (TSF)¹	Confining Pressure (KSF)	Strain, %	Liquid Limit (LL), %	Plasticity Index (PI), %	MiniVane Shear Strength (KSF)	Passing No. 200 Sieve, %
	0						∇			Zero (0) feet top of deck Water line									
	5																		
	10									Mudline									
		■	9			1		▨	CL	Very soft dark gray sandy clay									
		■	2			2		▨		Very soft dark gray sandy clay with ferrous nodules	31								
	15	■	8			3		▨	CH	Very soft gray clay with ferrous nodules and shells									
		■	8.5			4		▨		Very soft tan and gray clay with ferrous nodules	34					58	38		
		■	6.5			5		▨		Very soft gray clay with ferrous nodules									
	20	■	8			6		▨		Very soft tan and gray clay with ferrous nodules	30					75	53		
		□	0			7		▨		Medium gray clay with sand pockets, lenses and ferrous nodules									
	25	■	4			8		▨		Stiff tan and gray clay with ferrous and calcareous nodules	42					76	53		
		■	9			9		▨		Medium brown and gray clay with ferrous nodules									
	30	■	9.5			10		▨		Stiff brown and gray clay with silt pockets and ferrous nodules	34					63	44		

*Indicates a remold was used for strength testing.

[1] FV = Field Vane shear strength corrected for material characteristics.

Log of Boring B-14

GEOENGINEERS

Project: Bayou Bonfouca Marsh Creation Project (PO-104)

Project Location: St. Tammany Parish, Louisiana

Project Number: 16715-023-00

Figure A-15

Sheet 1 of 1

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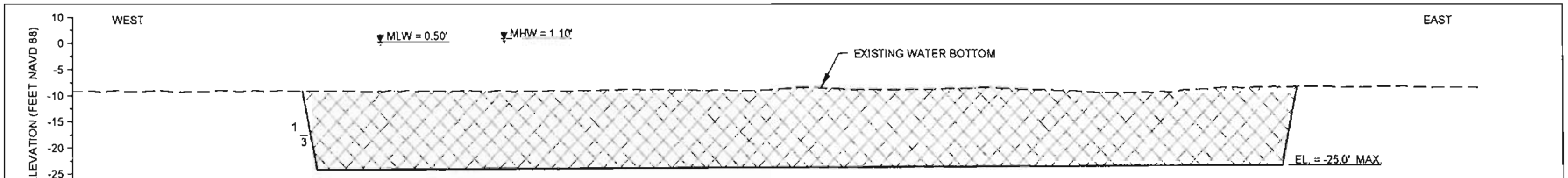
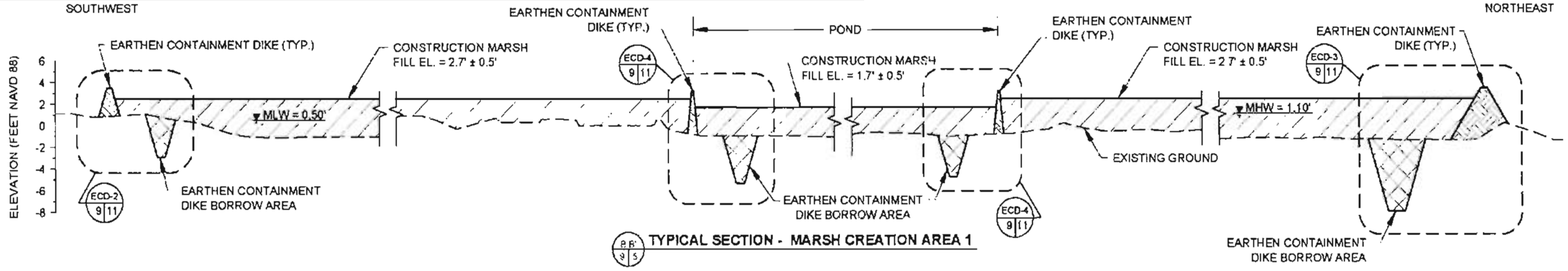
Appendix C

Borrow Pit and Marsh Creation Cross Sections

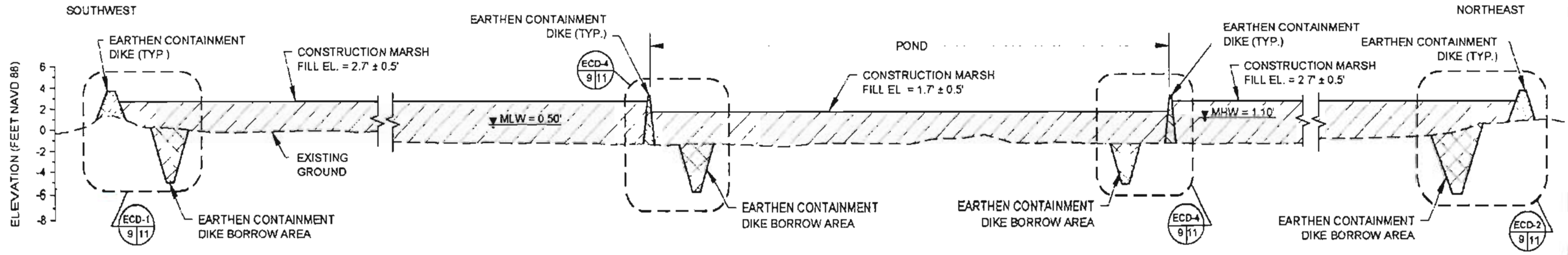


TYPICAL SECTION - BORROW AREA

HORIZONTAL GRAPHIC SCALE
300' 150' 0 300' 600'
20' 10' 0 20' 40'
VERTICAL GRAPHIC SCALE



TYPICAL SECTION - MARSH CREATION AREA 1



TYPICAL SECTION - MARSH CREATION AREA 1

HORIZONTAL GRAPHIC SCALE
100' 50' 0 100' 200'
10' 5' 0 10' 20'
VERTICAL GRAPHIC SCALE

NOTE:
DISCHARGE SHALL BE DIRECTED TO RETAIN AS MUCH MATERIAL AS POSSIBLE.

LEGEND

- ▨ EARTHEN CONTAINMENT DIKE
- ▨ EARTHEN CONTAINMENT DIKE BORROW AREA
- ▨ MARSH CREATION FILL
- - - - EXISTING GROUNDWATER BOTTOM

REV	DATE	DESCRIPTION	BY

COASTAL PROTECTION AND RESTORATION AUTHORITY
450 LAUREL STREET
BATON ROUGE, LOUISIANA 70801

BAYOU BONFOUCA MARSH CREATION PROJECT
STATE PROJECT NUMBER: PO-104
FEDERAL PROJECT NUMBER: PO-104

TYPICAL SECTIONS
DATE: SEPTEMBER 2012

DRAWN BY: KRISTI CANTU
DESIGNED BY: JOSEPH GUILLORY, E.I.
APPROVED BY: SHANNON HAYNES P.E.
SHEET 9 OF 27

Appendix X

Information from Benthic Studies done in Lake Pontchartrain and Lake Borgne

Table 1. Comparison of most abundant benthic species in Lake Pontchartrain

Year	1974[1]	1978[2]	2002-2004[3]	2004[4]	2005[4]	2005[5]	2006[4]	Most common Taxa[6]
Taxa	Amnicolidae	*Probythinella louisianae*	*Rangia cuneata*	*Rangia cuneata*	Oligochaeta	*Steblospio benediciti*	Oligochaeta	*Rangia Cuneata* (6)
	Littoridina texadina	*Mulinia pontchartrainensis*	*Texadina sphinctostoma*	Oligochaeta	*Steblospio benediciti*	Coelotanypus spp.	*Cerapus benthophilus*	Nemertea (5)
	Mytilus edulis	*Rangia cuneata*	Mediomastus spp.	*Probythinella protera*	Nemertea	Mediomastus spp.	*Rangia cuneata*	*Texadina sphinctostoma* (4)
	Rangia cuneata	*Texadina sphinctostoma*	*Mulinia lateralis*	*Texadina sphinctostoma*	Chironomids	*Parandalia tricuspis*	*Steblospio benediciti*	*Parandalia Americana* (4)
	Mulinia pontchartrainensis	*Amphicteis floridus*	*Cerapus benthophilus*	Chironomids	*Parandalia americana*	*Rangia cuneata*	Nemertea	*Steblospio benediciti* (4)
	Polychaeta	Chironomids	*Probythinella louisianae*	*Cerapus benthophilus*	*Rangia cuneata*	*Mediomastus ambiseta*	*Parandalia americana*	*Amphicteis floridus* (3)
	Diptera	*Macoma mitchelli*	*Ischadium recurvum*	*Amphicteis floridus*	*Amphicteis floridus*	Mactridae	*Texadina sphinctostoma*	*Cerapus benthophilus* (3)
		Congeria leucophaeta	*Hobsonia florida*	*Parandalia americana*		*Americamysis almyra*	Chironomids	Chironomids (3)
		Parandalia americana	Mactridae	Nemertea		*Ameroculodes miltoni*		
		Nemertea	Amphicteis spp.	*Steblospio benediciti*		Nemertea		

[1] Summary of species collected at Station 20 (southeastern portion of the lake) in 1974 (Price and Kuckyr 1974). Substrate was classified as sandy-clay sediment with approximately 50 percent sand and 20 percent clay. See Table 3.

[2] Top 10 Macrofaunal (abundance) in Lake Pontchartrain in 1978 (Stone, 1980). See Table 4.

[3] Dominant infaunal species (10 most abundant in decreasing order) in Lake Pontchartrain (2000-2004) (Macauleyet al., 2007)

[4] Poirrier 2009 See Table 5

[5] Dominant infaunal species (10 most abundant in decreasing order) in Lake Pontchartrain (2005) (Macauleyet al., 2007) See Table 6.

[6] Number in parenthesis equals number of occurrences.

Table 2. Comparison of species composition of Lake Borgne samples. Values represent percent of total abundance for selected species (Ray 2007).

Taxa	**This Study**	**EPA 1991**	**EPA 1992**	**EPA 1993**	**EPA 1994**
Mediomastus sp.	28.96	6.43	32.98	3.72	42.03
Streblospio benedicti	7.04	40.49	21.38	0.00	3.86
Parandalia sp.	8.50	0.00	4.32	11.74	6.76
Hobsonia florida	0.43	14.67	0.99	0.59	15.46
Mulinia lateralis	3.57	1.36	4.15	1.37	0.00
Mulinia pontchartrainensis	3.79	0.36	1.77	0.59	3.38
Nemertea	2.58	0.09	1.56	0.00	1.93
Rangia cuneata	*	6.43	0.04	3.52	6.28

*Substantial numbers of *Rangia cuneata* shells were present in northern reach of the sampling area but few live specimens were encountered.

Table 3. Summary of species collected at Station 20 (southeastern portion of the lake) in 1974 (Price and Kuckyr 1974). Substrate was classified as sandy-clay sediment with approximately 50 percent sand and 20 percent clay.

Name	Total (N)	N/m^2
Amnicolidae	524	2062
Littoridina texadina	233	917
Mytilus edulis	1	4
Rangia cuneata	29	114
Mulinia pontchartrainensis	22	87
Polychaeta	4	16
Diptera	5	20

Table 4. Top 10 Macrofaunal (abundance) in Lake Pontchartrain in 1978 (Stone, 1980)

Name	Total (N)	N/m^{2*}	SE	Percent of Total	Rank
Probythinella louisianae	8422	1079.3	307.9	34.6	1
Mulinia pontchartrainensis	5868	752.0	165.3	24.1	2
Rangia cuneata	3265	418.4	67.6	13.4	3
Texadina sphinctostoma	2007	257.2	62.1	8.3	4
Amphicteis floridus	1649	211.3	49.3	6.8	5
Chironomids	1348	172.7	18.1	5.5	6
Macoma mitchelli	520	66.6	12.0	2.1	7
Congeria leucophaeta	647	82.9	20.4	2.7	8
Parandalia americana	175	22.4	5.2	0.7	9
Nemerteans	109	14.0	1.6	0.4	10

*Total number per square meter

Table 5. Comparison of dominant taxa pre- and post-Hurricane Katrina (Poirrier 2009)

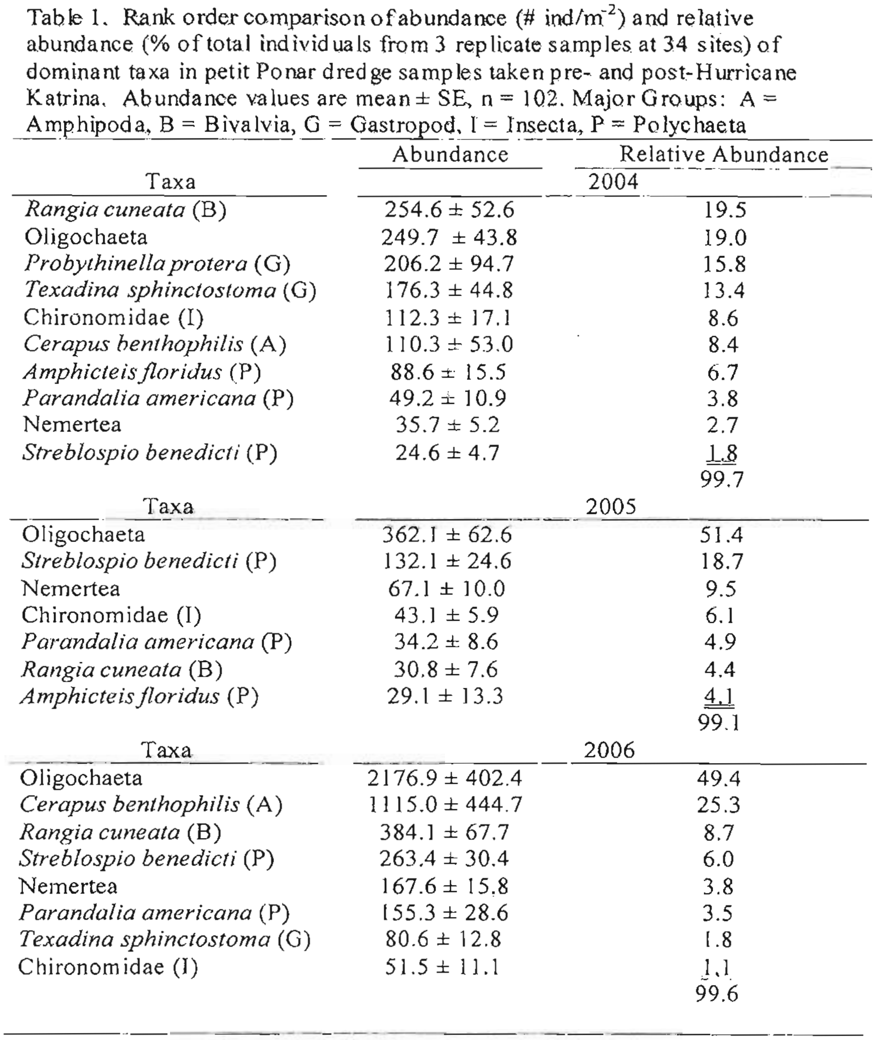


Table 1. Rank order comparison of abundance (# ind/m^{-2}) and relative abundance (% of total individuals from 3 replicate samples at 34 sites) of dominant taxa in petit Ponar dredge samples taken pre- and post-Hurricane Katrina. Abundance values are mean ± SE, n = 102. Major Groups: A = Amphipoda, B = Bivalvia, G = Gastropod, I = Insecta, P = Polychaeta

Taxa	Abundance	Relative Abundance
	2004	
Rangia cuneata (B)	254.6 ± 52.6	19.5
Oligochaeta	249.7 ± 43.8	19.0
Probythinella protera (G)	206.2 ± 94.7	15.8
Texadina sphinctostoma (G)	176.3 ± 44.8	13.4
Chironomidae (I)	112.3 ± 17.1	8.6
Cerapus benthophilis (A)	110.3 ± 53.0	8.4
Amphicteis floridus (P)	88.6 ± 15.5	6.7
Parandalia americana (P)	49.2 ± 10.9	3.8
Nemertea	35.7 ± 5.2	2.7
Streblospio benedicti (P)	24.6 ± 4.7	1.8
		99.7
Taxa	2005	
Oligochaeta	362.1 ± 62.6	51.4
Streblospio benedicti (P)	132.1 ± 24.6	18.7
Nemertea	67.1 ± 10.0	9.5
Chironomidae (I)	43.1 ± 5.9	6.1
Parandalia americana (P)	34.2 ± 8.6	4.9
Rangia cuneata (B)	30.8 ± 7.6	4.4
Amphicteis floridus (P)	29.1 ± 13.3	4.1
		99.1
Taxa	2006	
Oligochaeta	2176.9 ± 402.4	49.4
Cerapus benthophilis (A)	1115.0 ± 444.7	25.3
Rangia cuneata (B)	384.1 ± 67.7	8.7
Streblospio benedicti (P)	263.4 ± 30.4	6.0
Nemertea	167.6 ± 15.8	3.8
Parandalia americana (P)	155.3 ± 28.6	3.5
Texadina sphinctostoma (G)	80.6 ± 12.8	1.8
Chironomidae (I)	51.5 ± 11.1	1.1
		99.6

Table 6. Comparison of dominant infaunal species (10 most abundant in decreasing order) in Lake Pontchartrain before (2000-2004) versus after Hurricane Katrina (2005). Also shown in parentheses is the number of samples (n) for each sampling period combination. (Macauleyet al., 2007)

Survey Area	Pre-Hurricane (2000-2004)				Post-Hurricane (2005)			
	Taxa	**Mean # Ind./m2**	**% Cum. Density**	**% Occurrence**	**Taxa**	**Mean # Ind./m2**	**% Cum. Density**	**% Occurrence**
	(n=46)				(n=29)			
	Rangia cuneata	278	19	59	Steblospio benedicit	41	24	48
	Texadina sphinctostoma	199	33	22	Coelotanypus spp.	37	45	59
	Mediomastus spp.	111	41	39	Mediomastus spp.	21	57	21
	Mulinia lateralis	110	49	11	Parandalia tricuspis	19	67	21
	Cerapus benthophilus	82	55	4	Rangia cuneata	9	73	14
	Probythinella louisianae	76	60	9	Mediomastus ambiseta	9	78	28
	Ischadium recurvum	72	65	22	Mactridae	8	82	10
	Hobsonia florida	60	69	13	Americamysis almyra	3	84	7
	Mactridae	45	72	22	Ameroculodes miltoni	3	86	7
	Amphicteis spp.	39	75	2	Nemertea	3	88	10