ESSENTIAL FISH HABITAT ASSESSMENT

BONNET CARRÉ SPILLWAY OPERATIONS

October 2023

U.S. Army Corps of Engineers
Mississippi Valley Division
Regional Planning and Environment Division South
New Orleans District

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

AHMS	Atlantic Highly Migratory Species
APE	Area of Potential Effects
bbls	Barrels (2 sacks = 1 bbl)
BCS	Bonnet Carré Spillway
°C	Degrees Celsius
C-CAP	Coastal Change Analysis Program
CEQ	Council for Environmental Quality
cfs	Cubic feet per second
cm	Centimeters
CPI	Composite pollution index
CPRA	Coastal Protection and Restoration Authority
DDT	Dichlorodiphenyltrichloroethane
DIP	Dissolved inorganic phosphorus
DO	Dissolved oxygen
EEZ	Exclusive economic zone
EFH	Essential fish habitat
EIS	Environmental impact statement
ELC	Eastern Louisiana Coastal HUC
EPA	Environmental Protection Agency
°F	Degrees Fahrenheit
FL	Fork length
FMP	Fishery Management Plan
GMFMC	Gulf of Mexico Fishery Management Council
GOM	Gulf of Mexico
HAPC	Habitats of particular concern
HUC	Hydrologic Unit Code
in	Inches
L	Liter
Lat	Latitude
LDWF	Louisiana Department of Wildlife and Fisheries
Long	Longitude
LP	Lake Pontchartrain
LPB	Lake Pontchartrain Basin
LPE	Lake Pontchartrain Estuary
LPH	Lake Pontchartrain HUC
m	Meters
MCB	Mississippi Coastal Basin
MCH	Mississippi Coastal HUC
MDEQ	Mississippi Department of Environmental Quality
mg	Milligram
MRGO	Mississippi River Gulf Outlet
MS Bight	Mississippi Bight
MS Sound	Mississippi Sound
MSR	Mississippi River
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

OFS	Operational Forecast System
ppt	Parts per thousand
PL	Public law
SAV	Submerged aquatic vegetation
TL	Total length
TSS	Total suspended sediments
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
YOY	Young of year

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1 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Mississippi River Valley Division, Regional Planning and Environmental Division South, has prepared this Essential Fish Habitat (EFH) assessment to satisfy consultation requirements established in the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), as amended, Public Law (P.L.) 104-208, for future operations of the Bonnet Carré Spillway (BCS or Spillway). The BCS is operated in accordance with the Flood Control Act of 1928 and accompanying Chief of Engineers Report to Congress, House Document 90, 70th Congress, 1st Session, Jan. 1, 1928 (also known as the "Jadwin Report"). Additionally, the Corps has prepared and published guidance documents to assist the Corps in its routine management and operation of the BCS. One such document is the Mississippi River and Tributaries, Water Control Manual, Bonnet Carre' Spillway (last revised September 1999), which states that BCS "will normally be operated when the flow in the Mississippi River below Morganza reaches 1,250,000 cubic feet per second (cfs) on a rising hydrograph or to preserve a desired level of freeboard on deficient levees through the New Orleans area. The Spillway will be controlled so that the flow below Bonnet Carré in the Mississippi River does not exceed 1,250,000 cfs." This EFH assessment is intended to cover all potential effects to EFH associated with operation of the BCS as authorized.

1.1 BONNET CARRÉ SPILLWAY

1.1.1 <u>Location and Purpose</u>

The BCS is located approximately 25 river miles upstream of New Orleans in St. Charles Parish, Louisiana (Figure 1 and Figure 2). Situated between New Orleans and Baton Rouge and traversed by Interstate 10 and U.S. 61, the Spillway is a significant landscape feature in southeastern Louisiana. Construction of the Spillway including guide levees, highway and railroad crossings, was completed in 1936.

The Spillway was constructed to reduce flood damage risk and loss of life in the New Orleans metropolitan area and other downstream communities, caused by high flood stages along the Mississippi River. Construction of the Spillway structure began in 1929 and was completed in 1931. The Spillway is designed to function like a valve that can be opened to divert a portion of the river's flow into Lake Pontchartrain, helping to relieve stress on the levees downstream and prevent overtopping. The Spillway is designed to convey 250,000 cubic feet per second (cfs) of Mississippi River floodwaters from the weir structure to Lake Pontchartrain (Figure 3).

1.1.2 <u>Project Design</u>

The BCS consists of a massive concrete weir structure adjacent to the Mississippi River, upper and lower guide levees, a 7,623 acre floodway that stretches from the Mississippi River to Lake Pontchartrain, Spillway office and warehouse buildings, various highway and railroad crossings, and miscellaneous pipeline and utility crossings.

1.1.2.1 Control Structure

The control structure is a concrete, gravity overfall dam controlled by manually operated timber needles. The control structure is founded on untreated timber pilings and has a steel sheet piling cutoff wall 45 to 55 feet in depth on the riverside of the weir. Immediately lakeward of the control structure and integral to it is a shallow, reinforced concrete stilling basin approximately 50 feet wide with three rows of low concrete baffle piers. Beyond the lakeward row of baffle piers there is a heavy articulated concrete mat 175 to 225 feet wide, underlain by an inverted filter of gravel, spalls, and riprap. The control structure is 7,698 feet in length. It consists of 350 bays, each 20 feet in width, separated by reinforced concrete piers 2 feet thick which carry two sets of steel beams as operating rail bridges. There are 176 bays with a weir crest of 17.0 feet NGVD and the remaining 174 bays have a weir crest of 15.0 feet NGVD. Each bay is closed with 20 timber needles whose actual dimensions are 8” x 11.5” to permit operation without binding. The loose fit of the needles also allows seepage of river water into the floodway during high Mississippi River stages. The lengths of the timber needles are 10 and 12 feet, depending on the elevation of the crest of the control structure’s weir. When in place, the needles are seated on the control structure crest and lean against a reaction beam. When the bays are opened, the needles are stored by hooking one end of each below the upstream service bridge and resting the other end on the reaction beam. Two diesel-powered, traveling gantry cranes are provided for removing and installing the needles.

1.1.2.2 Floodway

The floodway conveys the floodwaters from the weir structure to Lake Pontchartrain. This flooding is confined by upper and lower guide levees. The elevation of the levees is approximately 19 feet NGVD. The floodway is 5.7 miles long, approximately 7,700 feet wide at the river end and approximately 12,400 feet wide at the lake end. Ground elevations in the floodway range from approximately 12 feet NGVD near the river to 0 feet NGVD at the Lake Pontchartrain shoreline. The area of the floodway is approximately 7,623 acres.

1.1.2.3 Project Buildings

The Spillway office building is located directly adjacent to the downstream terminus of the Spillway structure. It is situated on the protected side slope of the Mississippi River Levee and its confluence with the lower guide levee and is elevated to allow full view of the structure and bordering floodway. The building includes an office for the Spillway manager, a reception area, a large conference room, a rest room, and a small kitchen area.

Adjacent to the office building and located on the protected side of the levee is the maintenance facility and fenced storage yard. Spillway maintenance equipment is stored in this area.

1.1.2.4 Highway and Railroad Crossings

The floodway is crossed by two highways and a local parish road. I-10 crosses the floodway approximately 2.1 miles east of U.S. 611, following the southern boundary of Lake Pontchartrain. It is a divided bridge resting on concrete piers. U.S. 61, also known as Airline Highway, is located in the central portion of the floodway. This crossing is also elevated on concrete piers for the majority of its length in the floodway. Earthen embankments extend for some distance into the floodway from both ends of the bridge.

The remaining road crossing is St. Charles Parish Road 12 (SC-12) immediately lakeward of the Spillway structure (Figure 1). This is a grade level crossing which essentially is a continuation of Louisiana Highway 48 (River Road). SC-12 is also known as Spillway Road. Another roadway located on Spillway lands is Louisiana Highway 628, also known as CC Road, which connects River Road on the upstream side of the Spillway with U.S. 61. This roadway is located on the protected side of the upper guide levee.

The floodway is crossed by three railroad lines. All three lines predate the construction of the Spillway and, therefore, required the construction of new bridge crossings at the time of Spillway construction. Two of the lines are located between the Spillway structure and U.S. 61. Closest to the structure is the Canadian National Railroad - Baton Rouge Subdivision. The next rail line away from the Spillway structure is the Kansas City Southern Railway – New Orleans Subdivision located just south of U.S. 61. The final railroad crossing in the floodway is the Canadian National Railroad - McComb Subdivision which is located near Lake Pontchartrain just south of I-10.

1.1.2.5 Miscellaneous Features

In addition to the highway and railroad crossings, the BCS contains numerous pipeline, powerline and other utility rights-of-way. Miscellaneous encroachments on Spillway lands such as foot bridges over the outside of drainage canals, radio tower locations, etc. also exist. These uses are allowed under various outgrants.

1.1.3 Authorization

The BCS was authorized by the Flood Control Act of 15 May 1928, as amended. It is an integral part of the comprehensive Mississippi River and Tributaries Project which was implemented in response to the Great Flood of 1927. The authorizing legislation requires that the Spillway be operated to prevent river flows from exceeding 1,250,000 cfs at New Orleans.

1.1.4 Operation

First opened during the 1937 flood, the Spillway has also been used in the floods of 1945, 1950, 1973, 1975, 1979, 1983, 1997, 2008, 2011, 2016, 2018, twice in 2019, and 2020. Dates and maximum flows for each opening are provided in Table 1 below.

Table 1. Bonnet Carré Spillway Openings

Year	Days Open	Bays Opened	Maximum Flow (cfs)	Total Volume Passed (km^3)	Scale of Event*
1937	48	285	211,000	15.2	High
1945	57	350	318,000	30.1	High
1950	38	350	228,000	13.4	Med
1973	75	350	207,000	23.5	High
1975	13	225	110,000	2.11	Low
1979	45	350	228,000	13.9	Med
1983	35	350	268,000	15.2	High
1997	31	298	243,000	11.7	Med
2008	31	160	160,000	7.5	Low
2011	42	330	316,000	21.9	High
2016	22	210	203,000	6.9	Low
2018	22	183	196,000	5.8	Low
2019a	43	206	213,000	38.1	High
2019b	78	168	161,000		
2020	28	90	90,000	3.98	Low

*For more information on how the scale of each event was categorized, see Section 1.3

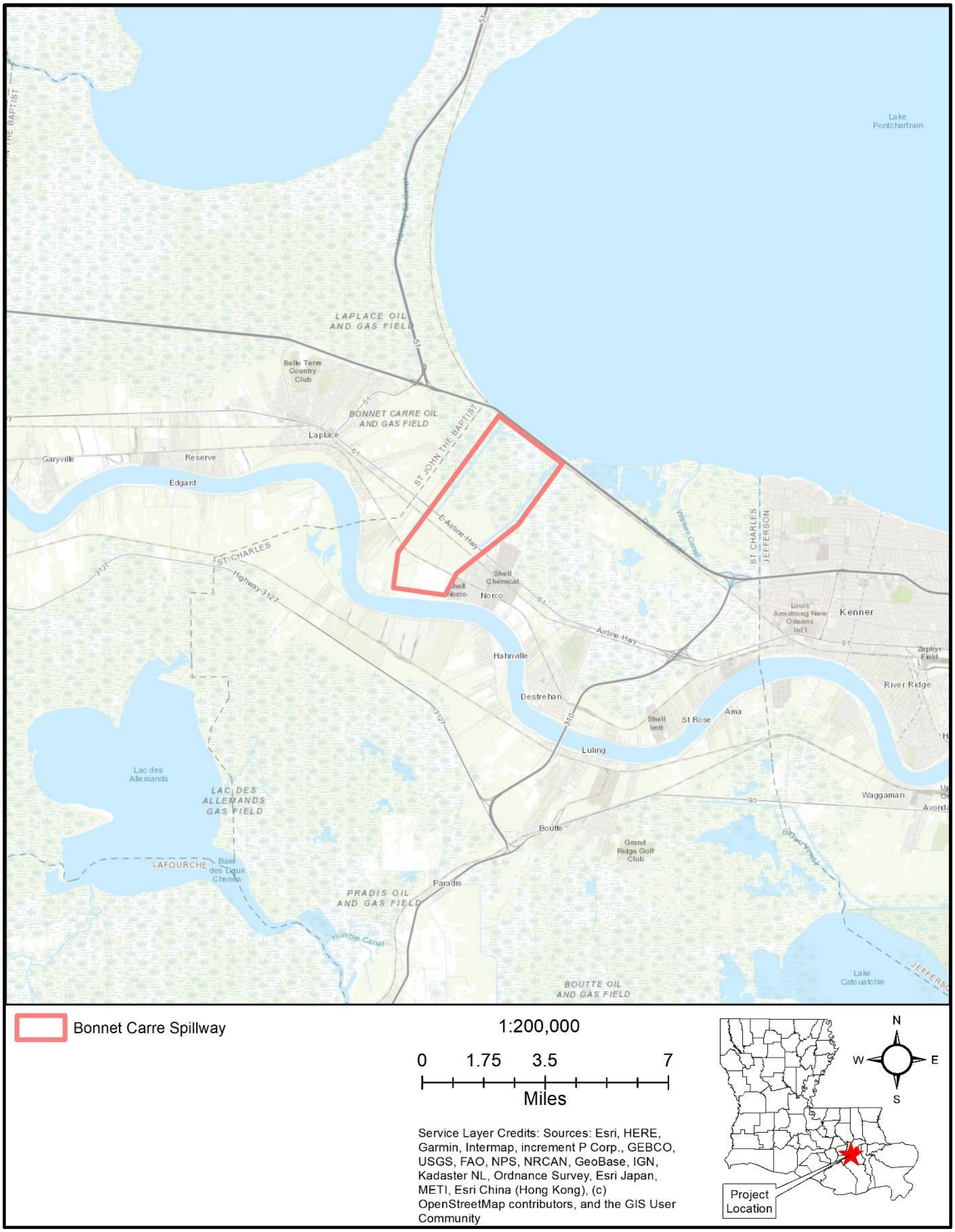


Figure 1. Bonnet Carré Spillway Vicinity Map

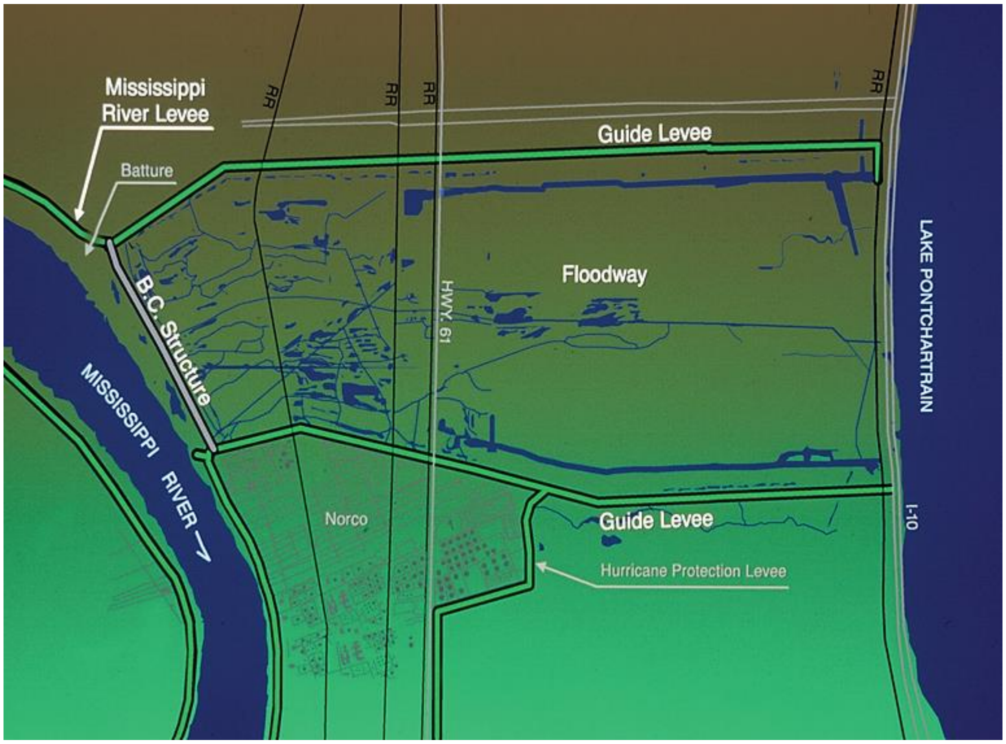


Figure 2. BCS Project Map.

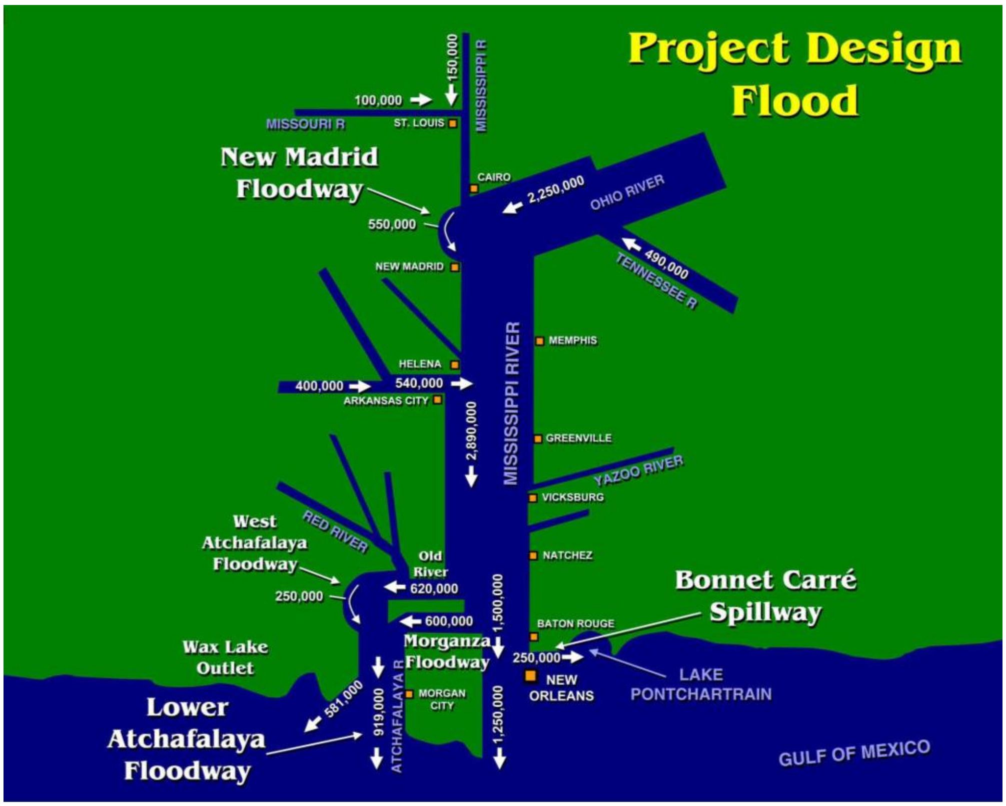
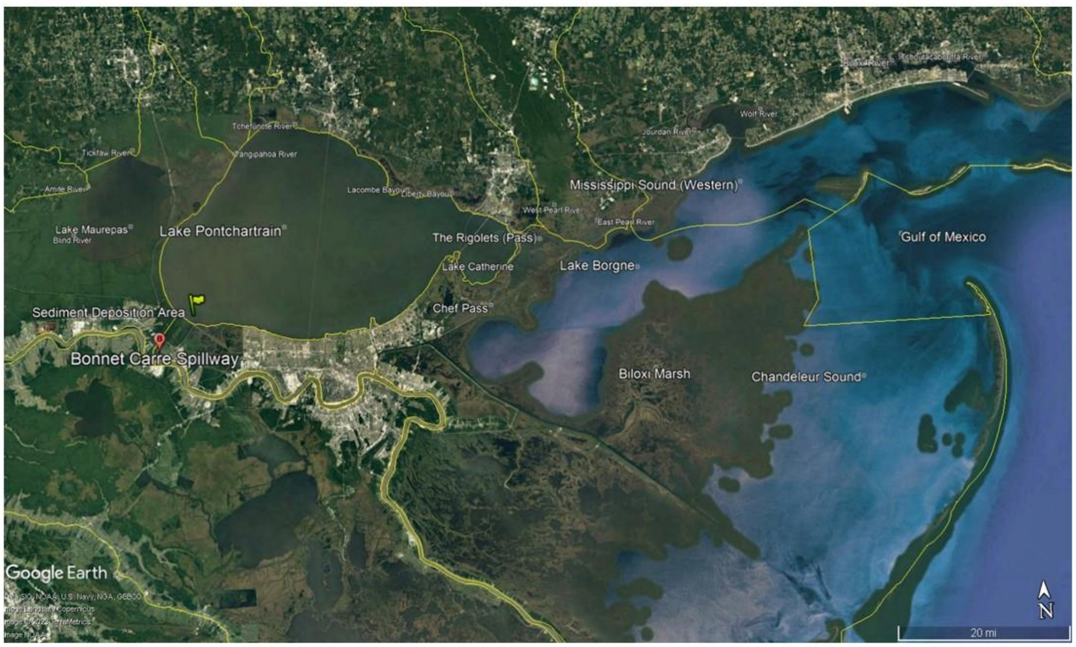


Figure 3. Project Design Flood for the BCS.

1.2 AREA OF POTENTIAL EFFECTS (APE)

The BCS is located in St. Charles Parish, Louisiana, and protects New Orleans and other downstream communities during major floods on the lower Mississippi River (Figures 1-3). For purposes of consultation, the area of potential effects includes all areas reasonably expected to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. Due to the nature of the BCS, the areas to be affected directly or indirectly will vary based on the duration and flow associated with a particular spillway opening. In addition, there are other sources of freshwater entering the area, particularly during major flood events, making it difficult to estimate the exact limits of any potential effects from operating the BCS. To ensure this analysis captures all areas which could potentially be affected, USACE has determined that the area of potential effects includes the BCS, Lake Pontchartrain, Lake Borgne, most of the Biloxi Marsh, the Western Mississippi Sound (West of the Gulfport Ship Channel), the Western Chandeleur Sound and a small portion of the Gulf of Mexico. This determination was based on a combination of data which is discussed primarily in Section 3.2 below showing salinity gradients during and shortly after operation of the BCS in conjunction with USACE water quality monitoring.



* Yellow Lines Depict 8 Digit Hydrologic Unit Codes (HUC) Boundaries

Figure 4. Map depicting the various waterbodies in the vicinity of the BCS,

1.3 SCOPE OF ANALYSIS

This assessment analyzes a range of potential future operations of the BCS by looking at data from past events that represent high, medium, and low volume operations. Historically, operations have varied from smaller scale openings, such as the 1975 and the 2020 events that involved low release volumes, to larger scale openings like the operations in 1945, 1983, 2011, and 2019 during which the volume of water released was much higher (see Table 1, which categorizes each previous operation by scale based on the total volume of water passed through the BCS during each event). Large scale operations have a higher potential to effect managed EFH. The exact impacts will also vary by local conditions and time of year. However, the local watersheds are somewhat accustomed to episodic fluctuations in salinity due to annual flood events from local rivers. Still, the opening of the BCS does at times alter the typical water conditions (salinity, temperature, etc.) found locally. Small scale operations of the BCS typically have few long-term ramifications and result in only minor effects to local ecosystems, similar to those episodic events from local river systems. Therefore, larger scale events (such as 2019) that have a greater potential to adversely affect managed EFH, provide a more comprehensive picture of potential impacts. Any attempt to quantify the threshold at which potential effects from the BCS exceed those found from typical flood events from local systems would require additional data collection. For purposes of this analysis, USACE defined a low volume event as an event which released less than 7.5 km^3 of water from the beginning of the opening to the end, and a high volume event as any event which released over 15 km^3. This interpretation was based on the data found in Table 1.

1.4 ESSENTIAL FISH HABITAT

The MSFCMA, as amended, Public Law (P.L.) 104-208, addresses the authorized responsibilities for the protection of EFH by National Marine Fisheries Service (NMFS) in association with regional fishery management councils.

EFH was defined by the U.S. Congress in the 1996 amendments to the MSFCMA as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Regional fishery management councils are required to provide both text descriptions and maps of EFH, and to review EFH information every five years. The 1996 amendment to the MSFCMA mandates that regional fishery management councils delineate EFH for managed species (16 USC 1801 et seq.). The Gulf of Mexico Fishery Management Council (GMFMC) defines six Fishery Management Plans (FMP) for the Gulf of Mexico: shrimp, red drum, reef fish, coastal migratory pelagics, corals, and spiny lobster. In addition, NMFS’ Highly Migratory Species Division manages an FMP for Highly migratory species (HMS; sharks, tuna, billfish, and swordfish) as they cross domestic and international boundaries. Managed species in and around the area of potential effects are included under the following FMPs, each of which includes one or more species:

- Shrimp Fishery of the Gulf of Mexico, U.S. Waters;
- Red Drum Fishery of the Gulf of Mexico;
- Reef Fish of the Gulf of Mexico;
- Coastal Migratory Pelagic Resources in the Gulf of Mexico and South Atlantic; and
- Atlantic HMS

EFH was first designated for GMFMC species in 1998 and subsequently refined by a 2005 amendment and corresponding EIS (GMFMC 2004 and 2005). Reviews were undertaken in 2010 and 2016, both of which further refined the EFH and corresponding mapping data. However, the regulatory definitions have not been altered since the Generic Amendment in 2005.

EFH for HMS is defined by the 2006 Consolidated Atlantic HMS FMP and its amendments. The most recent amendment was finalized in September 2017 (82 FR 42329). Although HMS may be found globally, the MSFCMA only authorized EFH in federal, state, or territorial waters to the seaward limit of the U.S. Exclusive Economic Zone (EEZ).

EFH includes habitats necessary for various life stages of fish species and provides a regulatory mechanism linking estuarine and marine habitats. Coastal wetlands provide important habitat for numerous fish species along the northern Gulf of Mexico, and access to these areas is a function of hydrology (Minello 1999, Beck et al. 2001, Baker et al. 2013a).

Habitat areas of particular concern (HAPC) are subsets of EFH that are ecologically important, sensitive, stressed, and/or rare. Although designated HAPCs have no regulatory protections above all other EFH, projects impacting HAPCs may be more scrutinized and may be subject to additional conservation measures (NOAA 2016). No HAPCs are located within the area of potential effects.

2 AFFECTED ENVIRONMENT

2.1 BONNET CARRÉ SPILLWAY PROJECT AREA

2.1.1 Climate

The climate in the Bonnet Carré Spillway area is humid subtropical, characterized by mild winters and hot, humid summers. The area is dominated by warm, moist, maritime tropical air from the adjacent Gulf of Mexico. This maritime air is displaced frequently during winter and spring by incursions of continental polar air from Canada that usually persists no longer than three to four days. These incursions of cold air occur less frequently in autumn and only rarely in summer. Tropical storms and hurricanes are likely to affect the area three out of every ten years, with a severe hurricane causing widespread damage once every two or three decades. Annual average temperature is 70 degrees Fahrenheit (°F), with monthly normal temperatures varying from 81°F in July to 53°F in January. Average annual precipitation is 60 inches, varying from 7 inches in July to 3 inches in October. Annual average evapotranspiration varies from a maximum rate of 66.5 inches to a minimum rate of 41.6 inches. The predominant wind directions are south to south-southeast from January through July and northeast to east-northeast from September through November. River fog is prevalent in the winter and spring when the temperature of the Mississippi River is cooler than the air temperature.

2.1.2 Geology and Geomorphology

The Bonnet Carré Spillway consists of approximately 7,623 acres located on the east side of the Mississippi River in southeastern Louisiana. The lands, characteristic of an alluvial flood plain, vary in elevation from 12 feet near the river to mean sea level near Lake Pontchartrain. The water areas consisting of the Mississippi River, Lake Pontchartrain, borrow pits, drainage canals, and natural bayous form the principal physiographic features. Guide levees extend across the floodway from approximately 7,700 feet at the river to approximately 12,400 feet at the lake end. Two miles lakeward of the river, the swamp land extends about 4 miles to Lake Pontchartrain, averaging 1 to 2 feet above mean sea level. The area is similar to most deltaic plain environments in that it is of low elevation, low relief, and gentle slopes. There are no obvious significant geologic features within the confines of the spillway. Subsurface faults are located in the spillway area but cause little apparent surface displacement (Gagliano 2003). Mineral deposits in the area include petroleum, sand, gravel, and clay.

2.1.3 Soils and Topography

Soils are derived from alluvial deposits and organic matter. Swamp soils consist of soft to very soft organic clays with layers of silt and peat, wood and roots, and high water content. Such soils usually support tree growth. Marsh soils, consisting of soft to very soft organic clays of high water content and layers of silt and peat, support grasses and sedge growth. Natural levee soils derived from recent Mississippi River deposits consist of stiff to very stiff oxidized clays with layers of silts, silty sands, and sands of low water content (McDaniel 1987).

The Convent-Commerce soil series, widespread within the spillway area, consists of level to gently undulating, poorly drained soils that have a loamy surface and subsurface layer, or have a loamy or clayey surface layer and a clayey subsoil (McDaniel 1987).

2.2 WATERSHEDS

2.2.1 Lake Pontchartrain Basin (HUC 080902);

The Lake Pontchartrain Basin (Incorporates HUC 08090202 and HUC 08090203) is a 12,173 km^2 (4,700 mi^2) watershed, and it encompasses 16 parishes in southeast Louisiana. It is one of the largest estuarine ecosystems on the Gulf coast and one of the largest in the United States. The Lake Pontchartrain Basin has the most diverse complex of environments in Louisiana, ranging from rolling woodlands in northern portions of the Basin to coastal wetlands in the southern part of the Basin. At the center of the Basin is the 1,632 km^2 (630 mi^2) Lake Pontchartrain and the largest population center in Louisiana, the Greater New Orleans area, with 1.5 million individuals. Climate is integral to the natural systems of Pontchartrain Basin. Short- and long-term climate variability has an enormous impact on the seasonal and long-term health of any ecosystem. Annual average temperatures range from 19 to 21°C (66 to 69°F) , with July averaging 28°C (82°F) and January averaging 12°C (53°F). Snow rarely falls in the southern sections, with only small snowfalls usually recorded in the northern areas. The statewide annual rainfall is about 142 cm (56 in) a year, with the northern regions averaging 117 cm (46 in) and some of the southern coastal parishes averaging as high as 167 cm (66 in) of rainfall a year. (https://pubs.usgs.gov/of/2002/of02-206/intro/intro.html).

Figure 5. Lake Pontchartrain Basin (HUC 080902)

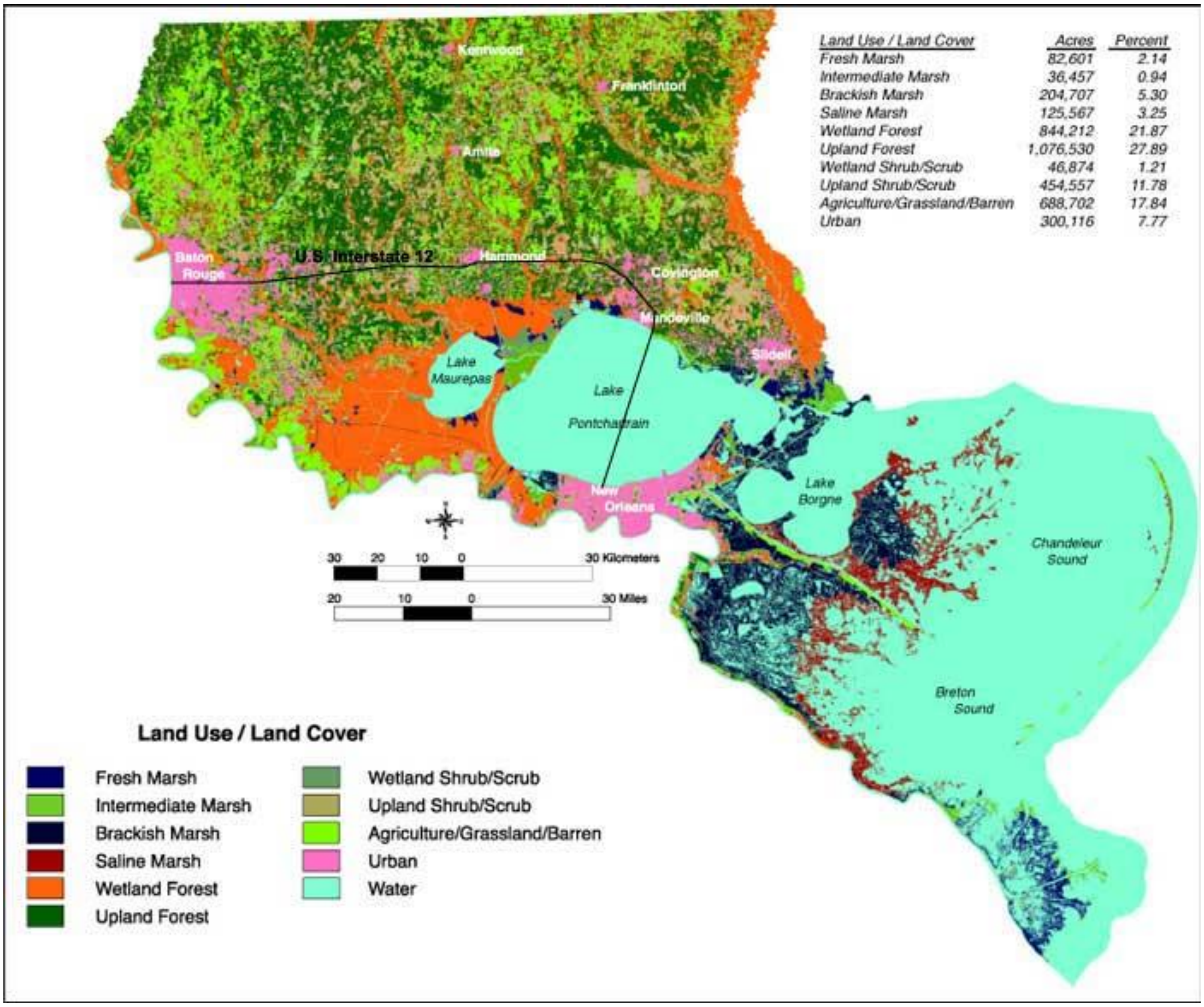


Figure 6. Land use classification within HUC 080902.

2.2.2 Mississippi Coastal Basin (HUC 03170009)

The Mississippi Coastal Watershed (HUC 03170009) covers approximately 4,059 square miles, stretching from Louisiana to Alabama. The hydrology of the area is heavily influenced by the Mississippi River, which provides a vast amount of freshwater to the Gulf of Mexico. All climate features are similar to the Lake Pontchartrain Basin referenced above. The potential effects of BCS operation to this HUC are generally limited to the area West of the Gulfport Ship Channel. Details are provided later within this assessment. Spillway waters are first diverted from the Mississippi River through the Bonnet Carré structure into Lake Pontchartrain and from there into Lake Borgne and western Mississippi Sound. The Pearl and Pascagoula Rivers empty directly into the Sound while the Jourdan and Wolf Rivers first drain into the Bay of St. Louis and then into the Sound. Similarly, the Biloxi and Tchoutacabouffa Rivers empty into the Back Bay of Biloxi before discharging into the Sound. The combined drainage of all these stream systems totals approximately 51,000 km². The Pearl River, St. Louis Bay, Biloxi Bay and Pascagoula River estuarine systems empty into Mississippi Sound. Combined drainage area from streams and rivers entering the Mississippi estuarine basin is approximately 50,919 km². The Pearl River and Pascagoula River drainage areas far exceed those of Biloxi and St. Louis Bays.

Pascagoula River has a drainage area of 24,346 km² with an average discharge of 430 m³/s. Pearl River drains 22,533 km² and has an average discharge of 365 m³/s. The combined drainage area for rivers emptying into Biloxi and St. Louis Bays is 3,626 km² with an average discharge of 79 m³/s. Silty clay is the dominant sediment in Mississippi Sound. Coastal bays receive large volumes of sandy, silty-sandy sediments from the surrounding mainland. In addition, these embayments and the Sound proper receive clay-silt sediments from the rivers. Fine sediments are also carried into the Sound via tidal currents from Lake Pontchartrain and Mobile Bay. The central portion of the Sound is composed of silt and clay muds. In some areas these sediments grade into fine and very fine sands. Medium and coarse sands characterize the barrier islands and are also found along the mainland beach west of the Pascagoula River. Medium to coarse sands extend from Round Island in Mississippi Sound to Horn Island.
The shallowness of the Sound (average depth at mean low water is 2 m), and its sediments and wave action are responsible for the turbidity of the water. In most months, nearshore waters are brown in color due to suspended fine sediment in the water column. In periods of peak river flow, these muddy waters may reach and extend beyond the barrier islands (GMFMC October 1998).

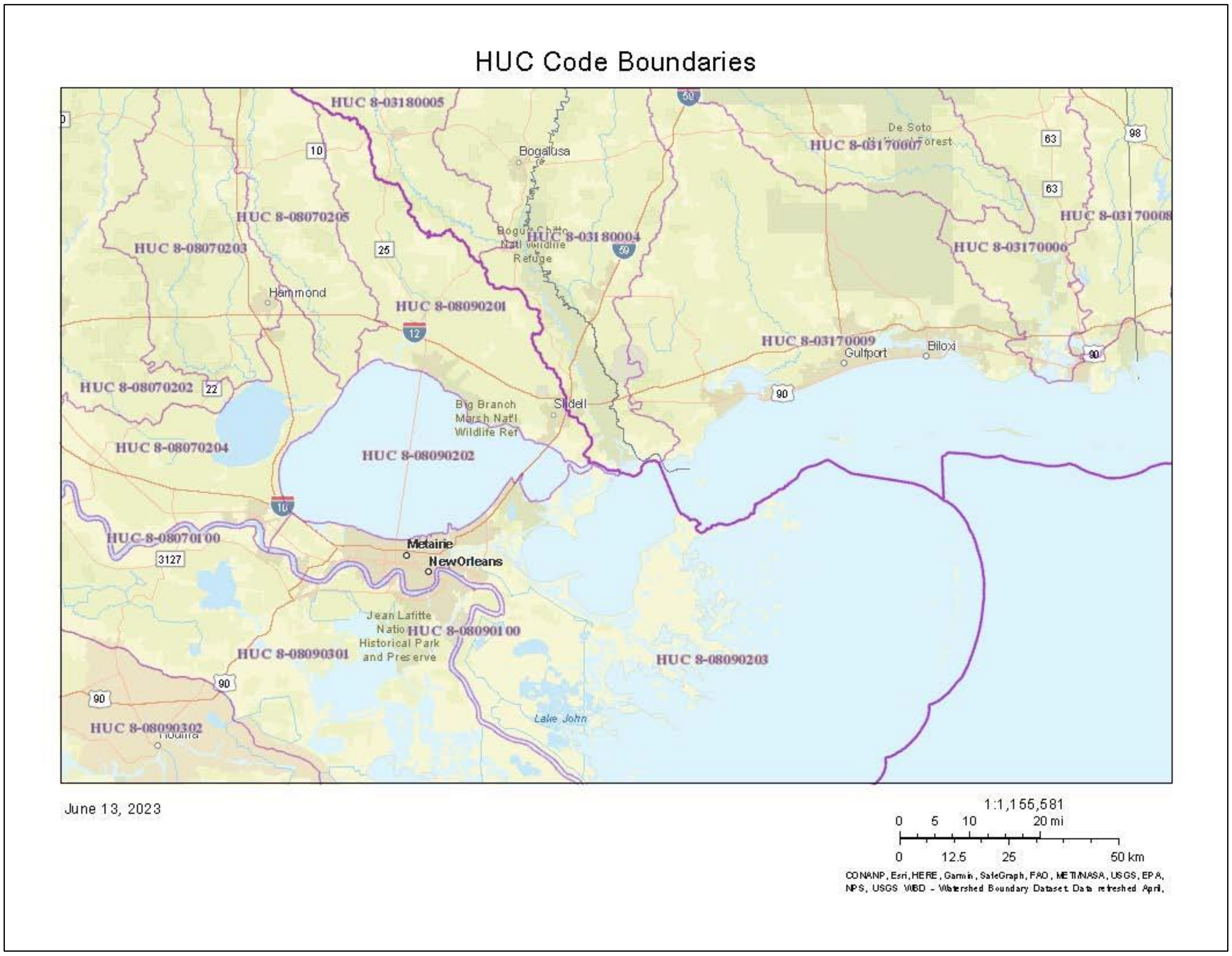


Figure 7. Map of Mississippi Coastal Watershed (HUC 03170009).

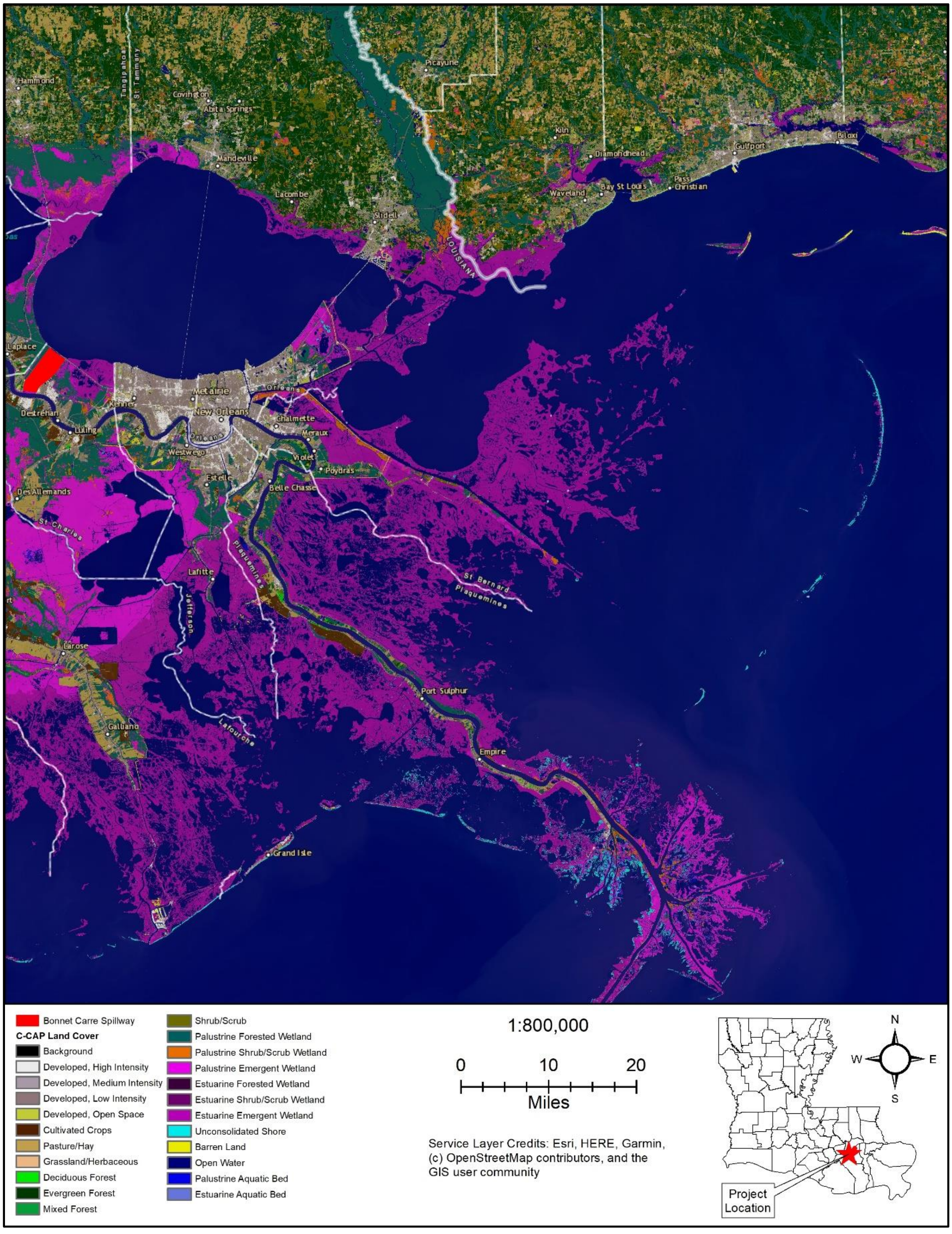


Figure 8. Land cover within the vicinity of the BCS. Data acquired from NOAA's Coastal Change Analysis Program (C-CAP).

2.3 ESSENTIAL FISH HABITAT

Six of the 12 habitats identified as necessary for life stages of fish, and therefore classified as EFH, occur within the area of potential effects:

- Emergent marshes
- Submerged aquatic vegetation (SAV);
- Soft bottom;
- Hard bottom (includes shell bottom and oyster reefs);
- Water column; and
- Mangroves

2.3.1 Emergent Marshes

Wetlands provide a diverse set of functions and provide ecological, economic, and social benefits. The ability to perform a function is influenced by characteristics of the wetland and associated physical, chemical, and biological processes. Louisiana's coastal wetlands provide habitat for wildlife, finfish, shellfish, and other aquatic organisms, including threatened or endangered species. Emergent marshes are classified by their salinity regimes and the corresponding plant communities; although, plant communities commonly possess a combination of plant species present in several classes of marsh (Chabreck 1972).

2.3.1.1 Fresh Marsh

Fresh marsh typically lies farther inland than other marsh types and is not influenced by tidal actions (Chabreck 1972). Fresh marshes are often the most diverse class of marsh and include dominant species such as maidencane (*Panicum hemitomon*), dollarweed (*Hydrocotyle sp.*), water hyacinth (*Eichornia crassipes*), pickerelweed (*Pontederia cordata*), bull tongue (*Sagittaria lancifolia*), and alligator weed (*Alternanthera philoxeroides*) (Chabreck 1972, Gosselink 1984). Fresh marsh within the area of potential effects is primarily concentrated along the westernmost interior shores of the Lake Pontchartrain Basin and portions of the interior marshes of western Mississippi Sound (MS Sound).

2.3.1.2 Intermediate Marsh

Intermediate marsh has a low salinity (approximately 0.0 to 5 ppt) and generally appears as a narrow band separating brackish marsh from a fresh marsh. Intermediate marsh supports a wide variety of plants including marshhay cordgrass (*Spartina patens*), deerpea (*Vigna luteola*), giant bullrush (*Schoenoplectus californicus*), saw-grass (*Cladium jamaicense*) and roseau cane (*Phragmites australis*). Due to the wide salinity tolerance range associated with many wetland plant species, intermediate marsh frequently includes species common in fresh marsh and brackish marsh (Chabreck 1972). Within the area of potential effects, small areas of intermediate marsh are interspersed among fresh and brackish marsh along the interior of Lake Pontchartrain.

2.3.1.3 Brackish Marsh

Seaward of intermediate marsh, brackish marsh has a salinity ranging from approximately 5 to 18 ppt, and *Spartina patens* is usually the dominant species (Chabreck 1972, Gosselink 1984).
Similar to intermediate marsh, brackish marsh provides valuable nursery habitat for larval and juvenile forms of many estuarine and marine species as well as wintering habitat for large numbers of waterfowl. Within the area of potential effects, brackish marsh can be found along the interior shores of eastern Lake Pontchartrain and the interior marshes of Lake Borgne and Biloxi Marsh.

2.3.1.4 Salt Marsh

Salinity within the salt marsh ranges from 18.0 to 30 ppt and can experience salinity shifts on a seasonal, and sometimes daily, basis depending on weather conditions, tides, and rainfall (Conner and Day 1987). *Spartina alterniflora* is commonly the dominant vegetation present (Chabreck 1972). Warmer temperatures and decreasing frequency of freeze events are contributing to the expansion of black mangroves (*Avicennia germinans*) into the salt marshes of southeast Louisiana (Ning et al. 2003, IPCC 2007, Perry and Mendelssohn 2009, Sherrod and McMillan 1985). Salt marsh within the area of potential effects is primarily located along the shorelines of Lake Borgne and outer coastal marsh habitats of Biloxi Marsh and Mississippi that extend into the Gulf of Mexico.

2.3.2 SAV

SAV supports a diverse epiphytic biota, exports organic matter and nutrients into the water column, oxygenates the water column and stabilized bottom sediments by reducing current velocity and wave energy. In turn, these processes affect species composition, biomass, and distribution of the SAV as well as the fauna that rely on SAV for habitat (Koch 2001). Salinity, water depth, and turbidity influence SAV species distributions and biomass. Abundance and biomass have been found to be significantly lower in the saline environment compared to other marsh habitats (Hillmann et al. 2017). Within Lake Pontchartrain, the dominant SAV species are American wild celery (*Vallisneria americana* Michx) and Widgeon grass (*Ruppia maritima* L.), both of which declined by 50-75% between 1954 and 1992 due to water quality impairment (Turner et al. 1980, Cho and Poirrier 2005). The largest remaining SAV beds in Lake Pontchartrain occur along the northeastern shore, and only small patches remain on the southeastern shore (Cho and Poirrier 2005). Historically, SAV has been absent from the western shorelines of Lake Pontchartrain (Cho 2003). SAV beds comprised primarily of Widgeon grass and Eurasian water milfoil (*Myriophyllum spicatum*) are common within the littoral zones, ponds and small bayous of Lake Borgne, Lake Catherine, and Biloxi Marsh (Poirrier et al. 2017). It is likely that other SAV exist within the APE; however, most of the areas have not been surveyed for SAV. A recent model predicted there is a high likelihood that SAV is found in several locations within the APE (DeMarco et al., 2018). These areas were primarily within the Biloxi Marsh, sporadically around Lake Borgne, around Lake Catherine, and Lake Pontchartrain.

2.3.3 Soft Bottom

Soft bottoms consist of unconsolidated sediment and unvegetated areas. They include mud, clay, sand and silt substrates, and are the most extensive habitat in the area of potential effects extending from the interior of western Lake Pontchartrain to the easternmost portion of the area of potential effects located in Chandeleur Sound and MS Sound. Soft bottoms provide essential habitat throughout many life stages of fish and shellfish. They may also be important nursery areas for some species. Many species utilize soft bottom habitats in early life stages, then move to deeper habitats or emigrate to shelf habitats in adulthood. Species use and abundance may be affected by characteristics including substrate grain size, salinity, turbidity, dissolved oxygen levels, and water circulation.

2.3.4 Hard Bottom

Hard bottom habitat occurs where rocks or other hard surfaces are exposed from water bottoms. Hard bottom habitat often provides the only structure and refuge for open ocean species, attracting large numbers of fish and aquatic species that utilize hard bottom habitat for foraging, spawning, and refuge.

2.3.4.1 Sand/Shell Bottom

Shell bottoms include course sandy material, shell, and a mix of shell hash or rubble. Low-profile accumulations of shell provide structure, refuge and concentrated food resources for various fish and invertebrate species (Zimmerman et al. 1989, Patterson et al. 2005, Wells et al. 2008).

Eastern oysters are sessile filter feeders distributed from the Gulf of St. Lawrence to the Gulf of Mexico and are common in coastal basins of the northern Gulf of Mexico (NOAA 1997). Eastern oysters provide numerous ecosystem services, including enhancement of biodiversity, water quality improvement, and shoreline stabilization (NOAA 1997). Within the area of potential effects, oyster reefs and seed grounds are located within the vicinity of Lake Borgne, Biloxi Marsh, Chandeleur Sound, and MS Sound (Figures 9 and 10). Oyster reefs provide valuable hard-structure habitat that estuarine fish and invertebrates can use for feeding and as predation refuge (La Peyre et al. 2014). Higher fish species richness, biomass and abundance have been documented at oyster reefs compared to unstructured estuarine habitat (Coen et al. 2007). Oyster reefs can also help reduce wave stress and stabilize shorelines to reduce marsh erosion and shoreline retreat rates (La Peyre et al. 2014, La Peyre et al. 2015, Pizza et al. 2005).

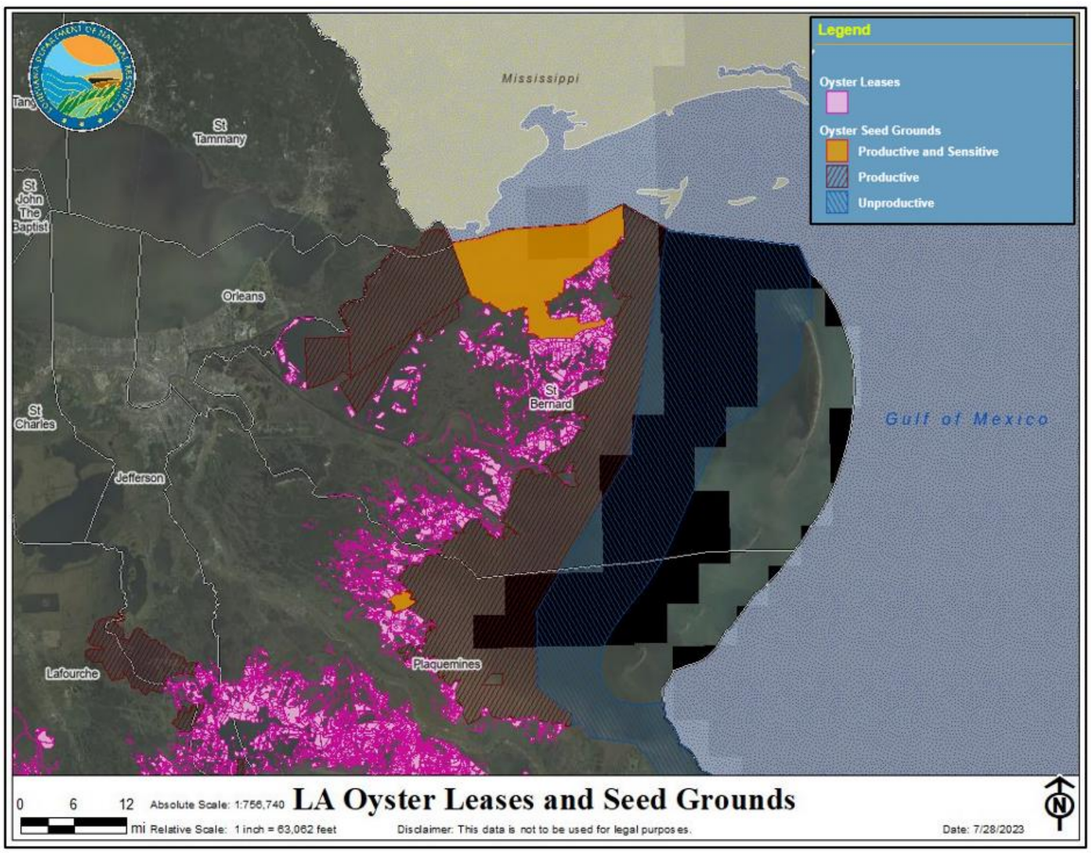


Figure 9. Louisiana Oyster Leases and Seed Grounds in the vicinity of the area of potential effects. Figure obtained from LDNR - Strategic Online Natural Resources Information System (SONRIS).

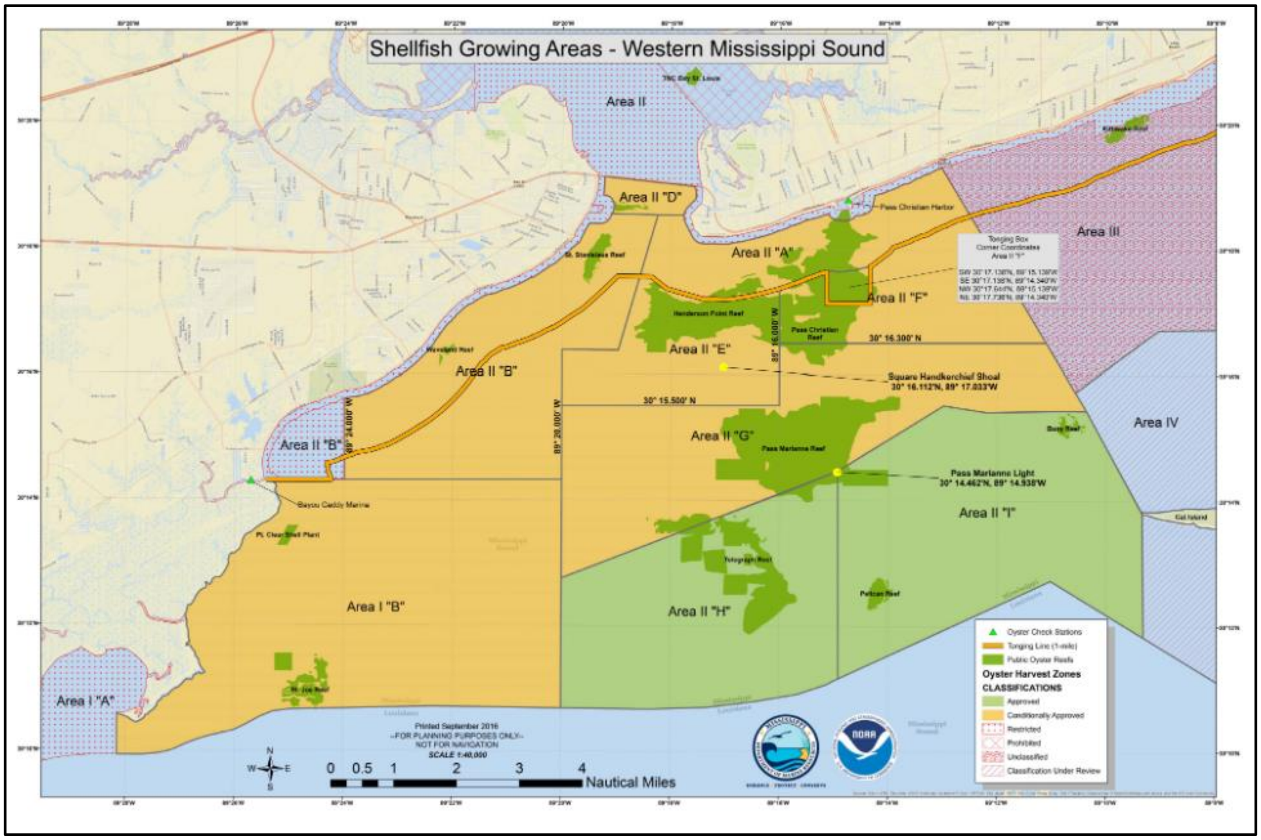


Figure 10. Oyster reefs and oyster growing areas of western MS Sound. Figure obtained from the Shellfish Bureau of MDMR.

2.3.5 Water Column

Open water in the area of potential effects includes natural and dredged/excavated channels and open water ponds or bays that are designated as deepwater habitats by Cowardin et al. (1979). These open water habitats are further classified as either lacustrine or riverine for freshwater systems and estuarine or marine for saltwater systems. The area of potential effects from the western portion of Lake Pontchartrain east to the coastal areas of Louisiana and Mississippi is an estuarine system, and transitions to a marine system along the outermost portions of the area of potential effects located in the open waters of the Gulf of Mexico.

2.3.6 Mangroves

Mangrove forests typically only grow in tropical and subtropical latitudes, but increasing temperatures and less frequent extreme freezes have facilitated northward expansions of the black mangrove (*Avicennia germinans*) into the marshes of coastal Gulf of Mexico (IPCC 2007, Ning et al. 2003, Perry and Mendelssohn 2009, Sherrod and McMillan 1985). Black mangroves colonize bare patches in the higher elevations of salt marshes and have demonstrated the ability to outcompete salt marsh plants in the areas by shading (Patterson et al. 1997, Pickens and Hester 2010, Stevens et al. 2006). Like marshes, mangrove forests are highly productive and support a diversity of ecologically important fauna (Smee et al. 2017, Vaslet et al. 2012). Black mangrove observations along coastal Louisiana are shown in Figure 11 (Osland et al. 2020).

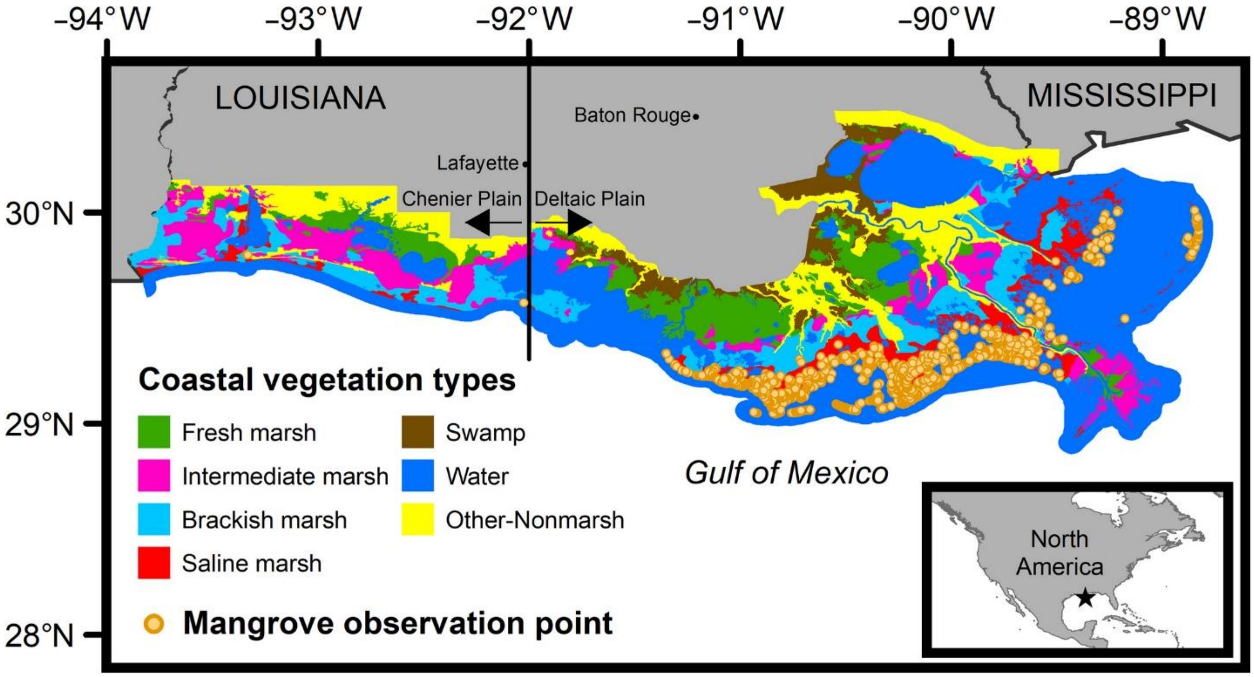


Figure 11. Map of black mangrove observations in coastal Louisiana (Osland et al. 2020).

2.4 FISHERIES SPECIES

Several federally managed fish and shellfish species and their EFH are known to occur within the area of potential effects. These include 3 shrimp species, red drum, 2 coastal migratory pelagic fish species, 2 reef fish species, and 9 highly migratory fish species (Table 2).

Table 2. Species, life history stages, and associated EFH habitat types present within the area of potential effects.

FMP	Species	Life Stage	EFH Habitat
Shrimp	Brown Shrimp	postlarvae	water column associated; nearshore
		juveniles	submerged aquatic vegetation; emergent marsh; oyster reef; soft bottom; sand/shell; estuarine
		subadults	soft bottom; sand/shell; nearshore; estuarine
	Pink Shrimp	juveniles	submerged aquatic vegetation; soft bottom; sand/shell; mangroves; oyster reef; estuarine; submerged aquatic vegetation; mostly nearshore
		subadults	submerged aquatic vegetation; soft bottom; sand/shell; mangroves; mostly nearshore
	White Shrimp	postlarvae	water column associated
		juveniles	emergent marsh; submerged aquatic vegetation; oyster reef; soft bottom; mangroves
		subadults	soft bottom; sand/shell
		adults	soft bottom
		spawning adults	soft bottom
Red Drum	Red Drum	eggs	water column associated; nearshore
		larvae	submerged aquatic vegetation; soft bottom; water column
		postlarvae	submerged aquatic vegetation; emergent marsh; soft bottom
		early juveniles	submerged aquatic vegetation; soft bottom; hard bottom; sand/shell
		late juveniles	submerged aquatic vegetation; emergent marsh; soft bottom; sand/shell
		adults	submerged aquatic vegetation; emergent marsh; soft bottom; hard bottom; sand/shell
Coastal Migratory Pelagic Fish	Spanish Mackerel	early juveniles	estuarine; water column associated; nearshore
		late juveniles	estuarine; water column associated; nearshore
		adults	estuarine; nearshore; water column associated
	Cobia	eggs	water column associated
		juveniles	water column associated; nearshore
		adults	water column associated; nearshore
		larvae	water column associated
Reef Fish	Lane Snapper	larvae	water column associated; submerged aquatic vegetation; nearshore; estuarine
		postlarvae	water column associated; submerged aquatic vegetation; nearshore; estuarine
		juveniles	submerged aquatic vegetation; sand/shell; soft bottom; banks/shoals; mangrove; nearshore; estuarine
	Gray Snapper	adults	nearshore: soft bottom, hard bottom, sand/shell; estuarine: soft bottom, emergent marsh
		juveniles	nearshore: soft bottom, hard bottom, sand/shell; estuarine: soft bottom, emergent marsh
		postlarvae	water column associated; submerged aquatic vegetation; nearshore; estuarine
Highly Migratory Species	Atlantic Sharpnose Shark	adults	water column associated; nearshore
		juveniles	water column associated; nearshore
		neonate	water column associated; nearshore
	Blacktip Shark	adults	water column associated; nearshore
		juveniles	water column associated; nearshore
		neonate	water column associated; nearshore; estuarine
	Bonnethead Shark	adults	water column associated; nearshore
		juveniles	water column associated; nearshore
		neonate	water column associated; nearshore
	Bull Shark	adults	water column associated; nearshore; estuarine
		juveniles	water column associated; nearshore; estuarine
		neonate	water column associated; nearshore; estuarine
	Finetooth Shark	adults	water column associated; nearshore
		juveniles	water column associated; nearshore
		neonate	water column associated; nearshore
	Lemon Shark	adults	water column associated; nearshore
	Sailfish	adults	water column associated; nearshore
	Scalloped Hammerhead Shark	adults	water column associated; nearshore
		juveniles	water column associated; nearshore
	Spinner Shark	adults	water column associated; nearshore
		juveniles	water column associated; nearshore
		neonate	water column associated; nearshore

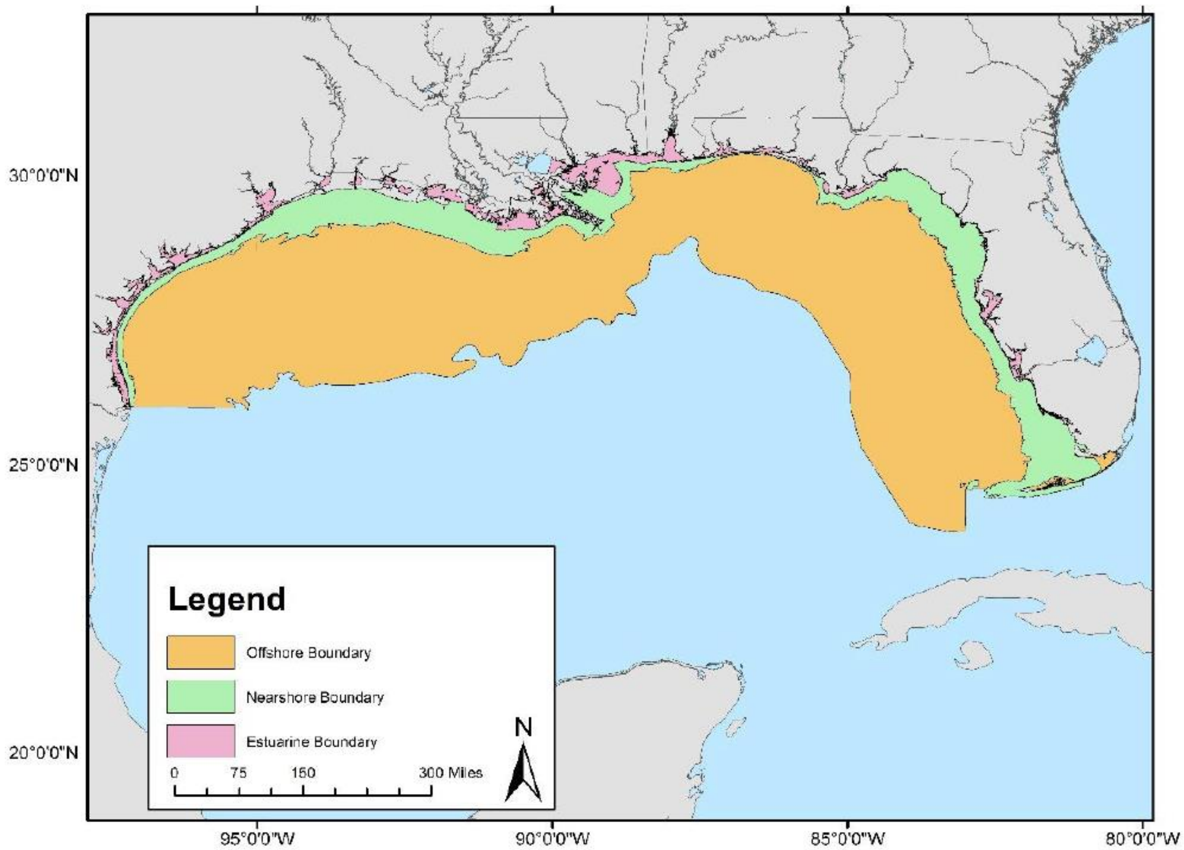


Figure 12. Spatial depiction of estuarine (inside barrier island and estuaries), nearshore (less than 18 m in depth), and offshore (greater than 18 m in depth) habitat zones referenced in species descriptions (GMFMC 2016).

2.4.1 Coastal Migratory Pelagic Fish

EFH for coastal migratory pelagic fish consists of Gulf of Mexico waters and substrates extending from the US/Mexico border to the boundary between the areas covered by the GMFMC and the South Atlantic FMC from estuarine out to depths of 183 meters (NOAA 2016).

2.4.1.1 Spanish Mackerel (Scomberomorus maculatus)

Spanish mackerel occur in coastal zones of the western Atlantic and throughout the Gulf of Mexico at depths up to 75 m (GMCMC 2016). Spanish mackerel is an epipelagic and neritic species often found in large schools which, in the past, have covered several square kilometers of area (NOAA 1997, Berrien and Finan 1977). Spawning occurs from May to September, with eggs occurring at depths less than 50 m (GMFMC 2016). Juveniles are found offshore and in beach surf, and are not considered estuarine dependent (NOAA 1997). Adults are typically found offshore in neritic waters and along coastal areas, usually near barrier islands and passes (NOAA 1997). Spanish mackerel is an important commercial and recreational species along the Gulf Coast, prized for its high food quality (NOAA 1997, Kilma 1959, Moe 1972, Powell 1975).

2.4.1.2 Cobia (*Rachycentron canadum*)

Cobia are a predatory pelagic species found in coastal nearshore and offshore waters of the Gulf of Mexico, at depths ranging from 1 meter to 70 meters. They are most commonly associated with shoals over hard banks, buoys, shipwrecks, oil rigs and other hard surfaces (GMFMC 2016). Adults feed on fishes and crustaceans, including crabs and shrimp. Cobia migrate seasonally from March through October between spawning and rearing habitats, determined primarily by suitable temperature conditions.

2.4.2 Red Drum (*Sciaenops ocellatus*)

EFH for red drum within the Gulf of Mexico consists of all Gulf of Mexico estuaries; waters and substrates extending from Vermilion Bay, Louisiana to the eastern edge of Mobile Bay, Alabama out to depths of approximately 45 meters; waters and substrates extending from Crystal River, Florida to Naples, Florida between depths of approximately 9 and 18 meters; waters and substrates extending from Cape Sable, Florida to the boundary between the areas covered by the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council between depths of 9 and 18 meters (GMFMC 2021).

2.4.2.1 Red Drum

Depending on life stage, red drum are found from estuarine to offshore waters and occur over a variety of habitat types including SAV, soft bottom, hard bottom, emergent marsh, sand/shell; in early life stages they are associated with the water column (GMFMC 2004, 2016). Red drum spawn on the northern Gulf of Mexico shelf during a relatively brief period, generally August into October (Wilson and Nieland 1994). The larvae and early juveniles are carried by tides and currents in late fall to the shallow estuaries, with peak ingress occurring in October. Larvae are carried through barrier island passes in the surface waters and juveniles move from the bay up the estuary to quiet backwater nursery areas to grow.

2.4.3 Reef Fish

EFH for reef fish consists of Gulf of Mexico waters and substrates extending from the US/Mexico border to the boundary between the areas covered by the GMFMC and the South Atlantic FMC from estuarine waters out to depths of 183 meters (NOAA 2015). The following reef species may occur within the area of potential effects.

2.4.3.1 Lane Snapper (*Lutjanus synagris*)

Lane snapper can be found throughout the Gulf of Mexico and in the western Atlantic from North Carolina to southeastern Brazil. Juveniles and adults are found across most habitat types, including SAV, sand/shell, reefs, soft bottom, banks, shoals, and mangroves. Adults occupy nearshore and offshore waters, at depths from 4 meters to 132 meters and temperatures of 61 °F to 84 °F (GMFMC 2016).

2.4.3.2 Gray Snapper (*Lutjanus griseus*)

Gray snapper occur in estuaries and shelf waters of the Gulf of Mexico and are particularly abundant off south and southwest Florida. Considered to be one of the more abundant snappers inshore, the gray snapper inhabits waters to depths of about 180 meters. Adults are demersal and mid-water dwellers, occurring in marine estuarine and riverine habitats. They occur up to 19.9 miles offshore and inshore as far as coastal plain freshwater creeks and rivers (GMFMC 2016).

2.4.4 Shrimp

EFH for shrimp consists of Gulf of Mexico waters and substrates extending from the US/Mexico border to Fort Walton Beach, Florida. Within the area of potential effects, EFH includes estuarine waters out to depths of 183 meters, and waters substrates extending from Grand Isle, Louisiana to Pensacola Bay, Florida, between depths of 183 to 594 meters (NOAA 2015).

2.4.4.1 Brown Shrimp (Farfantepenaeus aztecus)

Brown shrimp are benthic omnivores distributed from Massachusetts to southern Florida, and throughout the Gulf Coast to the northwestern Yucatan Peninsula (NOAA 1997). The highest abundance of brown shrimp occurs along the Louisiana, Texas, and Mississippi coasts and the shelf waters in the northern Gulf Coast. (Allen et al. 1980, NOAA 1985, Williams 1984). Brown shrimp are an estuarine-dependent species, spending some or all of their life cycle within an estuary. Brown shrimp spawn in depths greater than 18 m during the fall and spring, and postlarvae migrate to estuaries primarily from February to April (GMFMC 2004). Subadult brown shrimp migrate to offshore areas in the summer, supporting valuable commercial inshore and offshore fisheries (GMFMC 2016).

2.4.4.2 White Shrimp (Litopenaeus setiferus)

White shrimp can be found in coastal Gulf of Mexico within estuaries and nearshore habitat up to depths of 40 m (GMFMC 2016). White shrimp spawn from spring through fall in depths between 9-34 m, and postlarvae migrations into estuaries occur from spring through fall, with migration peaking in June and September (GMFMC 2016). Juvenile white shrimp inhabit mostly mud bottoms, feeding on sand, detritus, organic matter and various crustaceans (Darnell 1958, GMFMC 2016). Adult white shrimp inhabit soft mud or silt bottoms of the Gulf at depths less than 30 m (GMFMC 2004).

2.4.4.3 Pink Shrimp (Farfantepenaeus duorarum)

Pink shrimp occur in estuaries and nearshore to depths up to 110 m, with population densities highest in Gulf waters in or near seagrasses at depths ranging from 9-48 m (GMFMC 2016). Pink shrimp spawn year-round in the Tortugas, and postlarvae migrate into estuaries primarily during the spring and fall (GMFMC 2016). They prefer to inhabit sand/shell mud mixtures with less than one percent organic material, feeding on macrophytes, algae, diatoms, crustaceans, and fish (Eldred et al. 1961).

2.4.5 Atlantic Highly Migratory Species

2.4.5.1 Atlantic Sharpnose Shark (Rhizoprionodon terraenovae)

The Atlantic sharpnose shark is a small, abundant coastal shark known to occur in a variety of coastal habitats and bottom types in the Gulf of Mexico (Figure 10) (Cortés 2002, McCandless et al. 2002). This wide-ranging habitat utilization reflects seasonal migration patterns consisting of a migration to coastal waters beginning in April and emigration offshore in the fall (Carlson and Brusher 1999). Atlantic sharpnose sharks across all size classes primarily feed on teleost fishes (Drymon et al. 2012).

EFH for Atlantic sharpnose shark life stages are as follows:

- Neonate and YOY EFH includes Gulf of Mexico coastal areas including offshore of Naples, Florida; localized areas between Panama City, Florida to Apalachicola; and between Mobile Bay, Alabama, and southern Texas (NMFS 2017).

- Juvenile (50 to 61 cm FL) and Adults (≥ 62 cm FL) EFH includes Gulf of Mexico coastal areas from the Florida Keys to Texas, out to a depth of 200 m (NMFS 2017).

2.4.5.2 Blacktip Shark (Carcharhinus limbatus)

The blacktip shark is circumtropical in shallow coastal waters and offshore surface waters of the continental shelves along southeastern United States from Virginia to Florida and the Gulf of Mexico. The blacktip shark is a fast-moving shark that often forms large schools that migrate seasonally north to south along the coast (Heupel and Simpfendorfer 2005). Adults are typically found further offshore than juveniles. Blacktip sharks are associated with warmer temperatures, slightly lowered DO, and mid to deeper water with a salinity of 30 percent or greater (McCallister et al. 2013; Ward-Paige et al. 2014) as well as near tidal inlets of moderate salinities that are proximate to deeper waters (Froeschke et al. 2010).

EFH for blacktip shark life stages are as follows:

- Neonate and YOY (≤61 cm fork length) EFH includes coastal areas, including estuaries, out to the 30 m depth contour in the Gulf of Mexico from the Florida Keys to southern Texas. EFH includes central Louisiana's nearshore coastal waters which serve as important pupping and nursery areas, such as habitats north of Dauphin Island, in the lower reaches of Mobile Bay, Fort Morgan, Sand Island, north of Horn Island, and near the mouth of Bay St. Louis. Neonates EFH is associated with water temperatures ranging from 20.8 to 32.2 °C, salinities ranging from 22.4 to 36.4 ppt, water depth ranging from 0.9 to 7.6 meters, and DO ranging from 4.32 to 7.7 mg/L in silt, sand, mud, and seagrass habitats (NMFS 2017).

- Juvenile (62 to 118 cm FL) and adult (≥ 119 cm FL) EFH includes Coastal areas out to 100 m depth contour in the Gulf of Mexico from the Florida Keys to southern Texas. EFH also includes coastal areas of Mississippi and Louisiana, including Mississippi Sound, Mobile Bay, Terrebonne Bay, Timbalier Bay, and Chandeleur Sound. EFH is associated with water temperatures ranging from 19.8 to 32.2 °C, salinities ranging from 7.0 to 36.8 ppt, water depth ranging from 0.7 to 9.4 m, and DO ranging from 4.28 to 8.30 mg/L. EFH includes multiple types of substrate - silt, sand, mud, and seagrass habitats (NMFS 2017).

2.4.5.3 Bonnethead Shark (Sphyrna tiburo)

The bonnethead shark inhabits the sand and mud bottoms of the shallow, warm coastal waters of the western hemisphere primarily feeding on benthic prey species such as crustaceans and mollusks (NMFS 2017, Castro 1983). Adults in northern Gulf of Mexico prefer habitats with temperatures higher than 30 °C and salinities ranging from 30 to 35 ppt (Ward-Paige et al. 2014). Bonnethead sharks are a fast-growing species and reproduce annually with one of the shortest gestation periods, estimated at 4.5 to 5 months, of all shark species (Parsons 1993). They do not migrate long distances and there is little to no mixing of populations and thus, scientific review of stock assessments indicates the presence of separate Gulf of Mexico and Atlantic stocks (Lombardi-Carlson 2007, NMFS 2017).

EFH for bonnethead shark life stages are as follows:

- Neonate and YOY (< 45 cm FL) EFH includes coastal areas from the Florida Keys through eastern Mississippi and from western Louisiana to Texas EFH includes important summer nursery areas for the Gulf of Mexico bonnethead.

- Juveniles (46 to 65 cm FL) EFH includes coastal areas in the Gulf of Mexico from the Florida Keys to Chandeleur Sound and along Texas.

- Adult (> 66 cm FL) EFH includes coastal areas from the Florida Keys to Chandeleur Sound, and along Texas, from Chandeleur Sound, Louisiana, and eastern Mississippi.

2.4.5.4 Bull Shark (Carcharhinus leucas)

The bull shark is a large, shallow-water shark that is common in warm seas and estuaries and is the only shark species possessing the physiological capability to travel hundreds of kilometers upstream while spending extended periods of time in freshwater (Castro 1983, Thorson et al. 1973). Bull sharks are distributed from New York to Brazil, including the Gulf of Mexico and Caribbean Sea. Louisiana's coastal estuaries serve an important nursery for bull sharks, including the interior of Lake Pontchartrain, the Pearl River system, Little Lake, Barataria Bay and its inland waters, the Terrebonne and Timbalier Bay system, and the Atchafalaya and Vermilion Bay system (Blackburn et al. 2007).

EFH for bull shark life stages are as follows:

- Neonate and YOY (< 77 cm FL) EFH in the Gulf of Mexico includes localized areas off the west coast of Florida such as the Caloosahatchee River area, Yankeetown, Tampa Bay, Charlotte Harbor, Ten Thousand Islands, and the Keys; the Florida Panhandle; coastal habitats between Mobile Bay and Lake Borgne. Coastal areas along Texas to the mouth of the Mississippi River, particularly the inland bay and bayou systems of Louisiana (i.e., interior of Lake Pontchartrain, the Pearl River system, Little Lake/Barataria Bay and its inland waters, the Terrebonne/Timbalier Bay system, and the Atchafalaya/Vermilion Bay system). EFH for neonates/YOY includes areas of shallow depth (less than 9 m) in lower salinity estuaries and river mouths (as low as 0.9 ppt) until water temperatures reach 21 °C.

- Juveniles (78 to 188 cm FL) and adults (> 189 cm FL) EFH in the Gulf of Mexico includes the Florida Keys, Ten Thousand Islands, Charlotte Harbor, Tampa Bay, Yankeetown, Pine Island Sound, the Florida panhandle, Mississippi Sound and Mobile Bay off the coasts of Mississippi and Alabama, interior of Lake Pontchartrain, the Pearl River system, around the Chandeluer Sound on the east side of the Mississippi River Delta, Little Lake/Barataria Bay and its inland waters, the Terrebonne/Timbalier Bay system, and the Atchafalaya/Vermilion Bay system in the coastal waters off Louisiana, the west side of Mississippi River Delta and, and coastal areas along the Texas coast, especially Matagorda Bay and San Antonio Bays.

2.4.5.5 Finetooth Shark (Carcharhinus isodon)

The finetooth shark is an inshore shark species found along the southeastern United States and the Gulf of Mexico (Castro 1983). The finetooth shark is often found near beaches and in bays and estuaries generally occurring in water temperatures averaging approximately 27 °C and shallow water depths of approximately 4 m (Carlson 2002).

EFH for finetooth shark life stages is as follows:

- EFH in the Gulf of Mexico includes shallow coastal waters of the northeastern Gulf of Mexico with muddy bottom (19.5-31.4 °C, 19-38 ppt, 2.3-5.3 m depth) the seaward side of coastal islands, especially around the mouth of the Apalachicola River and the gulf side of St. Vincent Island to just southeast of St. Andrews Bay Inlet, Florida. Also includes St. Vincent Sound, Saint Andrew Sound, Saint Joseph Bay, and Apalachicola Bay. Hyper-saline environmental conditions may spatially or temporally restrict neonate/YOY EFH in the western Gulf of Mexico, and should not be included in EFH. EFH also includes Bay St. Louis; Perdido Sound; Bon Secour Bay and lower Mobile Bay, Alabama; Terrebonne and Timbalier bay system, Louisiana (25.3-32.1 °C, 0.6 - 4.9 m depth); the Mississippi Sound, specifically north of and off western Horn, Sound, and Round Islands (YOY), between the islands and the coast of Louisiana; coastal areas of Texas, including portions of Corpus Cristi Bay, Aransas and Copano Bays, San Antonio Bay, Espiritu Santo Bay, Matagorda Bay, Galveston Bay, and Trinity Bay) (19.2-30.6 °C, 16-36 m depth) ; and beaches of the southeastern Texas coast (2.1-5.5 m depth) (NMFS 2017).

2.4.5.6 Lemon Shark (Negaprion brevirostris)

The lemon shark is a top predator in nearshore, shallow coastal areas, especially around coral reefs, with distribution extending throughout the Gulf of Mexico (Snelson and Williams 1981, Morrissey and Gruber 1993, NMFS 2017). Tagged lemon sharks indicated a wide geographical range during the summer months and an annual, temperature-driven pattern of migration to southeast Florida in the winter (Kessel et al. 2014).

EFH for lemon shark life stages are as follows:

- Neonate and YOY (≤ 75 cm FL) EFH includes the north side of the Florida Keys and Florida Bay to Naples, and coastal areas along Texas between Galveston Island and the Texas/Mexico border. Nursery areas are also immediately adjacent to the Chandeleur Islands off Louisiana, and include seagrass beds in shallow water (less than 2 m deep).

- Juveniles (76 to 200 cm FL) EFH includes habitats on the north side of the Florida Keys and Florida Bay to Naples especially areas where temperatures ranged between 26.4 to 31.3 °C, salinities of 23.2 to 31.2 ppt, depth of 0.9-5.4 m and DO of 5.2 to 6.7 mL/L in mud and seagrass areas (Bethea et al. 2014). EFH also includes coastal areas along Texas, and the Chandeleur Islands off Louisiana. EFH in the U.S. Caribbean includes coastal waters off Puerto Rico and the U.S. Virgin Islands.

2.4.5.7 Sailfish (Istiophorus platypterus)

Sailfish are circumtropical, epipelagic and coastal to oceanic species usually found within temperatures ranging from 21 to 28° C (Post 1998, Hoolihan et al. 2011). In the winter, sailfish can be found in small schools in offshore waters throughout the Gulf of Mexico, and disburse along the U.S. coast during the summer (NMFS 2017).

EFH for sailfish life stages are as follows:

- Spawning, eggs and larvae EFH in the Gulf of Mexico consists of offshore pelagic habitats from the Florida Keys to the continental shelf off of southern Texas. EFH extends from the 200m bathymetric line to the seaward extent of the U.S. EEZ (NMFS 2017).

- Juveniles (20 – 179 cm LJFL) EFH includes localized EFH in the central and northern Gulf of Mexico, between Apalachicola and southern Texas. Eastern Puerto Rico and Virgin Islands (NMFS 2017).

- Adults (≥ 180 cm LJFL) EFH in the Gulf of Mexico spans from coastal habitats off the western Florida panhandle and coastal Louisiana to offshore pelagic habitats associated with the continental shelf westward to the coast of Texas (NMFS 2017).

2.4.5.8 Scalloped Hammerhead Shark (Sphyrna mokarran)

The scalloped hammerhead shark is a large, widely distributed, schooling hammerhead shark once noted as being the most abundant hammerhead shark in the tropics (Compagno 1984). Scalloped hammerhead sharks are dependent upon coastal nursery areas and, within northern Gulf of Mexico, temperature and salinity are the most influential factors determining the occurrence of juveniles (Duncan et al. 2006, NMFS 2017).

EFH for scalloped hammerhead shark life stages are as follows:

- Neonate and YOY (≤ 45 cm TL) EFH includes coastal areas in the Gulf of Mexico including those adjacent to Charlotte Harbor and Tampa Bay, coastal areas of Florida around Apalachicola and Cape San Blas, and coastal Texas. EFH is located in temperatures of 23.2 to 30.2 °C, salinities of 27.6 to 36.3 ppt, DO of 5.1 to 5.5 mL/L, depths in the 5 to 6 m, and mud and seagrass substrate (NMFS 2017).

- Juveniles and adults (> 45 cm FL) EFH is located in the northern Gulf of Mexico from eastern Louisiana to Pensacola, Florida (Mississippi Delta to DeSoto Canyon) (NMFS 2017).

2.4.5.9 Spinner Shark (Carcharhinus falciformis)

Spinner shark is a common coastal-pelagic shark found on continental and insular shelf habitats in tropical and subtropical waters at depths ranging from less than 30 m deep inshore to at least 150 m deep offshore (Aubrey and Snelson 2007,Compagno 1984). Spinner sharks are a migratory species, but its migratory patterns are not well understood. Juveniles are typically found inshore of the 20 m bathymetric line, and adults are found inshore and offshore but generally not found in inland bays or bayous (NMFS 2017).

EFH for spinner shark life stages are as follows:

- Neonate and YOY (≤ 57 cm FL) EFH in the Gulf of Mexico includes coastal areas surrounding the Florida Keys and from the Big Bend Region to southern Texas. Gulf of Mexico EFH consists of sandy bottom areas where sea surface temperatures range from 24.5 to 30.5 °C and mean salinity is around 36 ppt (NMFS 2017).

- Juvenile and adult (> 57 cm FL) EFH in the Gulf of Mexico includes coastal areas from Apalachicola, Florida to southern Texas. In all locations, juveniles EFH extends from shore to depths to 20m, whereas adult EFH extends from shore to 90m in depth (NMFS 2017).

2.4.6 Prey for Managed Species

In addition to being designated EFH for federally managed species, the area potentially impacted by BCS operation also includes habitat for a variety of prey for species managed under the MSFCMA.

2.4.6.1 Blue Crab (Callinectes sapidus)

Blue crabs are found in coastal bays and estuaries around the world and are abundant in all life stages throughout the estuaries of the Gulf Coast (NOAA 1997). Blue crab eggs hatch near the mouths of estuaries and, following a one-month period of larval development in offshore waters, return to the estuaries where they tend to remain for the majority of their lives (O'Connell et al. 2017, Oesterling and Evink 1977, Perry et al. 1995). Small juveniles prefer shallow vegetated habitats while larger juveniles prefer muddy or sandy substrates in deeper channels and bays. Adult males spend most of their time in low salinity waters of upper estuaries, and females migrate to these lower salinities to mate (NOAA 1997, Williams 1984). After mating, females move in June and July to higher salinity regions of the lower estuary and near barrier islands. Adult blue crabs support important commercial and recreational fisheries in the Gulf and Atlantic Coasts.

2.4.6.2 Gulf Menhaden (Brevoortia patronus)

Gulf menhaden are abundant and primarily found in the Gulf of Mexico, forming large schools that support an extensive fishery dating back to the late 19th century (Nicholson 1978). Menhaden have a critical ecosystem role as a primary consumer and as prey to a wide variety of predators including piscivorous fishes (Ahrenholz 1991, Vaughan et al. 2007). Spawning occurs on the shelf, and larvae are carried into estuaries by currents. Feeding larvae move farther up the estuaries into shallow bays and river tributaries where they remain during the early juvenile stages of development (Christmas et al. 1982). As development continues, menhaden move into the higher salinity, deeper waters of the estuaries. Adult menhaden move inshore and into estuaries and rivers during spring and summer, and then onto the shelf to spawn during the fall and winter (Deegan 1990, Shaw et al. 1985).

2.4.6.3 Spotted Seatrout (Cynoscion nebulosus)

Spotted seatrout are non-migratory and estuarine-dependent, usually remaining in and near their natal estuaries (Callihan et al. 2013, Murphy 2011). All life stages of seatrout are common along the Gulf Coast, with life stage occurrences dependent upon the regions and salinity zones of the estuaries (Helser et al. 1993, Shepard 1986). Eggs are spawned in seagrasses or barrier island passes in the late spring and summer in the lower estuary (Sable et al. 2017). Larvae move into shallower channels to the intermediate and brackish salinity zones. Early juveniles remain in shallow marsh or SAV habitats for 4 to 5 months until they reach approximately 7 to 7.9 inches TL (Nieland et al. 2002). Late juvenile and adult spotted seatrout move throughout the estuary, likely in response to temperature and food supply, moving to warmer shallow waters along shorelines and the upper estuary in the winter and deeper cooler waters of the bays and barrier island passes in the summer. Adults move to the deep channels and the barrier island passes to spawn in the summer.

2.4.6.4 *Sand Seatrout (Cynoscion arenarius)*

Sand seatrout is one of the most abundant fisheries in estuarine and nearshore waters of the Gulf of Mexico (Gunter 1945, Christmas and Walker 1973). The sand seatrout is truly estuarine dependent and spends most of its life within estuaries with a distribution range limited to the coastal and shelf waters of the Gulf of Mexico (NOAA 1997). Larvae and juveniles prefer grass beds and marsh areas with soft bottoms, while adults can be found over most estuarine bottom types (NOAA 1997, Conner and Truesdale 1972, Benson 1982). The sand seatrout serves as an import link between estuarine and marine food webs as it provides a direct link between the primary consumers and the top predators (NOAA 1997). The abundance of sand seatrout, ranking among the top five most abundant species in demersal fish surveys, makes it one of the most important species caught in the industrial bottomfish and foodfish fisheries of the north Gulf of Mexico and the species is a major component of bycatch is shrimp trawls (Sheridan et al. 1984, Sutter and McIlwain 1987, NOAA 1997).

2.4.6.5 *Southern Flounder (Paralichthys lethostigma)*

The southern flounder is distributed throughout coastal and estuarine habitats of the Gulf of Mexico from Florida to Texas (NOAA 1997). Eggs and early larval stages are marine, occurring in neritic waters. Juveniles and adults are estuarine, riverine and marine in coastal areas depending on the size of the flounder, and can be found at depths up to approximately 40 m (NOAA 1997, Fischer 1978). Adults emigrate from estuaries to spawn in offshore waters during the fall and winter (Gunter 1945, Kelley 1965, Shepard 1986). Southern flounder occupy fine, unconsolidated substrates of clay silts and organic-rich muddy sands (Fischer 1978, Lee et al. 1980).

2.4.6.6 *Striped Mullet (Mugil cephalus)*

Striped mullet occur world-wide in warm tropical, sub-tropical and temperate waters (Anderson 1958, Moore 1974, Hoese and Moore 1977, Martin and Drewry 1978, Lee et al. 1980, Ward and Armstrong 1980). The species is pelagic at all life stages, occurring throughout the Gulf of Mexico in shallow marine and estuarine habitats (Gunter 1945, Moore 1974, Ward and Armstrong 1980, Arnold and Thompson 1958, Hoese and Moore 1977, Martin and Drewry 1978). Striped mullet live in a wide range of habitats and depths, depending on life stage, season, and location, including open beaches, flats, lagoons, bays, rivers, salt marshes, and grass beds (Gunter 1945, Kirby 1949, Breuer 1957, Renfro 1960, NOAA 1997). Striped mullet is one of the most important commercial fisheries in southern United States and Gulf Coast landings contribute the majority of the total U.S. catch (Newlin 1993). They are an important forage fish, forming a major component in the flow of energy through the estuarine system by feeding at the lowest trophic levels and providing food to birds and many important commercial and game fish (Kilby 1949, Fontenot and Rogillio 1970, Moore 1974, Sogard et al. 1989).

2.4.6.7 *Atlantic Croaker (Micropogonias undulatus)*

Atlantic croaker is a highly abundant species occurring in the Gulf of Mexico from southern Florida to central Mexico (NOAA 1997, Chao and Musick 1977, Hoese and Moore 1977, Fischer 1978). Juveniles and adults are estuarine dependent, while eggs and larvae are pelagic, and found within the mid to outer continental shelf (NOAA 1997). All life stages of Atlantic croaker, with the exception of eggs and larvae, prefer soft bottom habitats (Lassuy 1983). Larval croaker feed on zooplankton, while juveniles and adults are opportunistic benthic carnivores and prey upon benthic invertebrates and fishes (Lassuy 1983, Mercer 1989).

2.4.6.8 Pinfish (Lagodon rhomboides)

Pinfish are abundant throughout the Gulf of Mexico with the exception of the very turbid brackish waters of Louisiana west of the mouth of the Mississippi River (Hoese and Moore 1977). The pinfish is an estuarine dependent species numerically dominant in the shallow, subtidal seagrass communities in the Gulf, and often so abundant and predaceous that it is believed to alter the composition of estuarine epifaunal communities (Orth and Heck 1980, Coen et al. 1981, Stoner 1980, Stoner 1982, NOAA 1997). The consumption of plants and detritus by pinfish also make it important in the export of organic materials in estuaries (NOAA 1997).

2.4.6.9 Spot (Leiostomus xanthurus)

In the Gulf of Mexico, spot are common in both bays and open Gulf areas throughout the coastal shelf from Florida Bay to the Rio Grande River (Hoese and Moore 1977, Shipp 1986). Spot larvae are found in more saline nearshore habitats, and have been collected in the northern Gulf of Mexico on the continental shelf at depths up to 40 m (NOAA 1997). Younger juveniles are often found in the shallow upper estuaries of tidal creeks, and sometimes in seagrass beds, while older juveniles move to deeper, more saline areas of estuaries (Wang and Kernahan 1979, Mercer 1989, Hales and Van Den Avyle 1989). Adults migrate seasonally between estuarine and coastal waters, with movement offshore occurring in the fall (Hales and Van Den Avyle 1989). The spot can be a common inhabitant in environmentally stressed estuaries due to its tolerance of a wide range of environmental conditions (Killam et al. 1992).

2.4.6.10 Bay Anchovy (Anchoa mitchilli)

Bay anchovy are abundant in all life stages in the estuaries of the northern Gulf of Mexico, and the species likely has the greatest biomass of any fish in estuarine waters of both the southeastern U.S. and the Gulf of Mexico (Morton 1989, NOAA 1997). Habitat for all life stages of the bay anchovy are water-column associated, with larger bay anchovy preferring deeper water farther from shore, over coarser substrates and cooler temperatures (NOAA 1997, Jones et al. 2002). Due to its high biomass and importance in estuarine food webs, bay anchovy is often used as an indicator species of estuarine health (NOAA 1997).

2.4.6.11 Gulf Killifish (Fundulus grandis)

Gulf killifish within the Gulf of Mexico occur within estuaries from Florida to Texas (Springer and Woodburn 1960, Price and Schlueter 1985, Comp 1985, NOAA 1997). All life stages of gulf killifish are estuarine residents, inhabiting shallow waters near the shores of oyster bars, tidal pools, sloughs, salt water creeks, bayous, marsh pools, and coastal inland ponds (Gunter 1945, Gunter 1950, Reid 1955, Simpson and Gunter 1956, Renfro 1960, Gunter 1967, Wagner 1973, Hoese and Moore 1977, Swift et al. 1977). In estuaries, they are common among emergent vegetation and over bottoms that consist of hard muddy sand, mud, silt, clay, detritus, or shell, with occasional seagrass or algae present (Gunter 1945, Reid 1955, Simpson and Gunter 1956, Renfro 1960, Springer and Woodburn 1960, NOAA 1997).

Figure 13. Coastal Migratory Pelagic fish EFH within the vicinity of the BCS.

Figure 14. Red Drum EFH within the vicinity of the BCS.

Figure 15. Reef Fish EFH within the vicinity of the BCS.

Figure 16. Shrimp EFH within the vicinity of the BCS.

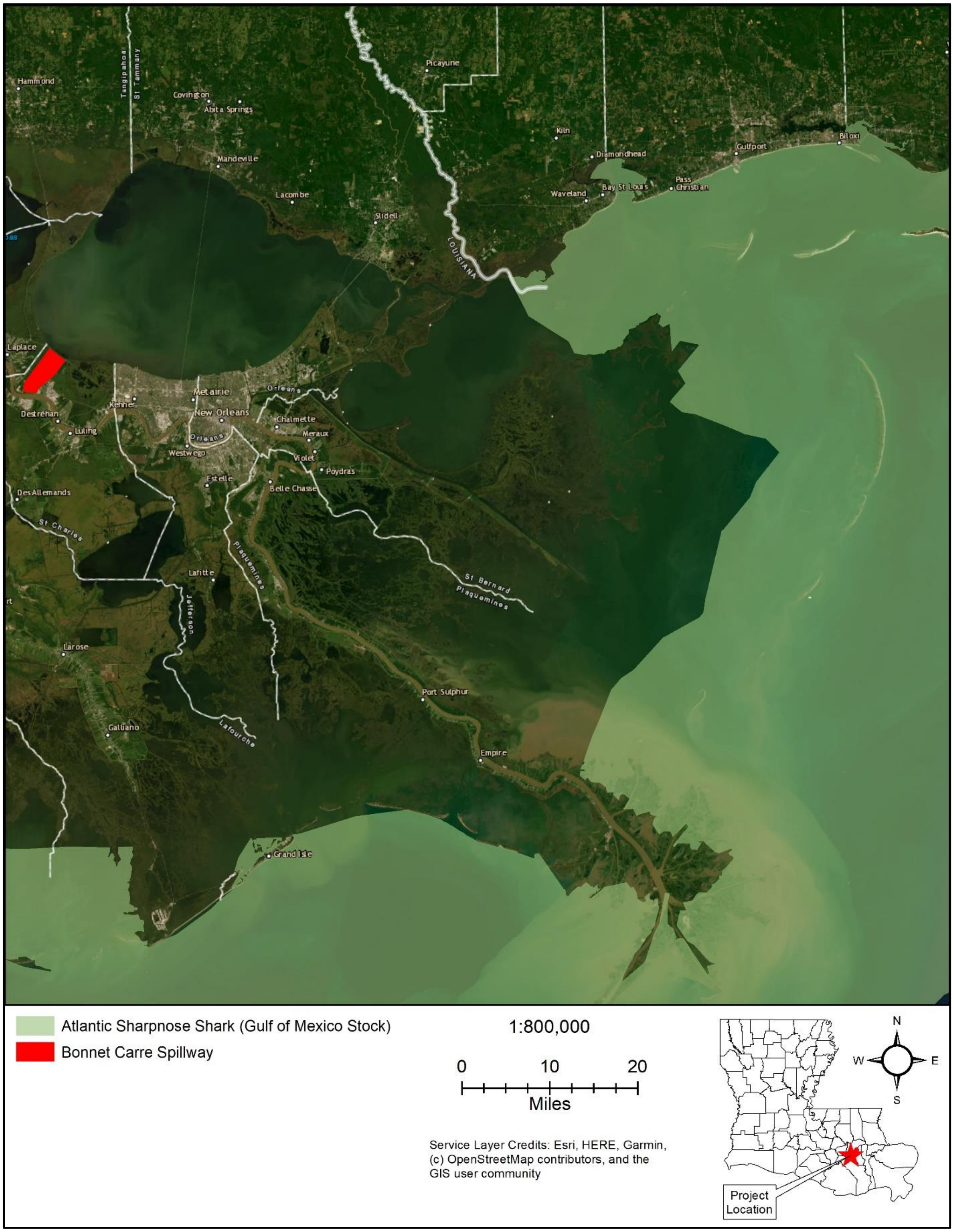


Figure 17. Atlantic Sharpnose Shark EFH within the vicinity of the BCS.

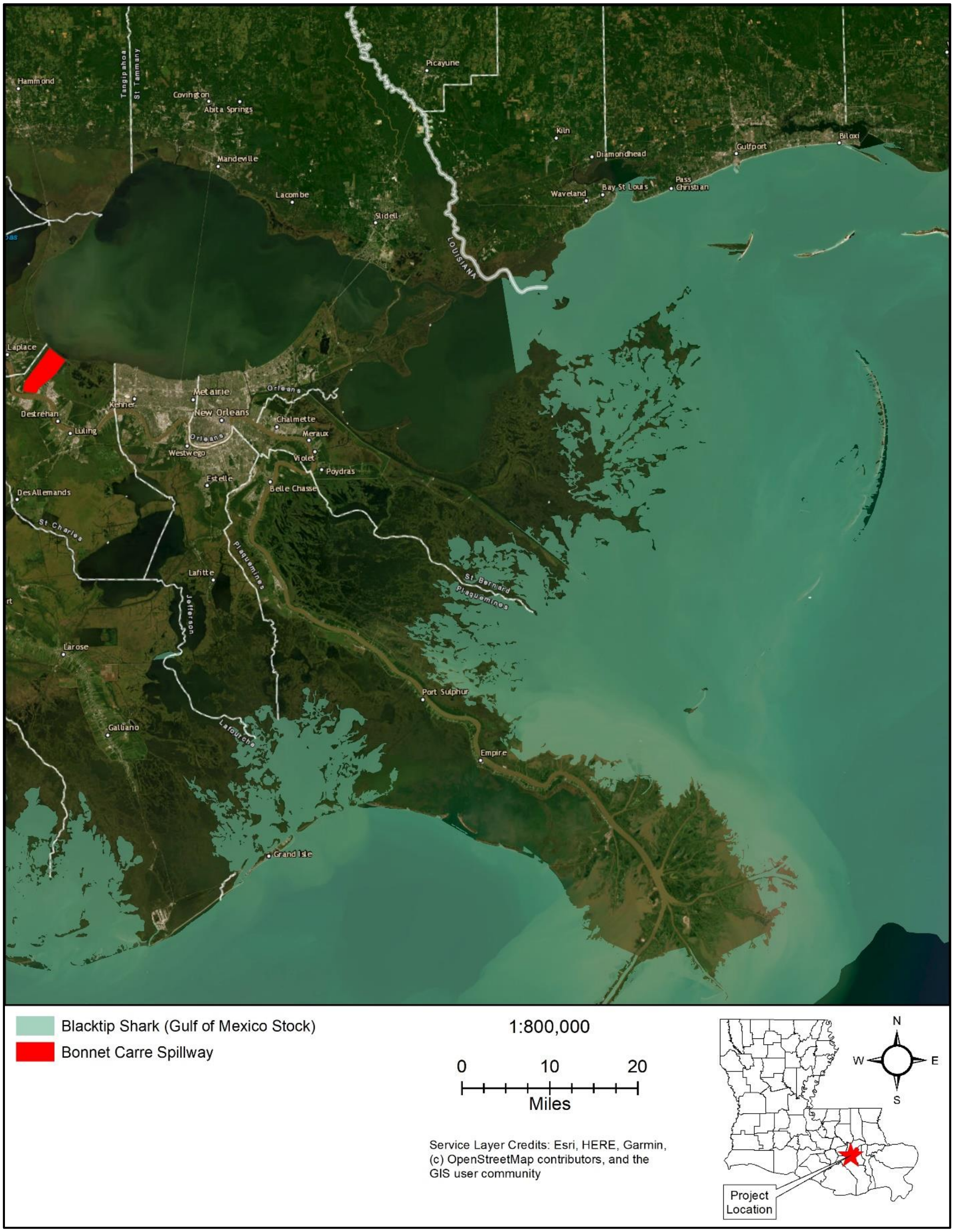


Figure 18. Blacktip Shark EFH within the vicinity of the BCS.

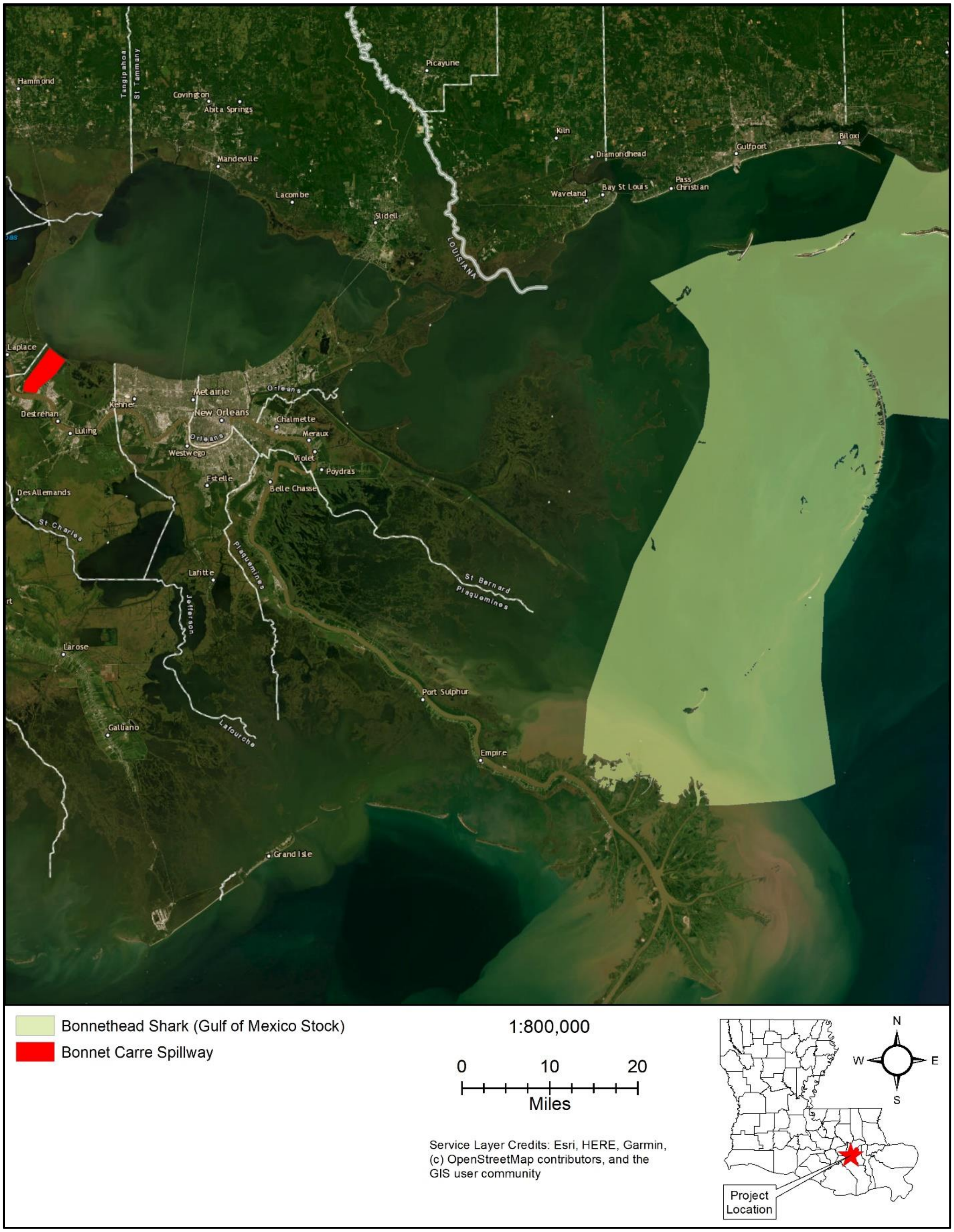


Figure 19. Bonnethead Shark EFH within the vicinity of the BCS.

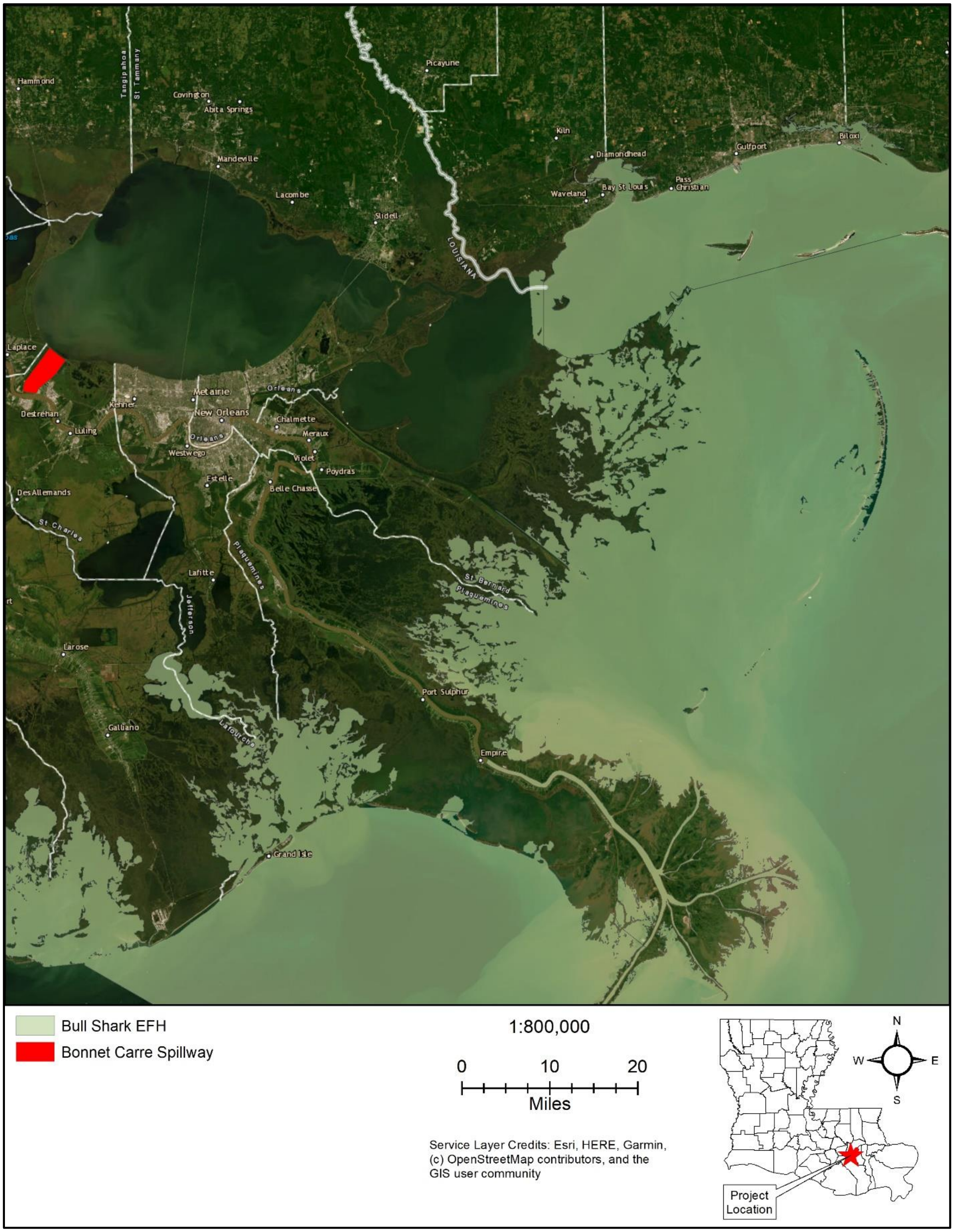


Figure 20. Bull Shark EFH within the vicinity of the BCS.

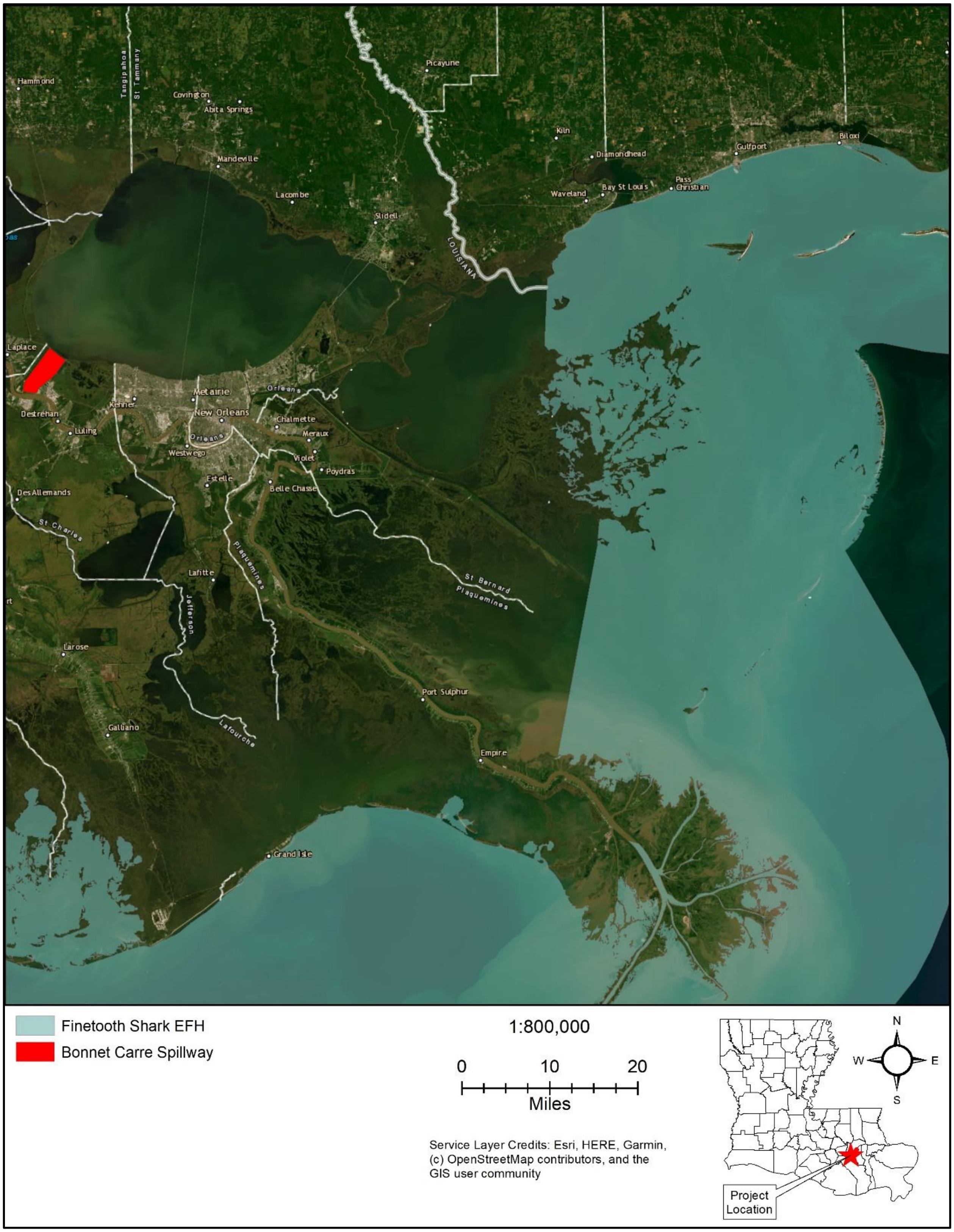


Figure 21. Finetooth Shark EFH within the watersheds impacted by BCS operation.

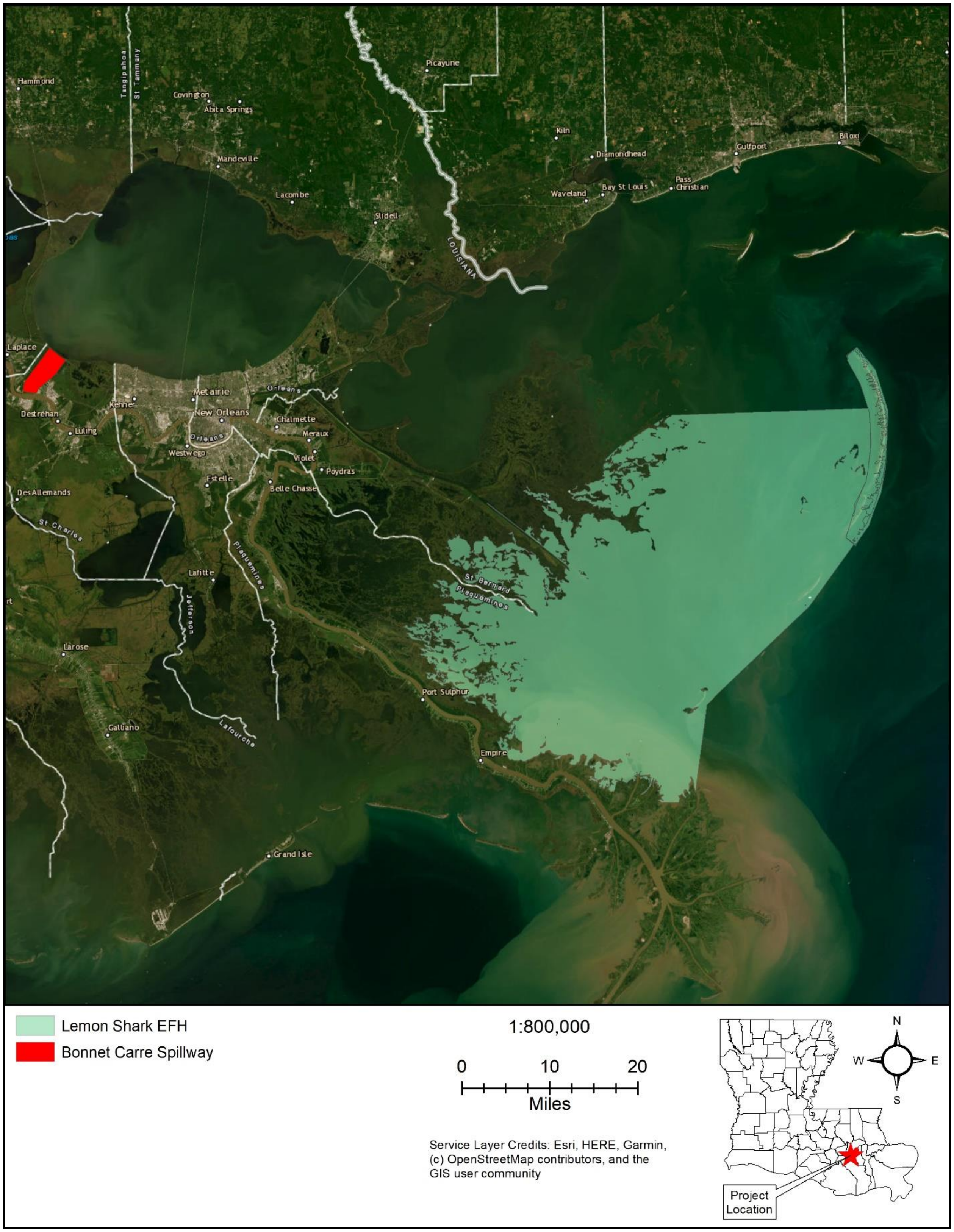


Figure 22. Lemon Shark EFH within the vicinity of the BCS.

Figure 23. Sailfish EFH within the vicinity of the BCS.

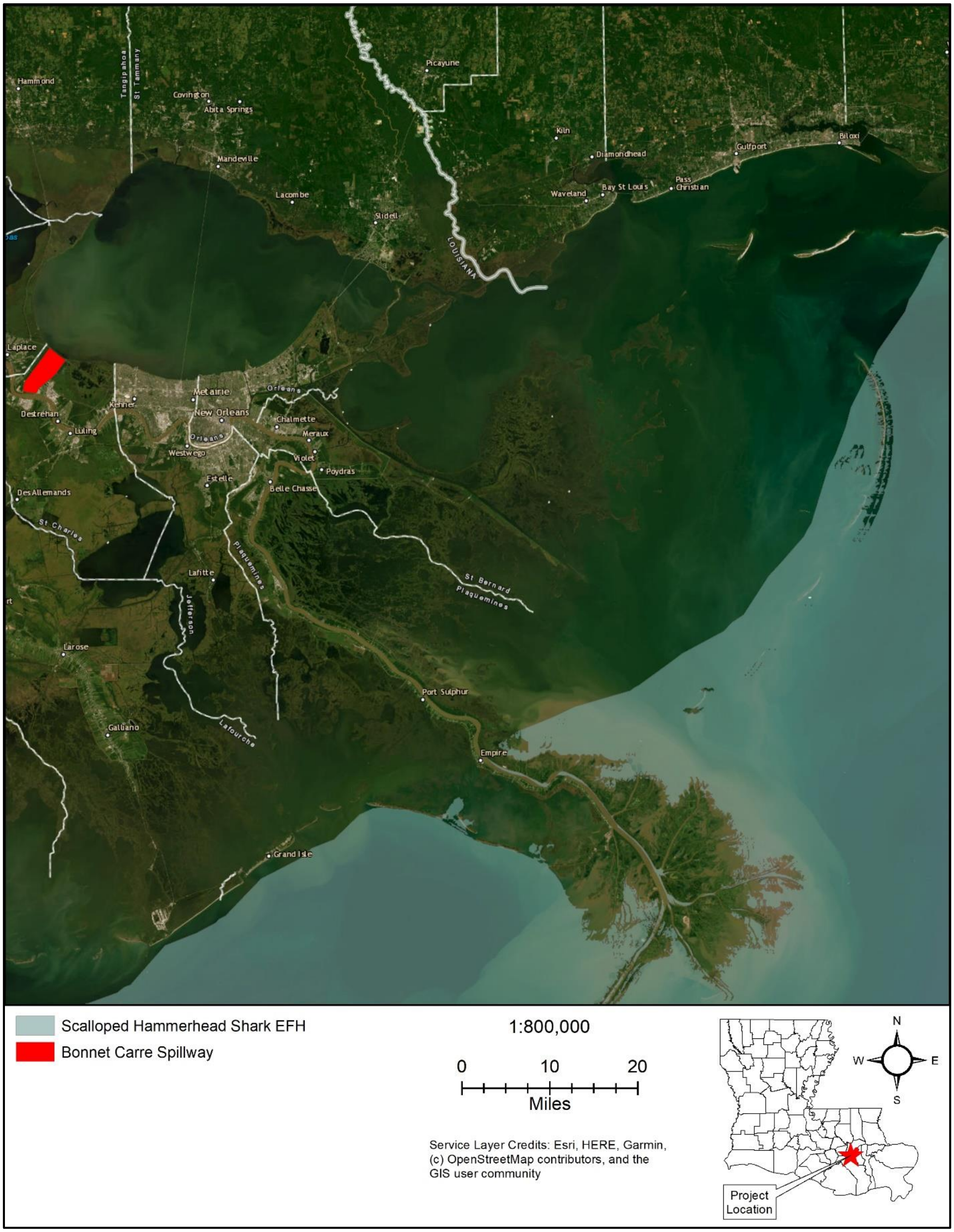


Figure 24. Scalloped Hammerhead Shark EFH within the vicinity of the BCS.

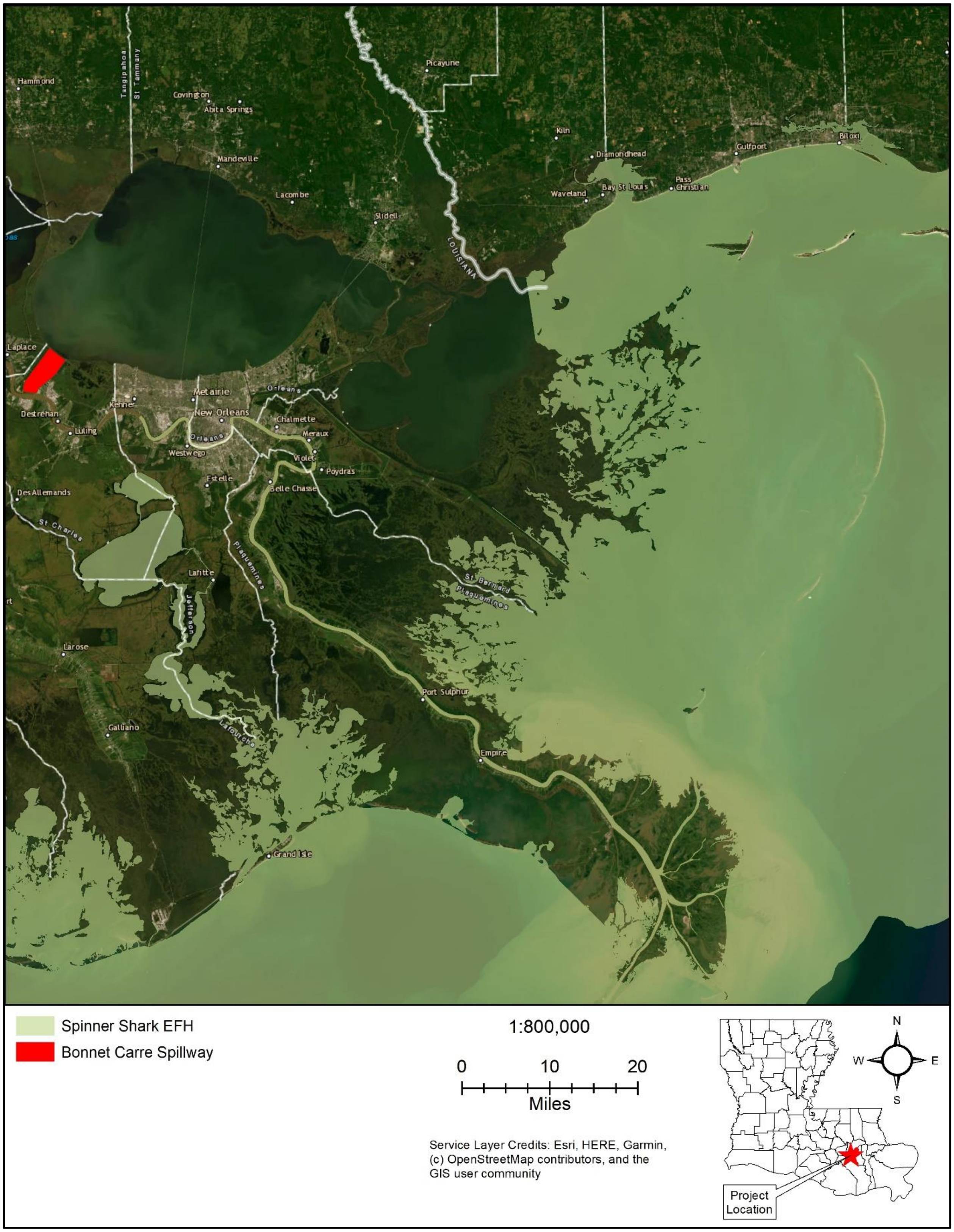


Figure 25. Spinner Shark EFH within the vicinity of the BCS.

3 OPERATION AND MAINTENANCE IMPACTS

3.1 USGS SAMPLING STATIONS

The U.S. Geological Survey (USGS) operates several continuous water-quality gages in Lake Pontchartrain and the Mississippi (MS) Sound and collects discrete water quality samples at several other stations during Bonnet Carré Spillway (BCS) operation in partnership with USACE. Data from the stations shown below are the focus of this report.

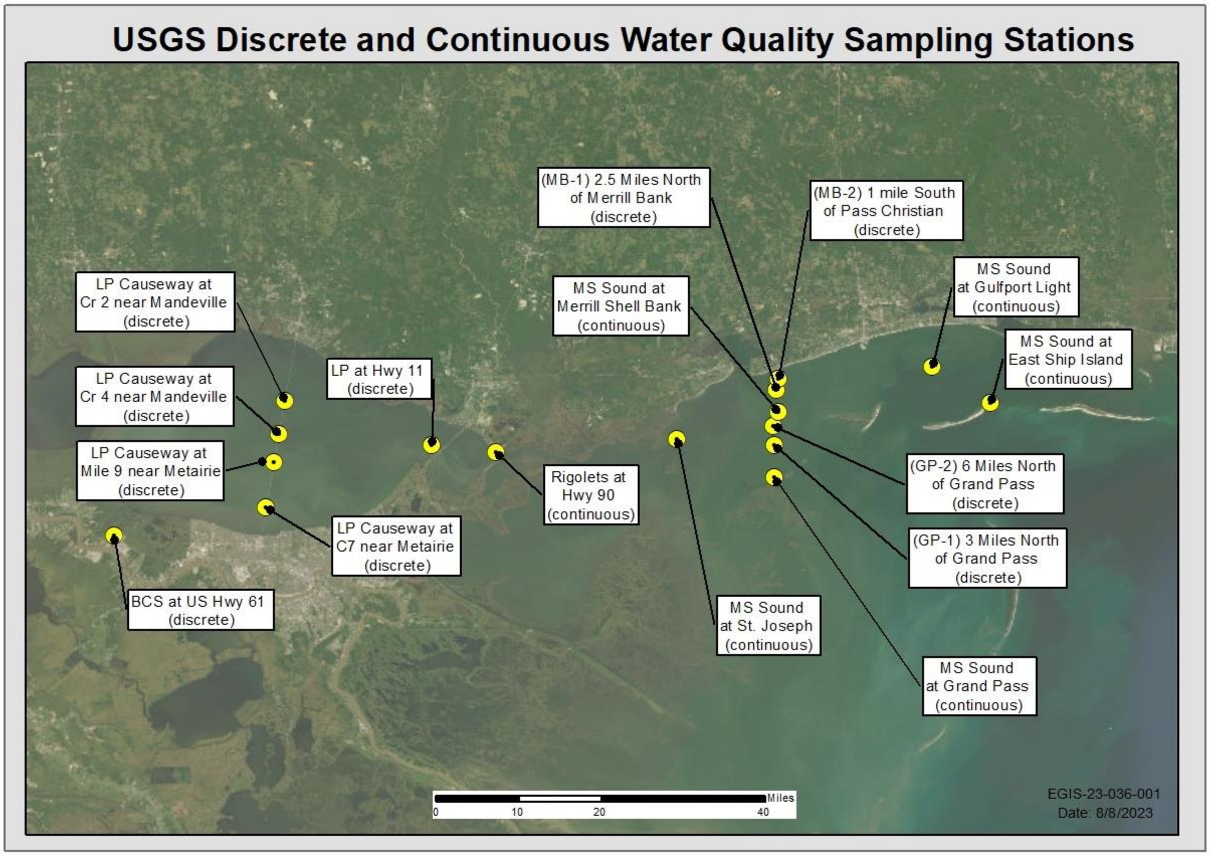


Figure 26. USGS Sampling Stations within the area of potential effects.

This report cites several studies that investigated Lake Pontchartrain and the MS Sound water quality as it relates to the operation of the BCS. Sample locations not shown in Figure 26 can instead be found in the referenced reports.

USGS discharge measurements were used to estimate the contribution of the local northern tributaries to the area of potential effects. The gages used are shown below in Figure 27. The total tributary discharge is computed by summing the timeseries for each respective gage, to provide an estimate of tributary contribution to the area of potential effects.

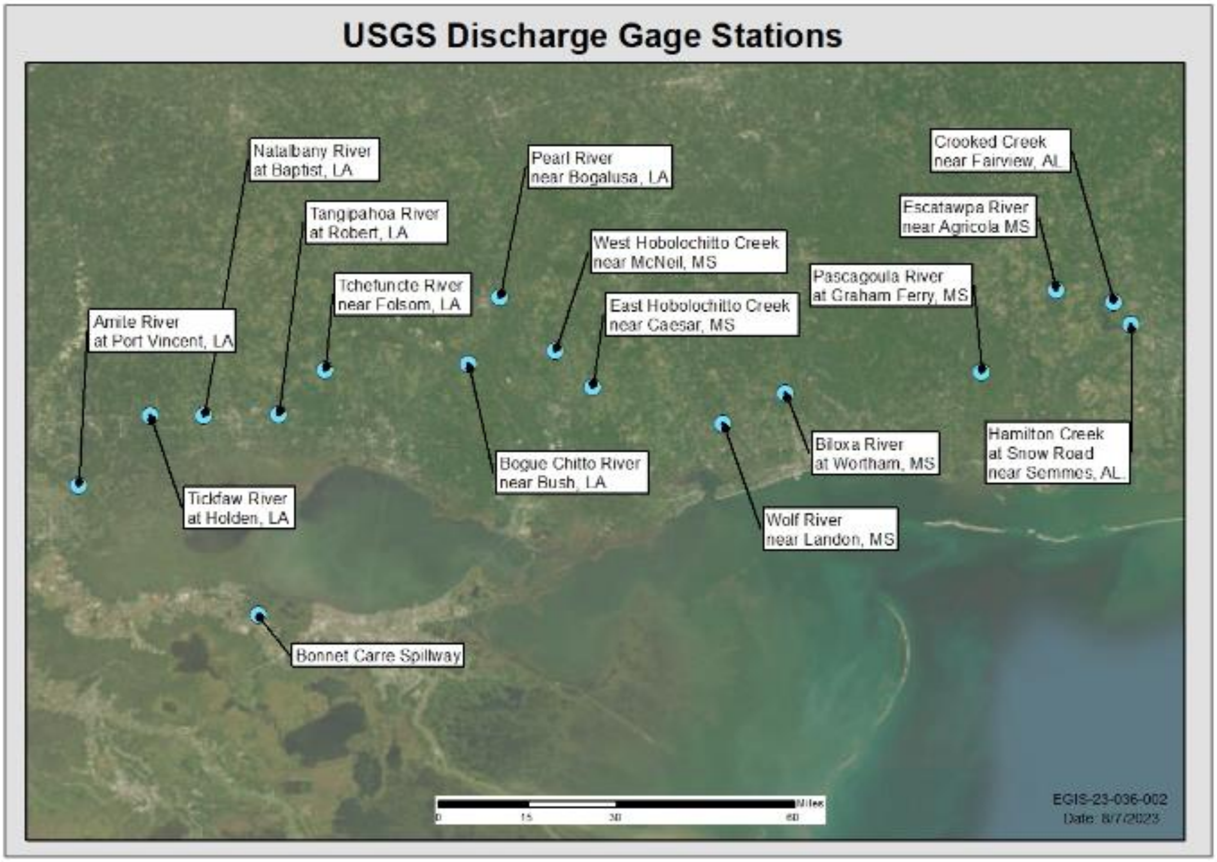


Figure 27. USGS stream gaging stations used to estimate local tributary discharge.

3.2 SALINITY

3.2.1 Baseline

All salinity measurements reported here are assumed to be surface salinities unless specified otherwise. Lake Pontchartrain salinities range between 2 and 14 parts per thousand (ppt) with a salinity gradient that is most salty near the New Orleans Land Bridge, and freshest in the western Lake Pontchartrain near Pass Manchac (Georgiou et al. 2009). This range is shown below in Figure 28.

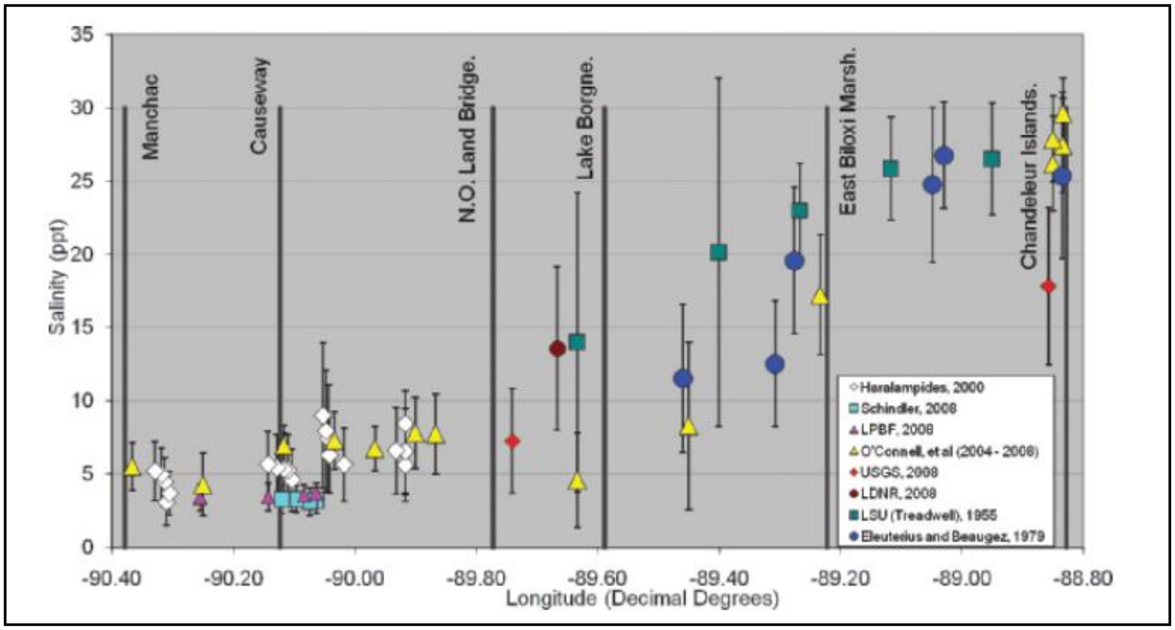


Figure 28. From Georgiou et al. 2009, salinity ranges throughout LPE.

Salinities in Lake Pontchartrain are affected by local river discharge (Georgiou et al. 2009). When river discharge is high in the spring, lake salinities can drop below 1 ppt (NOAA 2023). During the fall and winter salinities are typically higher. Since the closure of the Mississippi River Gulf Outlet (MRGO) in 2009, average salinities in Lake Pontchartrain have been lower, since MRGO was a significant entry point for high salinity water from the Gulf of Mexico (GoM). Long-term (2007-present) salinity measurements from the USGS gage at the Rigolets at Highway 90 on the eastern edge of the Lake show that the median salinity is 5.5 ppt.

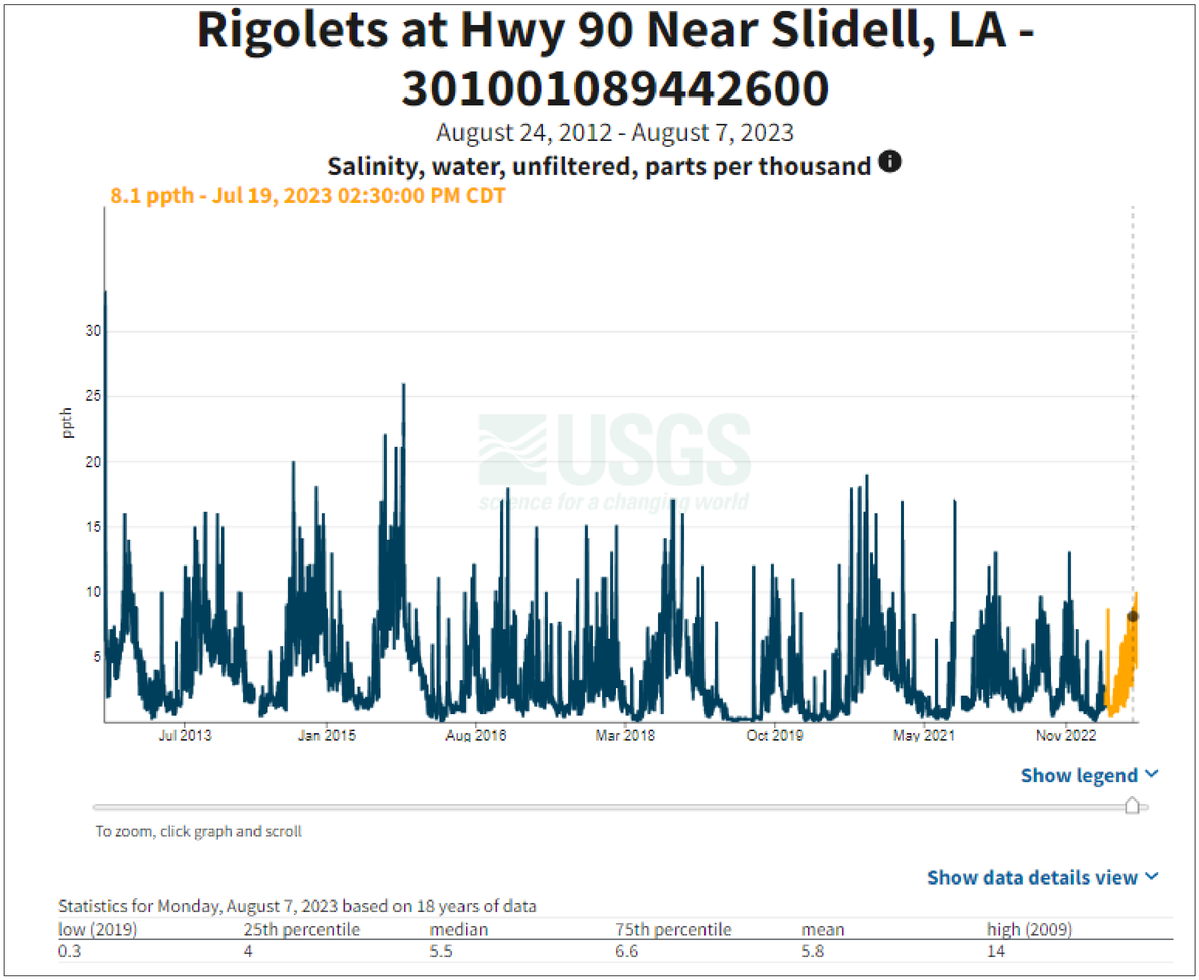


Figure 29. USGS Rigolets at Highway 90 gage salinity measurements.

There are also long-term (2007-Present) salinity gages operated by the Louisiana Coastwide Reference Monitoring System, though these gages are in the marshes on the edges of the Lake, the Rigolets gage is the only long-term salinity gage within Lake Pontchartrain. Figure 30 shows the April 28th, 2023 predicted salinities for Lake Pontchartrain from National Oceanic and Atmospheric Administration's Operational Forecast System, estimating salinity to be between 3.6 and 5.4 ppt throughout the southern portion of the lake, and estimating 1.8 to 3.6 ppt near the north shore where many local rivers enter the lake. The model estimates salinities east of the lake to be between 0 and 1.8 ppt, likely due to discharges from the Pearl River. The same forecast model for August 6th, 2023 (Figure 31) shows salinities in the range of 5.4 to 7.2 close to the Inner Harbor Navigational Canal, likely due to saltwater intrusion from the Gulf of Mexico. These figures are included to show another estimation of baseline Lake Pontchartrain salinities. The year 2023 has been relatively dry with low local tributary input.

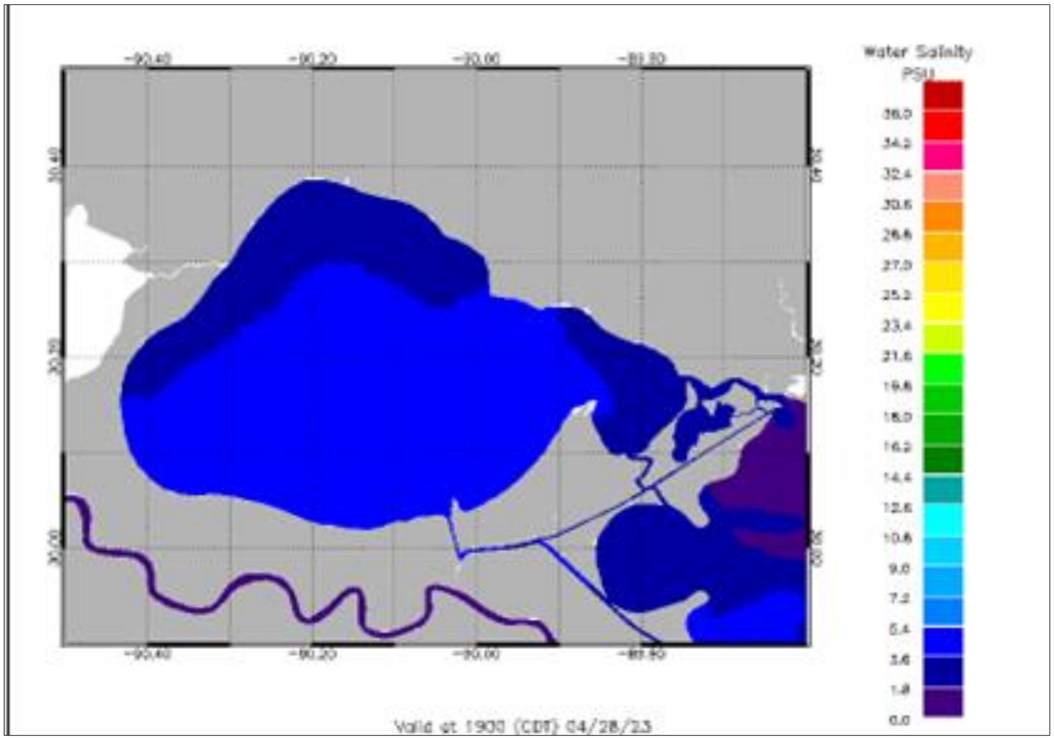


Figure 30. Predicted salinities for Lake Pontchartrain April 2023. Obtained from NOAA OFS.

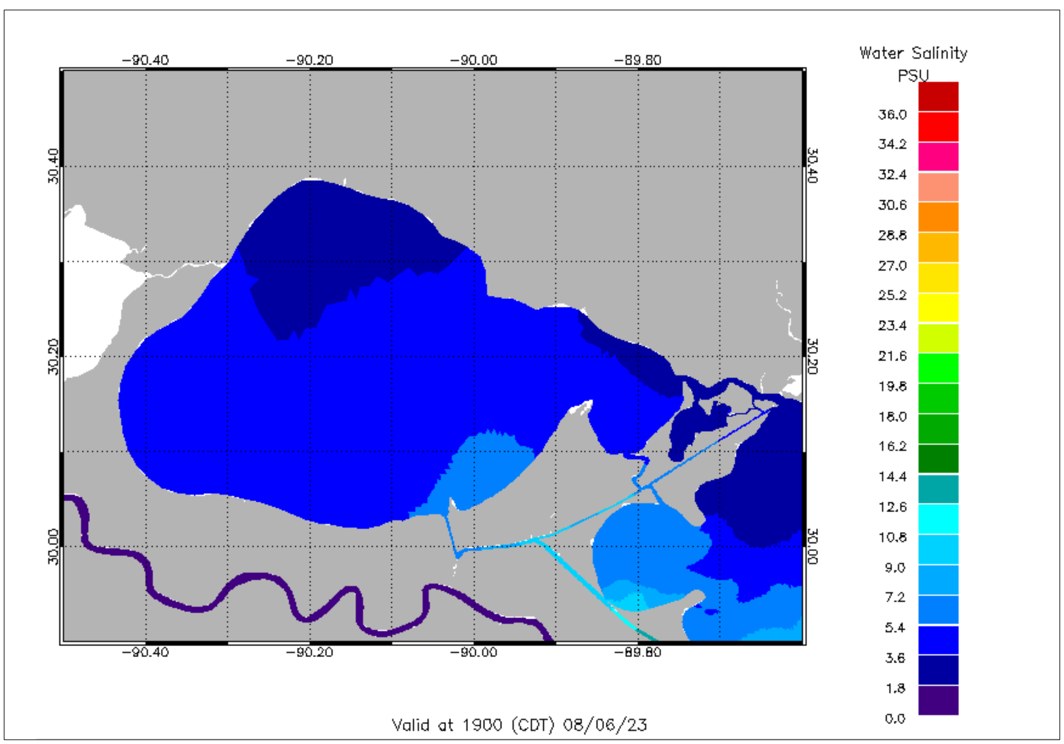


Figure 31. Predicted salinities for Lake Pontchartrain August 2023. Obtained from NOAA OFS.

Figure 28 from Georgiou et al. 2009 also shows average salinities in the Biloxi Marsh and Chandeleur Sound. These baseline salinity ranges are similar to salinity ranges found in the Mississippi Sound. Gledhill et al characterized the MS Sound as “a well-mixed estuary fringed with brackish salt marshes with various natural freshwater inputs and salinities ranging from 5 to 20 in nearshore areas heavily influenced by local rivers, and 20 to 25 in offshore areas with greater exposure to GoM waters” (Gledhill et al. 2020). Continuous gages in the MS Sound estimate the long-term median salinity values, shown in Table 3. For some portions of the gage record where specific conductivity is available but not salinity, salinity was calculated according to Miller et al. 1988.

Table 3. Median Salinity Records at USGS Continuous Sample Stations in the MS Sound

USGS Station	Median Salinity	Gage Record
St Joseph Island Light	16 ppt (converted from median specific conductance)	18 years
Merrill Shell Bank Light	21 ppt (converted from median specific conductance)	18 years
Grand Pass	17 ppt	16 years
Gulfport Light	24 ppt	8 years
East Ship Island	27 ppt (converted from median specific conductance)	12 years

The USGS provides seasonal statistics for these five stations, as well shown below:

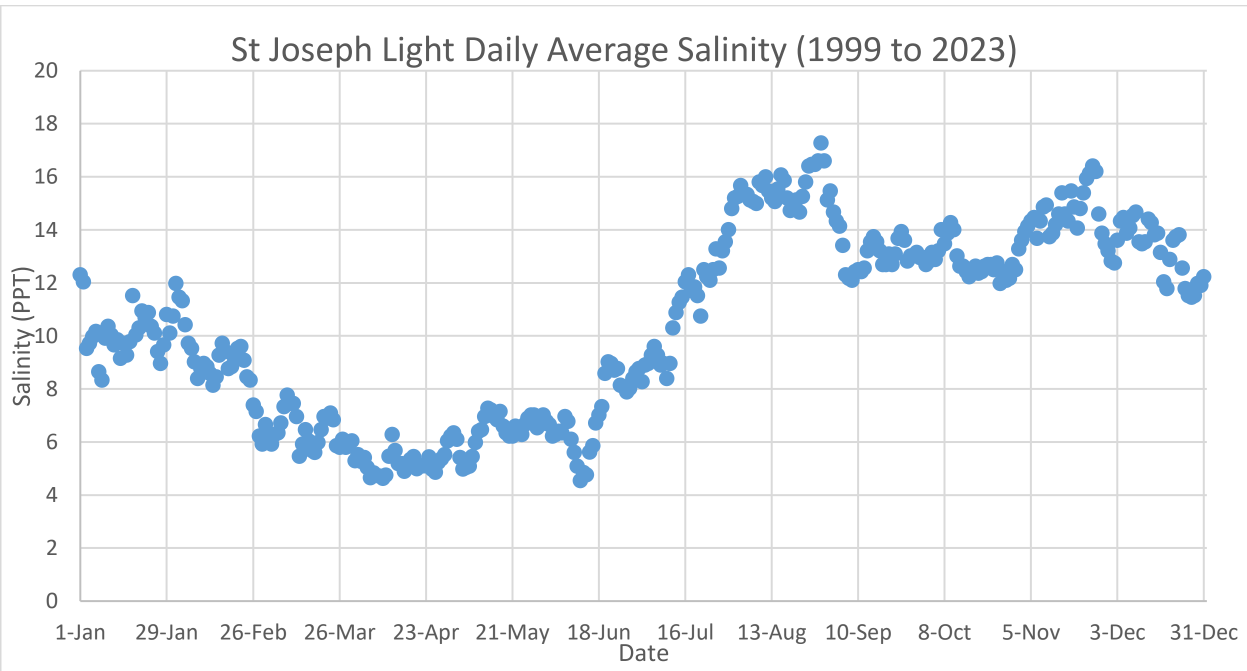


Figure 32. MS Sound at USGS St Joseph Island Light mean daily salinity values (1999-2023).

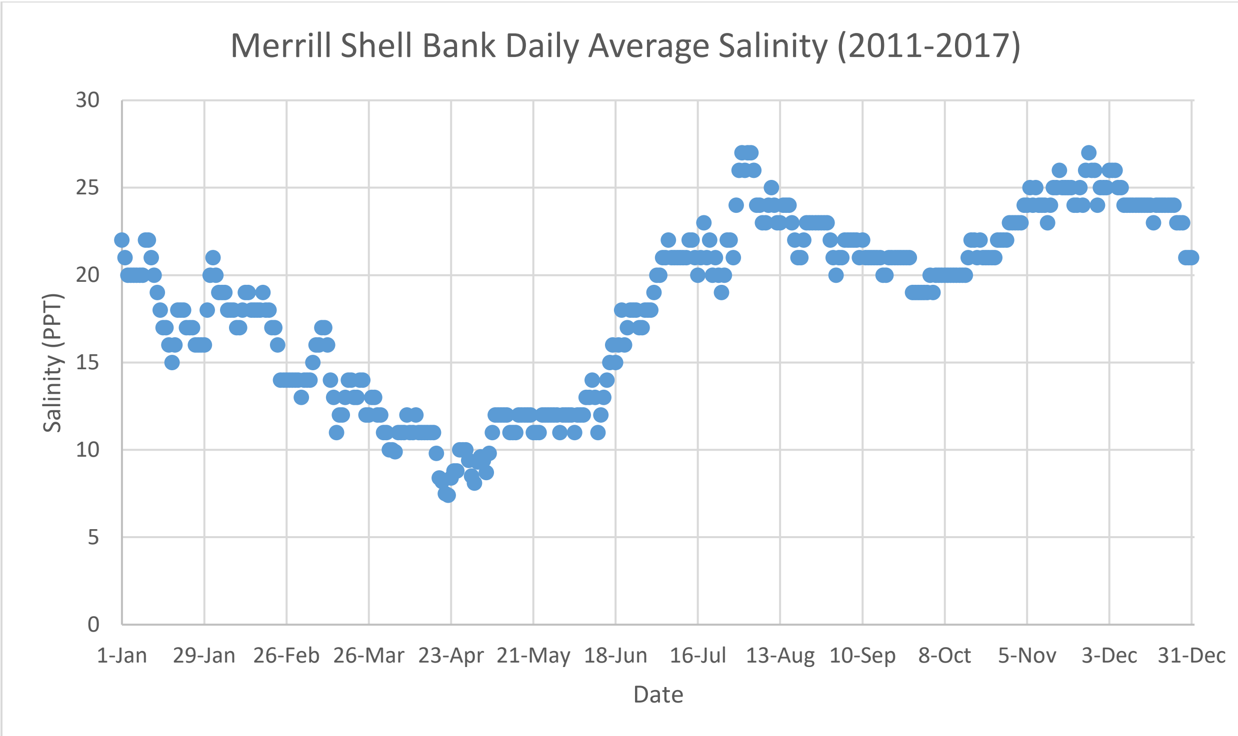


Figure 33. MS Sound at USGS Merrill Shell Bank Light mean daily salinity values (2011-2017).

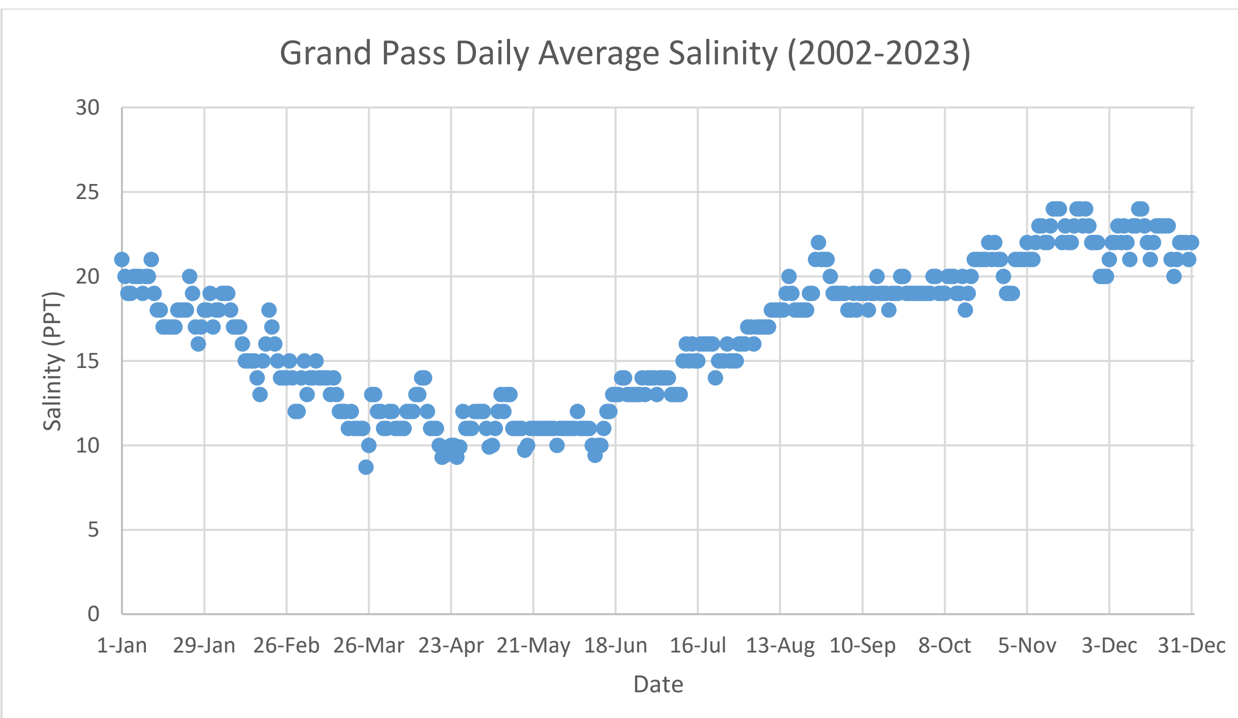


Figure 34. MS Sound near Grand Pass mean daily salinity values (2002-2023).

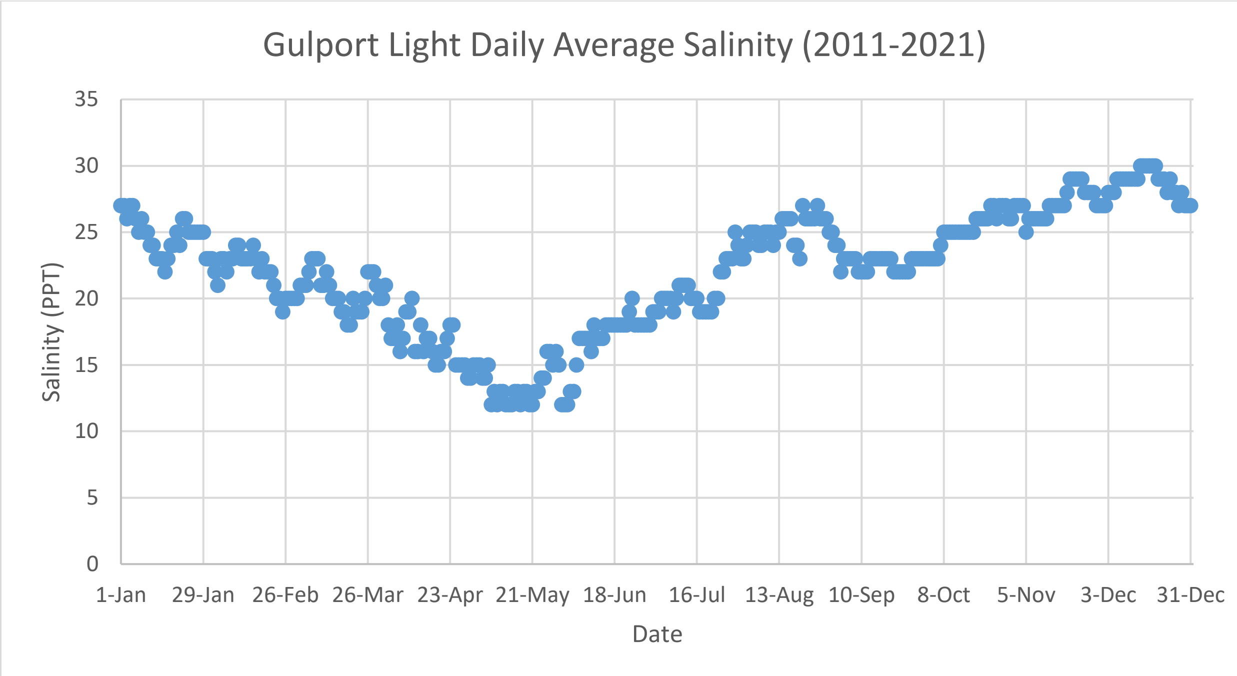


Figure 35. MS Sound at USGS Gulfport Light mean daily salinity values (2011-2021).

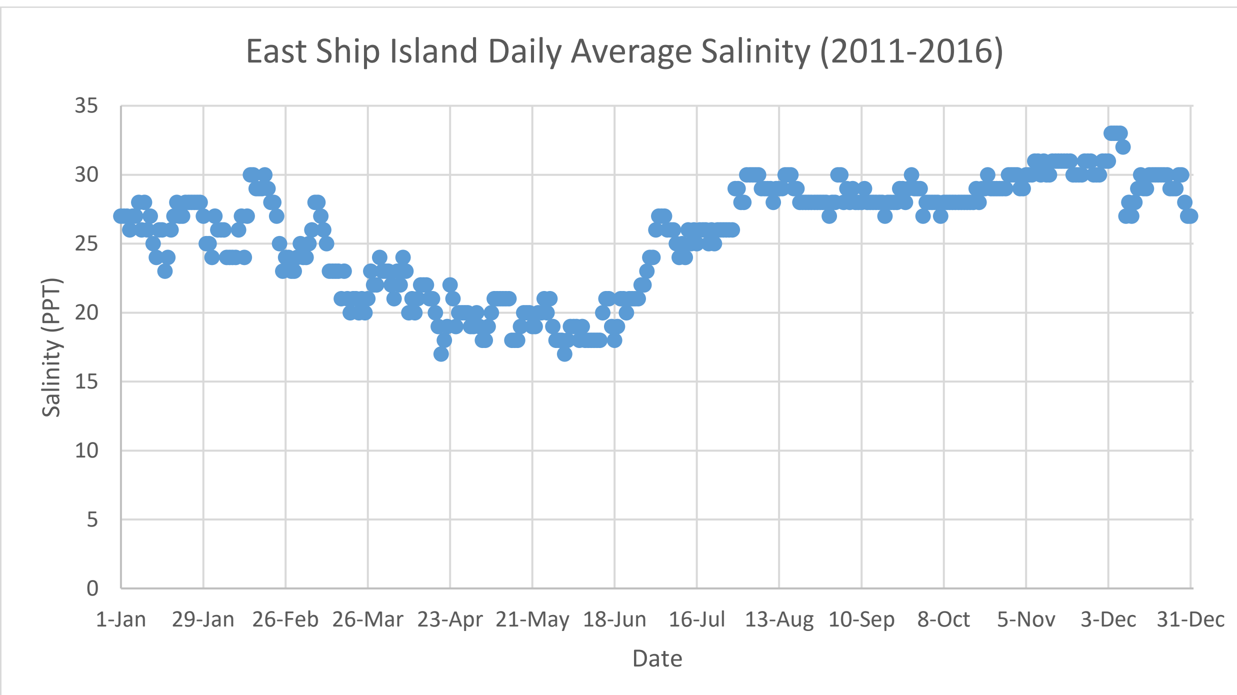


Figure 36. MS Sound at USGS East Ship Island Light mean daily salinity values (2011-2016).

2017 northern tributary flow rates and salinities at the St. Joseph Island Light, Merrill Shell Bank Light, and Grand Pass gages are plotted in Figure 37. This report uses the 2017 salinity data as an example of salinity patterns with no BCS operation, and near-average northern tributary flow volumes. The determination of near-average northern tributary flow is based on summing the daily average streamflow from the gages shown in figure 26 for each year from 2010 to 2020. Based on this estimation method, the total flow from tributaries in 2017 was approximately 10% higher than average for the period of record. Elevated tributary flows in early June overlap with a decrease in MS Sound salinity. The tributary flow and salinity patterns in late June show the response of the region to Tropical Storm (TS) Cindy, which brought heavy rain to Mississippi and Alabama. The spike in salinity is likely due to Gulf of Mexico storm surge, and the elevated streamflow from the heavy rainfall subsequently lowers the MS Sound salinities. This is an example of how rapidly the salinity can change in the MS Sound due to storm events.

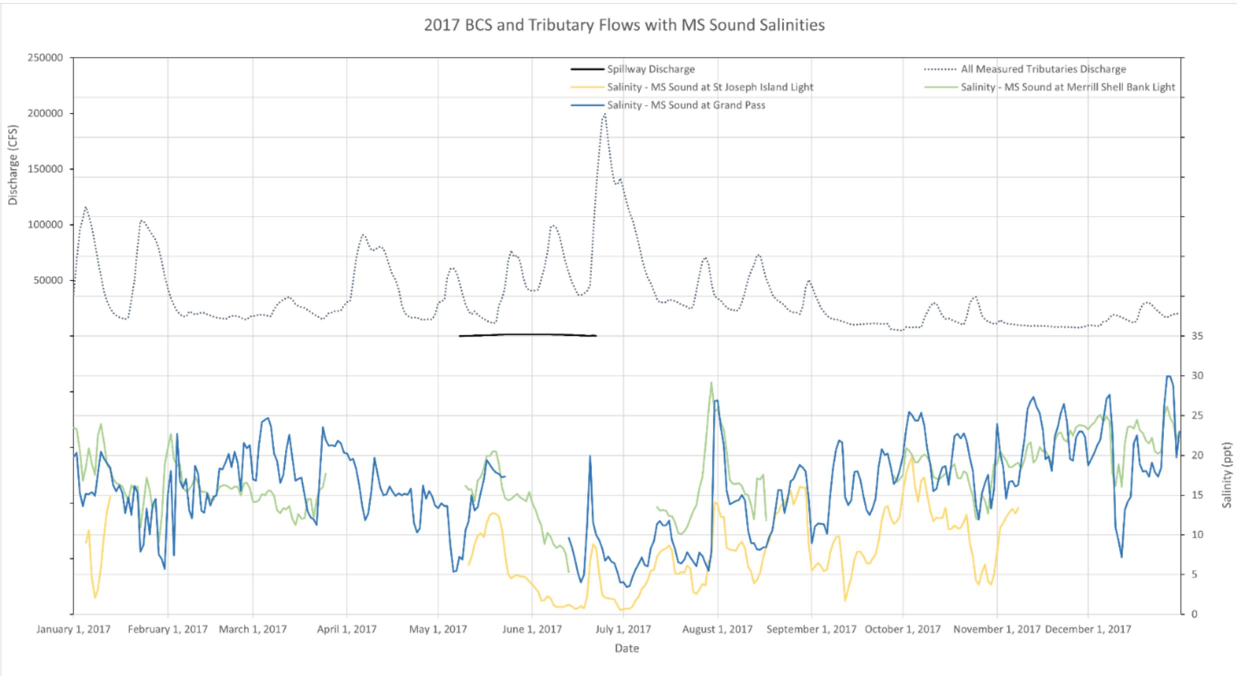


Figure 37. 2017 Northern Tributary Inflows and Salinity Measurements in the MS Sound.

The Pontchartrain Conservancy Hydrocoast maps are another tool for salinity distribution in the Lake Pontchartrain Estuary and MS Sound. The Hydrocoast maps aggregate data from several different sources, and collect their own supplemental data, to create surface salinity contour maps throughout the Lake Pontchartrain Estuary. These maps are representative of 2-week average surface salinity conditions in the region (Lopez et al. 2015). Figure 38 shows the Hydrocoast map for June 26 to July 2, 2017, coinciding with a spike in northern tributary flows.

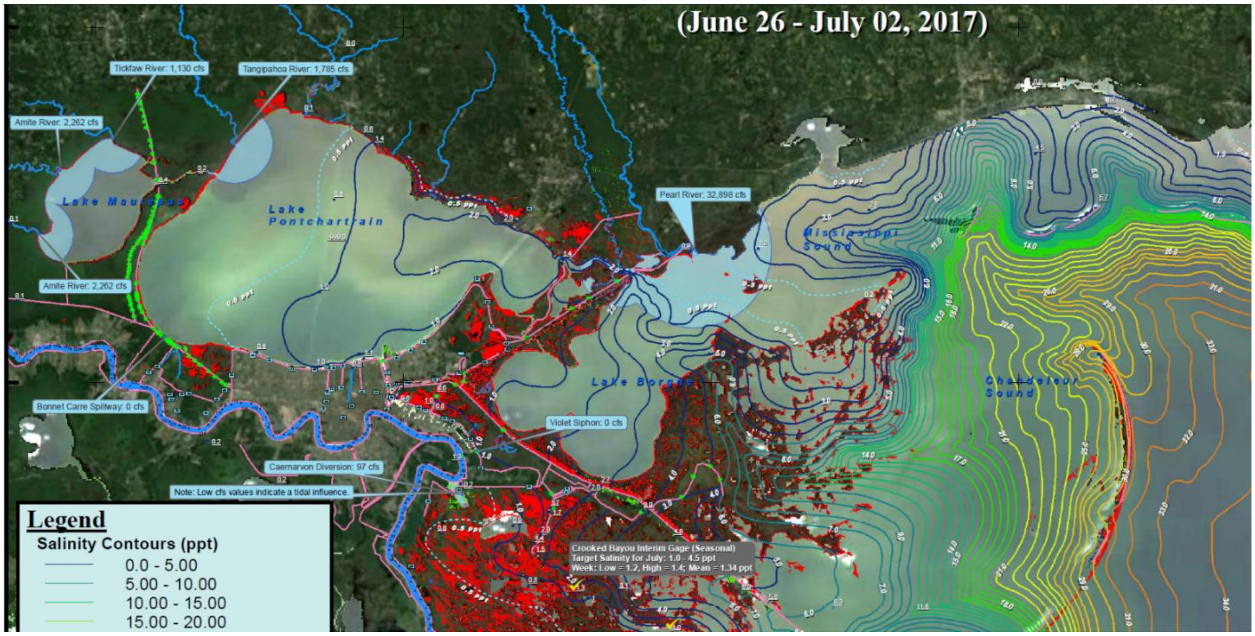


Figure 38. June 26th to July 2nd Hydrocoast Map for Salinity.

3.2.2 BCS Impacts on Salinity

Impacts on salinity from BCS operations will vary depending on the scale of the opening. Large scale events with long durations and/or high flows will typically have a greater impact on salinity, whereas small and medium scale events will typically result in lesser impact on salinity. As examples of how different operations have historically impacted EFH, the impacts of the 2011, 2016, and 2019 BCS openings will be the focus of this analysis and will be used to make general conclusions about salinity impacts due to the BCS. The 2011 opening represents a large scale opening with low tributary inflows. The 2016 event represents a small-scale event with average tributary inflows. The 2019 opening represents a large scale opening with high tributary inflows.

3.2.2.1 Lake Pontchartrain

As the direct outfall area of the BCS, Lake Pontchartrain experiences significant freshening due to BCS operations. Discrete samples collected by the USGS in 2011, 2016, and 2019 depict the BCS impact in Lake Pontchartrain (Heal et al. 2023).

2019

Discrete salinity samples were collected at 3 stations along the Causeway as well as at Highway 11 on the eastern edge of the Lake on 9 dates between February 27th and October 22nd, 2019. Salinity measurements on February 27th and 28th were between 1.3 and 2 ppt across the four stations. February 27th was the date of the first BCS opening in 2019, and thus the full influence of BCS release water would not have reached those stations on that date. On March 12th and 13th, samples taken at the southern Causeway station near Metairie showed significant freshening (salinity = 0.13 ppt) while the two Causeway stations further north still had salinities >1.5 ppt. Meanwhile, the Hwy 11 station measured 0.45 ppt, suggesting that the BCS flow followed the southern rim of the Lake. For six sampling dates between March 26th and August 2nd, salinities at all four stations measured less than 0.5 ppt. By October 18th, salinities had recovered to above the February 27th levels at three of the four stations, with the Causeway station near Metairie remaining below 1 ppt. Figure 39 shows Lake Pontchartrain salinities in 2019.

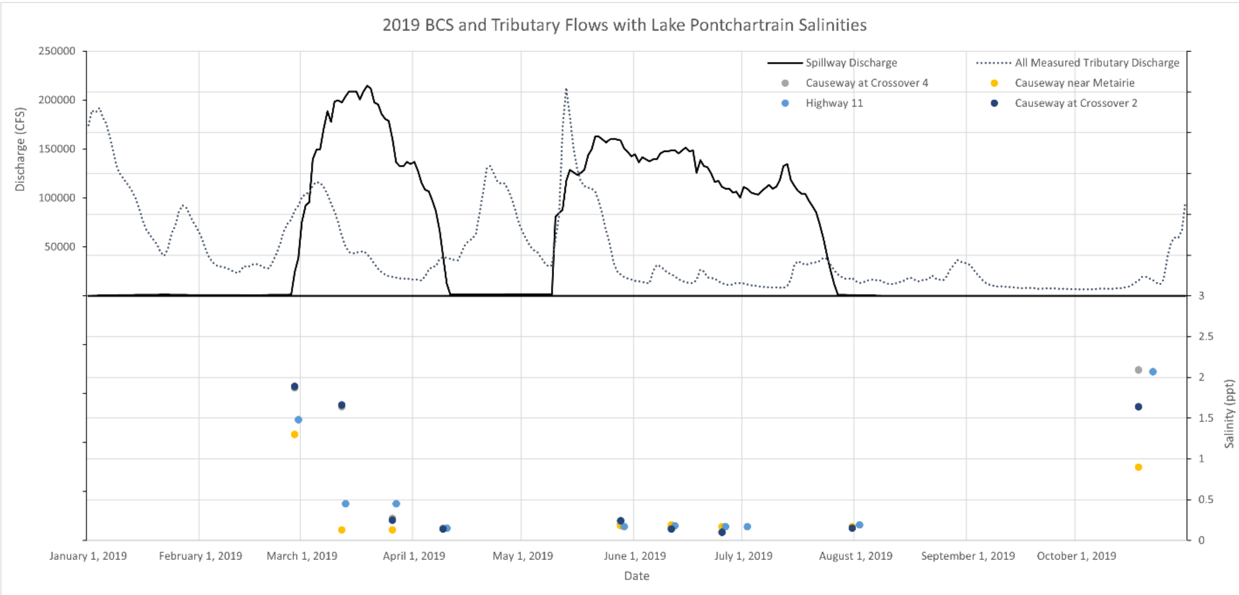


Figure 39. 2019 BCS discharge and Lake Pontchartrain Surface Salinities.

Sampling during the 2016 and 2011 openings followed a similar pattern as 2019. The salinity measurements also suggest that BCS release water flowed along the southern edge of the Lake, with salinities along the southern edge and at Highway 11 on the eastern side dropping sooner than salinities in the center and northern sections of the Lake. Results from those years are shown below.

2016

Figure 40 shows that salinities dropped from between 2 and 4 ppt in early January to below 2 ppt for most of the year, remaining below 2 ppt into August of 2016.

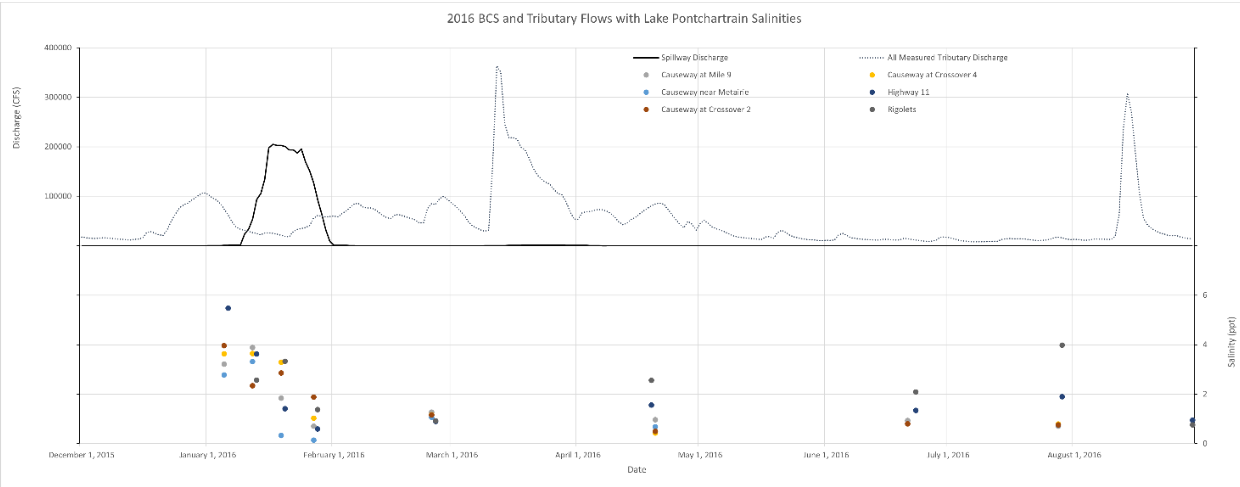


Figure 40. 2016 BCS discharge and Lake Pontchartrain Surface Salinities.

2011

Figure 41 shows that salinities dropped from above 4 ppt at most stations before May 19th to below 2 ppt and remained between zero and two ppt until after August 19th.

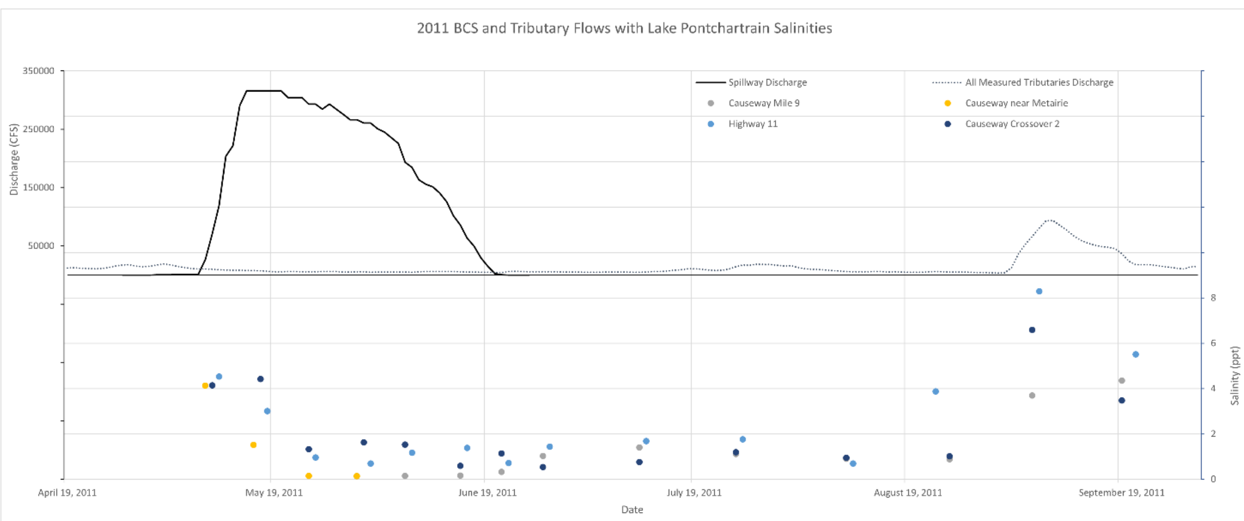


Figure 41. 2011 BCS discharge and Lake Pontchartrain Surface Salinities.

3.2.2.2 Mississippi Sound

Gledhill et al. monitored salinity in the Mississippi Sound during and after the 2019 BCS double opening. Surface salinity was sampled at six stations in the Sound on four dates: April 23rd (T-0, 12 days after the first spillway closing), May 6th (T-1, 25 days after first closing), May 24th (T-2, 14 days after the second opening) and September 27th (T-3, 60 days after the second closing). These stations were at different locations than the USGS stations and are shown in Figure 41. Samples taken on T-0 showed depressed salinities less than 1 ppt at the four stations further west, but showed that Henderson Point Reef and Kittiwake Reef (two easternmost stations) had higher salinities of 3.14 and 4.21 ppt. The baseline salinities in this area can be estimated using USGS salinity measurements near Grand Pass and Merrill Shell Bank Lighthouse. The baseline salinity estimates at the Merrill (observations from 2011 – 2017) and Grand Pass (observations from 2002 – 2023) gages for the months of April – May in this area range from 8.5 to 13 ppt. Therefore, the Henderson and Kittiwake Reef stations appear to be affected by a freshwater pulse on the April 23rd sampling date. The May 6th salinity samples show that five of the six stations have lower salinities than April 23rd, suggesting that freshwater influence grew between those two dates, despite the BCS being closed. Salinities at Henderson and Kittiwake were reduced by 50% between April 23rd and May 6th. Samples taken on May 24th salinities <1 ppt at the Henderson and Kittiwake, with the other four stations remaining fresh, suggesting that the influence of the 2nd BCS opening had reached all six of the stations on May 24th. Salinities on September 27th were near the baseline average of 15-21 ppt at all stations, except for Back Bay St. Louis, which was not measured. Salinity data collected by the USGS in 2019 can help illustrate the timing of the salinity rebound in the MS Sound (Heal et al. 2023). USGS gages within the MS Sound at Grand Pass, Merrill Shell Bank, St. Joseph, and Gulfport Light collected salinity data throughout the summer of 2019. The Gulfport Light gage, north of Ship Island measured 12 ppt on April 1st, was consistently below 5 ppt between May 12th and June 4th, and recovered to 15 ppt by June 11th. Figure 42 shows the data collected from the Grand Pass, Merrill Shell Bank, St. Joseph, Gulfport Light, and East Ship USGS continuous salinity gages, plotted next to BCS and northern tributary discharge.

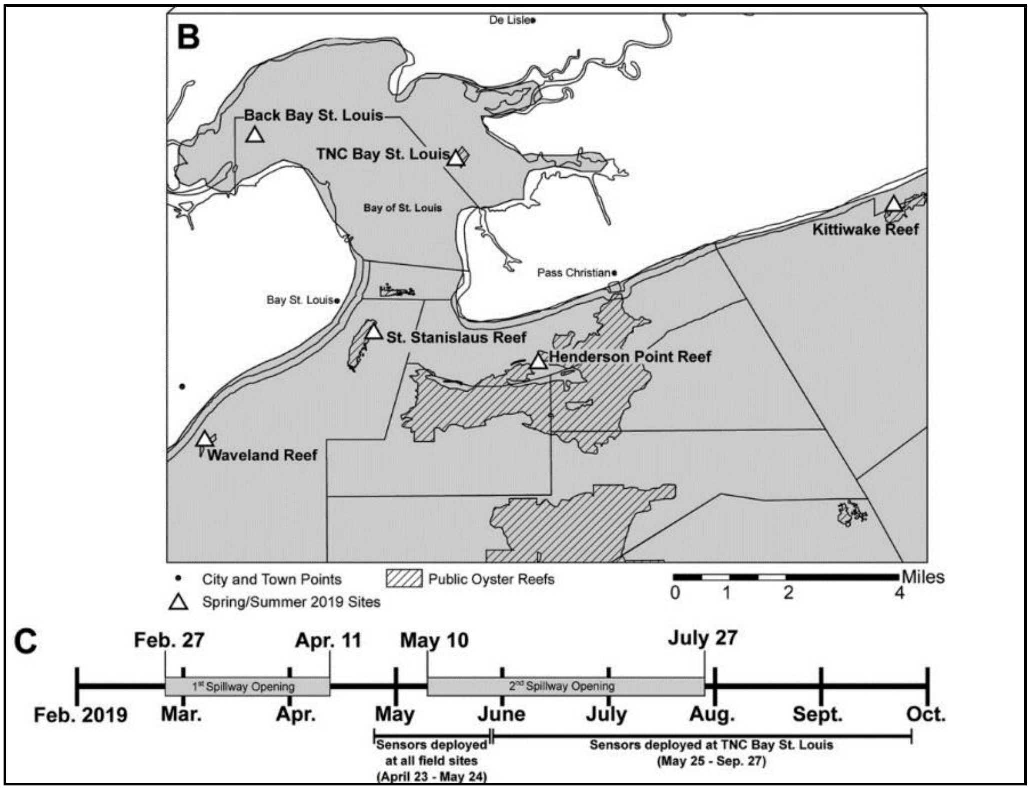


Figure 42. Gledhill et al. sampling stations.

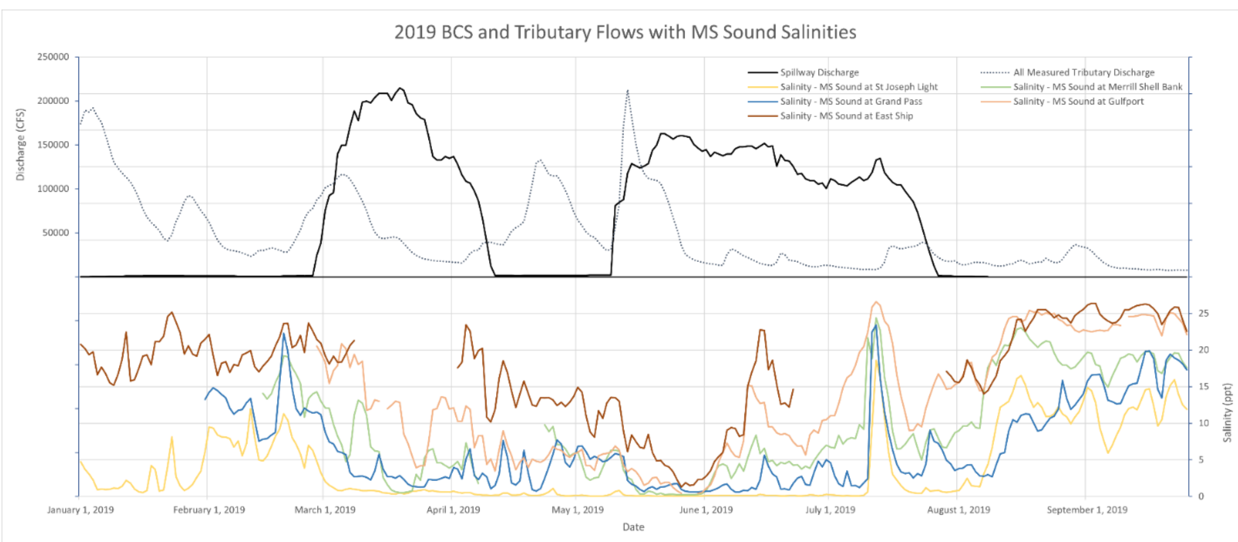


Figure 43. BCS and northern tributary flow and salinity in the MS Sound.

The discharge from the BCS and northern tributaries caused freshening conditions at all sampling stations in the MS Sound, with the largest influence occurring in late May, and with the salinity rebounding by mid-August. Figure 43 also shows the contributions from northern tributary flow, which was higher than average in 2019 based on USGS daily average flow rate data.

Bottom salinities were recorded less frequently than surface salinities. Five measurements taken at the Grand Pass and Merrill gages from March – October show freshening and recovery during that period.

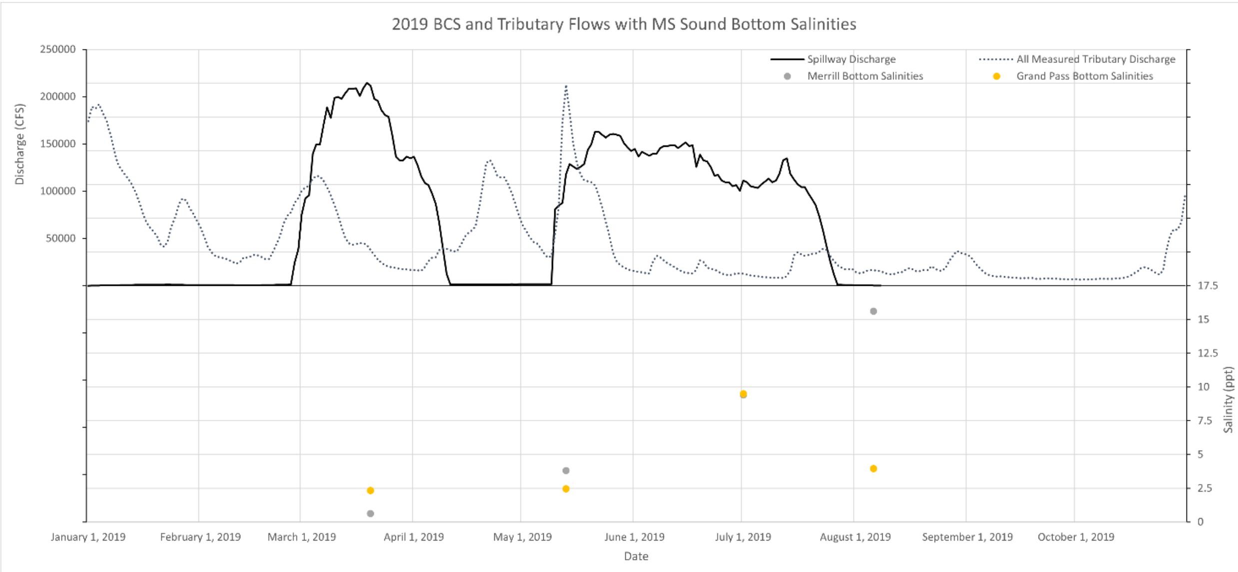


Figure 44. Bottom Salinities in the MS Sound during 2019 Operation.

Numerical models have been built to try to assess the salinity influence of the BCS. Armstrong et al. 2021 built a msbCOAWST model with 24 vertical layers to assess the salinity influence of the BCS. Their report highlights the influence of the BCS on bottom salinities in the western MS Sound, stating that their model results show 72 and 78 additional days of bottom water salinity < 2 ppt in some areas during the first and second 2019 openings respectively. Figure 45 below shows a map of the areas experiencing additional days of salinities < 2 ppt due to the BCS, based on comparing a model run with the BCS and a model run without the BCS.

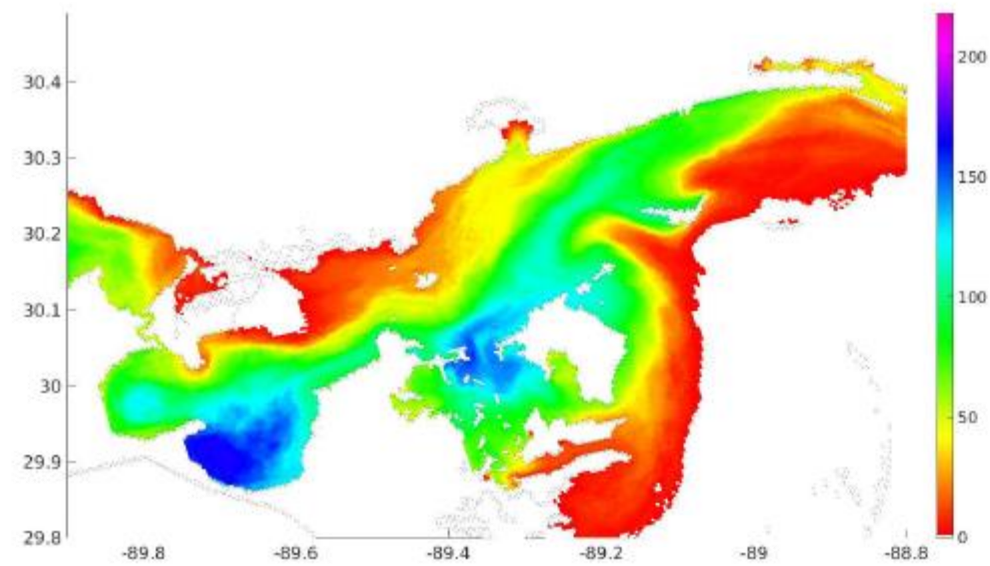


Fig. 13. Difference in cumulative days where daily average salinity is below 2 from February 26, 2019 through July 27th, 2019 for the run with Bonnet Carré Spillway (BCS) minus the run without BCS.

Figure 45. From Armstrong et al. 2021.

Wiggert et al. 2022 uses a similar model as Armstrong et al. to evaluate the Mid-Breton Diversion project. In this paper, Wiggert et al. present figures that estimate where MS bottom salinity is below 5 ppt due to BCS operation. This figure is shown below. The Mid-Breton diversion is not included in this model run.

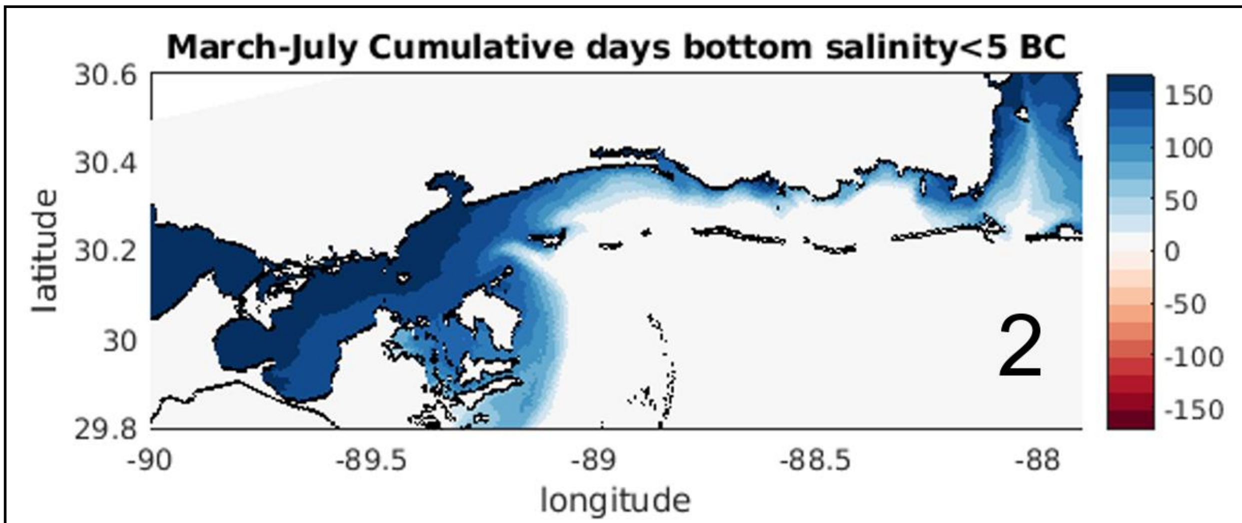


Figure 46. Cumulative days in 2019 when bottom water salinities were below 5 ppt based on msbCOAWST model outputs (Wiggert et al. 2022).

Figure 47 shows a hydrocoast map of salinity contours for late May to early June of 2019.

In conclusion, the 2019 BCS double opening contributed to salinities in Lake Pontchartrain remaining below 0.5 ppt throughout the summer of 2019, showing recovery by October at the latest. The maximum extent of the bottom salinity 5 ppt isohaline likely occurred in late May and early June, and likely ran north-south between the Biloxi Marshes and Chandeleur Sound, and between Cat Island and Ship Island, based on the msbCOAWST modeling. The surface salinity 5 ppt isohaline extended further into Chandeleur Sound and around Ship Island. The Pontchartrain Conservancy collected salinity data in 2019 which informs their Hydrocoast maps and show salinities below 5 ppt to the south of Ship Island. As shown in figure 26, the period of greatest freshening in the MS Sound was caused by simultaneous high flows from both the BCS and northern tributaries.

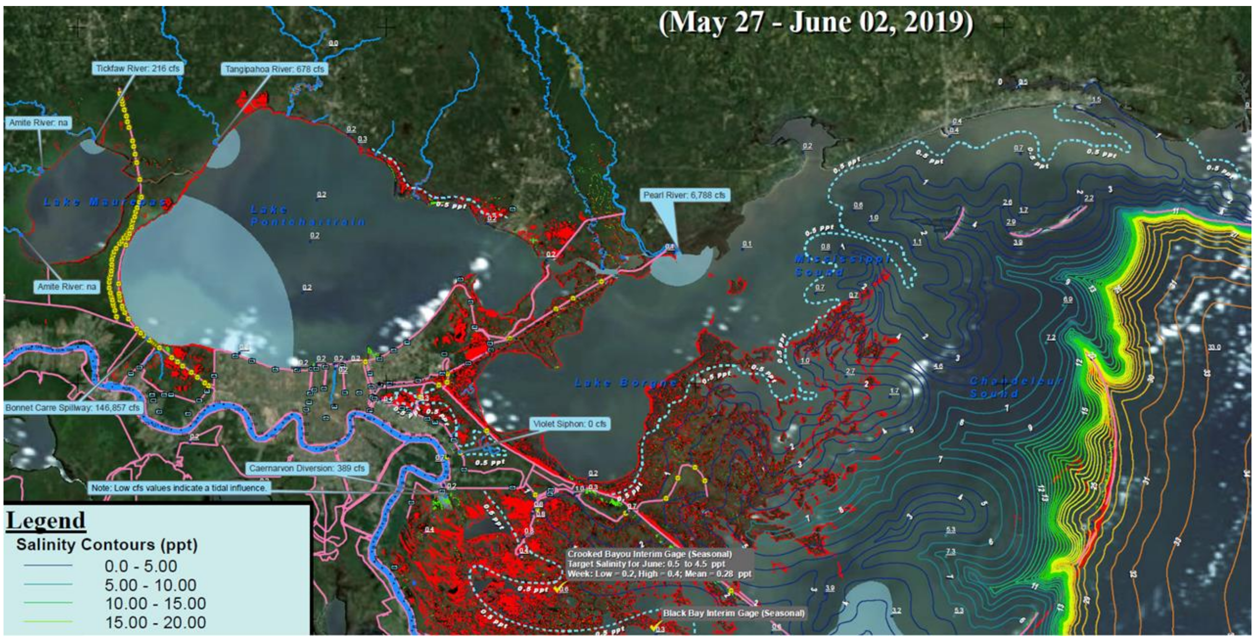


Figure 47. Hydrocoast map in late May to early June of 2019.

The 2016 BCS opening had a relatively less freshening effect in Mississippi Sound, based on the salinity gage records at the St. Joseph Light, Merrill Shell Bank Light, Grand Pass, Gulfport Light, and East Ship USGS stations, shown in Figure 47. The scale and duration of freshening is similar to the freshening following a northern tributary flow spike occurring in mid-March. Unlike the 2019 event, the BCS and tributary discharge do not coincide and the freshening is much less persistent in 2016.

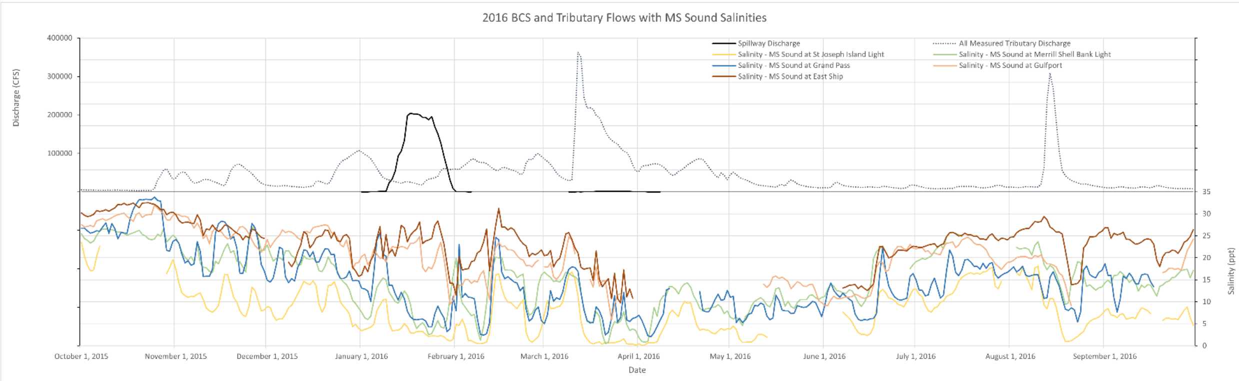


Figure 48. 2016 BCS and Tributary Flows and MS Sound Salinities.

The 2016 Hydrocoast Map for late January shows the 0.5 ppt isohaline extending to the Rigolets, and this area of freshwater overlaps with a visible sediment plume in the satellite imagery. The Hydrocoast contours combined with the MS Sound salinities suggest that the freshening from the 2016 BCS opening were mostly contained to Lake Pontchartrain.

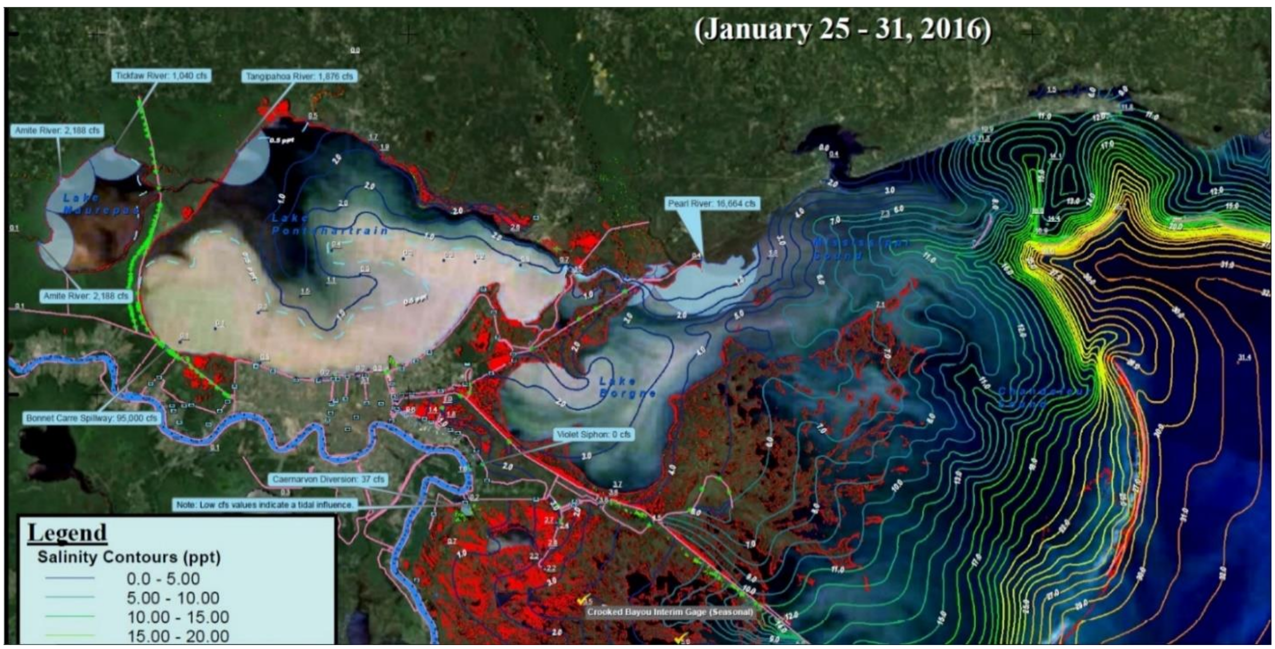


Figure 49. Hydrocoast Salinity Map January 25th – 31st 2016.

In conclusion, a small-scale event, such as the 2016 opening, is expected to cause less freshening than a larger scale opening in terms of duration (figure 43 versus figure 48) and extent (figure 47 versus figure 49).

The 2011 BCS opening had very little accompanying local tributary inflows. Freshening at St. Joseph Light station started 4-7 days after spillway flow began, with Grand Pass and Merrill Shell Bank Light freshening starting about a week after the opening began. Salinities began to recover during the week of June 16th, 2011, about 4 days before the spillway was closed. Figure 50 shows that the freshening effects were short-lived during the 2011 event.

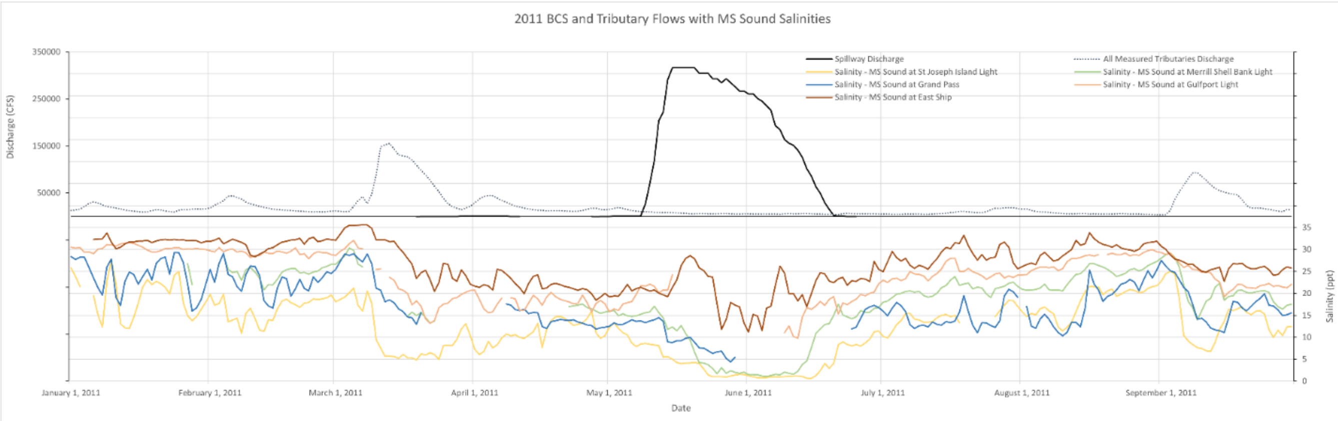
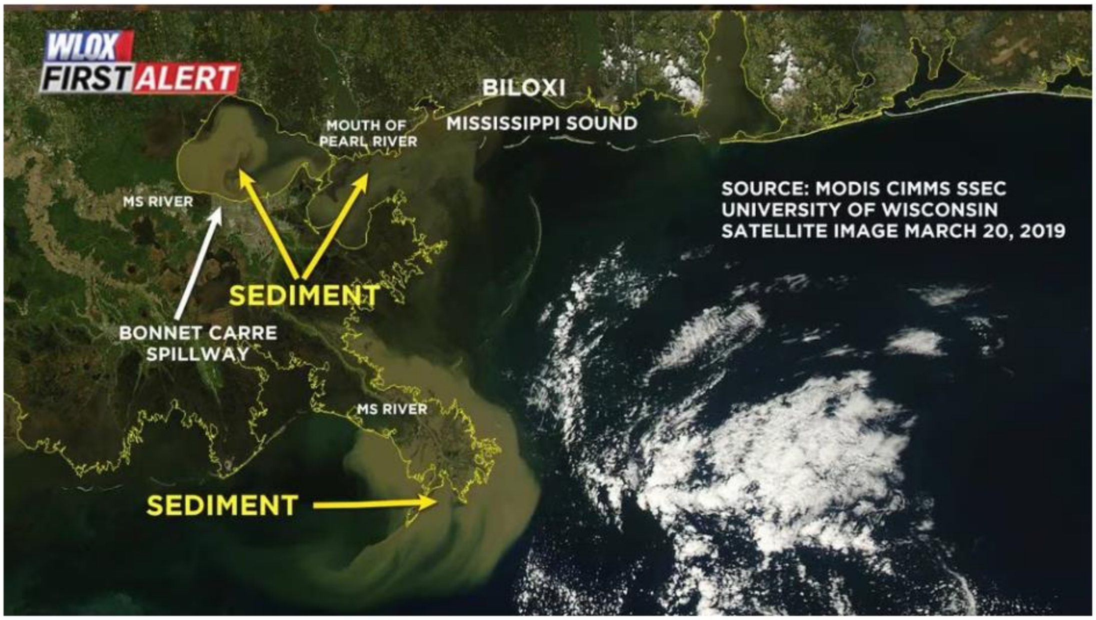


Figure 50. 2011 BCS and Tributary Flows and MS Sound Salinities.

The area impacted by the 2011 BCS opening appears similar to the 2019 opening, based on the freshening observed at all MS Sound stations in the figure above. The freshening was far less severe at the East Ship station, though spillway flows appear to have lowered salinities by approximately 10 ppt for about a week. There are no Hydrocoast Maps for 2011. Comparing this opening to the 2019 second opening suggests that local tributaries had a large effect on the MS Sound salinities in 2019, since the total discharge of the spillway openings are similar.

3.3 TURBIDITY AND SUSPENDED SEDIMENT

Total suspended sediment (TSS) is a direct measurement of the mass of particulate matter that is trapped by a standard filter when the sample is filtered and is expressed as a concentration. Turbidity is a measure of light reflectance, which is correlated to the amount of particulates in the water. Turbidity and TSS can be damaging for aquatic ecosystems due to light inhibition. Suspended sediments are often carriers of contaminants and nutrients like phosphate. Satellite imagery illustrates the large sediment plume that flows with the BCS waters, as well as the plumes at the mouth of the Mississippi River and Pearl Rivers (Figure 51, Jeansonne 2019).



Sediment from Mississippi River floodwaters can be seen moving into Lake Pontchartrain and the Mississippi Sound as water flows out of the Bonnet Carre Spillway (MODIS CIMMS University of Wisconsin)

Figure 51. BCS sediment plume on March 20th 2019, along with plumes at the mouth of the Mississippi River and Pearl River, from Mississippi WLOX (Jeansonne 2019).

TSS and turbidity increase in Lake Pontchartrain during BCS operation due to the high energy of the spillway flows, which can entrain more sediment. Sediment settles out of the water column as the spillway's flow loses energy. The same dynamic exists for most rivers entering coastal areas, as can be seen for the MS River and the Pearl River in Figure 50 above. USGS sampling during the 2019 BCS operation measured Secchi depths as a proxy for TSS and turbidity, which is another optical measurement that records the depth of visibility using a weighted optical target hanging off a measuring line. A low Secchi depth reading correlates to high turbidity and TSS. Secchi depth is correlated to the euphotic zone, defined as the depths where 1% of the light level reaches and where photosynthetic organisms can survive. This correlation is complicated (Luhtala et al. 2013) but can be approximated by multiplying the Secchi depth by 2.8 to estimate the euphotic zone (Kudela). The results for select stations are plotted below:

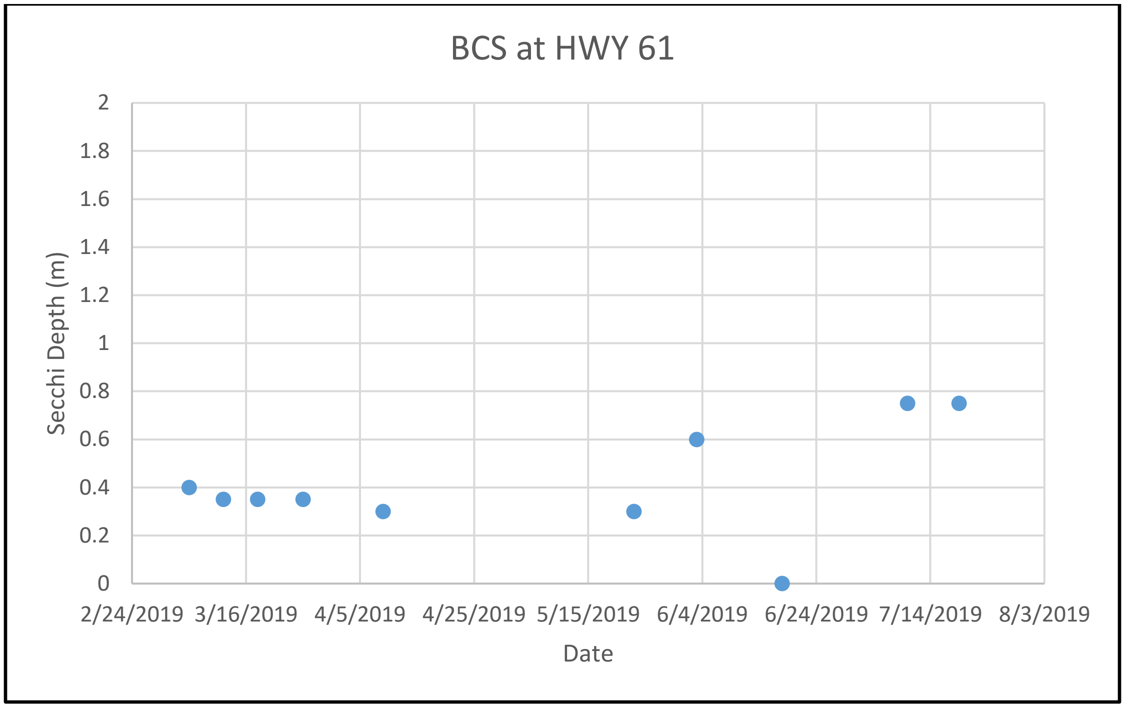


Figure 52. Secchi depths recorded at USGS Station BCS at HWY 61.

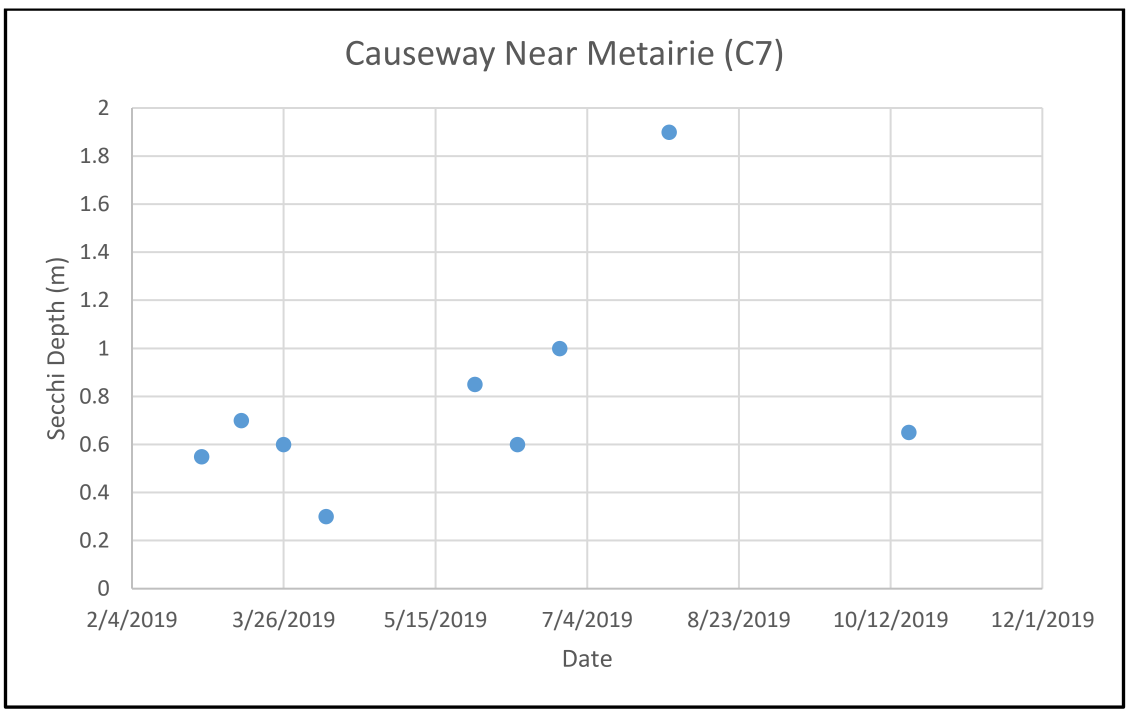


Figure 53. Secchi depths recorded at USGS Station Causeway Near Metairie (C7).

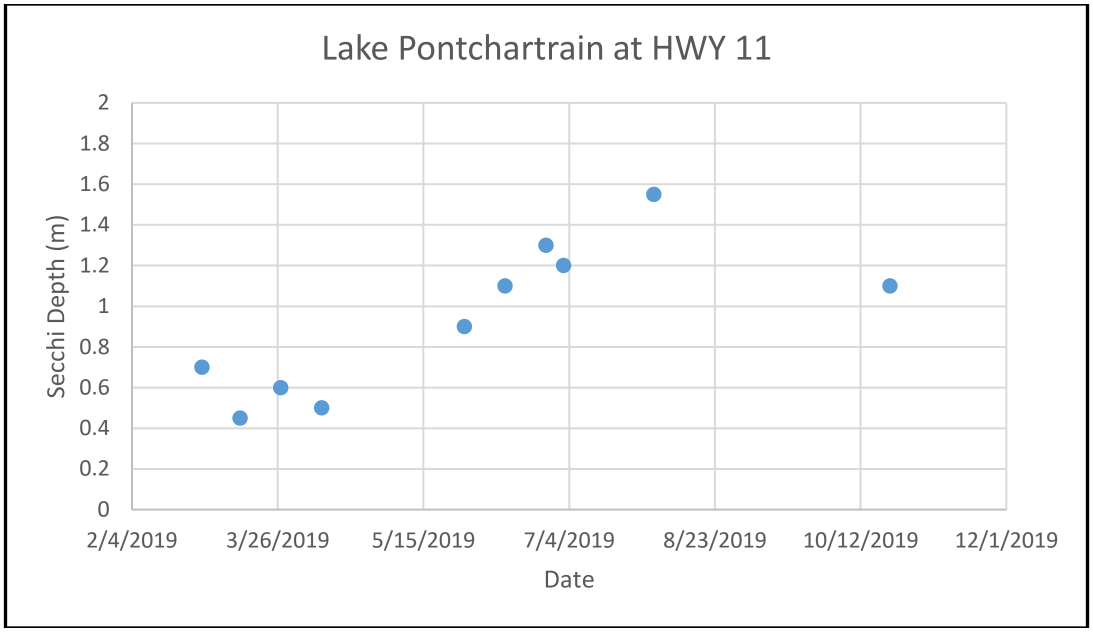


Figure 54. Secchi depths recorded at USGS Station Lake Pontchartrain at HWY 11.

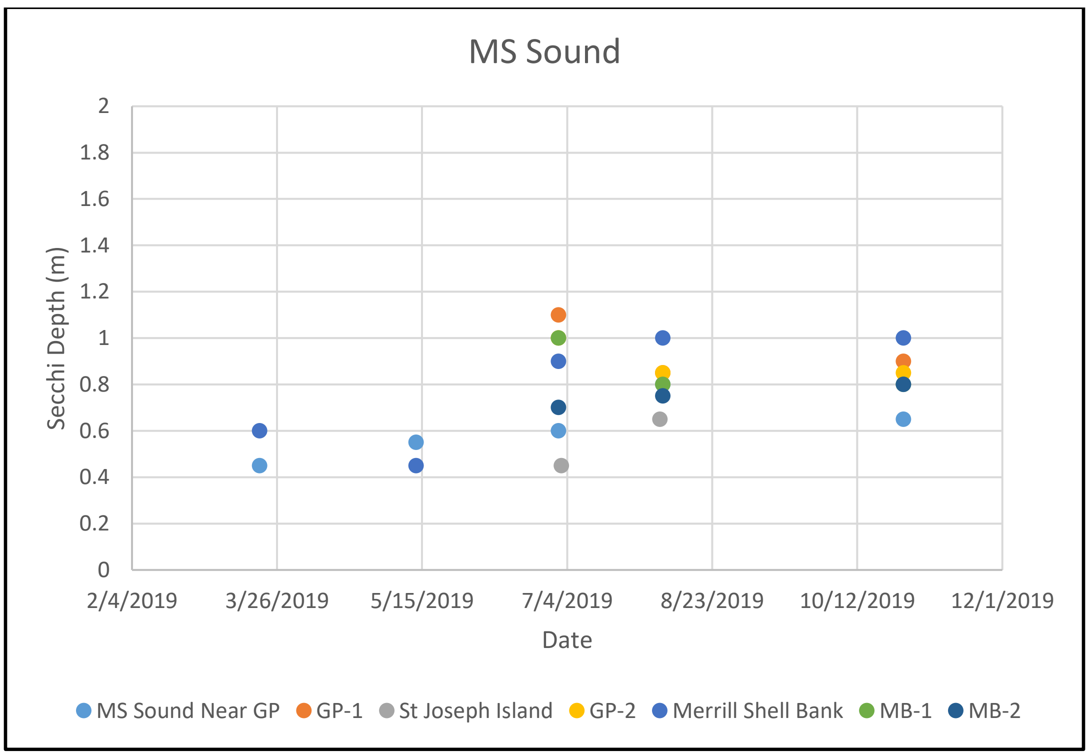


Figure 55. Secchi depths recorded at USGS Stations within MS Sound.

These results show that Secchi depths were lowest during the first 2019 Spillway opening (February 27th to April 11th). The second opening does not appear to have the same level of TSS/turbidity impact, since Secchi depths at most stations are rising during this period (May 10th to July 27th). The rapid rebound in water clarity may be due to biologic activity, like in Lake Tahoe, California, where zooplankton is credited with increasing water clarity (Weber 2013).

Turbidity measurements from long-term continuous USGS gages at Gulfport Light and East Ship Island offer another way to approximate turbidity impacts. The turbidity record from 2017 through 2019 shows the range of turbidity values for a non-BCS year (2017) and a large BCS year (2019). The data shows high turbidity during the spring of 2017 at both gages. Fewer data points are available during the spring of 2019, but the max values are lower than observed in 2017, suggesting that the BCS is not the primary driver of turbidity in that region of the MS Sound. These stations are further east than the grab sample locations shown in figure 33 above, and it is likely that suspended sediments would settle or disperse by the time BCS water gets to them. The East Ship Island gage has a stretch of continuous turbidity readings from April 3rd to June 19th, 2019, when the impacts of BCS salinity are estimated to be highest in the MS Sound. This data shows an average turbidity of 8.41 FNU (FNU is roughly equivalent to NTU) (The Wastewater Blog, 2021), ranging between 6.5 and 11.00 FNU. USGS considers 10 NTU or lower to be low turbidity (Water Science School, 2018), indicating that high turbidities from the BCS were not an issue in that location from April 3rd to June 19th.

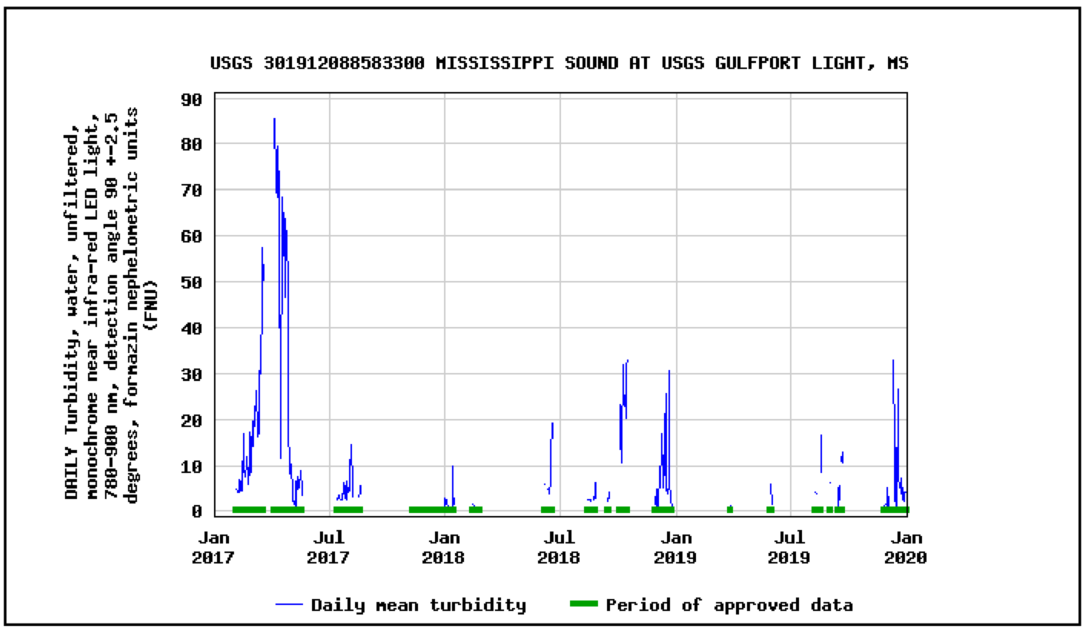


Figure 56. Turbidity measurements recorded at USGS Station Gulfport Light.

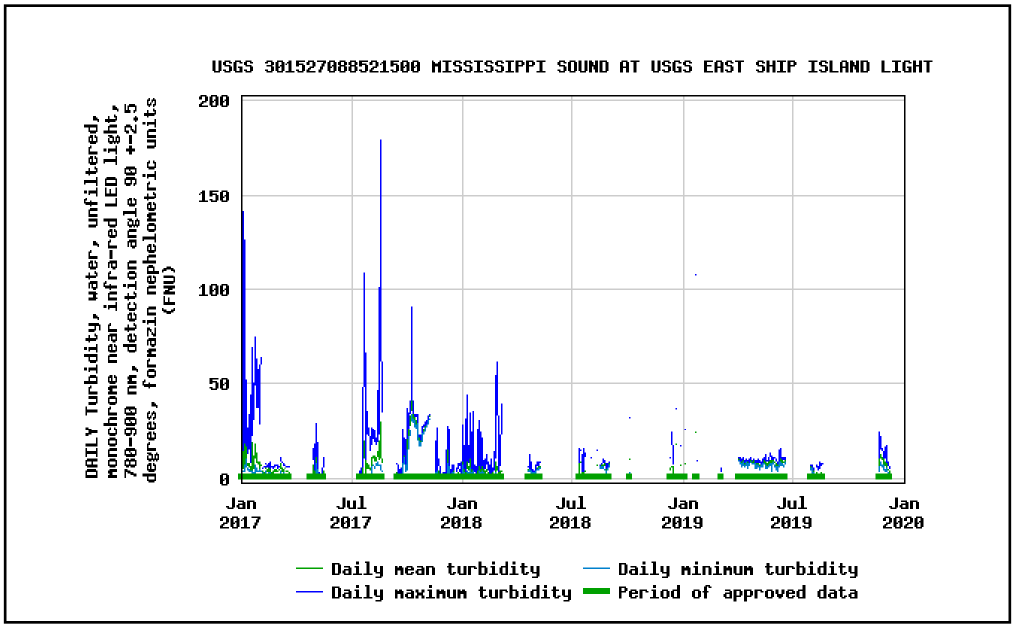


Figure 57. Turbidity measurements recorded at USGS Station East Ship Island.

Several studies have measured the extent and duration of high TSS and turbidity due to the BCS in other years when the spillway opened.

Roy et al. 2013 measured Secchi depths along a 10-station transect extending straight out from the BCS outfall into Lake Pontchartrain for the 2011 BCS opening. Measurements show that the Spillway initially reduces Secchi depths from 0.9m on May 8th to 0.3m in late May during the Spillway opening. Secchi depths increased to >1m at all stations in late June and up to 3.4m at the station approximately 11km from the Spillway.

Chao et al. 2014 quantified sediment flux from the BCS into Lake Pontchartrain (LP) during the 1997 opening, estimating the total amount of inflowing sediment to be 9.1 million tons, based on a TSS of 241 mg/L at the Spillway gates. Using satellite imagery as a comparison, Chao et al showed that TSS moved first along the southern edge but gradually expanded north and impacted the entire lake approximately one month after the spillway opening. They also state that the recovery period to seasonally average TSS levels was about 2 to 3 months.

Brammer et al. 2007 recorded Secchi depth measurements along 5 stations east-west across LP, and 2 along the New Orleans lakefront, in their review of BCS impacts to macroinvertebrates after the 1997 opening. The Secchi depths before the opening was between 1-5 meters, but dropped below 0.3m after the opening, and remained low (below 0.6m) through June 6th except at the easternmost site. By July 28th, the visibility had returned to above 1m Secchi depths at all stations except station 4, the 2nd easternmost station, where Secchi depths remained around .6m.

Based on the turbidity measurements from the USGS gages in MS Sound (Figure 56 and 57), there does not appear to be a correlation between BCS flows and turbidity increases in that area of the MS Sound. In contrast, the literature shows that Lake Pontchartrain experiences high TSS concentrations and low water clarity usually during the earlier stages of BCS operation. Data from

2019 shows water clarity improving throughout the summer, even as the BCS continued to operate.

3.4 SEDIMENT DEPOSITION

As suspended sediments settle out of the BCS waters, the sediment deposition can become an issue for submerged aquatic vegetation (SAV), oysters, and other benthic organisms. Damage can occur when sediment obstructs substrate habitat, or when organisms are smothered in sediments or exposed to pollution carried by the sediments (Wilber et al 2010). Kroes et al. 2023 estimated the mass balance of the sediment that passed through the BCS during 2019 and concluded that most sediment deposition occurs within the floodway. They estimate the total sediment load passing highway 61 (about 1/3rd of the way down the floodway) to be 4.25 teragrams or 4,250,000 metric tonnes.

The quantity of sediment passing through the BCS was also estimated in Meselhe et al. 2016. The authors created a 3D numerical model using Delft 3D and calibrated and validated the model using sediment flux estimates from the 1997, 2008, and 2011 BCS openings. The paper estimates diverted fine sediment loads for the three openings to be 175,000, 1,100,000, and 200,000 metric tonnes respectively. It estimates diverted sand loads to be 15,000, 30,000, and 10,000 metric tonnes respectively.

A USGS webpage article discusses BCS sedimentation due to the 1997 Spillway opening and describes a “large lobe of silty sand an average of 19 cm thick near the spillway mouth.” The article calculates the total quantity of wet sediment to total 9.1 million tons and calculates that this amount of sediment spread evenly across the Lake would have a depth of 0.42 centimeters. This page also describes heavy metal sampling conducted on the sediment from this opening, and found that the levels of copper, lead, and zinc were similar to “data from nationwide sediment samplings in coastal waterways.” (USGS, “Summary of Geological and Chemical Data (cont.) Mississippi River Influence – Bonnet Carre Spillway”).

Several studies have been done on sedimentation and turbidity impacts in Lake Pontchartrain. Poirrier et al 2017 document the reduction in SAV coverage in Lake Pontchartrain between 1953 and 1990, attributing much of that reduction to increases in turbidity. Poirrier identifies urbanization and shell dredging and the primary cause of these increases. The Bonnet Carré Spillway is mentioned in this study, but as a carrier of nutrient pollution. The sedimentation impacts of Bonnet Carré are not discussed.

Brammer et al. 2007 conducted a study on the impacts of the 1997 BCS opening on Lake Pontchartrain’s infaunal macroinvertebrates. This study did not find sedimentation to be a problem for these species, concluding that sedimentation due to the BCS may provide beneficial nutrients. However, this study does not consider all benthic organisms. Overall, the study did not highlight that sedimentation was much of a factor in BCS impacts during 1997. Overall, there are still some data gaps present on overall effect of sedimentation to all managed species. It is likely that if sedimentation occurs within SAV or oyster beds it would adversely affect those resources.

In summary, the BCS deposits large sediment loads in the immediate outfall area of the Spillway in Lake Pontchartrain, and likely impacts the organisms in this outfall area. Sedimentation due to BCS operation is likely not an issue for organisms outside of Lake Pontchartrain, suggested by the lack of literature documenting the issue, and literature documenting the heavy sedimentation immediately next to the spillway outfall.

3.5 NUTRIENTS AND DISSOLVED OXYGEN

Nutrient loading from the BCS is a high priority problem due to the ecosystem impacts that rapid nutrient changes can create. Several studies collected data on the scale, timing, and migration of different nutrients, primarily nitrogen (N), phosphorus (P), and silica-based (Si) compounds. Nutrients fuel biological processes, such as algae growth, which in turn impact dissolved oxygen levels. Pulses of nutrients fuel algal blooms that cannot survive at ambient nutrient levels, leading to mass die-offs that consume dissolved oxygen (DO). Some species of algae, such as cyanobacteria species, release toxic substances. Several BCS openings have been followed by algal blooms and subsequent low oxygen events, including the 1997, 2008 and 2019 openings. The nutrient and DO dynamics following the 1997 and 2008 spillway openings have been studied in detail. The 2019 nutrient and DO dynamics have not been analyzed in published documents to the same extent, but news reports and presentations document the toxic algal blooms and DO depletion that occurred that year.

USGS nutrient sampling within the BCS at Hwy 61 during the 2019 BCS operation measured a range of N and P species (USGS Water Data). The total loads of total N (TN) and total P (TP) during the 2019 BCS opening were estimated by multiplying the measured concentrations by the BCS daily average flow rates (USACE, "Spillway Operation Effects"). TN and TP concentrations were linearly interpolated to estimate concentrations for the entire duration of BCS operation. TN was explicitly measured, while TP was estimated as the sum of elemental P and orthophosphate. The concentration measurements ranged from 1.4 to 1.9 mg/L and .293 to .487 mg/L for TN and TP respectively. The TN and TP total loads flowing into the BCS were 63,366 and 13,911 tonnes respectively in 2019. Kroes et al. 2023 estimated that nutrients removed due to sedimentation in the spillway to be 4,900 and 3,420 tonnes of TN and TP respectively, leaving approximately 58,466 and 10,491 tonnes of TN and TP entering Lake Pontchartrain.

Harmful algal blooms (HABs) were reported during the summer of 2019 in Lake Pontchartrain (Phillips, 2019), as well as in the MS Sound. According to a USGS data release describing algae and toxin sampling in 2019 (Rowley et al. 2021):

"The timing and magnitude of the 2019 [BCS] diversions provided nutrient flux and freshwater inflows that resulted in algal accumulations that included harmful algal bloom species with possible algal toxins in coastal zones in Mississippi. Especially hard hit was the Mississippi shoreline/beach area, where bloom status for several species of algae was recorded along with elevated algal toxin levels. The Mississippi Department of Environmental Quality issued water contact advisories for 21 different beach locations from June until October 2019 (MDEQ, 2019, 1p)."

There is a press release from NOAA and news reports citing cyanobacteria as the source of toxins (NOAA, 2019, The Weather Channel, 2019). Algae toxin sampling reported by the USGS (Rowley et al. 2021) showed 15 samples with microcystin levels above the level of detection, with the highest concentrations measured in local tributaries – 4.65 and 2.81 µg/L in the Pearl and Pascagoula Rivers respectively. These samples do not have associated dates but were collected between July 1st and November 30th, 2019. The high toxin levels found in northern tributaries as well as the high tributary flows occurring during that time suggest that northern tributaries could be the source of the 2019 HAB in the MS Sound. Another toxin sampling effort conducted by the USGS and reported on their NWIS database measured 0.13 µg/L concentrations of total microcystin at two stations in the MS Sound (Grand Pass and Merrill Shell Bank Light) on July 1st, with no other samples measuring any toxins above the detection limit (USGS Water Data).

However, peer reviewed analyses of the algal toxins and species measured during this time have not been conducted.

Dissolved oxygen measurements conducted by USGS showed steady declines in DO values in Lake Pontchartrain throughout the 2019 sampling period, likely due to warming temperatures since warmer water has less capacity for DO than colder water. Minimum DO measurements in LP during the 2019 sample was approximately 6 mg/L for both surface and bottom samples, suggesting a well-mixed system that is not experiencing hypoxia. Hypoxic conditions are defined as DO concentrations below 2 mg/L (Dzwonkowski et al., Gulf State Fisheries Commission, 2019). DO values below 2 mg/L were observed in the MS Sound in the month of July. These samples were from the bottom of the water column, whereas surface water sampled on the same date had DO levels above 6 mg/L, suggesting a stratified water column. These observations are consistent with findings made by the Gulf States Fisheries Commission studying the effects of the 2019 opening in the MS Bight, which presented data on hypoxic conditions further south and east from the USGS sampling stations, beyond the chain of barrier islands. However, as the Commission points out, hypoxic conditions in the MS Sound occur with and without BCS openings due to seasonal stratification (Dzwonkowski et al. 2018).

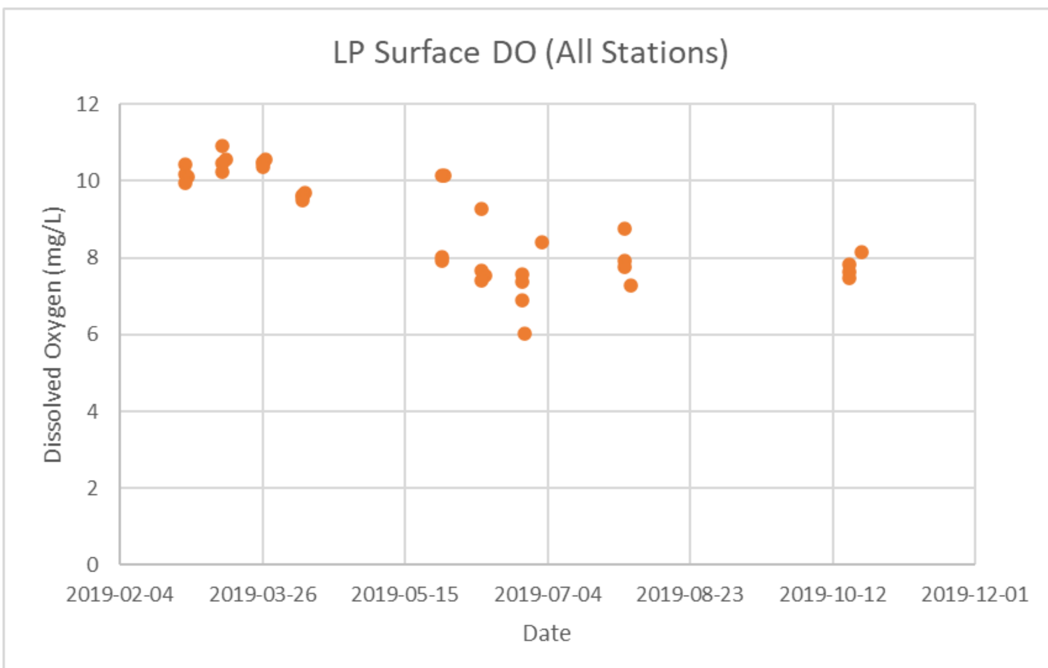


Figure 58. Surface dissolved oxygen measurements recorded at all USGS stations within Lake Pontchartrain in 2019.

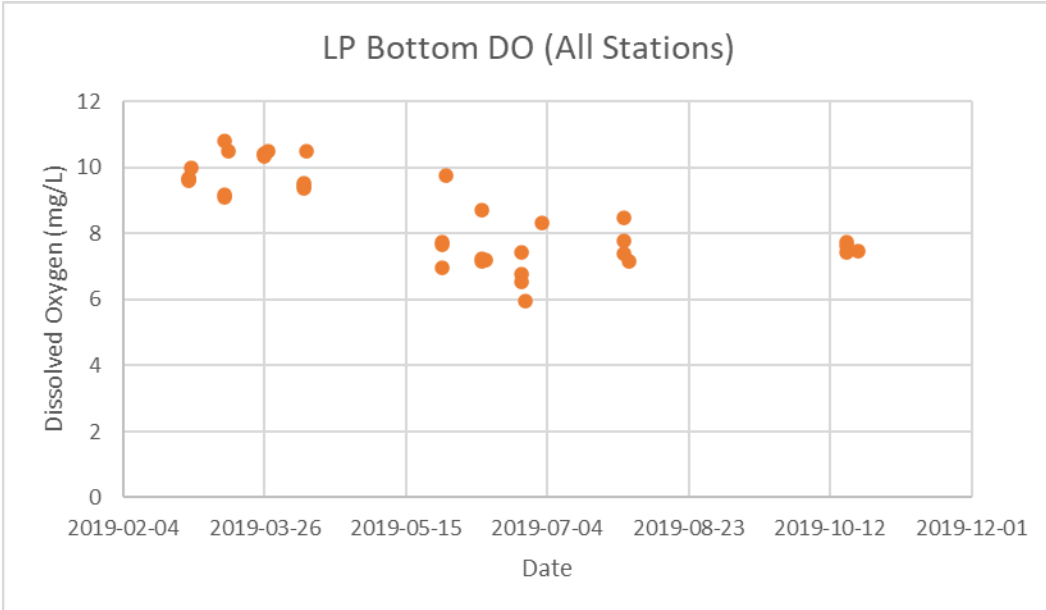


Figure 59. Water bottom dissolved oxygen measurements recorded at all USGS stations within Lake Pontchartrain in 2019.

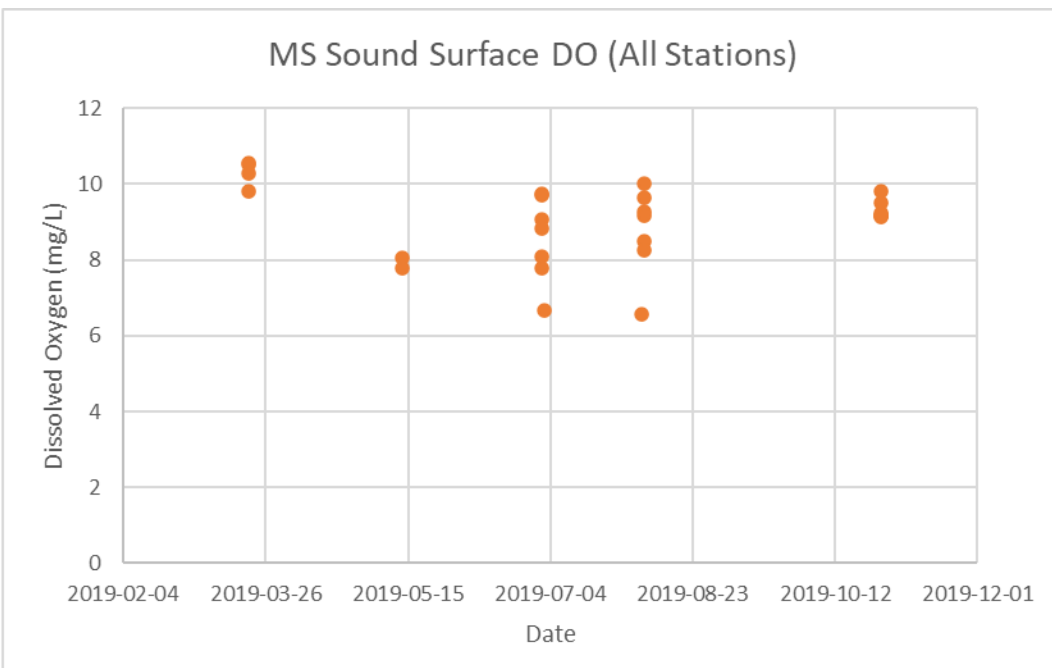


Figure 60. Surface dissolved oxygen measurements recorded at all USGS stations within MS Sound in 2019.

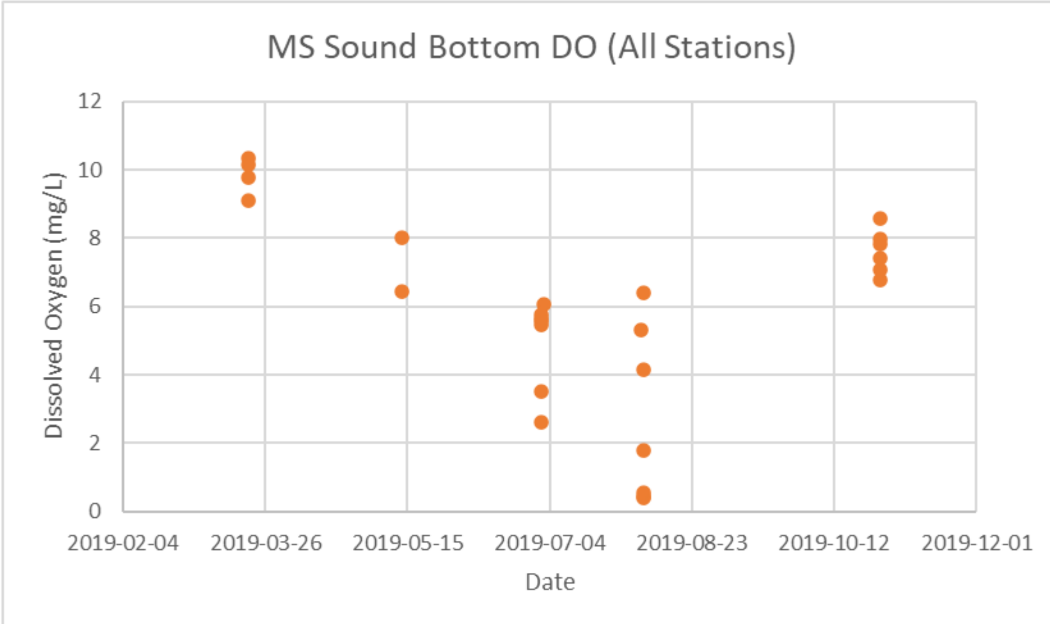


Figure 61. Water bottom dissolved oxygen measurements recorded at all USGS stations within MS Sound in 2019.

Mize and Demcheck 2009 conducted a detailed study on nutrient and phytoplankton dynamics in LP following the 2008 BCS opening. The TN and TP loading from this opening are estimated at approximately 13,150 and 2,515 metric tonnes respectively. They measured dissolved nitrate concentrations during the 2008 BCS opening at station C7, near Metairie on the causeway bridge. Nitrate concentrations increased from approximately 0.6 to 1.5 mg/L in late April and early May, identified in their paper as period 2, the period of maximum influence of the BCS. The nitrate concentration dropped back to near baseline levels by late May, whereas salinity did not return to baseline conditions until late July. The difference in salinity and nutrient recovery periods is likely due to microbial processes that can remove certain types of nitrogen from the system. Spatially averaged dissolved phosphorus concentrations were not significantly different between the four periods identified in this paper, measuring between 0.07 and 0.1 mg/L. However, orthophosphate, the most bioavailable form of phosphate, did drop to a minimum during the second time window. Mize and Demcheck attribute this to the tendency of LP phytoplankton communities to react to different limiting nutrients. LP phytoplankton are typically nitrogen limited (Turner 1999). Since N species spike in phase 2, phosphorus likely replaces it as the limiting nutrient, thus P is drawn down by organism growth. Dissolved silica concentrations were also at their lowest during period 2, measuring 1.31 mg/L, compared to pre-spillway concentrations of 4.13 mg/L. Dissolved silica measurements from Mississippi River (MSR) water in this study were 6.16 mg/L, suggesting that the drop in dissolved silica is not due to dilution, but some other process, likely bioaccumulation.

Mize and Demcheck 2009 identified the algae taxa present in LP after the 2008 Spillway opening. They show that diatoms species dominated MSR water species composition, while LP water was diverse prior to opening, with dinoflagellates, Chlorophyta, and diatoms all well represented. However, in period 2 (April 29th – May 29th) during the opening, cyanobacteria concentrations began to grow, and by periods 3 and 4, in months after the BCS closure, cyanobacteria were by far the dominant genera of algae. Cyanobacteria are associated with HABs, which produce harmful toxins.

Roy et al. 2013 explored nutrient dynamics after the 2011 BCS opening, identifying a similar spike and rapid decrease in nitrates as Mize and Demcheck 2009. Roy describes a distinct nitrate collapse, which is defined as the time between Spillway closure and the date when nitrate levels drop below 0.1 mg/L "within the region of the estuary affected by the diversion." All measurements were taken along a 10-station transect extending straight out from the BCS outfall into Lake Pontchartrain. Roy compared the timing of the collapse period for the 2011 opening with that of the 1997 and 2008 openings. The 1997 opening represents a medium scale opening with above average tributary flow compared to the last 10 years and the 2008 opening represents a small opening with below average tributary flow. The nitrate collapse period in 2008 and 2011 were both 21 days, while it was 87 days in 1997. Roy also states that chlorophyll-a measurements were much higher in 1997 than in 2008 or 2011. Regarding dissolved inorganic phosphorus (DIP), Roy measured initial decreases in concentration along the sample transect from June 4th to June 30th, with values dropping to near zero, before rebounding above the MSR inflow concentration of 0.054 mg/L. The DIP fluctuations are likely due to the same nutrient ratio dynamics described by Mize and Demcheck – Roy cites their paper to explain the DIP drop. The rapid DIP rebound in 2011 is explained by internal loading from sediments since northern tributaries were in drought condition according to the paper. Roy observed a similar dissolved silica drop in 2011 as was observed in 2008, suggesting a similar dynamic of N overloading leading to consumption of other nutrients due to organism growth. The TN and TP loads from the 2011 BCS opening are estimated to be 36,500 and 3,300 metric tonnes respectively (Welch et al.).

Lane et al. 1999 provided a more detailed description of the possible causes of the nitrate decline post-spillway closure, focused on the 1994 BCS opening. Lane states that both denitrifying bacteria – which converts nitrates to nitrites and nitrites to nitrogen gas – as well as bioaccumulation in growing organisms, lead to the rapid decline of nitrate concentrations delivered by the BCS.

Dortch et al. 1998 reported on the 1997 bloom, observing 96% relative abundance of cyanobacteria (genera *Anabaena* and *Microcystis*) at the blooms peak in mid-June. The 2011 opening released about 57% of the volume compared to the 2019 opening, and USGS data from Heal et al. 2023 shows depressed salinities after the opening at MS Sound monitoring stations, so for this comparison, it is assumed that 2011 had a similar area of potential effects as 2019. Roy et al. 2016 found no evidence of cyanobacterial blooms in LP after the 2011 opening, and there were no MS beach closures that year either. Roy et al. 2013 compares the 2011, 2008, and 1997 openings, asking why the 2011 did not produce a cyanobacterial bloom. The report notes that the 2011 opening dwarfed the northern tributary contributions, whereas 1997 and 2008 had relatively even contributions from tributary and BCS flows. 2011 had lower wind speeds post-opening compared to 1997 and 2008, which would theoretically support algal growth. Ultimately, Roy attributes the lack of cyanobacterial HAB formation to higher hydraulic flushing rates from the higher BCS flow rates. The 2011 opening occurred about a year after the Deepwater Horizon Oil Spill, which undoubtedly affected the ecological dynamics during this time-period.

In summary, nutrient and dissolved oxygen dynamics during and after BCS operation are complicated. LP and the MS Sound consistently experience spikes in nitrogen species, primarily nitrates, and orthophosphates from BCS flows, followed by rapid drawdowns of these nutrients attributed to biologic activity. In some years (1997, 2008, and 2019), this biologic activity is considered harmful. Other years, such as 2011, this biologic activity is not considered harmful. DO depletion due to biologic activity is an issue in the MS Sound, where stratification exacerbates DO drawdown. DO depletion does not appear to be as problematic in LP, likely due to more mixing and oxygen replenishment from the atmosphere. While estimating the temporal and spatial patterns of algae blooms and DO is challenging due to their dynamic nature, the 2019 HAB led to 3 months of beach closures in Mississippi – from early July to early October. This 2019 HAB depicts the potential scale of influence from a large-scale opening, though northern tributary flow could have played a role. The importance of local tributary influence is reinforced by the lack of bloom after the large-scale 2011 BCS opening, which coincided with low tributary flow. Smaller scale BCS openings such as the 1997 and 2008 openings influenced the nutrient cycles which led to HABs in Lake Pontchartrain, but did not lead to HABs in the MS Sound, suggesting that the scale of the opening determines the spatial extent of these effects.

3.6 pH

Turner 2021 reported on long term pH trends in the Mississippi River, finding average pH to be 8.2 in 2019. Turner notes that the pH has gone up in the past few decades due to less pollution in the river. USGS discrete sampling conducted in 2019 in the spillway, Lake Pontchartrain and the MS Sound measured pH in that same range, with an average of 8.1 at the LP and MS Sound stations, and a BCS average of 7.5 over the course of the sampling period (February 2019 – November 2019). Data from 2011 and 2008 BCS openings show similar pH trends, with LP and MS Sound averaging 8.1 over the course of operation, and BCS samples measuring 7.7 for both years. This difference makes sense, as the EPA reports that within estuaries there is typically lower pH in fresher water, with pH increasing with salinity due to higher quantities of pH-buffering minerals (US EPA, 2006). Mize and Demcheck 2009 describe pH fluctuations of 1-2 units during the peak of the 2008 BCS operation. No damage related to abrupt changes to pH, such as shell dissolution, have been identified by USACE as a result of BCS operations. Gledhill et al. 2020 measured pH in their analysis of oyster mortality, reporting salinities as low as 6.94 in Bay St. Louis, MS in late May 2019, coinciding with the maximum freshening in MS Sound. The pH in Bay St. Louis had recovered to 7.7 or above by September 2019. Gledhill does not comment on the effects of pH on oyster survival. Algal growth has an impact on pH since it consumes dissolved carbon in photosynthesis, thus raising pH levels. Overall, pH fluctuations due to BCS operation do not appear to create a significant risk to organisms in LP or the MS Sound, due to improved MSR water quality.

3.7 WATER QUALITY AND CONTAMINANTS

The Mississippi River carries contaminants due to the size of its watershed and the many industrial and agricultural activities that take place in the watershed. While pollution levels in the MSR have improved in the past few decades (Turner, 2021), the MSR water can still contain potentially harmful chemicals. Louisiana’s Department of Environmental Quality tests for 59 different organic compounds at three Mississippi River sites, which are chemicals typically associated with industrial pollution. LDEQ reports on the water quality of all water bodies in Louisiana, and a summary of their organic compound monitoring is shown below:

“Between October 4, 2016, and September 22, 2020, 65,769 organic chemical analyses were recorded by LDEQ. Of these, only 520 results, or 0.79 percent of all samples analyzed, resulted in detectable concentrations of the chemical analyzed. The 520 detections resulted in eleven human health drinking water supply or human health non-drinking water supply criteria exceedances. This represents only 0.017 percent of all available chemical sample results” (LDEQ 2022). Pollution due to industrial organic compounds in BCS waters is likely not significant due to the rarity of impairment in the Mississippi River. This type of pollution has not been attributed to the BCS in any research paper or report.

LDEQ also monitors for pesticides such as Carbofuran, DDT (Dichlorodiphenyltrichloroethane), Fipronil, Methoxychlor, and Toxaphene, and Atrazine. Atrazine is a good indicator compound for pesticide pollution as it is common in the MSR watershed and does not sorb to sediment or breakdown very fast, so it is transported along with MSR water (Hanson et al. 2020). Welch et al. with the USGS estimated the Atrazine flux through the BCS during 2011 at 12 metric tonnes. USGS sampling throughout the 2011 BCS operation shows how Atrazine concentrations fluctuated.

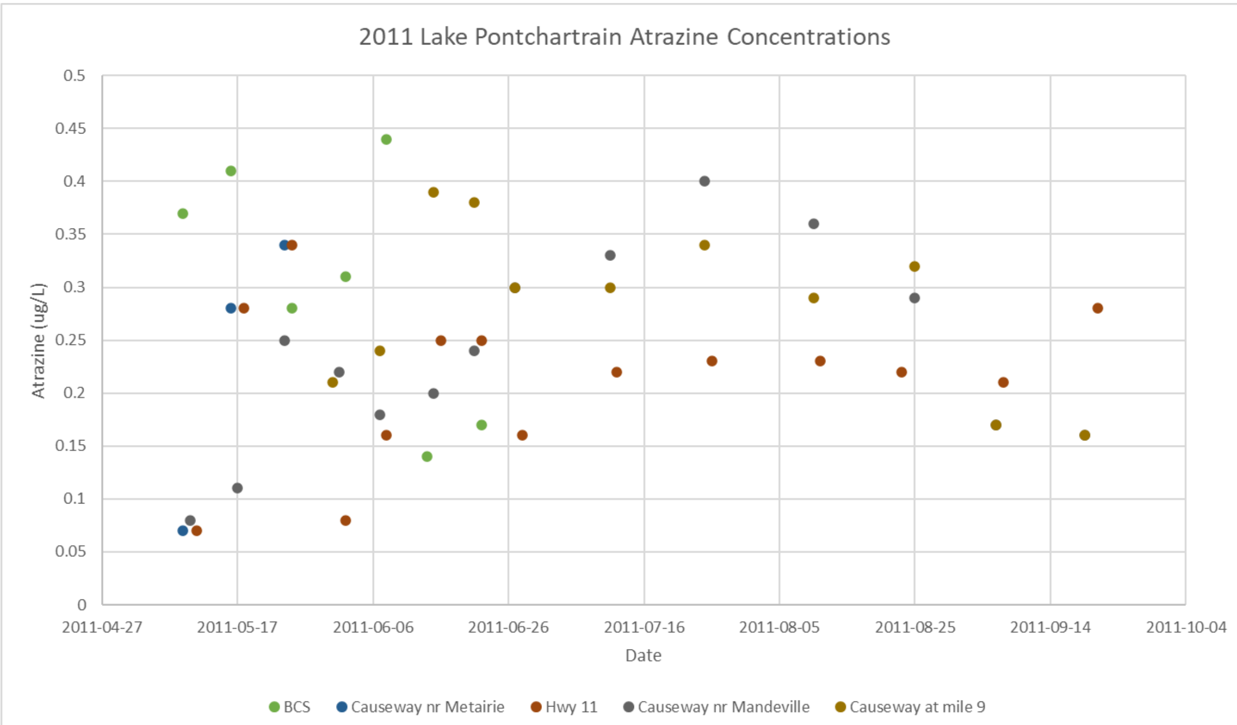


Figure 62. USGS sampling of atrazine throughout the 2011 BCS operation.

Atrazine levels in 2019 recorded a higher maximum value than in 2011. Concentrations in the MS Sound in 2019 are lower than in Lake Pontchartrain. All values recorded are lower than inhalation or drinking water values considered toxic (Texas State Soil and Water Conservation Board 2001, Hanson et al. 2020). Gledhill et al. 2020 and Brammer et al. 2007 make no mention of pesticides in their analysis on harmful water quality conditions for oysters and infaunal macroinvertebrates, respectively.

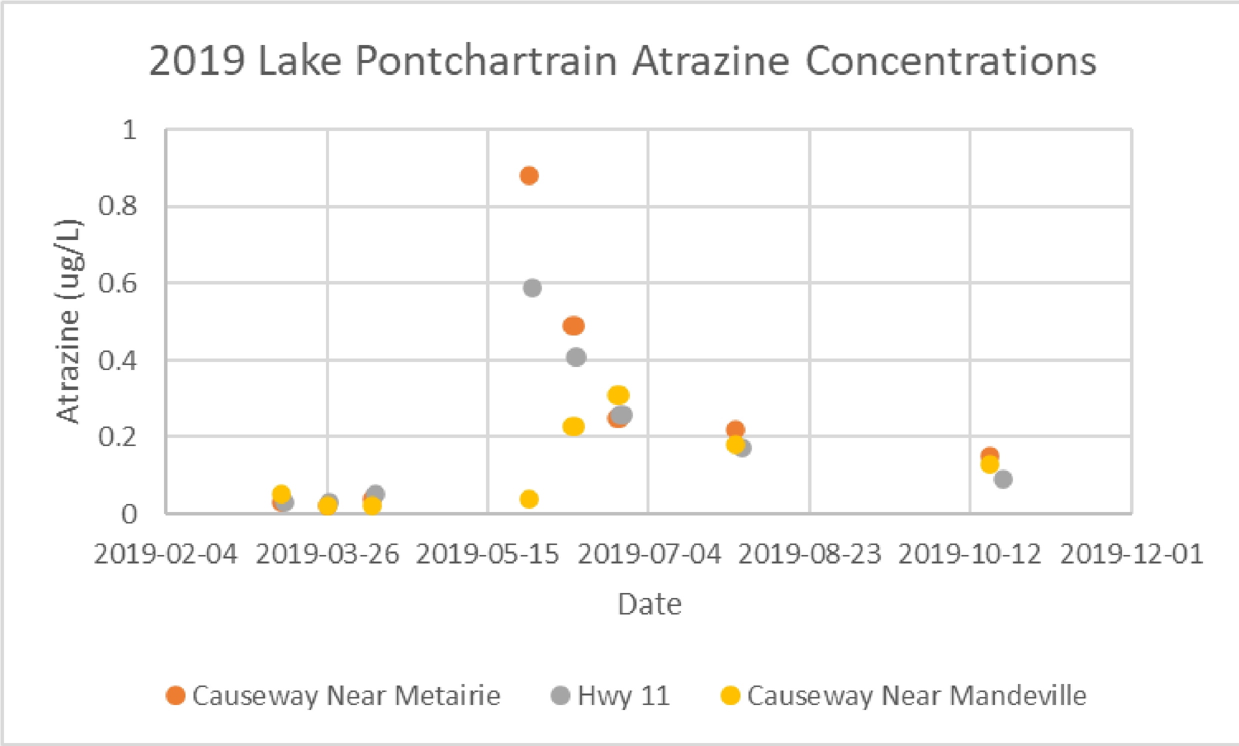


Figure 63. Atrazine concentrations recorded by USGS within Lake Pontchartrain in 2019.

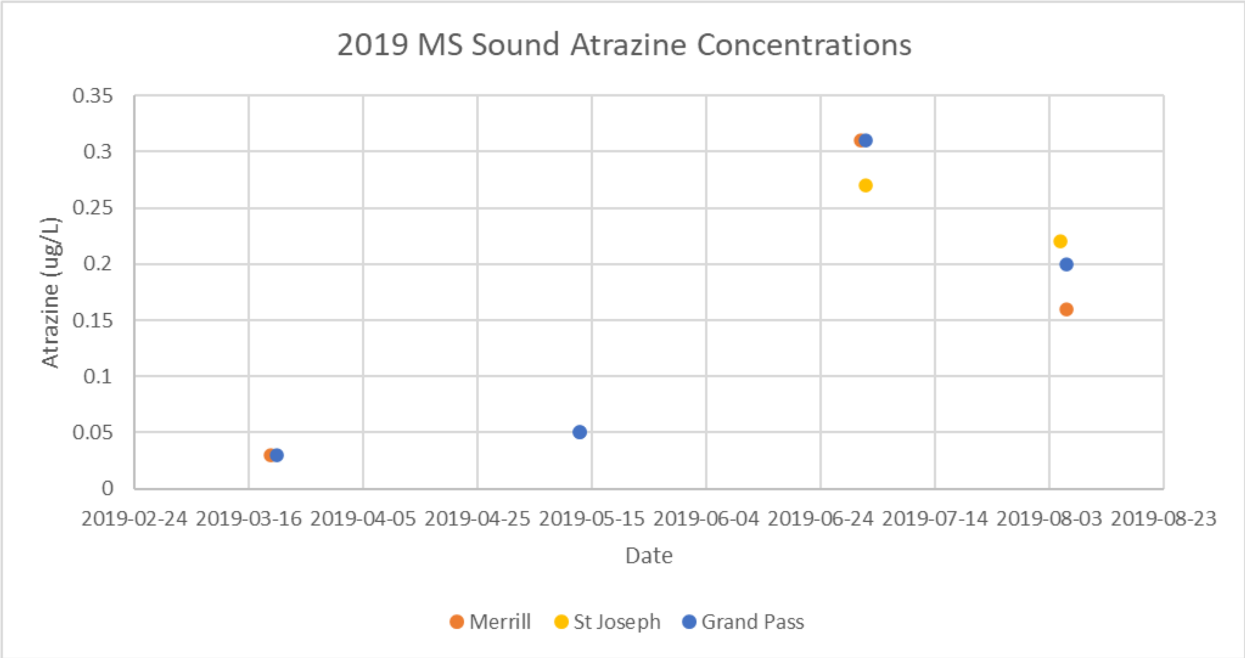


Figure 64. Atrazine concentrations recorded by USGS within MS Sound in 2019. Note: Grand Pass sample dates shifted 1-day for visualization purposes.

Turner 2021 describes other harmful pollution that has been found in the Mississippi River, including bacteria, lead, and sulphate, based on measurements at St. Francisville, Plaquemine, and Belle Chasse. The bacteria measured in this report are coliform and fecal coliform. The Mississippi River has had median fecal coliform and cell densities of 100 per 100 mL since 2010. Lead concentrations have dropped significantly in the past few decades, averaging .18 ug/L when LDEQ MSR lead sampling stopped in 2011. In 2019 sulphate concentrations were around 40 mg/L at the 3 monitoring stations. Turner shows how sulphate concentrations and pH levels vary inversely with strong correlation. While Turner describes how this type of pollution has been damaging in the past in the MSR, damage from this type of pollution has not been identified by USACE from BCS operations.

3.7.1 Organic Pollution

The Mize and Demcheck 2009 paper also discusses generic organic pollution, using algae taxa as indicators via the Palmer composite pollution index (CPI), which identifies algal species that are tolerant of high organic pollution characteristic of sanitary sewage (Palmer, 1969). The CPI doubled between periods 2 and 3 and remained high for period 4. However, this is not enough evidence to indicate sanitary sewage pollution due to BCS, and direct bacterial measurements should be used for this purpose.

3.8 WATER MOVEMENT AND FLOW

The BCS enters Lake Pontchartrain in its southwestern corner, and the spillway flows move west to east across Lake Pontchartrain, through the Rigolets, toward the Mississippi Sound and Mississippi Bight. Past studies of stratification in Lake Pontchartrain show that stratification is rare with or without a BCS opening, and often more a function of saltwater intrusion than freshwater inflows (Haralampides et al. 2000). Roy et al. 2016 observed no difference in water quality parameters during 2011 (BCS opening) and 2012 (no opening) sampled at various depths. Data collected during the 2019 opening shows salinity increasing with depth in the Mississippi Sound, suggesting some amount of stratification during that event. However, as the Gulf States Marine Fisheries Commission points out, seasonal stratification occurs in the MS Sound with and without BCS operation (Dzwonkowski 2019).

Parra et al. 2019 conducted a comprehensive study of water circulation throughout the Lake Pontchartrain Estuary, MS Sound, and MS Bight during the 2016 BCS operation. The MS Bight is the region of the Gulf of Mexico immediately south and east of the Mississippi coast barrier islands. The study used satellite imagery, in-situ sampling, and tracer modeling to estimate the different water sources that were circulating in those areas. They determined that westward winds slowed the migration of the BCS plume out of LP, and that satellite data showed the plume's leading edge exiting the lake at nine days after the opening. The study conducted conservative tracer modeling, which demonstrated that BCS water pushed Mobile Bay water further east. Different freshwater sources were also identified in this study using oxygen isotope measurements. Figure 75 from Parra et al. (2019) shows that isotope data indicated high proportions of MSR water near the birdsfoot delta and some MSR water in the western MS Sound, while the MS Bight had lower levels of MSR water.

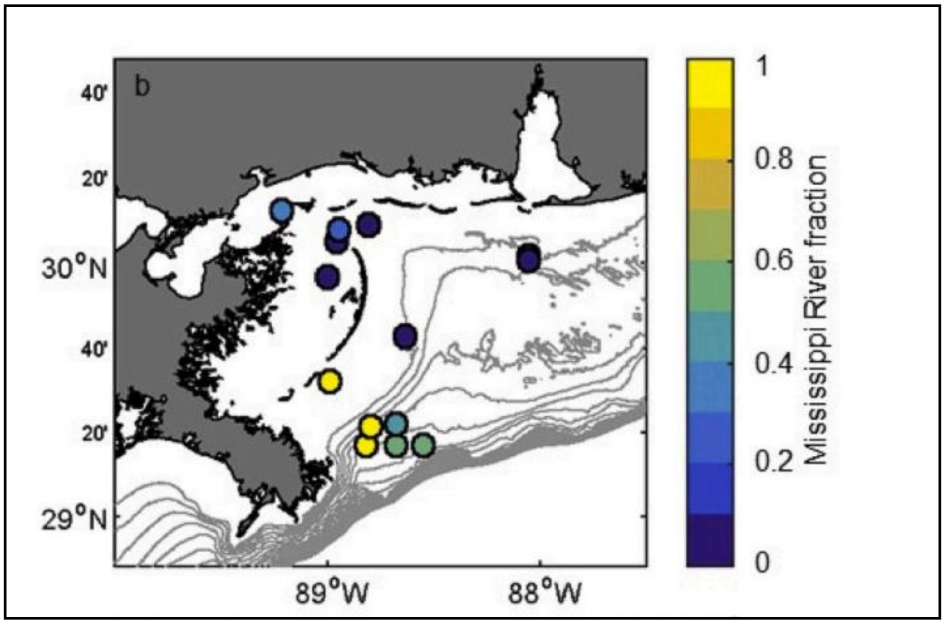


Figure 65. Isotope data from Parra et al. 2019.

Chao et al. 2014 built a sediment transport model that was used to explore impacts of the 1997 BCS opening. They identified wind and tide as the primary drivers of circulation in LP, but noted that the BCS flows dominated these other circulation drivers during the 1997 opening, moving "completely different from the flow patterns induced by tide and wind." Chilmakuri 2006 explored the impact of wind driven flows on the BCS plume by comparing multiple model runs to satellite imagery of the 1997 BCS plume. He found that a model run with a spatially variable wind pattern based on historic data created a plume that more accurately resembled the satellite imagery than a model run with a spatially constant wind applied. Specifically, counterclockwise wind gyres in the central region of the lake pushed the plume southward on March 26th, nine days after the BCS opening. Huang et al. 2019 noted that the Coriolis effect will push the plume to the right as it moves away from the spillway, which is supported by the plume's typical path along the south shore.

There was no study that looked specifically at circulation effects due to northern tributary flows. The Parra et al. 2019 study observes the large-scale interplay of BCS and Mobile River flows, but based on the lack of literature, this review neglects the impact of northern tributary inputs on circulation. However, the migration of northern tributary flows can be observed using water quality parameters, such as salinity and oxygen isotopes. The tributary flows are assumed to be acted on by predominate circulation patterns and are not the driver of these patterns. The BCS is shown to be a strong driver of circulation patterns. Nevertheless, it is likely that these north to south flows have a small north to south influence on LPE and MS Sound circulation.

Sanial et al. 2019 explored identifying sources of different water masses based on oxygen isotope measurements, in addition to salinity values. Their study focused on the proportion of MSR water from the Delta versus the proportion from northern tributaries in the MS Bight and concluded that the northern tributaries contributed more water to the MS Bight than the MSR, based on data from 2011 (June – November), 2015 (late October), and 2016 (February, April, July). This same analysis was performed by USGS on data collected during the 2019 double opening, and interpretation of this data is shown in figures 76 and 77 (Heal et al. 2023). These figures show the proportion of different water sources at different sample locations and the corresponding salinities at those locations. These figures indicate that before Hurricane Barry, the MSR made up most of the water at Hwy 11 and over half the water one mile north of Grand Pass in MS Sound, but that after Hurricane Barry, local tributaries made up a greater proportion of the water, contributing nearly all the freshwater one mile north of Grand Pass (written comm., Scott Mize, USGS, August 2019).

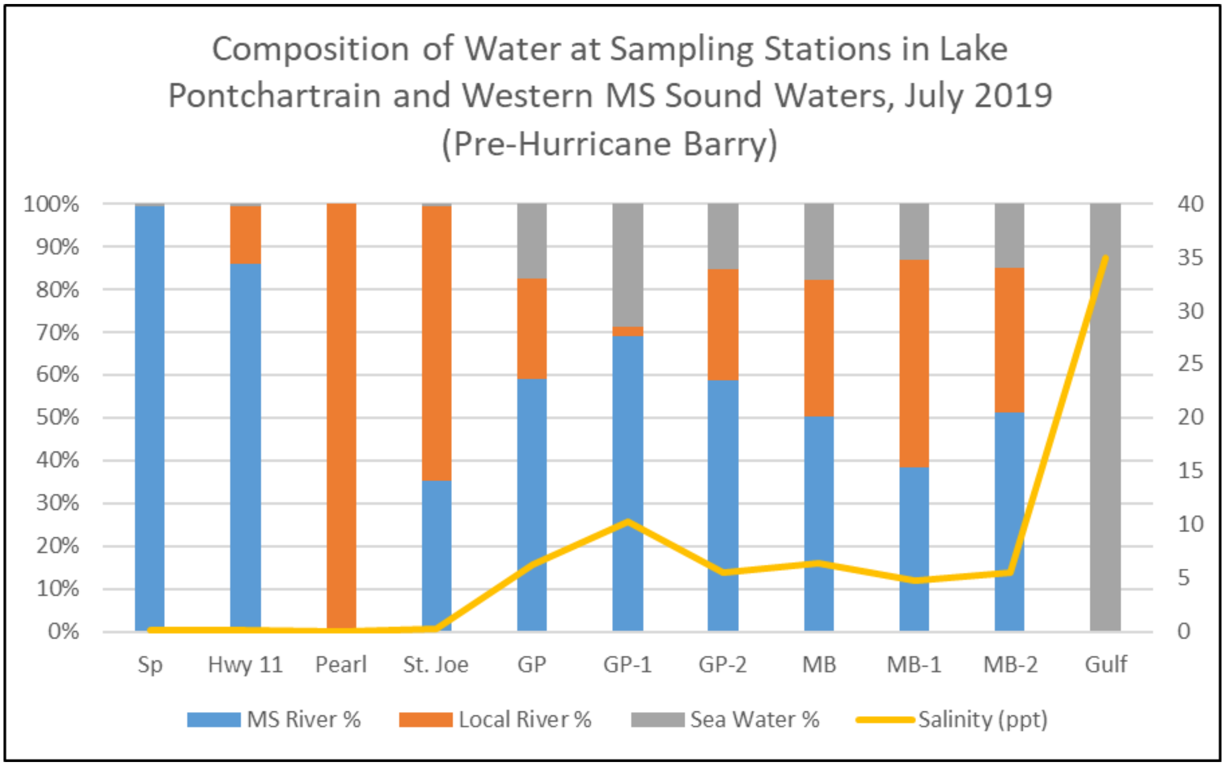


Figure 66. Isotope data and water proportions based on data from Heal et al. 2023, and methods from Sanial et al. 2019.

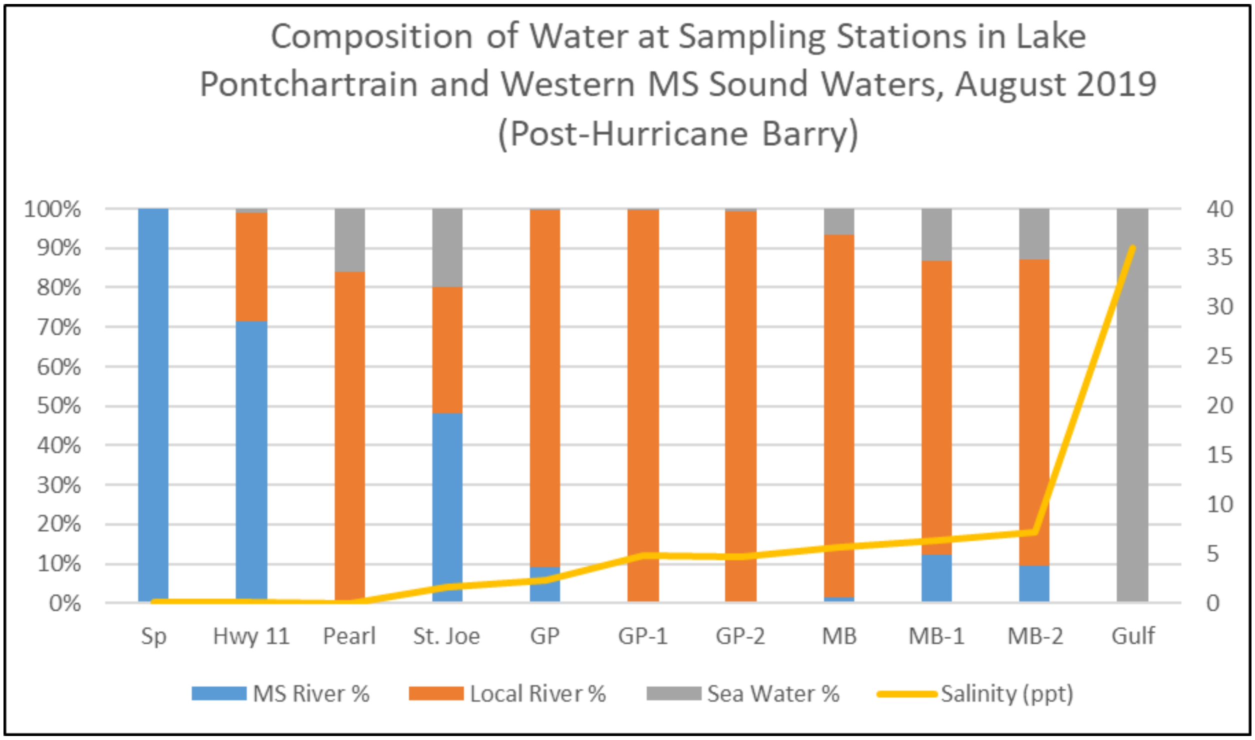


Figure 67. Isotope data and water proportions based on data from Heal et al. 2023, and methods from Sanial et al. 2019.

3.9 IMPACTS TO EFH

3.9.1 <u>Emergent marshes</u>

Operation of the BCS, even though not intended to build land, has potential to deposit large amounts of sediment resulting in land gain and elevation increase of existing marshes (Nittrouer et al. 2012, Kroes et al. 2015, Carle et al. 2015, Kroes et al. 2023). Sediment deposition resulting from BCS operation has been observed primarily within the floodway and immediately adjacent to the outfall located within Lake Pontchartrain (Kroes et al. 2023). Mud flats and emergent marsh potentially resulting from the deposition of sediments from freshwater diversions may create additional value for fish and wildlife, providing important edge habitat for fish and invertebrates for feeding, reproduction, and refuge (Peterson and Turner 1994, Day et al. 2003). The areas of sedimentation with potential for promoting vegetative establishment and creation of an emergent marsh would likely be limited to the areas surrounding the outfall and within western Lake Pontchartrain, with sedimentation decreasing as sediment is transported eastward through the APE.

Impacts to emergent marsh associated with the deposition of sediments within the area of potential effects would be dependent upon the scale of the diversion event, with high-scale events resulting in the largest amount of sediment deposition. As described in Section 3.4, sediment loads as high as 4.25 million metric tonnes have been documented for high-scale diversion events, with significantly reduced sediment loads observed for the medium and low-scale events. Impacts associated with high-scale events are expected to be major, long-term, and positive as the sedimentation may contribute to the creation of additional emergent marsh habitat within the area of potential effects. Impacts associated with sedimentation may occur during medium and low-scale events; however, these impacts will likely be minor or negligible and temporary due to reduced sediment load.

Operation of the BCS will result in a temporary reduction of salinities within the area of potential effects. While the freshening of the area of potential effects is considered temporary, the duration of freshening will be dependent upon the scale of the diversion event. High-scale diversion events will result in increased duration of reduced salinities within the area of potential effects; however, due to the temporary nature of the freshening during a BCS opening and the euryhaline composition of the existing emergent marshes, it is not expected that a temporary reduction of salinities within the APE will adversely impact emergent marshes.

3.9.2 SAV

Salinity reductions resulting from BCS operation may result in temporarily increased habitat suitability for SAV species adapted to fresh water in the area of potential effects. Higher species richness and biomass of SAV have been documented in fresher marshes compared to intermediate, brackish or saline sites (Chabreck 1972, Cho and Biber 2016, Hillmann et al. 2017). Prolonged durations of salinity reductions associated with high-scale diversion events would extend the timeframe of increased habitat suitability compared to the medium or low-scale diversion events. However, regardless of the scale of the event, upon return to preoperational conditions following BCS closure, SAV beds would likely return to their previous species composition and freshwater species that established during BCS operation would likely be reduced over time. Additionally, most of the existing SAV in the area of potential effects are euryhaline and can tolerate a range of salinities, so negative impacts to SAV from salinity changes are unlikely. Therefore, impacts of salinity reductions on SAV associated with BCS operations are expected to be minimal and temporary for all diversion events. During high-scale diversion events, salinity reductions are expected to extend into the easternmost portions of the APE located within the western half of Chandeleur Sound, but these impacts are not expected to extend into the known SAV beds surrounding the Chandleur Islands, as the Chandeleur Islands are outside of the APE for BCS operations.

Light availability is one of the primary factors that determines SAV distribution within Lake Pontchartrain (Poirrier et al. 2009), and temporary increases in turbidity associated with BCS operation may reduce the amount of surface light that reaches the waterbottom to levels below the minimum light requirements of SAV species. Significantly prolonged increases in turbidity and suspended sediment concentrations have been observed for high-scale diversion events.
A comparison of SAV surveys from 1996 to 1997 indicated the March 1997 BCS opening, classified as a high-scale event, caused a significant decrease in certain species of SAV (Poirrier et al. 1999) partially attributed to the increased turbidity within the area of potential effects. Increased turbidity and suspended sediment concentration have also been observed during medium and low-scale events, but with reduced suspended sediment concentration and duration of impacts when compared to the high-scale events. Following closure of the BCS, SAV recovery within the APE is expected, but the timeline for SAV recovery will be dependent upon the scale of the diversion event, with high-scale diversion events likely delaying recovery due to increased and prolonged impacts to light availability. Impacts to SAV resulting from the temporarily increased turbidity and suspended sediment concentration are considered temporary and minor.

Harmful algal blooms (HABs) resulting from BCS operation can directly impact SAV within the APE by decreasing light availability for SAV (Backman and Barilotti 1976,) as these aggregations of organisms discolor water or float on the surface of the water as a scum. HABs further impact SAV through competition for nutrient and CO_2 uptake (Hauxwell et al. 2001). The potential for

HABs is increased with high-scale diversion events, such as the documented HABs reported in the summer of 2019 in Lake Pontchartrain; however, HABs resulting from medium to low-scale diversion events may occur. The area of disturbance and duration of HABs is dependent upon a variety of environmental factors, but the significant influx of nutrients associated with high-scale diversion events will likely increase the size and duration of HABs compared to the reduced influx of nutrients associated with medium and low-scale diversion events. Impacts associated with HABs are considered minor and temporary as a return to preoperational conditions and recovery of SAV are expected following HABs that may occur as a result of BCS operation.

Overall, BCS operation is expected to have a major initial impact to SAV within the APE, with high-scale diversion events resulting in the most significant impacts due to increased impacts associated with turbidity and light availability reductions; however, these impacts are expected to be temporary and recovery of SAV is expected as turbidity and light availability return to preoperational conditions following closure of the BCS.

3.9.3 Soft and Hard Bottoms

Operation of the BCS will result in changes to water bottoms due to the deposition of sediments potentially causing bottom habitat throughout Lake Pontchartrain to become shallower, with the area in the vicinity of the outfall of the BCS being subject to the highest sedimentation. While burial of some benthic habitats may occur, recovery of benthic macroinvertebrates following burial by a thin layer of sediment is typically rapid, with total infaunal abundance being similar to pre-burial abundance within 3-10 months of burial (Wilber et al. 2007). Impacts to benthic organisms within the immediate vicinity of the outfall in western Lake Pontchartrain may be greater as sediment deposition will be highest in this area and may exceed post-burial survival and recovery capabilities of benthic organisms. Sediment deposition in this area would be most significant during a high-scale diversion event and increased impacts to benthic organisms would be expected. Impacts would occur during medium and low-scale diversion events; however, these impacts would be greatly reduced due to the decreased sediment load associated with smaller diversion events. Outside the area near the outfall where sediment deposition is the highest, sediment deposition would be similar to typical deposition patterns, and therefore, BCS operation would likely cause negligible changes to water bottom communities regardless of the scale of the diversion event. The areas outside of Lake Pontchartrain would not be appreciably affected by sediment deposition due to their distance from the BCS.

Salinity is considered among the most important environmental variables determining the distribution and abundance of benthic communities in estuaries (Remane and Schlieper 1971); therefore, prolonged BCS operation may result in temporary changes in benthic community species composition, abundance, and biomass within the APE. The areas with higher average salinities are located further from the BCS. The benthic species in those areas (like Lake Borgne, Mississippi Sound and the Gulf of Mexico) would be less adaptable to significant salinity shifts. These potential impacts would be most significant during a high-scale diversion event where there is the potential for extended durations of reduced salinities and an increase in areas of reduced salinity. Medium and low-scale events could also result in salinity shifts, but with reduced duration and areas of disturbance compared to the larger, high-scale diversion events. However, impacts associated with salinity shifts on hard bottom habitat, including salinity shifts associated with high-scale diversion events, would be minor and temporary as the use of the hard bottom by EFH managed species would continue. However, species comprising these hard bottom habitats would likely be adversely impacted by high-scale events. While high-scale events may prolong the return to preoperational conditions, salinities are expected to return preoperational conditions following closure of the BCS.

3.9.3.1 Oyster Reefs

Sedimentation resulting from BCS operations has been primarily limited to the area within western Lake Pontchartrain immediately adjacent to the outfall of the BCS, an area absent of oyster reef habitat. During high-scale diversion events, sedimentation impacts may extend further out from the outfall. However, areas known to support oyster reef habitat such as Lake Borgne, Biloxi Marsh and MS Sound are unlikely to see significant sediment deposition capable of resulting in burial and loss of oyster reef habitat. Any sedimentation that may occur as a result of BCS operation would be minor and not significantly increased from the typical sedimentation rates of the existing naturally turbid environment. Sedimentation impacts are not expected for medium to low-scale diversion events as the sediment load for these events is greatly reduced compared to high-scale events and impacts will likely not extend into parts of the APE where oyster reef habitat is present. Therefore, only minor impacts to oyster reef habitat are expected from sedimentation resulting from high-scale BCS operations. Salinity changes may result in oyster mortality when salinities drop below 5ppt for extended periods of time. However, once BCS operations are ceased, favorable conditions for oyster spat set and growth are expected to return. In addition, oyster reefs that experience salinity induced mortality still act as EFH by providing structured hard substrate habitat benefits to federally managed fisheries and their prey. Therefore, it is expected the range of BCS discharges are unlikely to have long term impacts to oyster reefs as EFH for federally managed species.

3.9.4 <u>Water Column</u>

Releases of freshwater, nutrients, and sediment from the Mississippi River during operation of the BCS have the potential to impact water column habitat throughout most of the area of potential effects. High-scale diversion events will result in increased and prolonged effects that will likely impact the entirety of the water column within the APE, while medium to low-scale diversion events will be limited to the portions of the APE closer to the outfall of the BCS. Impacts associated with all BCS operations, including all scales of diversion events, are considered temporary and minor with a return to preoperational conditions following BCS closure. Impacts are greater nearer to the BCS outfall. Impacts from sediment greatly diminish as the distance from the BCS increases.

Many species within this area have salinity ranges that include salinities down to 0 ppt, and tolerance ranges that allow for a level of adaptability to salinity regime shifts. Estuarine species will often use areas of very low salinity as predation refuge and can often adapt to salinity variability through osmoregulation or relocation, although both tactics require energy expenditure which could otherwise be used for growth. Therefore, these species are not expected to be significantly negatively affected by temporarily lowered salinity regimes and major, temporary, and positive impacts on species with lower salinity preferences may occur as saltwater intrusion into the areas of potential effects, is curtailed. Prolonged durations and increased areas of reduced salinities are expected with high-scale diversion events, with impacts extending throughout the entirety of the APE. An increase in positive effects is expected for species with lower salinity preferences during these high-scale events. Medium and low-scale events would result in positive impacts for these species as well, but within a reduced area, mostly limited to the Lake Pontchartrain Basin, and with a reduced duration of freshening. Species for which lower salinities are outside of the optimal ranges may experience moderate, adverse, and temporary impacts associated with areas found in the easternmost APE predicted to experience significant drops in salinity while the BCS is operated.

Input of riverine water from the BCS will also affect water temperatures as river water tends to be cooler than the water present within the area of potential effects. Although, temperature differentials would quickly decrease as the inflowing river waters mix with waters of the APE, and the effects of colder waters would decrease with distance from the outfall. The extent of temperature shifts within the APE is dependent upon the scale of the diversion event and the time of year the diversion event occurs, with high-scale diversion events being capable of discharging a significant amount of water into the APE; however, when considering even the largest diversion event, the overall direct effects of decreased average temperatures and acute temperature changes on faunal populations at these discrete locations and time periods would likely be minor to negligible and temporary.

3.9.5 Mangroves

Freeze events and temperature control the distribution of black mangrove forests in Louisiana and across the northern Gulf of Mexico (Osland et al. 2017). Temporary freshening of the area of potential effects is not expected to impact mangrove habitat due to the broad salinity tolerance of mangrove species, with young seedlings being able to tolerate salinities from 0-72 ppt, and increased growth rates associated with lower salinities (McMillan 1971, Ball 1988, Alleman and Hester 2011, Matto et al. 2023). Additionally, distribution of mangroves within the area of potential effects are limited to the outermost estuarine habitats of coastal Louisiana near the boundary of the area of potential effects associated with BCS operation. Freshening of these areas resulting from BCS operation would likely be limited to high-scale diversion events. However, any impacts that may occur during a high-scale diversion event would be considered minor and temporary, with a rapid return to preoperational conditions following closure of the BCS.

3.10 IMPACTS TO EFH SPECIES

Table 4 below lists and describes the features of the HUC codes within the APE.

Table 4. HUC Codes of the APE

Area Designation	Name & Number of HUC	Common Features
ELC	Eastern Louisiana Coastal; 08090203	Lake Borgne, Biloxi Marsh, Lake Catherine, The Rigolets, Chef Pass, Western Chandeleur Sound (Excluding Chandeleur Islands)
MCH	Mississippi Coastal; 03170009	Western Mississippi Sound
LPH	Lake Pontchartrain; 08090202	Lake Pontchartrain
GOM	Gulf Of Mexico (No HUC Assigned)	A small part of the Gulf of Mexico potentially effected during high scale events is located outside of HUC designations.

EFH species, and their respective life stages, that are known to occur within the APE, and that may experience impacts from low, medium and high-scale diversion events within the noted HUCs, are listed within Table 5 below. Detailed accounts of specific impacts to each life stage of the stated EFH species is included within the next section.

Table 5. Impacts to EFH Species within the APE

Common Name	Scientific Name	Life Stage	EFH	Potentially Affected By Low Scale Events within the following HUCs	Potentially Affected By Medium Scale Events within the following HUCs	Potentially Affected By High Scale Events within the following HUCs
Red drum (Optimal salinity 20-40 ppt; This species readily adapts to lower salinities)	*Sciaenops ocellatus*	Eggs	water column associated; nearshore	LPH	LPH;	LPH; ELC; MCH
		Larvae	submerged aquatic vegetation; soft bottom; water column	LPH	LPH;	LPH; ELC; MCH
		Post Larvae	submerged aquatic vegetation; emergent marsh; soft bottom	LPH	LPH	LPH; ELC; MCH
		Early Juveniles	submerged aquatic vegetation; soft bottom; hard bottom; sand/shell	LPH	LPH; GOM	LPH; ELC; MCH; GOM
		Late Juveniles	submerged aquatic vegetation; emergent marsh; soft bottom; sand/shell	LPH	LPH; GOM	LPH; ELC; MCH; GOM
		Adult	submerged aquatic vegetation; emergent marsh; soft bottom; hard bottom; sand/shell	LPH	LPH; GOM	LPH; ELC; MCH; GOM
Brown shrimp (Optimal salinity 10-20 ppt)	*Crangon crangon*	Larvae/Postlarvae	water column associated; nearshore	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH;
		Juvenile	submerged aquatic vegetation; emergent marsh; oyster reef; soft bottom; sand/shell; estuarine	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH
		Subadult	soft bottom; sand/shell; nearshore; estuarine	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH; GOM
		Adult	soft bottom; sand/shell; nearshore; estuarine	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH; GOM
White shrimp (Optimal salinity 1-15 ppt)	*LitoLitopenaeus setiferus*	Postlarvae	water column associated	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH;
		Juvenile	Emergent marsh; submerged aquatic vegetation; oyster reef; soft bottom; mangroves	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH;
		Subadult	soft bottom; sand/shell	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH; GOM
		Adults/Spawning Adult	soft bottom	LPH; ELC; MCH	LPH; ELC; MCH	LPH; ELC; MCH; GOM
Pink Shrimp (Optimal salinity 25-45 ppt)	*Farfantepenaeus duorarum*	Juvenile	submerged aquatic vegetation; soft bottom; sand/shell; mangroves; oyster reef; estuarine; submerged aquatic vegetation; mostly nearshore	N/A	ELC GOM	ELC GOM
		Subadult	submerged aquatic vegetation; soft bottom; sand/shell; mangroves; mostly nearshore	N/A	ELC; MCH; GOM	ELC; MCH; GOM
Reef Fish						
Lane snapper	*Lutjanus synagris*	Larvae/Postlarvae	Nearshore SAV, estuarine, planktonic 4-132 m	N/A	ELC; MCH; GOM	ELC; MCH; GOM

(Optimal salinity 19-35 ppt)		Juvenile	Nearshore SAV, estuarine sand/shell/mud/soft bottom, banks/shoals, mangrove 4-132 m.	N/A	ELC; MCH	ELC; MCH; GOM
		Adult	Nearshore SAV, estuarine sand/shell/mud/soft bottom, banks/shoals 4-132 m	N/A	MCH; GOM	ELC; MCH; GOM
Gray snapper (Optimal salinity 1-35 ppt)	*Lutjanus griseus*	Larvae/Postlarvae	Nearshore SAV, nearshore hardbottom/banks/shoals, estuarine mud/soft/sand/shell bottom, estuarine emergent marsh, 0-180 m	N/A	ELC; MCH; GOM	ELC; MCH; GOM
		Juvenile	Nearshore SAV, nearshore hardbottom/banks/shoals, estuarine mud/soft/sand/shell bottom, estuarine emergent marsh, 0-180 m	N/A	ELC; MCH; GOM	ELC; MCH; GOM
		Adult	Nearshore SAV, nearshore hardbottom/banks/shoals, estuarine mud/soft/sand/shell bottom, estuarine emergent marsh, 0-180 m	N/A	ELC; MCH; GOM	ELC; MCH; GOM
Coastal Migratory Pelagics						
Cobia (Optimal salinity 24-36 ppt)	*Rachycentron canadum*	Eggs/Postlarvae/Juvenile/Adult	Nearshore pelagic	N/A	ELC; MCH; GOM	ELC; ELC; MCH; GOM
Spanish Mackerel (Optimal salinity 0-31 ppt)	*Scomberomorus maculatus*	Juvenile	Nearshore, drift algae (Sargassum), estuarine	N/A	ELC; MCH; GOM	ELC; MCH; GOM
		Adult	Nearshore pelagic, estuarine	N/A	ELC; MCH GOM	ELC; MCH; GOM
Highly Migratory Species in the Project Area (These species, except for Bull Sharks, typically prefer salinity above 20ppt)						
Scalloped Hammerhead Shark	*Sphyrna lewini*	Neonate	All nearshore waters to 30 fathoms	N/A	N/A	MCH; GOM
		Juvenile	water column associated; nearshore	N/A	N/A	MCH; GOM
Blacktip Shark	*Carcharhinus limbatus*	Neonate & Juvenile	water column associated; nearshore; estuarine	N/A	ELC; MCH; GOM	ELC; MCH; GOM
		Adult	water column associated; nearshore	N/A	ELC; MCH; GOM	ELC; MCH; GOM
Finetooth Shark	*Carcharhinus isodon*	Neonate	water column associated; nearshore	N/A	ELC; MCH; GOM	ELC; MCH; GOM
		Juvenile & Adult	water column associated; nearshore	N/A	ELC; MCH; GOM	ELC; MCH; GOM
Spinner Shark	*Carcharhinus brevipinna*	Neonate	water column associated; nearshore	N/A	ELC; MCH	ELC; MCH; GOM

		Juvenile	water column associated; nearshore	N/A	ELC; MCH	ELC; MCH; GOM
Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	Neonate	water column associated; nearshore	N/A	ELC; MCH	ELC; MCH; GOM
		Juvenile	water column associated; nearshore	N/A	ELC; MCH	ELC; MCH; GOM
		Adult	water column associated; nearshore	N/A	ELC; MCH	ELC; MCH; GOM
Sailfish	*Istiophorus platypterus*	Adult	water column associated; nearshore	N/A	N/A	MCH; GOM
Lemon Shark	*Negaprion brevirostris*	Adult	water column associated; nearshore	N/A	ELC; MCH	ELC; MCH; GOM
Bonnethead Shark	*Sphyrna tiburo*	Neonate,Juvenile, Adult	water column associated; nearshore	N/A	LPH; ELC; MCH	LPH; ELC; MCH; GOM
Bull Shark (do typically inhabit freshwater)	*Carcharhinus leucas*	Neonate	water column associated; nearshore; estuarine	N/A	LPH; ELC; MCH	LPH; ELC; MCH; GOM
		Juvenile	water column associated; nearshore; estuarine	N/A	LPH; ELC; MCH	LPH; ELC; MCH; GOM
		Adult	water column associated; nearshore; estuarine	N/A	LPH; ELC; MCH; GOM	LPH; ELC; MCH; GOM

* N/A in this table suggest the applicable species life stage would not be affected by the corresponding level of event.

3.11 WATER TEMPERATURE

Mississippi River water is typically colder than Lake Pontchartrain and MS Sound water. Mize and Demcheck 2009 described a 3-5 degree-celsius drop in water temperature observed at the LP monitoring stations during the 2008 BCS operation. A similar drop was observed at the LP Hwy 11 and Causeway near Metairie stations during the first 2019 opening. The USGS gage at the Rigolets near Highway 90 average monthly temperatures are shown below in figure 63, for the years 2003-2023. Average temperatures at this gage station are approximately 21 degrees Celsius in the month of April and 25 degrees Celsius in the month of May.

USGS 301001089442600 Rigolets at Hwy 90 near Slidell, LA

Available data for this site Time-series: Daily statistics GO

Orleans Parish, Louisiana
Hydrologic Unit Code 08090203
Latitude 30°10'01", Longitude 89°44'26" NAD83
Gage datum -1.00 feet above NAVD88

Output formats
HTML table of all data
Tab-separated data
Reselect output format

00010, Temperature, water, degrees Celsius,
Mean of daily mean values for each day for water year of record in, deg C (Calculation Period 2003-10-01 -> 2023-09-30)
Calculation period restricted by USGS staff due to special conditions at/near site

Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	13.4	12.1	16.1	20.6	23.5	27.7	29.9	30.1	29	26.5	20.7	15.5
2	13.2	12.3	16.1	20.7	23.9	27.8	30	30.2	29.1	26.1	20.5	15.3
3	12.7	12.4	16	20.9	24	28	30	30.2	29.1	26	20.3	15.3
4	12.5	12.2	15.7	21	23.9	28.2	30.1	30.3	29.1	25.8	20	15.2
5	12.4	12.2	15.8	20.8	24.1	28.3	30	30.3	29.2	25.6	19.8	15.2
6	12.4	12.4	15.8	20.7	24.1	28.3	29.7	30.5	29.1	25.6	19.8	15.2
7	12.3	12.5	16	20.5	24.4	28.3	29.7	30.7	28.9	25.6	19.8	14.9
8	12.1	12.7	16.3	20.5	24.7	28.6	29.8	30.7	29.1	25.4	19.6	14.7
9	12.1	13	16.7	20.6	24.9	28.8	30	30.6	29	25.3	19.4	14.5
10	12.3	13.2	17.1	21	25	28.8	30	30.6	28.9	25.3	19.1	14.5
11	12.1	13.4	17.4	21.3	25.2	28.8	30.1	30.5	28.7	25.3	18.9	14.2
12	12.1	13.3	17.5	21.6	25.6	28.9	30.1	30.3	28.8	25.3	18.7	14
13	12	12.9	17.6	21.7	25.7	29	30.1	30.1	28.6	25.2	18.1	14
14	11.8	13	17.8	21.5	25.8	29.2	30.1	30.1	28.4	25	17.5	14.1
15	11.7	13.2	18	21	25.7	29.3	29.9	30.1	28.3	24.9	17.2	14.1
16	11.7	13.4	18.2	20.9	25.7	29.5	29.8	30	28.2	24.8	16.9	13.9
17	11.4	13.5	18.3	21.1	25.7	29.6	29.7	30	28.1	24.5	16.8	13.9
18	11.5	13.7	18.3	21.3	25.7	29.6	29.9	30	28.3	24.1	16.6	13.6
19	11.7	13.8	18.6	21.5	25.8	29.6	29.9	29.9	28.2	23.5	16.4	13.5
20	11.7	14.2	18.7	21.4	26.2	29.6	30	29.9	28	23.1	16.2	13.3
21	11.8	14.5	18.8	21.7	26.4	29.6	30.1	30	27.7	23.1	16.2	13.3
22	11.8	14.9	18.8	22.1	26.6	29.6	30.1	30.1	27.7	23	16.1	13.5
23	11.6	15.2	19	22.5	26.8	29.6	30	30.3	27.7	22.7	16.2	13.3
24	11.5	15.5	19.3	22.6	27.1	29.7	30	30.1	27.7	22.4	16.2	13.1
25	11.6	15.5	19.6	22.8	27.1	29.7	30	30	27.7	22.2	16	12.9
26	11.8	15.4	19.8	23	27.1	29.6	30.1	29.8	27.9	22.2	16	12.6
27	11.8	15.5	20	23.1	27.3	29.7	30	29.6	27.7	22.1	15.8	12.7
28	12	16	20.4	23	27.5	29.8	30.2	29.2	27.4	21.6	15.5	13
29	11.9	14.6	20.5	23.2	27.6	29.7	30.2	29	27	21	15.6	13.2
30	11.8		20.5	23.3	27.6	29.8	30.3	29	26.8	20.7	15.8	13.3
31	11.9		20.6		27.6		30.1	29		20.8		13.4

Figure 68. Average monthly temperatures at the USGS Rigolets at Highway 90 gauge.

Figures 66-68 below show the USGS Rigolets at Hwy 90 temperature measurements for 2019, 2016, and 2011. In 2019, this gage recorded a 5-degree C drop in temperature approximately 1 week after the first spillway opening. However, temperature quickly rebounded. A 3-degree C drop in temperature was observed on April 20th, when the BCS was closed.

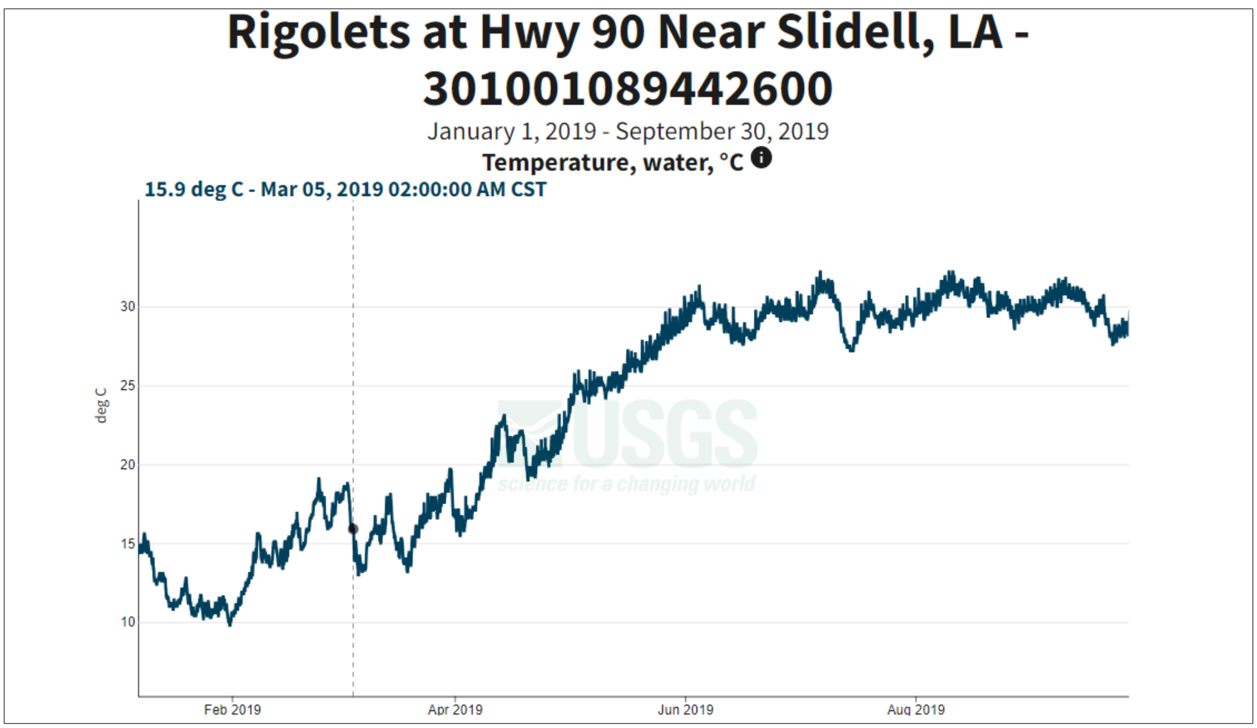


Figure 69. 2019 Temperature Measurements USGS Rigolets at Hwy 90.

In 2016, the temperature record is steadily declining as the BCS begins operation, as this occurs in the winter when temperatures are still trending down (Figure 67). The temperature rises in the week after BCS closure, but then drops again. Based on this gage record, it is difficult to isolate the impact of the BCS in 2016.

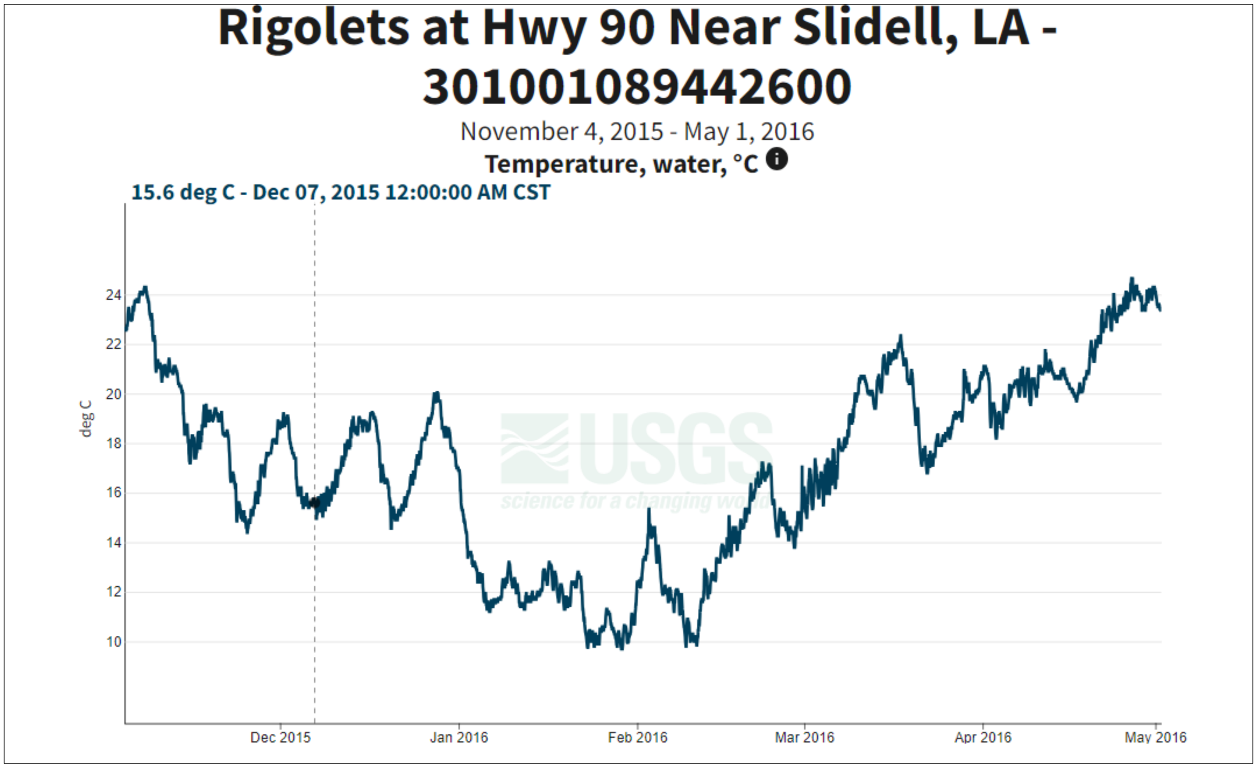


Figure 70. 2016 Temperature Measurements USGS Rigolets at Hwy 90.

The 2011 temperature gage record shows a 4-degree C drop in temperature occurring the week after the spillway opening, followed by a steady increase (Figure 68). The temperature remained close to the monthly average during this time.

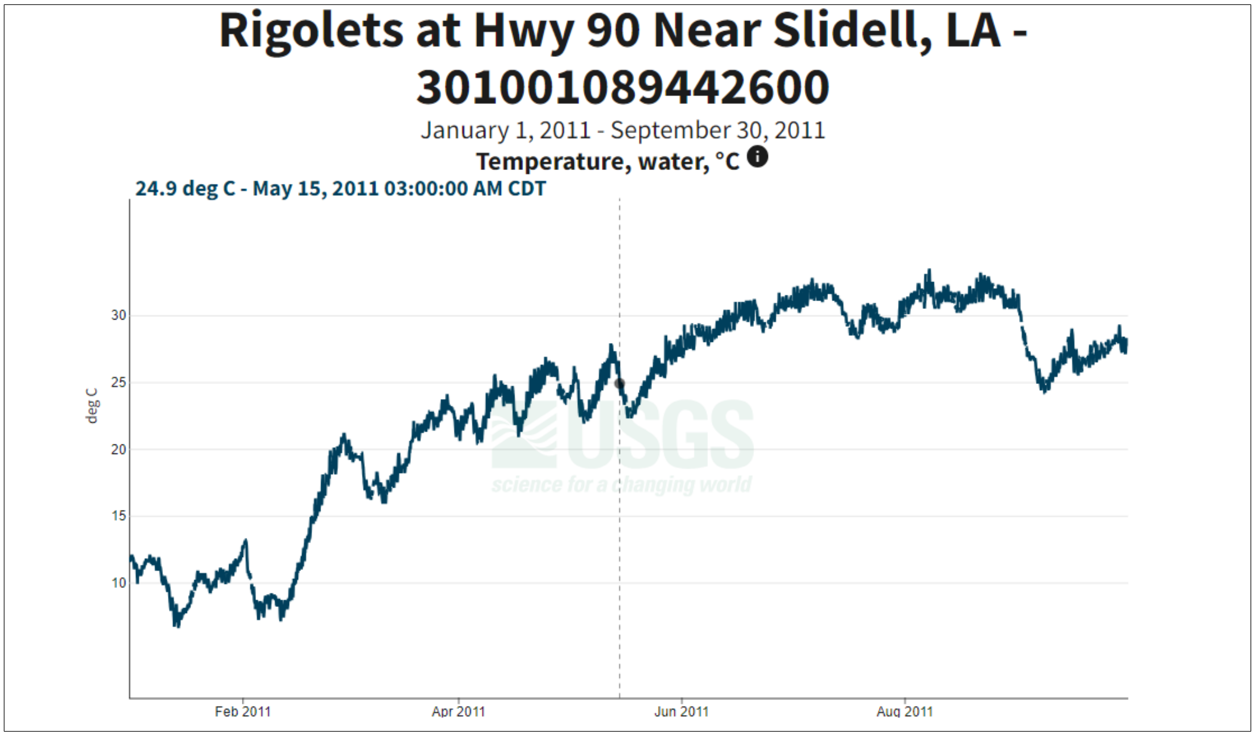


Figure 71. 2011 Temperature Measurements USGS Rigolets at Hwy 90.

Grab samples taken in Lake Pontchartrain and MS Sound, shown in Figure 69 below, shows regular seasonal fluctuations in temperature. These samples do not show an obvious temperature impact, likely due to the short duration of the temperature impacts.

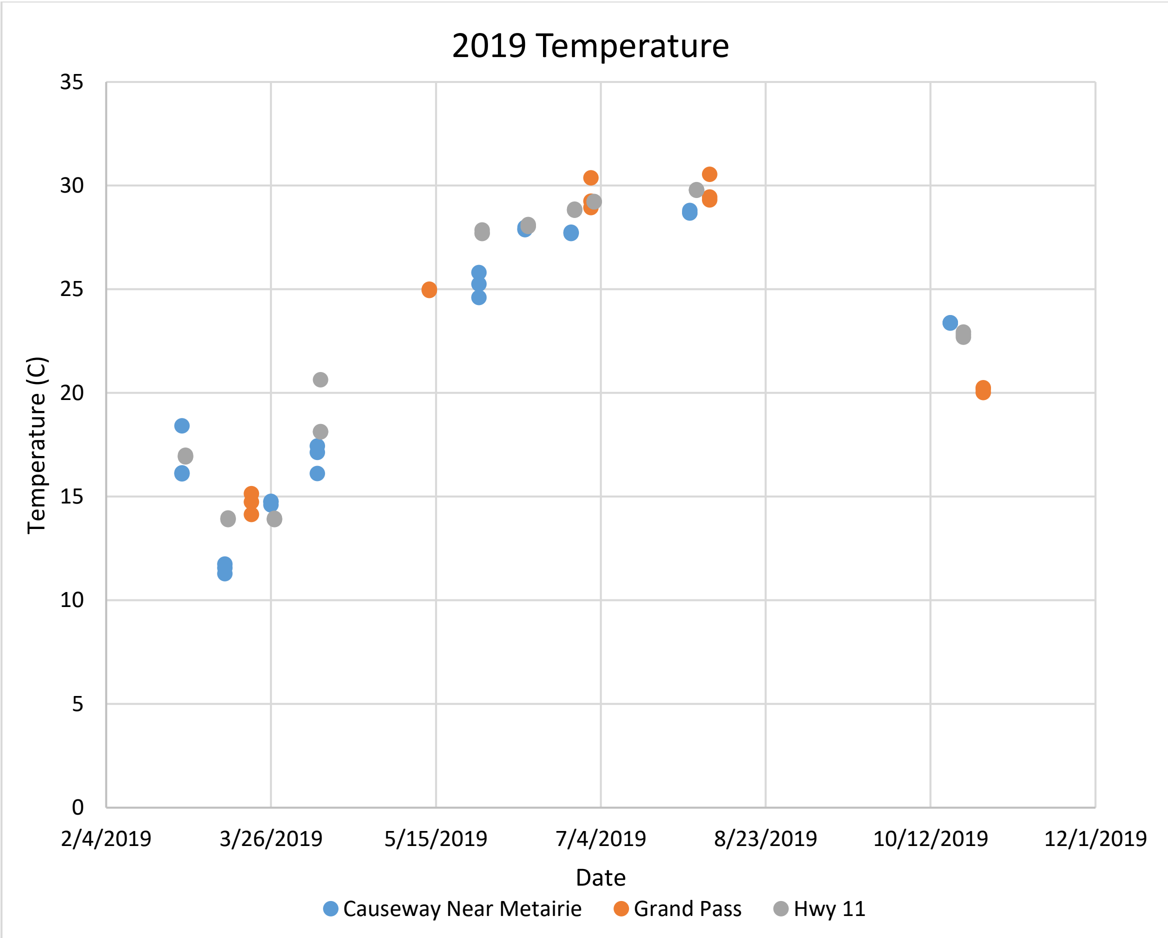


Figure 72. Water temperatures recorded at USGS stations within Lake Pontchartrain and MS Sound in 2019.

The continuous temperature sensors deployed by the USGS in MS Sound show similar annual temperature fluctuations for the years 2017-2019. While there are many forces that impact water temperature, this comparison does not show a clear decrease in temperature in the weeks following the 2019 BCS operation, compared to 2017, when the BCS was not opened. This is an indication that BCS impacts on water temperature in MS Sound are minimal, even with a large scale event.

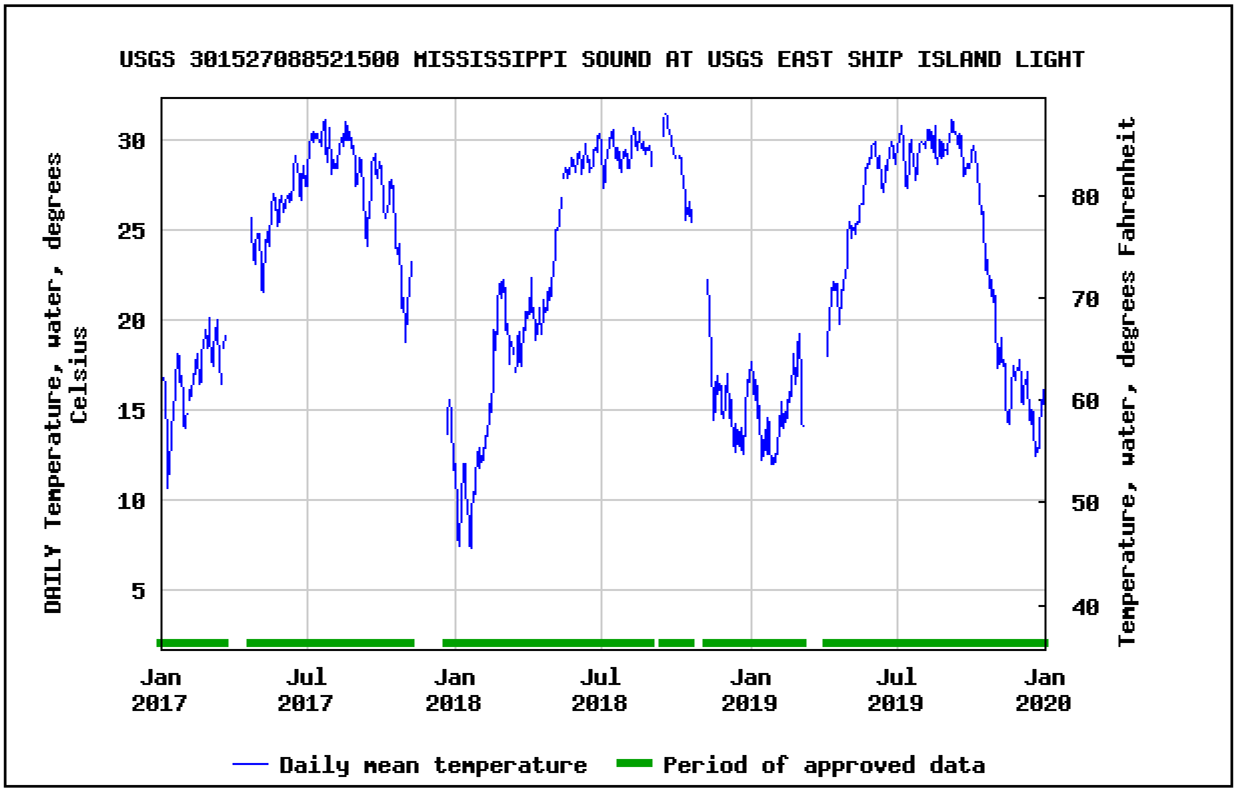


Figure 73. Daily mean water temperatures recorded at USGS Station East Ship Island.

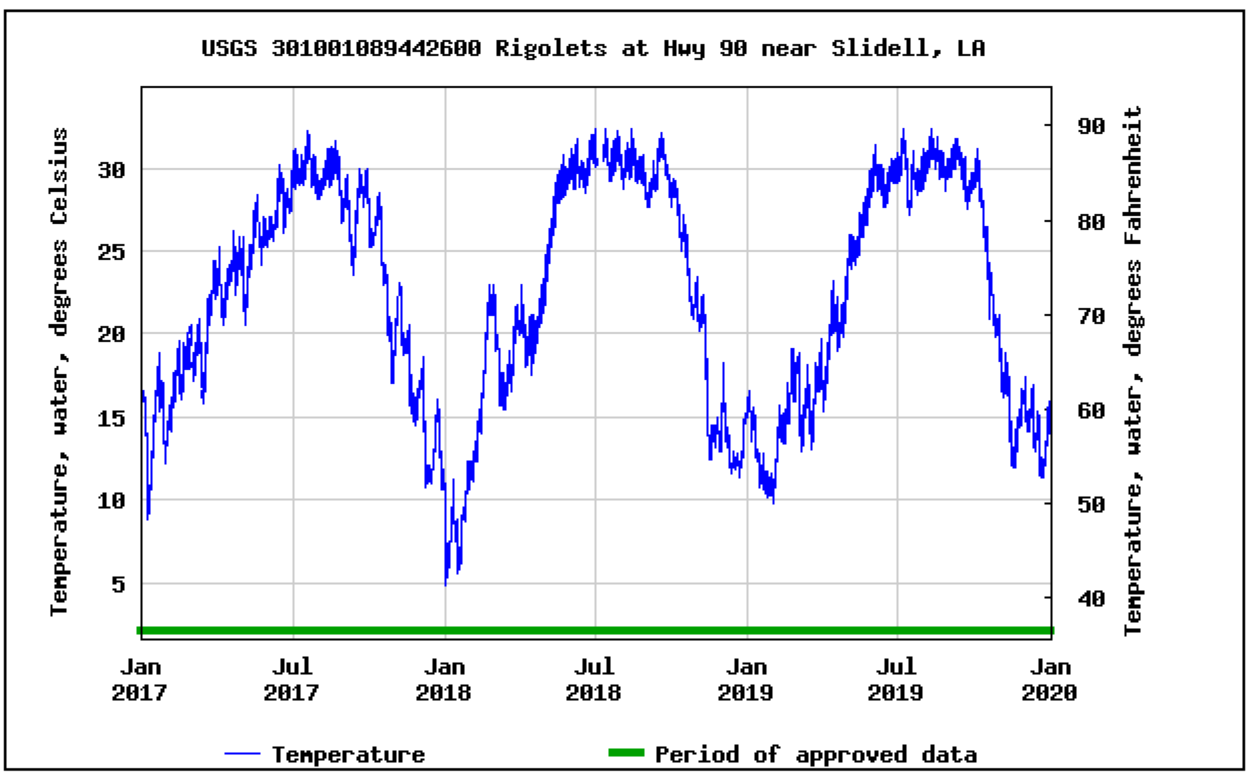


Figure 74. Water temperatures recorded at USGS Station HWY 90 near Slidell, LA.

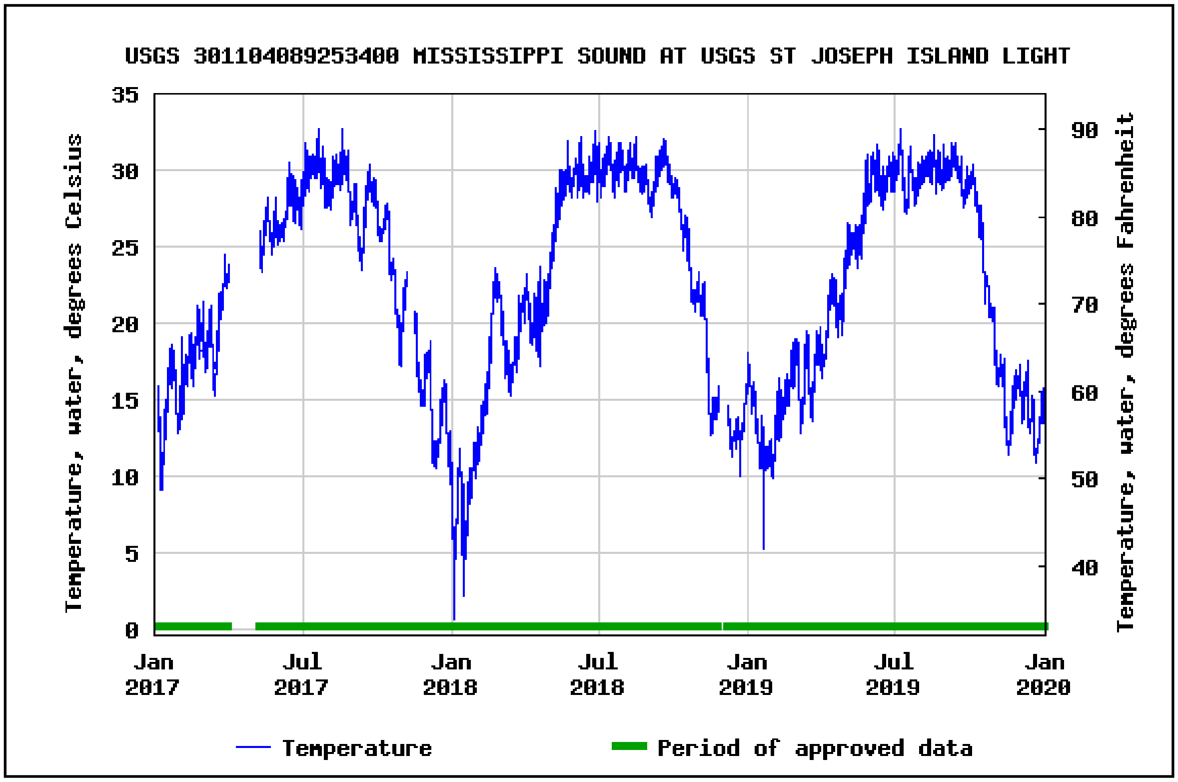


Figure 75. Water temperatures recorded at USGS Station St. Joseph Island Light.

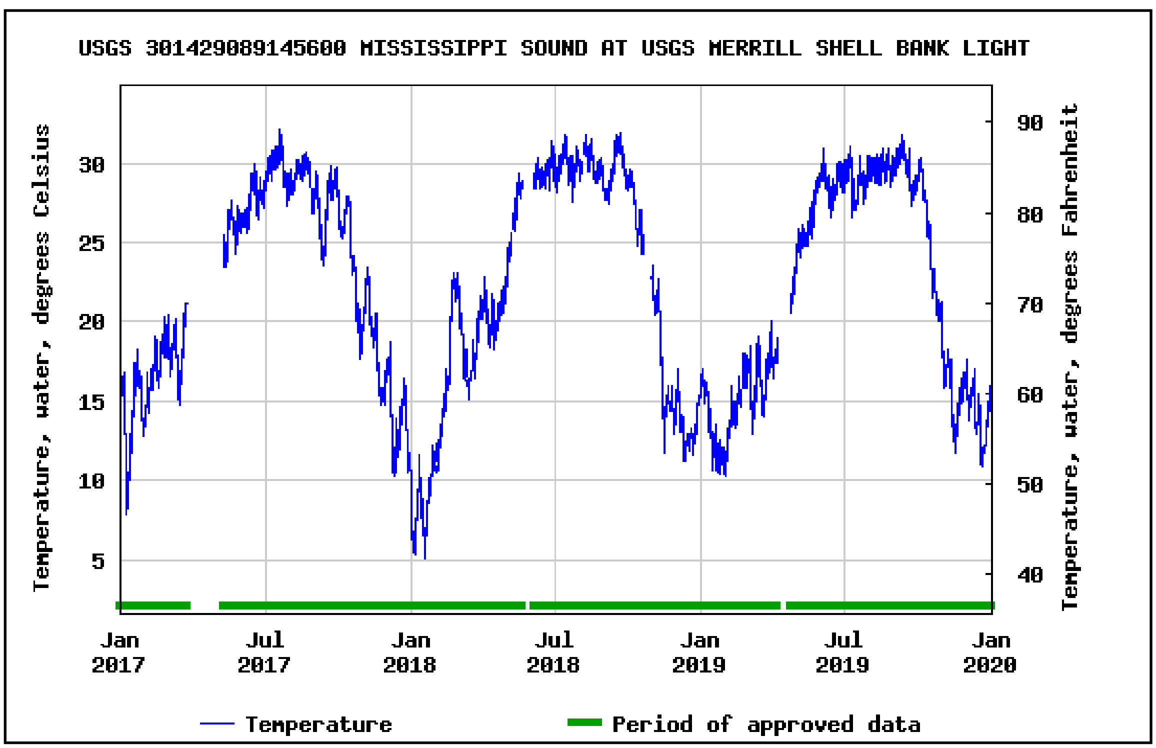


Figure 76. Water temperatures recorded at USGS Station Merrill Shell Bank Light.

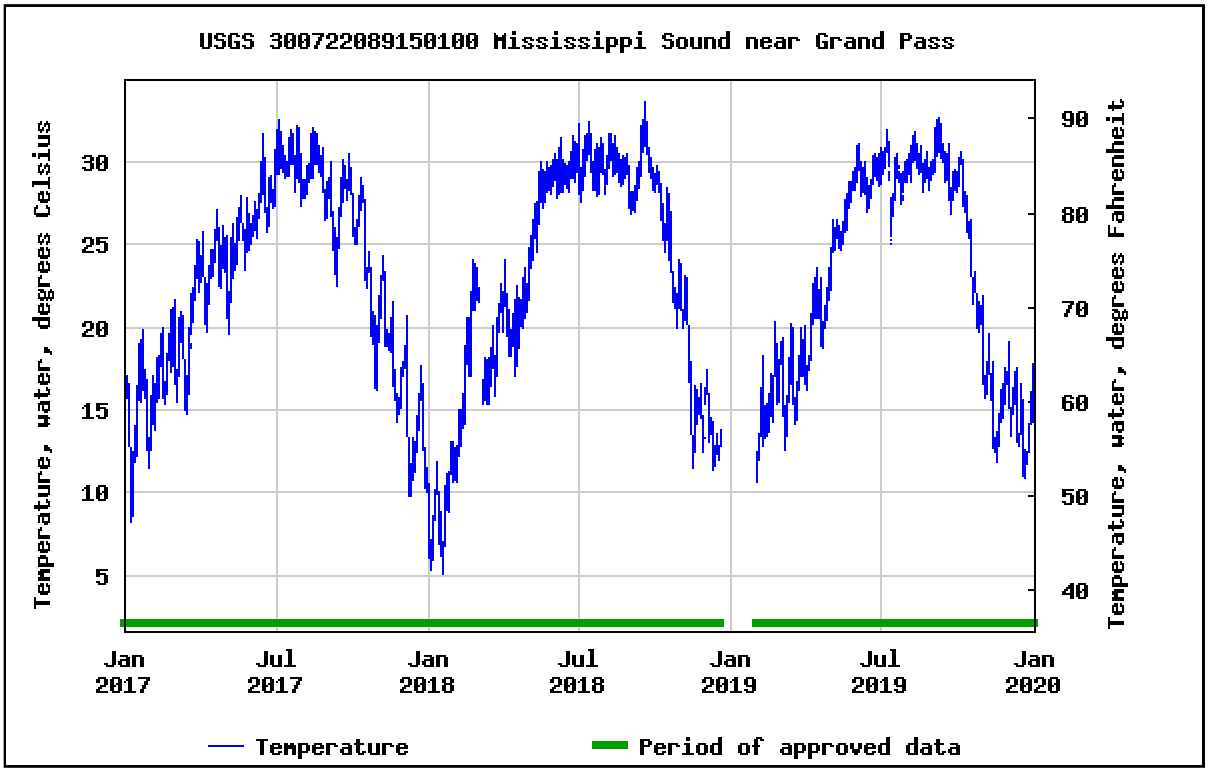


Figure 77. Water temperatures recorded at USGS Station MS Sound near Grand Pass.

In conclusion, the BCS inflows lower Lake Pontchartrain water levels by up to 5 degrees C in the spring months. While the 2011 and 2019 openings show temperature decreases that coincide with BCS operation, these decreases are short lived. The temperature impacts in the MS Sound are less impactful, likely due to the mixing that occurs as the BCS water moves across the Lake Pontchartrain estuary.

3.11.1 <u>Shrimp</u>

3.11.1.1 White Shrimp

White shrimp are capable of adapting to a wide range of salinity conditions; however, optimal salinity for white shrimp is between 1-15 ppt (Turner and Brody 1983) and prolonged exposure to low salinity conditions can result in negative energetic costs, reduced recruitment, and reduced growth rates (Rozas and Minello 2011). Salinity alterations associated with BCS operations are considered temporary, as a return to preoperational conditions is expected following closure of the BCS; however, high-scale diversion events are capable of producing prolonged, low-salinity conditions within the area of potential effects capable of resulting in minor impacts to white shrimp populations. Salinity alterations (below 5ppt) are expected within the APE during medium and low-scale diversion events as well, but these alterations would be limited to areas within the APE where lower salinities naturally occur and impacts associated with significant salinity alterations are expected to be minimal, such as Lake Pontchartrain.

White shrimp postlarvae emigrate into the lower estuaries of the interiors of Lake Pontchartrain Basin and the Mississippi Coastal Basin from late spring to late summer. Migration of white shrimp postlarvae into Lake Pontchartrain Basin and Mississippi Coastal Basin is unlikely to be adversely affected by the outflow of freshwater from diversion operations as flow velocities and directions are still somewhat variable and BCS openings have historically occurred most often in the spring months. However, BCS operation does have the potential to impact recruitment of white shrimp into portions of the estuary. This is especially true near the outfall in the western portion of Lake Pontchartrain where movement of incoming water would be flowing unidirectionally away from the diversion. These effects are expected to diminish with distance away from the outfall. Though potential flow impacts from diversion operations are possible, larvae will likely be able to recruit and sustain viable populations during high-scale diversion events and BCS impacts on white shrimp due to flow would be negligible throughout the APE.

The Caernarvon freshwater diversion, located on the east bank of the Mississippi River below New Orleans, delivers water into the Breton Sound estuary, similar to the diversion and receiving estuary system of the BCS. Reports of the effects of freshwater input from the Caernarvon diversion on finfish and shellfish in Breton Sound (de Mutsert and Cowan 2012) suggest white shrimp production could temporarily benefit from BCS operation. de Mutsert and Cowan (2012) reported greater abundance of white shrimp in the Breton Sound estuary after implementation of the Caernarvon Freshwater Diversion as compared to a control area. Benefits associated with freshwater input would be greatest during high-scale diversion events; however, medium, and low-scale diversion events are capable of diverting significant amounts of freshwater into the APE capable of providing benefits to shrimp production. These benefits would likely be minor, temporary and positive.

Nutrient addition caused by BCS operations may also help temporarily improve primary productivity supportive of the aquatic food web, with diversion events likely resulting in significant nutrient addition within the APE. This temporary increase in nutrients could increase phytoplankton and zooplankton populations, as well as a temporarily increased production of detritus and algae supportive of juvenile to subadult white shrimp growth. Nutrient addition resulting from high-scale diversion events would likely extend throughout most of the APE, with a reduction in nutrient addition associated with medium to low-scale diversion events. Any increases in nutrients and production that benefit white shrimp would be considered temporary, minor and positive.

3.11.1.2 Brown Shrimp

Adult brown shrimp and early larval life-stages are found off-shore where spawning occurs. The impacts associated with BCS operation, including all scales of diversion events, are not expected to adversely affect brown shrimp in these areas due to their tolerance for lower salinity environments.

Migration of brown shrimp into the Lake Pontchartrain Basin and Mississippi Coastal Basin is unlikely to be significantly affected by the outflow of freshwater resulting from BCS operation. The outflow of freshwater associated with high-scale diversion events would not result in impacts to migration of brown shrimp as these freshwater outflows are expected to be influenced by currents and circulation within Lake Pontchartrain, with effects diminishing with distance away from the outfall located on the western shoreline of the lake. The reduced outflow of medium and low-scale diversion events are not expected to result in impacts to brown shrimp migration.

However, BCS operation does have the potential to temporarily impact recruitment of brown shrimp postlarvae into portions of Lake Pontchartrain. Impacts will be greatest closest to the outfall location. Unidirectional outflow occurring during diversion events could impede the movement of brown shrimp postlarvae to wetlands and waterbodies located within the western interior of Lake Pontchartrain. High-scale diversion events occurring during postlarvae emigrations into Lake Pontchartrain in late spring and/or summer would result in the most significant impacts. These impacts are expected to diminish with distance away from the outfall. Outside the areas of the projected maximum flow velocities in western Lake Pontchartrain, there are many other locations and pathways where current velocities may not be significantly affected by diversion operations. Additionally, in similar systems, brown shrimp have been shown to recruit despite increased flows through these systems associated with diversion structures (Lindquist 2019). However, Lindquist noted that the atypical [high] river discharge events may have interfered with estuarine recruitment processes or displaced fish and shellfish from certain habitats, resulting in lower catches for certain species at a time or place. The effects of these events appeared to be short-term as catches often rebounded within two months of the event. Significant impacts to brown shrimp migrations within the APE are not expected for medium or low-scale diversion events as the flow velocities and salinity impacts are generally reduced compared to high-scale diversion events. High flow events may have an adverse effect on brown shrimp depending primarily upon the timing of a specific operational event.

BCS operation will result in temporary reductions in salinity throughout the APE which could result in reduced growth rates of juveniles and subadults within the basins. The optimal salinity range for juvenile brown shrimp is 10-20 ppt, with survival rates being similar across salinities from 2-25 ppt; however, biomass and weight gain decreased substantially below 4 ppt (Saoud and Davis 2003). Brown shrimp may be displaced during the BCS operation as salinities are temporarily reduced and habitat suitability is decreased throughout the Lake Pontchartrain and Mississippi Coastal Basins. Prolonged reduced salinities across the APE resulting from high-scale diversion events would result in increased potential for impacts, as additional time would be required for the return to preoperational environmental conditions. Upon return to preoperational environmental conditions within the basins following conclusion of the diversion event, it is expected that brown shrimp would return to these temporarily impacted areas. Similar systems have shown a return of brown shrimp to portions of basins impacted by freshwater diversions once the diversion operation ceased (Rozas et al. 2005). Salinity reductions are expected for medium to low-scale diversion events, but with reduced impacts (shorter duration, smaller scale, and less freshwater introduction) compared to the high-scale diversions.

3.11.1.3 Pink Shrimp

Pink shrimp spawn offshore in sand and shell habitats at salinities ranging from 25-45 ppt (GMFMC 2016). The impacts associated with BCS operation, including all scales of diversion events, are not expected to affect pink shrimp in these habitats as they are outside the APE.

Postlarvae and juvenile shrimp occur in estuarine and nearshore waters along a range of habitats including SAV, soft bottom, shell, and mangroves with salinities ranging from 0-65 ppt (GMFMC 2016). Reductions in salinity attributed to BCS operation within estuarine habitats of the APE would result in temporary impacts to postlarvae and juvenile pink shrimp as salinities greater than 30 ppt are considered optimal for these life stages of pink shrimp. High-scale diversion events would result in the most significant impacts to postlarvae and juvenile pink shrimp as these diversion events are associated with prolonged reductions in salinity and an increased area of disturbance. Medium and low-scale diversion events will also result in salinity reductions capable of producing impacts to postlarvae and juvenile shrimp, but a more limited area of disturbance with a more rapid return of preoperational conditions is expected with smaller scale diversions. Postlarvae migrate into the estuaries primarily during the spring and fall, and operation of the BCS during this time would result in increased potential for impacts associated with freshening of the area of potential effects. These potential effects would be limited to a geographically small area within the Southeastern Biloxi Marsh along the Chandeleur Sound.

Adult pink shrimp are primarily found offshore at depths up to 48 m (GMFMC 2004). Impacts associated with BCS operation are not expected to extend into these habitats, including impacts expected from the largest high-scale diversion event.

3.11.2 Red Drum

Because red drum spawning activity occurs offshore, outside of the APE, and eggs and larval life stages are found primarily offshore, BCS operation is not expected to directly affect spawning adults, eggs, or early larval life stages. Salinity appears to be an important factor in egg hatching and larval survival for the first 24 hours after egg hatching, with higher mortality in freshwater (Buckley 1984). Because red drum spawn offshore, outside of the area of potential effects of the largest high-scale diversion events, eggs and larvae less than 24 hours old are not expected to be exposed to salinity decreases associated with diversion operation. In the unlikely event that young larvae are transported into the area of potential effects during BCS operation, larvae could be subject to higher mortality.

Migration of red drum postlarvae into the Lake Pontchartrain Basin is unlikely to be adversely affected by the outflow of freshwater from diversion operations. However, unidirectional flows, occurring during BCS operation in the vicinity of the outfall located in western Lake Pontchartrain, would likely have some impact on postlarvae movement to adjacent wetlands and water bodies. These unidirectional flows would be greatest during high-scale diversion events and would likely result in the most significant impacts to migrating postlarvae within the vicinity of the outfall of the BCS. Impacts to postlarvae would be expected from medium and low-scale diversion events, but the reduced flows associated with these smaller diversion events would likely not inhibit migration to the same degree as high-scale diversion events. The unidirectional flows could result in a reduced amount of time to for recruitment in portions of Lake Pontchartrain Basin and may result in postlarvae being displaced into more eastern portions of Lake Pontchartrain. The potential for increased impacts to postlarvae migrating into western Lake Pontchartrain would be increased if a diversion event occurred during the fall and winter when red drum postlarvae are generally present. Potential for effects would diminish with distance from the BCS discharge point and with openings during the spring and summer months since red drum postlarvae do not enter the estuaries until late fall.

Young red drum are euryhaline and have been captured at salinities ranging from 0 ppt to 50 ppt and water temperatures from 13 °C to 30 °C, with potential for rearing of postlarval red drum in inland freshwater systems (NOAA 1997, GMFMC 2016). Studies of red drum survival in freshwater suggest that juveniles have comparable survival and food conversion efficiencies in both fresh and saltwater (Crocker et al. 1981). However, red drum do expend energy to maintain osmoregulation, and the metabolic cost increases as salinity decreases (Wakeman and Wohlschlag 1985). The temporary freshening of the APE could result in temporary metabolic costs to young red drum. An increase of impacts is expected during prolonged freshening of the APE associated with high-scale diversion events. Medium and low-scale diversion events are expected to result in salinity reductions that could impact young red drum, but these impacts would be less significant than high-scale diversions due to the reduced duration of freshening and area of disturbance.

Red drum juveniles and subadults also have broad salinity and temperature ranges (NOAA 1997, GMFMC 2016); therefore, it is unlikely that operation of the BCS would result in conditions outside of the tolerance of red drum juveniles and subadults. However, red drum juveniles and adults have an optimal range from 20 ppt to 40 ppt (NOAA 1997) and, outside this range, individuals are expected in incur higher metabolic costs to maintain osmoregulation which may reduce fitness. Thus, red drum, particularly larger adults, would likely move to habitats with higher salinities, and reductions in salinity resulting from BCS operation would impose metabolic costs to adult red drum. Increased metabolic costs are expected during high-scale diversion events where prolonged durations of reduced salinities have been observed within the APE; however, medium and low-scale diversion events may also result in impacts as reductions in salinity have been observed for these events in areas inhabited by adult red drum. Any impacts to red drum that may occur associated with BCS operations would be minor and temporary.

3.11.3 Coastal Migratory Pelagic Fish

3.11.3.1 Spanish Mackerel

Spanish mackerel spawn in nearshore and offshore waters of the inner continental shelf from May through September, with north-central Gulf of Mexico considered important spawning areas. BCS operation, particularly high-scale diversion events, during the spawning period may result in reductions in salinity within this habitat; however, these impacts would be minor and temporary, and large areas of suitable habitat are outside of the area of potential effects. Impacts to spawning habitat would also be minimal due to these habitats being located near the boundary of the area of potential effects for high-scale BCS diversion events. Impacts to spawning habitat would be more likely during a high-scale diversion event where salinity reductions have been observed throughout the APE. Medium and low-scale diversion events are not expected to result in significant salinity reductions in spawning areas of Spanish mackerel.

Juvenile Spanish mackerel are most prevalent from March to November in estuarine, nearshore and offshore waters ranging from 0-31 ppt (GMFMC 2016). Reductions in salinity attributed to BCS operation may result in temporarily reduced habitat suitability for juveniles within the estuaries of the APE. The reduction in habitat suitability is expected to be temporary and minor, and the broad salinity tolerance range of juveniles would enable movement to adjacent and more suitable habitats. Longer duration, higher volume flows associated with high-scale diversion events would potentially require juveniles to travel greater distances to reach suitable habitat. Impacts from medium and low-scale diversion events could occur, but the salinity reductions are less significant and impact a smaller area within the APE during these smaller diversion events, therefore juveniles will likely not need to travel long distances to reach suitable habitat. Impacts to juvenile Spanish mackerel that may occur as a result of BCS operations will be temporary and minor.

Adult Spanish mackerel migrate to northern Gulf of Mexico during the spring and can be found in estuarine, nearshore and offshore waters ranging in depths from 3-75 m and salinities of 0-31 ppt (GMFMC 2016). High-scale diversion events occurring during the spring may result in significant and prolonged salinity reductions which could impact adult Spanish mackerel present within the APE (Eastermost portion of the APE). Medium and low-scale diversion events are less likely to impact Spanish mackerel due to the reduced effects upon salinities within the APE. Any impacts that may occur as a result of BCS operations would be minor and temporary as adults within these impacted areas would likely move to more suitable habitats in the vicinity. The transition to more suitable habitat, if necessary, would require additional metabolic costs; however, these movements would likely be short in distance and duration due to the abundance of adjacent suitable habitat.

3.11.3.2 Cobia

Cobia are known to spawn in saline coastal bays and other nearshore areas. Larvae are commonly observed in habitats with salinities greater than 18.9 ppt. BCS operation would decrease salinity of the habitats located in the easternmost areas of the APE. Habitat near Cat Island and the outer Biloxi Marsh suitable for larvae could be impacted should BCS operation occur during the cobia spawning period which spans from April through September. Impacts to larvae would be greatest should a high-scale diversion event occur during the spawning period as significant, prolonged salinity reductions are associated with larger diversion events. The salinity shifts associated with medium to low-scale diversion events would likely not result in impacts to cobia larvae within the APE due to the reduced area and duration of salinity reductions associated with smaller scale diversion events. Impacts to Cobia larvae from higher scale diversion events would still be considered minor and temporary in nature.

Juvenile and adult cobia are water column associated and found within the nearshore and offshore waters of the Lake Pontchartrain Basin (Outer Biloxi Marsh and Chandeleur Sound) and the Mississippi Coastal Basin. Early juveniles have been found at salinities ranging from 30-36.4 ppt, and adults occur at 24.6-30 ppt. BCS operation could cause reductions in the salinity of these habitats; however, these impacts are unlikely and would be temporary in nature. Suitable adjacent saline and coastal shelf habitats would remain suitable for cobia. The juvenile and adult cobia would likely move to these adjacent suitable habitats with higher salinities, potentially resulting in increased metabolic costs during this transition. Additionally, the temporary impacts to suitable habitat for juvenile and adult cobia resulting from BCS operation would likely only occur during the longer duration, higher volume diversion events as these habitats are located along the periphery of the area of potential effects.

3.11.4 <u>Reef Fish</u>

3.11.4.1 Lane Snapper

Adult lane snapper spawn from May to August in offshore waters of the Gulf of Mexico. The impacts associated with BCS operation, including all scales of diversion events, are not expected to affect lane snapper in these habitats as they are outside the APE.

Juveniles are found throughout the Gulf of Mexico from late summer through early fall at depths of 0-24 m and salinities of 30-35.5 ppt (GMFMC 2016). BCS operation events occurring when juveniles are present within the APE may temporarily reduce the proportion of the coastal marine habitats of these watersheds that will be available for use by lane snapper as nursery areas. However, these coastal marine habitats utilized by lane snapper juveniles are near the boundary of the area of potential effects only impacted by a high-scale diversion event, and impacts are expected to be minor and temporary. Medium and low-scale diversion events would likely result in no impacts to juveniles.

Lane snapper adults have relatively specific salinity (19 to 35 ppt) requirements (Springer and Woodburn 1960) that likely limit species distribution within the area of potential effects to the coastal marine habitats near the boundary. While impacts are unlikely, any impacts that may occur would be the result of a high-scale diversion event and impacts would be temporary and minor. Additionally, little metabolic costs would be required by adults transitioning to adjacent habitats in avoidance of these potential impacts as abundant suitable habitat is present within these areas.

3.11.4.2 Gray Snapper

Gray snapper, considered to be one of the most abundant snappers inshore, spawn from June to August around offshore reefs and shoals (GMFMC 2016). Impacts to gray snapper associated with BCS operation are not expected to extend into these habitats.

Larvae are planktonic, occurring in peak abundance June through August in offshore shelf waters and near coral reefs (GMFMC 2016). BCS impacts to larvae are also not expected as these offshore shelf habitats are outside of the area of potential effects. Postlarvae move into estuarine habitat and are typically concentrated over dense SAV beds. Due to the broad salinity tolerance of gray snapper postlarvae, reduced salinities in estuarine habitats of the APE resulting from diversion events will not impact habitat suitability.

Adult and juveniles occur in marine, estuarine, and riverine dwellers, often found in estuaries, channels, bayous, ponds, grass beds, marshes, mangrove swamps, and freshwater creeks (GMFMC 2004). Gray snappers are tolerant of salinities ranging from 1-35 ppt (Starck and Schroeder 1971), and are likely present throughout much of the APE. This broad salinity tolerance makes them relatively insensitive to the freshening of these habitats resulting from BCS operation, thus, gray snapper utilization of the APE will not be impacted by diversion events.

3.11.5 Highly Migratory Species

3.11.5.1 Sharks

Apart from bull sharks, the shark species known to occur within the LPB and MCB tend to be found in salinities or 20 ppt or higher, with adults typically found further offshore than juveniles. Suitable habitat for the majority of shark species in the area of potential effects would be restricted to the marine nearshore waters found along the extreme eastern APE. Decreasing salinities as a result of all scales of BCS operations may temporarily reduce the habitat suitable for shark species in these areas, with potential metabolic costs associated with migration to adjacent suitable habitat. The migration distance to suitable habitat may increase with high-scale diversion events due to the significant and prolonged salinity reductions associated with larger diversion events. However, sharks are known to travel long distances, occasionally through unfavorable habitats (NMFS, 2017); thus, it is likely that sharks will continue to utilize the APE and impacts from BCS operation would be minimal and temporary.

Bull sharks are the only shark species known to occur within the more inland, low-salinity estuarine habitats of the area of potential effects. A stress response associated with metabolic and respiratory acidosis occurs at the low end of their salinity tolerances (Hyatt et al. 2018); however, bull sharks are the only species that is known to be physiologically capable of spending extending periods of time in freshwater in the United States (Thorson et al. 1973). Therefore, impacts associated with all scales of BCS operation to habitat suitability of bull sharks are unlikely.

3.12 IMPACTS TO PREY BASE

Changes in the supply of nutrients, resulting from BCS operation, have the potential to temporarily alter the seasonal production of high biomass, low trophic level consumer groups such as shrimp, anchovy, and gulf menhaden. The changes in abundance of phytoplankton, phytobenthos, and detritus anticipated during BCS operation may result in changes to high biomass prey species such as crabs and small forage fish. However, should important prey groups be disturbed or eliminated, the opportunistic, trophic generalist nature of many of the predators and the numerous and redundant food web connections within the area of potential effects would reduce the potential impacts associated with BCS operation. While high-scale diversion events have been associated with increased and prolonged disturbances within the APE, impacts to the prey base within the APE would still be considered temporary and negligible as the redundancy of the food web connections would continue to limit any potential impacts that may occur. The reduction in disturbances associated with medium and low-scale events would likely result in even fewer potential impacts to the prey base within the APE.

A study of the 1997 BCS opening, a high-scale diversion event, and subsequent freshwater input to Lake Pontchartrain indicated that infaunal macroinvertebrates were negatively impacted by some combination of the decrease in salinity, increase in cyanobacterial blooms, and hypoxia/anoxia related to the influx of fresh water from the MR (Brammer et al. 2007). The researchers noted that an oligohaline community did persist through the period of spillway operation, but that taxa dominance and composition changed over time. Prior to the opening, the five sampling sites were dominated by gastropods (snails) (November 1996) or oligochaetes (aquatic worms) (March 1997). During the spillway opening, oligochaetes and gastropods increased (markedly at some locations), but polychaetes (bristle worms) markedly decreased. One month after the spillway's closure (June 1997), polychaetes and many other species were rare or absent. Later months identified changing taxa and dominance, as well as the return of polychaetes. By July 1997 (three months after the spillway closure) the benthic community had begun to recover and values for diversity, abundance, and the number of taxa were not substantially different than pre-opening values. Benthos in the immediate outfall area would be most impacted by turbidity and sedimentation, but impacts would decrease with increasing distance from the diversion structure as the sediments settle out. Although impacts in the immediate outfall area would be temporarily moderate and adverse due to the amount of sediment projected to accumulate, with increased impacts in this area associated with high-scale diversion events, the benthic communities further from the outfall area would be subjected to less sediment accumulation and therefore would be more likely to have successful vertical migration through any accumulated sediment, resulting in temporary minor impacts in areas further from the outfall area. Overall, the impact on sedimentation on the benthic community is projected to be temporary, minor, and adverse.

3.13 IMPACTS TO FOOD WEB

Estuarine systems have many potential pathways to transfer energy and do not depend on one species or groups of species to support the food web, but rather contain many generalist feeders that are able to utilize different food sources. An investigation of the Lake Pontchartrain estuary, for example, indicated that most of the consumer species within the lake do not conform to specific trophic levels and often consume significant amounts of material from several different sources (Darnell 1961). The redundancy in the food webs of the APE likely results in resiliency to the temporary disturbances that may occur as a result of BCS operations. While high-scale diversion events will increase and prolong the effects associated with BCS operation, these effects are expected to be temporary and the redundancy of the food webs within the APE will maintain the ability to limit any potential impacts. Effects associated with medium to small-scale events are expected to be greatly reduced compared to the high-scale diversion events. The effects will vary based on the location within the APE and the scale of the operational event. However, all those effects are temporal and will return to preoperational conditions once the BCS operation is complete. However, there will be a temporal lag in the recovery. Therefore, impacts to the food web may occur during diversion events, but would be considered temporary.

Though some species or groups of organisms may be temporarily forced out of the system or killed by freshwater pulses resulting from BCS operation, with freshwater pulses being most significant and prolonged during high-scale diversion events, the temporary influx of freshwater delivers nutrients and basal resources into the estuarine habitat potentially resulting in a temporary increase in primary and secondary production and the creation of additional habitat for higher-level consumers that live or migrate to that area (Piazza and La Peyre 2012).

4 CUMULATIVE IMPACTS

During BCS operation there are many other sources of freshwater including the natural passes of the Mississippi River, numerous regional rivers, and local precipitation and runoff which influence salinity and other parameters in the area. It is difficult to differentiate between the freshwater introduced through the BCS and other sources of freshwater when analyzing potential effects. Operation of the BCS is expected to have direct impacts on EFH due to the introduction of freshwater flow and sediment laden water from the Mississippi River into Lake Pontchartrain Basin and the adjacent Eastern Louisiana Coastal and Mississippi Coastal Basins. As a result, these watersheds will experience reduced salinities and changes in other metrics of water quality including nutrient levels and minor changes to dissolved oxygen. These water quality parameters will affect the suitability of impacted habitat to support fishery species. These impacts are temporal in nature and conditions would typically return to normal shortly after operation of the BCS cease. However, effects to benthic species could last for a longer period. Those effects could be compounded by frequent operation of the BCS. The GMFMC considered the presence and operation of the Spillway in assessing EFH in the Gulf of Mexico. The Generic Amendment from October 1998 specified, “A periodic event that profoundly influences both the level of nutrients and salinity of Mississippi Sound is the opening of the Bonnet Carré Freshwater Diversion structure west of New Orleans, Louisiana. This flood control structure operated by the U.S. Army Corps of Engineers resulted in a discharge rate as high as 7,000 m^3/s (250,000 cfs) from the Mississippi River into neighboring Lake Pontchartrain and into the Sound”. They further stated that, “The effects of the spillway on fisheries is generally thought to be beneficial in the long term as a result of the nutrient influx that accompanies the diverted waters. Short term impacts such as high turbidity levels, increased concentrations of chlorophyll a, increased fecal and total coliform counts, high oyster mortalities and temporary displacement of certain stenohaline species have been noted. The sudden influx of nutrient-laden, cold fresh water into the estuarine environment can also adversely impact any species sensitive to abrupt salinity or temperature changes or the emigration of shrimp postlarvae that may coincide with the spillway opening during the spring months.” A future man-made diversion on the east side of the Mississippi River, such as the proposed Mid-Breton Diversion, when operated simultaneously with the Bonnet Carre Spillway, could accentuate the water quality impacts in the APE. However, a hypothetical man-made river diversion would likely have lower flow rate targets than the BCS, so these impacts would be scaled down in duration and extent. Additionally, the potential of natural crevasse formation along the east side of the MSR makes it difficult to assess what the future conditions will be, and how a man-made diversion would differ from future natural conditions.

5 MITIGATION

The USACE operates the Bonnet Carré Spillway during significant Mississippi River flood events to reduce downstream Mississippi River flows, including those past New Orleans, and to reduce the imminent potential for loss of life and property. BCS was planned and designed to divert up to 250,000 cfs and to prevent downstream Mississippi River flows from exceeding 1,250,000 cfs at New Orleans. Congress authorized BCS in accordance with these plans and designs. Accordingly, the BCS water control manual states that BCS “will normally be operated when the flow in the Mississippi River below Morganza reaches 1,250,000 cfs on a rising hydrograph or to preserve a desired level of freeboard on deficient levees through the New Orleans area. The Spillway will be controlled so that the flow below Bonnet Carré in the Mississippi River does not exceed 1,250,000 cfs." The water control manual further states that "[t]he normal operation is to prevent the flow in the Mississippi River past New Orleans from exceeding 1,250,000 cfs. This procedure is not deviated from because of environmental impacts to Lake Pontchartrain."

When river flows at the Red River Landing are predicted to reach 1.5 million cfs and rising, the Corps considers opening the Morganza Floodway. Given that the threshold for operating the BCS is lower, at only 1.25 million cfs, river conditions typically require the Corps to operate the BCS before conditions arise that would prompt the operation of Morganza upstream. Furthermore, whether Mississippi River water flows through the BCS or the Morganza Floodway, floodwaters all eventually enter the Gulf of Mexico where they have the potential to impact EFH.

The Morganza Floodway was authorized as a feature of the Mississippi River and Tributaries Project in Act of 15 June 1936, Chapter 548, 74th Congress, 2nd Session, 49 Stat 1508, in accordance with the recommendations in the report submitted by the Chief of Engineers to the Chairman of the Committee on Flood Control, dated February 12, 1935, and printed in House Committee on Flood Control Document No. 1, 74th Congress, First session. The Chief's Report sets forth the parameters for operations and expressly states that the floodway "is not to be operated at all unless the predicted flood exceeds the safe capacity of the leveed channels." The Morganza Floodway is designed to be operated in conjunction with the Old River Control Structure and the BCS as part of the MR&T system. To date, the Morganza Floodway has been operated twice: in 1973 and 2011. On both occasions, the Morganza was operated only after the BCS operations had commenced.

USACE has ruled out and does not propose any conservation or mitigation measures that would conflict with the Spillway's Congressionally authorized purpose or undermine its critical life safety function. Moreover, USACE cannot unilaterally pursue conservation or mitigation measures that would require Congressional action to modify our existing authorities. For these reasons, USACE does not propose conservation or mitigation options involving structural or operational changes to BCS or to upstream structures such as the Morganza Floodway. However, USACE has evaluated the benefits of enhanced data and information collection through additional monitoring.

USACE is currently involved in existing monitoring efforts in Lake Pontchartrain and portions of Mississippi Sound. In an effort to better understand the influence of BCS operations on the Lake Pontchartrain Estuary and eastern Mississippi Sound, USACE has worked with USGS over the years to conduct monitoring when the BCS opens. Although these monitoring efforts have yielded useful information, current monitoring efforts do not adequately characterize the baseline conditions within BCS receiving waters at times when the Spillway is not being operated. Accordingly, USACE has explored the option of expanding monitoring efforts to provide improved understanding of baseline conditions. In particular, USACE proposes to initiate additional water quality and harmful algal bloom baseline monitoring and continue source water tracking using isotope analysis. USACE believes these measures would provide information and data that could improve understanding of water quality-related stressors—including BCS operations and other flood event-related contributions of freshwater—to EFH in the APE. Understanding the contribution of all freshwater sources from the Mississippi River, local rivers and precipitation is important for distinguishing mixing and pinpointing potential impacts from the Spillway versus local runoff and other sources. Monitoring concentration of chlorophyll a in a surface water sample is an indicator for the concentration of algae. While algae are the basis of many food chains, algal blooms can potentially cause habitat degradation. Nutrients, ions and minerals may result in increases to phytoplankton which in combination with other factors may affect water column turbidity. Turbidity fluctuations from organic and inorganic elements within the water column can impact light transmission through the water column also effecting plants and cyanobacteria. Cyanobacteria can produce toxins that affect the nervous system (neurotoxins), including anatoxins and saxitoxins, toxins that affect the liver (hepatoxins), such as microcystins, nodularin, and saxitoxins, as well as toxins with less consistent effects on systems or organs, such as lipopolysaccharides (Chorus and Bartram 1999). The most common algal toxins documented in surface waters, both globally as well as in the Pontchartrain estuary, are Microcystins. USACE believes the data and information collected through this expanded monitoring effort would contribute to better understanding the impacts on EFH.

USACE proposes to continue to partner with USGS to expand our current monitoring efforts and conduct baseline monitoring that would increase our understanding of conditions in the Lake Pontchartrain Estuary and Mississippi Sound. USACE believes this monitoring information would be valuable and intends to pursue its collection. However, we must caveat that this commitment is subject to the availability of funding. The USACE can only commit to requesting funds and to expend those funds as appropriated by Congress and allocated through the budgeting process.

6 COORDINATION

This EFH Assessment will be provided to NMFS in accordance with the EFH Consultation requirements of the MSFMCA and 50 CFR 600.920.

7 CONCLUSION

The purpose of the BCS is to divert sufficient floodwater from the Mississippi River to the Gulf of Mexico via Lake Pontchartrain to minimize the flood damages in the lower river reaches and prevent the discharge in the Mississippi River from exceeding 1,250,000 cfs at New Orleans. The BCS was constructed at the site of a natural crevasse first noted in engineering surveys performed in the 1850s. The BCS was authorized in the Flood Control Act of in 1928 with initial construction completed in 1932. (USACE, 1999 Water Control Manual). USACE generally concurs with the findings of the GMFMC in their EFH assessments for the Gulf of Mexico. We find that data indicates Spillway operations have an adverse effect to some nonmotile benthic populations which serve as prey species within the area of potential effects. Other localized effects to brown shrimp and dependent species may occur for short periods of time during and shortly following operation of the BCS. The addition of water rich in nutrients to certain areas within the area prone to algal blooms may increase the likelihood of those blooms. Those blooms may subsequently have short term effects to managed species. USACE recognizes these effects are occurring as they were identified in previous environmental documents related to the BCS. The potential effects are summarized in Section 3 above and are specified by watershed area in Table 5. Generally speaking, low scale events will have lower overall effects and primarily impact EFH and managed species in the Lake Pontchartrain HUC rather than the areas further removed from the BCS such as the Mississippi Sound. As the magnitude of the BCS event increases, impacts to EFH and managed species usually increase. Those effects to managed species tend to increase proportionally as the discharged water makes its way into the Eastern Louisiana HUC and the Western Mississippi Sound. The greatest effects occur during long duration, high flow events (high scale events) when nutrient rich fresh water discharged through the BCS reaches the brackish and saline systems which dominate the Eastern Louisiana HUC and Western Mississippi Sound. The time of year of the BCS opening will also play a role in the magnitude of impacts to EFH and managed species.

8 PREPARED BY

This EFH assessment was prepared by biologist Tyler Stevens, environmental engineer Isaac Mudge, and biologist Howard Ladner.

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