MISSISSIPPI RIVER AND TRIBUTARIES SYSTEM

2011 POST-FLOOD REPORT

APPENDIX F
ENVIRONMENTAL AND CULTURAL RESOURCES

SECTION V

ENTRAINMENT OF PALLID STURGEON THROUGH FLOODWAYS DURING THE 2011 LOWER MISSISSIPPI RIVER FLOOD

Executive Summary

Operation of floodways in the Lower Mississippi River (New Madrid, Bonnet Carré, and Morganza) could potentially entrain federally endangered pallid sturgeon (*Scaphiryhnchus albus*) constituting at "take" under the Endangered Species Act. Based on experience at the Bonnet Carré Spillway after the 2008 opening, a recovery effort was launched to determine presence of pallid sturgeon in the floodways, successfully capture stranded sturgeon, and release them back into the Mississippi River. Each floodway had unique properties that required modified sampling approaches to effectively capture entrained sturgeon. Both the Bonnet Carré and Morganza floodways empty into large expanses of brackish water making detection very difficult; salinity tolerance of pallid sturgeon is unknown. Bonnet Carré and Morganza also have well-defined, low-flow channels that form when water recedes after closure making it relatively easy to capture entrained sturgeon if they move upstream towards the structure. However, pallids entrained in Morganza can move upstream in the Atchafalaya to the Old River Control Complex making it difficult to determine site-specific entrainment rates. Also, Morganza has a 7,000-acre forebay that becomes isolated from both the Atchafalaya and Mississippi Rivers at lower stages potentially trapping sturgeon. The New Madrid floodway in Missouri had widespread flooding with multiple inlets/outlets complicating effective sampling strategies. Despite these challenges, all three floodways were sampled multiple times to document sturgeon entrainment in the three major floodways and if possible, rescue sturgeon after closure of the structures.

Pallid sturgeon were collected only in the Bonnet Carré floodway after the structure was closed. The majority of these fish were relocated back into the Mississippi River; some were retained for taxonomic studies by USFWS. Field surveys indicated that it was unlikely that pallid sturgeon, an obligate riverine species, would be entrained through Morganza because of the long distance between the main channel of the Mississippi River and the structure. Pallid sturgeon entrained through New Madrid likely exited the floodway at one of the three crevasses; no pallid sturgeon were found in the scour holes after the flood subsided.

An additional study was conducted to determine the likelihood of Asian carp (silver and bighead carps) entering Eagle Lake when the Muddy Bayou structure was opened. Working with the Mississippi Department of Wildlife, Fisheries, and Parks, monitoring concluded that Asian carp came through the Muddy Bayou structure but none were detected or observed during subsequent surveys.

Detailed information on all of these activities associated with the 2011 Lower Mississippi River Flood is presented in the following chapters:

Chapter 1: Evaluation of Pallid Sturgeon Entering Birds Point- New Madrid Floodway

Birds Point- New Madrid Floodway - May 16-19 2011. The Birds Point - New Madrid Floodway was opened on 2 May 2011. The ERDC Fish Ecology Team and personnel from Memphis District and Missouri Department of Conservation sampled in the vicinity of the three inflow/outflow crevasses created in the frontline levee of Birds Point – New Madrid Floodway on May 16-19, 2011. The Floodway was completely inundated with high water velocities (>2 m/s) near the crevasses and lower end during this sampling event. Efforts were made to sample for the federally listed pallid sturgeon. The areas sampled included the lower inflow/outflow crevasse near New Madrid and St John's Bayou, the middle inflow/outflow crevasse in the vicinity of Big Oak Tree State Park and the upper inflow crevasse at Birds Point (Figures 1.1 – 1.3). The two lower crevasses were reached by boats launching at New Madrid; it was approximately 16 miles by boat from St. Johns structure to the crevasse adjacent to Big Oak State Park. The upper crevasse at Birds Point was reached by launching off the levee near sampling locations. Each reach was sampled overnight using five to six, 60 hook trotlines baited with worms and eight hoopnets of varying sizes (3' hoops with 1" mesh and 4' hoops with 4" mesh). Because of the high water velocities or shallow water conditions, gillnets and trawling were limited only to the middle crevasse near Big Oak Tree State Park.

Lower Crevasse (near New Madrid, MO and St John's Bayou). A total of 32 individuals were collected at the lower crevasse representing only seven species (Table 1.1). The majority of the fish collected were in hoopnets (Figure 1.4). The dominant species collected was silver carp and accounted for half of our sample. Notable fishes included black buffalo and stonecat. No sturgeon were observed or captured. Low catch on trotlines could be attributed to high water velocities at the lower crevasse. Trotlines had the majority of bait still on the line and were fished in velocities ranging from 1-2 meters/second compared to hoopnets fishing in velocities of 0.5 – 3 meters/second with similar water depths ranging 6-14 feet. Maximum depth detected at sampling sites was 31 feet.

Middle Crevasse (Vicinity of Big Oak Tree State Park). Eighteen species of fishes were collected at the middle crevasse (Table 1.1). The majority of the specimens (n=59) were collected in two experimental gill nets (90' long x 6' deep with 6, 15' long panels; mesh size ranged from 1" to 3 ½ "). These nets were set upstream of the crevasse in six feet of water with velocities 0.5 meters/second and fished overnight. Hoopnets and trotline sets fished in the downstream path of the crevasse had water velocities ranging from 0.49-5 feet/second and also provide additional catch for the total effort (n=25). Water depths at sampling locations ranged from 6 to12 feet. Additional species not included in this report were collected by personal with the Missouri Department of Conservation using a 20' small mesh trawl. Observation of their catch includes sunfishes and minnows. No sturgeon were observed or collected.

Upper Crevasse (at Birds Point). A total of 14 individuals were collected at the upper crevasse representing only four species (Table 1.1). Freshwater drum comprised 64% of the catch. The majority of the fish were collected on trotlines (n=12). Water depth in the vicinity of the gear was much shallower (2.5-6.9 feet) and velocities were much lower (<0.5 meters/second compared to the middle and lower crevasse (Figure 1-5). However, a scour hole did exist below one gap with water depths of 19 ft. Water dropped almost 1 foot overnight and we had difficulty retrieving the gear the next morning due to extreme shallow depths at some locations. Despite the low catch rates for the upper crevasse sets, a single shovelnose sturgeon was captured in the last hoopnet set on the last day of the trip (Figure 1.6). A rubber band was around the mid-section of the body (Figure 1.6), which was removed before we tagged and released the shovelnose sturgeon back into the Mississippi River. Despite all the effort using different sampling gear (hoopnets, trotlines, gillnets and trawls), this was the only sturgeon collected during this sampling event. Only one shovelnose sturgeon was collected in the upper inflow crevasses at Birds Point (Table 1.1). The fish was later tagged and released back into the Mississippi River.

Birds Point- New Madrid Floodway - July 8, 2011 and July 11-12, 2011. MVD's Commanding General and his staff visited Birds Point-New Madrid Floodway on July 7, 2011 and found a dead sturgeon at the upper crevasses of Birds Point. They delivered the sturgeon to ERDC Fish Ecology Team personnel for identification. We identified it as a shovelnose sturgeon, and the following business day the ERDC Fish Ecology Team returned to the Floodway to conduct additional sampling at the three crevasses.

The lower crevasses near New Madrid, MO were mainly small, shallow pools, which looked unsuitable for large fish like sturgeon. The small pools appeared to be created by the explosions when opening the lower crevasse. Many of the small pools had dried up, and those pools present were shallow, likely refilled with rain water, and had obvious signs of foraging wading birds (Figure 1.7). No sturgeon were found.

The middle crevasse (vicinity of Big Oak Tree State Park) was a large blue hole created by the scouring of the Mississippi River as it flowed through the crevasse. Because of its steep banks and size, we determined that additional sampling by boat would be necessary at a later date (Figure 1.8). Water quality taken at the surface showed high dissolve oxygen (9.4 mg/l) and a water temperature of 30.8 °C. A smaller scour hole existed near the large blue hole. We were able to sample it using two experimental gill nets (90' long x 6' deep with 6, 15' long panels; mesh size ranged from 1" to 3 ½ "). The dominant species collected was green sunfish, longnose gar and gizzard shad. Notable sport fish collected include largemouth bass and white bass. No sturgeon were observed or captured. Water quality was similar to the larger blue hole.

Our last sampling site was at the upper crevasse at Birds Point. In the upper crevasse there were many smaller blue holes (scour holes) created by the Mississippi River when the floodway was open. There was a massive fish kill in the lower blue hole at Birds Point where the Commanding General and staff had collected the dead shovelnose sturgeon. Based on low dissolve oxygen readings (<1.0 mg/l) at the bottom, it is likely that the fish kill was in response to the water being pumped out of the blue hole causing the mixing of bottom and surface water (Figures 1.9 and 1.10). Areas where dead fish were present on the shore or in blue hole were surveyed on foot for a total of four man hours. Because of the large number of dead fishes, we only kept track of the species present and ranked them in three categories (abundant, common, rare) (Table 1.2). All river sturgeons were counted, photographed, and measured if intact (Figures 1.11 and 1.12). If any dead sturgeon were questionable as being the federal endangered pallid sturgeon, they were brought back to the laboratory for verification. A total of 22 species of fishes comprising 11 families were observed or collected including 19 shovelnose sturgeon (Table 1.2). Some of these sturgeons were the smallest we have observed entrained measuring 8 1/2 inches fork length (Figure 1.13). Those specimens were identified as shovelnose sturgeon based on anal and dorsal fin ray counts. No pallid sturgeon were observed.

Birds Point- New Madrid Floodway - July 27-28, 2011. A ramp was constructed at the middle crevasse (vicinity of Big Oak Tree State Park) by Memphis District contractors to provide boat access.

Water quality parameters for oxygen and temperature were measured vertically at several locations in water depths of 35-40 feet (maximum depth was approximately 40 feet). Stratification was evident throughout the crevasse. At depths greater than 10-11 feet, dissolved oxygen was less than 1 mg/l and water temperature was 60°F. Surface waters were 88 °F and dissolved oxygen was 8.43 mg/L. Because of its large size, the blue hole was divided into three reaches (upper, middle and lower). In each reach, 3-4 experimental gill nets were deployed for approximately two hours. Due to stratification, all nets were fished in the upper water column where dissolved oxygen was sufficient to sustain fish. Once nets were deployed, a boat-electroshocker was used for 20-35 minutes to stimulate movement of fish in hopes that they would encounter the gill nets. A total of 12 species of fishes were collected including shortnose gar, bigmouth and smallmouth buffalo, and freshwater drum. Recreational fishes included white bass, largemouth bass, flathead catfish, channel catfish, blue catfish, and bluegill. This fish assemblage is similar to borrow pits in the Mississippi River batture. Two live shovelnose sturgeon were captured during our sampling efforts. No pallid sturgeon were observed.

In upper crevasse at Birds Point, we surveyed six blue holes on foot. In a blue hole next to the one that produced 20 shovelnose sturgeon in early July (Table 1.2), we picked up one shovelnose sturgeon. In an adjacent blue hole we picked up two more shovelnose sturgeon for a total of three sturgeon (Table 2). We also observed 16 other species of fishes. It was apparent that the blue hole had been pumped likely contributing to the fish kill and refilled with rainwater and underwater seepage.

Sturgeon Summary

- May 16-19
  - Birds Point - 1 shovelnose (live)
- July 12-13:
  - Birds Point - 19 shovelnose plus the General’s = 20 shovelnose (all dead)
- July 27-29:
  - Birds Point - 3 shovelnose dead
  - Big Oak - 2 shovelnose alive

TOTAL: 26 shovelnose sturgeon

Table 1.1. Species and Number of Fishes Captured in the Three Crevasses of the Frontline Levee of Birds Point- New Madrid Floodway Using Trotlines, Gillnets, and Hoop Nets, May 16-19 2011

Species	Lower Crevasse St. John's	Middle Crevasse Big Oak	Upper Crevasse Bird Point
Family Acipenseridae (sturgeon)			
Scaphirhynchus platorynchus, shovelnose sturgeon	-	-	1
Family Lepisosteidae (Gar)			
Lepisosteus oculatus, spotted gar	-	7	-
Lepisosteus osseus, longnose gar	-	2	-
Lepisosteus platyrhincus, shortnose gar	-	13	-
Family Clupeidae (Herring)			
Alosa chrysochloris, skipjack herring	-	4	-
Dorosoma cepedianum, gizzard shad	-	1	-
Dorosoma petenense, threadfin shad	-	8	-
Family Cyprinidae (Minnows)			
Cyprinus carpio, common carp	-	4	-
Hypophthalmichthys molitrix, silver carp	16	2	-
Hypophthalmichthys nobilis, bighead carp	-	-	-
Family Catostomidae (Suckers)			
Ictiobus bubalus, smallmouth buffalo	2	4	-
Ictiobus cyprinellus, bigmouth buffalo	6	5	-
Ictiobus niger, black buffalo	1	2	-
Family Ictaluridae (Catfishes)			
Ameiurus natalis, yellow bullhead	-	1	-
Ictalurus furcatus, blue catfish	4	10	3
Ictalurus punctatus, channel catfish	2	7	1
Noturus flavus, stonecat	1	-	-
Percichthyidae (Temperate Basses)			
Morone chrysops, white bass	-	2	-
Centrarchidae (Sunfishes)			
Lepomis macrochirus, bluegill	-	1	-
Pomoxis nigromaculatus, black crappie	-	1	-
Sciaenidae (Drums)			
Aplodinotus grunniens, freshwater drum	-	3	9
Total Number of Species	**7**	**18**	**4**

Table 1.2. Species List of Entrained Fishes Collected or Observed from Birds Point- New Madrid Floodway [1]

Species	May 16-18 ERDC, MDC, USACE	July 8, General and Staff	July 11-12 ERDC	July 27-28 ERDC	Total
Family Acipenseridae (Sturgeon)					
Scaphirhynchus platorynchus, shovelnose sturgeon	n=1	n=1	n=19	n=5	26
Family Polyodontidae (Paddlefish)					
Polyodon spathula, paddlefish	-	-	Common	Common	-
Family Lepisosteidae (Gar)					
Lepisosteus oculatus, spotted gar	7	-	Common	Common	-
Lepisosteus osseus, longnose gar	2	-	Common	Common	-
Lepisosteus platyrhincus, shortnose gar	13	-	Common	Common	-
Family Hiodontidae (Mooneyes					
Hiodon alosoides, goldeye	-	-	Rare	Rare	-
Family Clupeidae (Herring)					
Alosa chrysochloris, skipjack herring	4	-	Common	Common	-
Dorosoma cepedianum, gizzard shad	1	-	Abundant	Common	-
Dorosoma petenense, threadfin shad	8	-	Common	Common	-
Family Cyprinidae (Minnows)					
Cyprinus carpio, common carp	4	-	Common	Common	-
Hypophthalmichthys molitrix, silver carp	18	-	Abundant	Abundant	-
Hypophthalmichthys nobilis, bighead carp	-	-	Common	Rare	-
Pimephales vigilax, bullhead minnow	-	-	Common	Common	-
Family Catostomidae (Suckers)					
Ictiobus bubalus, smallmouth buffalo	6	-	Rare	-	-
Ictiobus cyprinellus, bigmouth buffalo	11	-	Common	-	-
Ictiobus niger, black buffalo	3	-	Common	-	-
Family Ictaluridae (Catfishes)					
Ameiurus natalis, yellow bullhead	1	-	Common	-	-
Ictalurus furcatus, blue catfish	17	-	Common	-	-
Ictalurus punctatus, channel catfish	10	-	Common	-	-
Pylodictis olivaris, Flathead catfish	-	-	Rare	-	-
Noturus flavus, stone cat	1	-	-	-	1
Percichthyidae (Temperate Basses)					
Morone chrysops, white bass	2	-	Rare	-	-
Morone mississippiensis, yellow bass	-	-	Rare	-	-
Centrarchidae (Sunfishes)					
Lepomis macrochirus, bluegill	1	-	Common	Common	-
Micropterus salmoides, largemouth bass	-	-	Rare	Rare	-
Pomoxis nigromaculatus, black crappie	1	-	Rare	Rare	-
Family Percidae (perches)					
Stizostedion canadense, sauger	-	-	Rare	Common	-
Sciaenidae (Drums)					
Aplodinotus grunniens, freshwater drum	12	-	Common	Common	-

ERDC – Fish Ecology Team, EL; MDC – Missouri Dept. of Conservation; USACE – Memphis District Biologists

Figure 1-1. Lower crevasse near St John's Bayou and New Madrid, MO.

Figure 1-2. The middle crevasse near Big Oak Tree State Park.

Figure 1-3. Upper crevasse at Birds Point.

Figure 1-4. Overnight hoopnet set with a catch of bighead and silver carp from the lower crevasse near St. John's Bayou and New Madrid, MO

Figure 1-5. A hoopnet set in the vicinity of the upper crevasse at Birds Point illustrating the shallow water and decreasing river levels that left the net exposed during the overnight set.

Figure 1-6. A shovelnose sturgeon captured in a hoopnet near the upper crevasse at Birds Point (upper) and the rubber band girdling the mid-section of the body (lower).

Figure 1.7. A shallow pool of the lower crevasses near New Madrid, MO and St John's Bayou).

Figure 1.8. A large blue hole created by the Mississippi River located at the Middle Crevasse (Vicinity of Big Oak Tree State Park).

Figure 1.9. Fish kill at the lower blue hole of Birds Point cause by low dissolved oxygen attributing to pumping the water body dry. Notice the steep bank much of the water has already been pump.

Figure 1.10. Gar and juvenile silver carp are the last to survive in the low dissolved oxygen.

Figure 1.11. A shovelnose sturgeon with many juvenile silver carp.

Figure 1.12. Each sturgeon was examined for a series of characters to determine its identification. Notice how the belly scales are complete, which is a good character for a shovelnose sturgeon.

Figure 1.13. The smallest entrained sturgeon observed by ERDC Fish Team Personal. Anal fin ray and dorsal fin ray counts confirmed that this individual was a shovelnose sturgeon.

Chapter 2: Evaluation of Pallid Sturgeon Entrained Through the Morganza Floodway

The ERDC Fish Ecology Team, with logistic support from Corps Rangers, New Orleans District, sampled the Morganza Spillway on July 14 and 18, 2011 for the federally listed pallid sturgeon. Areas sampled included below (downstream) the structure, the stilling basin and downstream canal, and the forebay above the structure using boat-electroshocker. Total shocking (pedal) time below the structure was 53 minutes and 19 minutes along the forebay above the structure (Figure 2.1). Water quality parameters varied below and above the structure (Table 2.1). Dissolved oxygen was 5 mg/l below the structure, and since these measurements were taken during early afternoon, hypoxic conditions probably occur during early morning hours. A total of six hauls was made with a 20-ft seine in the forebay. Areas where dead fish were present in scoured pools or on land below the structure were surveyed by two people on foot for a total combined time of nine 1/2 hours. Approximately one hour was expended in the forebay for dead fish. No sturgeon were observed or captured.

Because of the massive number of dead fishes present, we only kept track of species and ranked abundance into three categories (abundant, common, and rare). A total of 35 species of fishes comprised of 14 families were observed or collected (Table 2.2). Gar were observed swimming near the structure (Figure 2.2), but most fish were dead (Figures 2.3 – 2.5). The dominant fishes observed were silver carp, gizzard shad and bigmouth buffalo. Common fishes included gar, catfishes, silversides, and sunfishes. Rare fishes consisted of a few individuals of skipjack herring, mullet and flathead catfish. Based on previous life history studies, many of the fishes observed were backwater species. In addition, five species of freshwater mussels typically found in backwaters were observed (Table 2.3). Only a few riverine species were present.

The absence of sturgeon is likely due to the position of the Morganza Structure relative to the Mississippi River. The structure is set back a considerable distance from the River compared to the Bonnet Carré Spillway. In addition, fish originating from the Mississippi River must travel through backwaters in the floodplain and over the potato levee. These barriers likely hamper movement towards the structure. Consequently, it is our opinion that entrainment of pallid sturgeon, which is an obligate riverine fish, through the Morganza Spillway would be a rare event.

Table 2.1. Water Quality Data for Morganza Spillway, July 5, 2011

Parameters	Below Structure	Above Structure
Average Width (ft)	25	-
Average Depth (ft)	5.98	-
Average Velocity (ft/s)	0.79	-
Average Discharge (cfs)	354	-
Water Temperature (ºC)	29.50	31.38
Dissolved Oxygen (mg/L)	5.10	7.44
pH	7.36	7.63
Conductivity (mS)	0.344	0.332
Turbidity (NUT)	18.39	49.9

Table 2.2. Fish Species Documented in the Morganza Spillway

Species	Status
Family Polyodontidae (Paddlefish)	
Polyodon spathula, paddlefish	Common
Family Lepisosteidae (Gar)	
Lepisosteus oculatus, spotted gar	Common
Lepisosteus osseus, longnose gar	Common
Lepisosteus platyrhincus, shortnose gar	Common
Family Amiidae (Bowfin)	
Amia calva, bowfin	Common
Family Anguillidae (freshwater eels)	
Anguilla rostrata, American eel	Rare
Family Clupeidae (Herring)	
Alosa chrysochloris, skipjack herring	Common
Dorosoma cepedianum, gizzard shad	Abundant
Dorosoma petenense, threadfin shad	Common
Family Cyprinidae (Minnows)	
Cyprinus carpio, common carp	Common
Hypophthalmichthys molitrix, silver carp	Abundant
Hypophthalmichthys nobilis, bighead carp	Abundant
Ctenopharyngodon idella, grass carp	Rare
Family Catostomidae (Suckers)	
Ictiobus bubalus, smallmouth buffalo	Rare
Ictiobus cyprinellus, bigmouth buffalo	Common
Ictiobus niger, black buffalo	Common
Carpiodes carpio, river carpsucker	Rare
Family Ictaluridae (Catfishes)	
Ameiurus natalis, yellow bullhead	Common
Ameiurus melas, black bullhead	Common
Ictalurus furcatus, blue catfish	Rare
Ictalurus punctatus, channel catfish	Common
Pylodictis olivaris, flathead catfish	Rare
Family Belonidae (Needlefishes)	
Strongylura marina, Atlantic needlefish	Rare
Family Atherinidae (Silversides)	
Menidia beryllina, inland silverside	Common
Moronidae (Temperate Basses)	
Morone chrysops, white bass	Rare
Morone mississippiensis, yellow bass	Rare
Centrarchidae (Sunfishes)	
Lepomis cyanellus , green sunfish	Abundant
Lepomis gulosus, warmouth	Common
Lepomis megalotis, longear sunfish	Rare
Lepomis macrochirus, bluegill	Common
Micropterus salmoides, largemouth bass	Common
Pomoxis annularis, white crappie	Rare
Pomoxis nigromaculatus, black crappie	Common
Sciaenidae (Drums)	
Aplodinotus grunniens, freshwater drum	Rare
Family Mugilidae (Mullets)	
Mugil cephalus, striped mullet	Rare
Total Number of Species	**35**

Table 2.3. Alive and Dead Freshwater Mussels Observed Above and Below the Morganza Spillway

Species	Status
Family Unionidae	
Pyganodon grandis, giant floater	Abundant
Utterbackia imbecillis, paper pondshell	Common
Quadrula apiculata, southern mapleleaf	Common
Toxolasmus texasensis, Texas lilliput	Common
Uniomerus tetralasmus, pond horn	Common

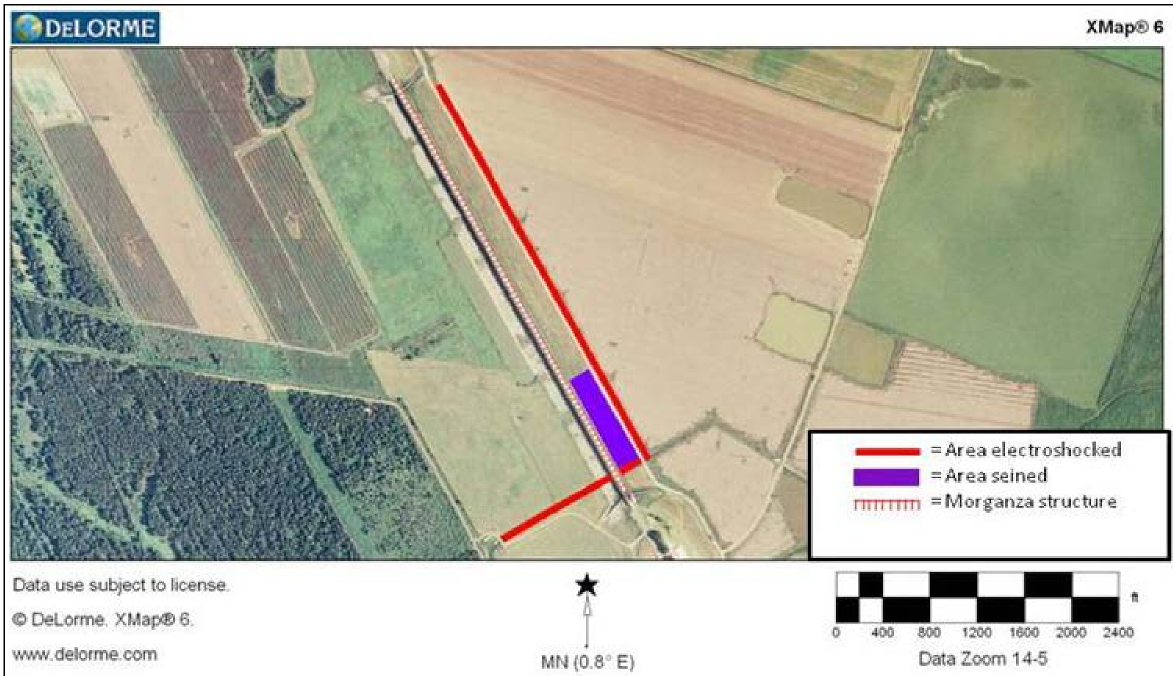


Figure 2.1. Aerial view of the Morganza Spillway showing the areas sampled using electroshocking and seines.

Figure 2.2. Gar species swimming in the current in the outflow sluice gates of the Morganza Spillway.

Figure 2.3. Alive and freshly dead fishes on July 14, 2011 downstream of the sluice gates of the Morganza Spillway. Cause of death is low dissolved oxygen. Notice many of the fishes (bass and bluegill) are backwater species and very few river species.

Figure 2.4. Rotten dead carp and buffalo below the Morganza Spillway structure.

Figure 2.5. Each fish was examined during the survey; however no sturgeon was found.

Chapter 3: Entrainment of Sturgeon Through the Bonnet Carré Spillway

The Bonnet Carré Spillway diverts flood waters from the Mississippi River into a floodway that empties into Lake Pontchartrain to reduce river stages at New Orleans. The spillway has been opened twice over the past four years, although frequency of openings prior to this period was approximately once every 10 years. In 2008, it was open for 27 days beginning April 11th, maximum number of bays in operation was 160 out of 350, and maximum discharge through the structure was 160,144 cfs. In 2011, it was open for 42 days beginning May 9th with a maximum of 330 open bays, which created discharges twice as high (315,930 cfs) compared to 2008. Once the structure is closed, discharge depends on the amount of water leaking through the pins.

During both openings, the U.S. Army Corps of Engineers (Corps), Louisiana Department of Wildlife and Fisheries (LDWF), and Nicholls State University evaluated entrainment of the federally-endangered pallid sturgeon (*Scaphiryhnchus albus*) through the structure. In both cases, sturgeon were captured during the first week after closing with sampling continuing for numerous weeks. Sampling also occurred one week prior to the 2011 opening, but no sturgeon were captured. Multiple sampling gears were used including electroshocker, seines, trawls, and gill nets.

Pre-Opening Sampling - May 4-5, 2011. Several reaches were sampled associated with the Bonnet Carré Spillway on May 4-5, 2011 for the federally listed pallid sturgeon. The reaches included the Mississippi River in the vicinity of the spillway structure, the upper portion of Barbars Canal, and the upper portion of Y Canal. Each reach was sampled using a boat-electroshocker at 60 Hz. At Barbars Canal and Y Canal, additional sampling gear was deployed which included experimental gillnets (90' long x 6' deep with 6, 15' long panels; mesh size ranged from 1" to 3 ½ "), a 2 ½ trammel net, and hoopnets of varying sizes (3' hoops with 1" mesh and 4' hoops with 4" mesh). Because of the rising water, only four hoopnets were fished overnight in Barbars Canal.

Barbars Canal. A total of 53 individuals were collected in Barbars Canal representing ten species (Table 3.1). The majority of the fish collected were by boat-electroshocking. Shocking time for this reach was 1,897 seconds. Gillnets and trammel nets were fished overnight resulting in six individuals being captured. Low catch in these gears was attributed to trash entangled in the nets from floating plant debris displaced by the rising water levels. Overnight hoopnet sets (4) resulted in a single silver carp (Figure 3.1). The dominant species collected was striped mullet, follow by silver carp and smallmouth buffalo. Rare fishes included bigmouth buffalo and flathead catfish. No sturgeon were observed or captured. Discharge in Barbars Canal was 763 cfs on May 4, 2011 and rising (Table 3.2).

Y Canal. Twenty-one species of fishes were collected in Y Canal (Table 3.1). Many of the species were represented by a single individual. Gizzard shad and striped mullet were the dominant species collected. No sturgeon were observed or collected. Boat-electroshocking was the most effective gear; however gill nets and hoopnets did provide additional catch for the total effort. Soak time for gillnets and shocking time was similar to the effort in Barbars Canal, however because of rising water within the floodway hoopnets were not fished overnight. On May 4, 2011, the discharge in Y Canal was 502 cfs and rising (Table 3.2). Discharge in Barbars Canal above the confluence of Y Canal was 763 cfs. Therefore, the approximate discharge in Barbars Canal below the confluence of Y Canal on May 4, 2011 was 1265 cfs (763+261 = 1265)

Mississippi River Reach. Electroshocking was conducted along the Bonnet Carré Spillway (MS River side). Three reaches (each end and the middle) of the spillway was shocked for 300 seconds and all fish stunned were captured and identified. Additional shocking was conducted in the vicinity of entire spillway structure in search for sturgeon only. That shocking time accounted for 2,256 seconds (Figure 3.2). No sturgeon were observed or captured. A total of eight species of fish were collected for the combined three reaches (Table 3.1).

Post-Closure: 2008 and 2011. Sampling began once the structure was closed. Three primary areas of the floodway were sampled regularly: stilling basin, canals (primarily Barbars and Y), and lakes (Figure 3.3). Over 24 days were expended by three crews working either together or separately representing LDWF, Nicholls State, and the Corps (ERDC and Bonnet Carré project staff primarily Bill Maus and Steve Stone).

Discharge patterns after the structure was closed differed substantially between the two years (Figure 3.5). The 2008 hydrograph exhibited a slow decline over a period of four weeks, whereas the 2011 hydrograph dropped to almost zero discharge in the floodway within a week. Pallid and shovelnose sturgeon catch generally followed the same trend as the hydrograph (Figure 3.5). Sturgeon were caught over a four-week period in 2008, whereas almost all sturgeon captured in 2011 occurred within the first week after closure. The greater magnitude of discharge through the floodway in 2011 may have been one contributing factor by displacing sturgeon to a greater extent. However, the abbreviated period of flow in the canals during 2011 also contributed to sturgeon catch patterns. Both pallid and shovelnose sturgeon are strongly rheotactic and orient into the direction of the flow. Water velocity in the canals below the structure essentially went to zero within a week after the 2011 closure and water levels dropped precipitously throughout the floodway. Therefore, displaced sturgeon were less likely to move towards the base of the structure as they did in 2008 when currents persisted for 4-5 weeks in the canals where most sturgeon were caught. Rapid drop in water levels in 2011 also hampered physical movement through or over road crossings that crisscross the floodway. Sturgeon essentially became stranded in 2011, with most individuals caught in the stilling basin below the structure or in floodway lakes that became disconnected with the canals.

Higher discharge and longer opening in 2011 resulted in greater number of sturgeon caught. In 2008, a total of 14 pallid and 41 shovelnose sturgeon were collected over a 4-week period. In 2011, a total of 20 pallid, 78 shovelnose, and one possible intermediate sturgeon were collected over a 1.5-week period. A notable collection was a tagged pallid sturgeon originally captured in the floodway during 2008 and released back into the Mississippi River. Pallid to shovelnose ratio were similar between the two years; 1:3 in 2008 and 1:4 in 2011. Ratio in this reach of the lower Mississippi River is typically 1:3. Mean length of pallid sturgeon collected in 2011 was 773 mm FL, compared to 712 mm FL in 2008. Sizes in 2011 ranged from 449 – 924 mm FL corresponding to ages ranging from 3 to greater than 15 years. Mean size of shovelnose sturgeon caught in 2011 was slightly smaller (607 mm FL) than in 2008 (665 mm FL).

Following the 2011 opening, we used acoustic telemetry to monitor movement of entrained shovelnose sturgeon (*Scaphiryhnchus platorynchus*), a species closely related to and sympatric with pallid sturgeon, within the floodway. Twelve VEMCO VR2Ws (remote receivers) were deployed from the Bonnet Carré floodway down Barbars Canal to Lake Pontchartrain to establish an automated acoustic telemetry array. Eighteen shovelnose sturgeon ranging in size from 501-830 mm FL were captured from upper Barbars, Y-Canal, and the Bonnet Carre' stilling basin and equipped with acoustic telemetry tags (V9 coded acoustic transmitters, 289 day battery life) during the period 20-27 June 2011. Tagged fish were then redistributed within the system near telemetry buoys (Barbars 1, 2, 4, 5, 8 and Y-canal 1, see Figure 3.4). The array was deployed from 20 June 2011 through 25 May 2012 and accumulated over 120,000 detections. No mortalities were reported and initially all individuals moved extensively near their original release point. There were no detection patterns to support movement of telemetry tagged individuals from the Bonnet Carre' floodway into Lake Pontchartrain after 13 July 2011.

The initial acoustic array within the floodway was deployed on 20 June prior to sampling but the remaining gates at Lake Pontchartrain were not deployed until 13 July. This created an "open window" for undocumented movement into Lake Pontchartrain (21 June-13 July = 20-32 days depending on when fish were captured, tagged and released). Six individuals were unaccounted for after 13 July suggesting they moved quickly through the floodway and into Lake Pontchartrain before the final gates were deployed. None were documented returning back to the floodway. Those fish that remained in the system experienced sporadic, localized movement. However, overall movement of telemetry tagged fish began to decrease by early August as water levels within the floodway decreased, in part creating isolated pools and remnant channels, and as water temperatures increased (31 C). Salinity during this period where the floodway enters Lake Pontchartrain was ≥ 2 ppt; detections during this period on the receivers nearest to Lake Pontchartrain were few to none.

The USFWS issued a non-jeopardy, emergency Biological Opinion for the 2008 opening with an estimated incidental loss of 88 adult pallid sturgeon. A Biological Opinion will likely be issued for the 2011 opening. Differences in hydrograph and catch rates should be considered for future operations. Rapid decreases in discharge below the structure, which happened in 2011, will probably result in more sturgeon becoming stranded and non-recoverable. Gradual decreases in discharges, like 2008, will provide rheotactic cues for sturgeon to move upstream towards the structure, congregate, and become easier to catch. Regardless of the discharge patterns, however, it has been demonstrated twice under different circumstances that rapid rescue of entrained pallid sturgeon can be successfully accomplished to minimize impacts to this endangered species.

Table 3.1. Number of Fishes Captured in Barbars Canal, Y Canal, and Mississippi River in the Vicinity of the Bonnet Carré Spillway Using All Gear Types, May 4-5, 2011

Species	Barbars Canal	Y Canal	MS River @ Spillway
Family Lepisosteidae (Gar)			
Lepisosteus osseus, longnose gar	2	1	-
Family Clupeidae (Herring)			
Alosa chrysochloris, skipjack herring	2	1	-
Dorosoma cepedianum, gizzard shad	2	12	9
Dorosoma petenense, threadfin shad	2	1	1
Family Cyprinidae (Minnows)			
Cyprinus carpio, common carp	-	1	1
Hypophthalmichthys molitrix, silver carp	6	1	1
Family Catostomidae (Suckers)			
Carpiodes carpio, river carpsucker	2	1	-
Ictiobus bubalus, smallmouth buffalo	6	3	-
Ictiobus cyprinellus, bigmouth buffalo	1	1	-
Ictiobus niger, black buffalo	-	-	1
Family Ictaluridae (Catfishes)			
Ictalurus furcatus, blue catfish		1	-
Ictalurus punctatus, channel catfish		2	-
Pylodictis olivaris, flathead catfish	1	-	-
Poeciliidae (Livebearers)			
Gambusia affinis, Western mosquito fish	-	1	-
Percichthyidae (Temperate Basses)			
Morone saxatilis, striped bass	-	-	1
Morone chrysops, white bass	-	-	1
Centrarchidae (Sunfishes)			
Lepomis cyanellus, green sunfish	-	1	-
Lepomis macrochirus, bluegill	-	4	-
Lepomis megalotis, longear sunfish	-	1	-
Lepomis microlophus, redear sunfish	-	1	-
Lepomis symmetricus, bantam sunfish	-	1	-
Micropterus salmoides, largemouth bass	-	1	-
Pomoxis annularis, white crappie	-	1	-
Sciaenidae (Drums)			
Aplodinotus grunniens, freshwater drum	-	1	-
Mugilidae			
Mugil cephalus, striped mullet	29	12	5
Total Number of Species	**10**	**21**	**8**

Table 3.2. Water Quality Data for Barbars Canal, Y Canal and Mississippi River in the Vicinity of the Bonnet Carré Spillway on May 5, 2011

Variable	Barbars Canal	Y Canal	MS River @ Spillway
Water Body Width (ft)	93	93	-
Depth (ft)			
Mean			7.4
Minimum	7.5	4.5	-
Maximum	11.4	9.6	-
Velocity (ft/s)			
Mean	0.83	0.71	-
Minimum	0.69	0.39	-
Maximum	1.1	1.4	-
Discharge (cfs)	763[1]	502	-
Water Temperature (ºC)	18.39	18.94	22.22
Dissolved Oxygen (mg/L)	6.75	8.40	7.06
pH	7.12	7.41	7.48
Conductivity (mS)	0.344	0.344	0.342
Turbidity (NTU)	47	42.2	38.2

[1] Discharge measured above the confluence of Y Canal

Figure 3.1. Running a large mesh hoopnet in Barbar's Canal; notice the silver carp in the net.

Figure 3.2. ERDC personal sampling for sturgeon using electroshocking in the vicinity of Bonnet Carre' Spillway.

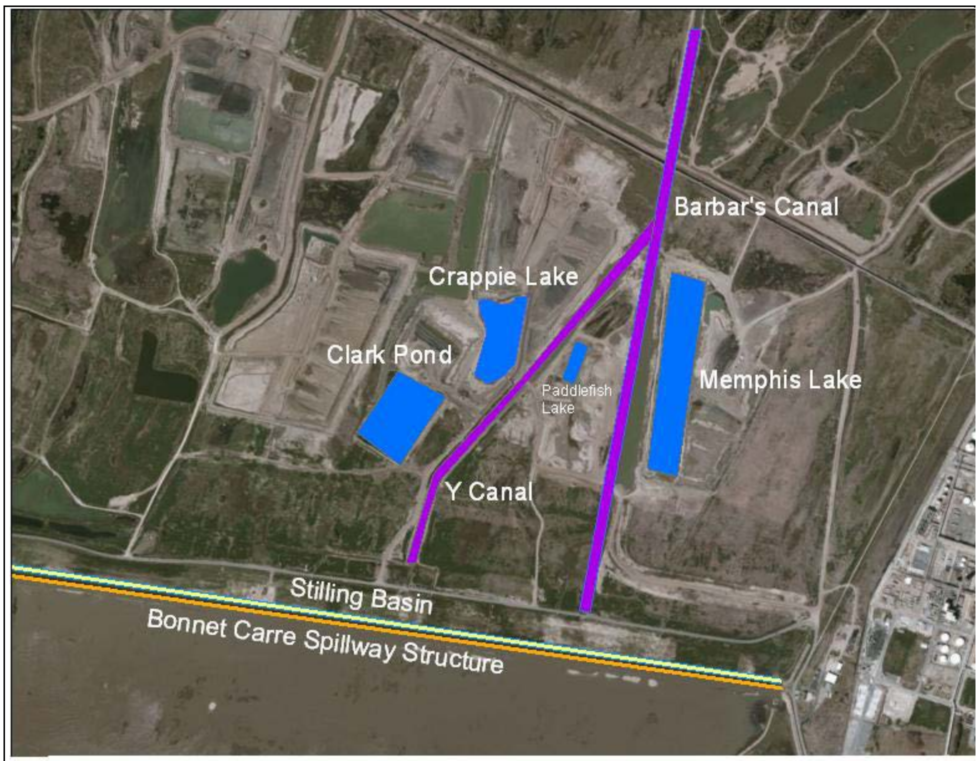


Figure 3.3. Three primary areas where sturgeon were collected in 2011: Stilling Basin, Canals (Barbars and Y), and Lakes.

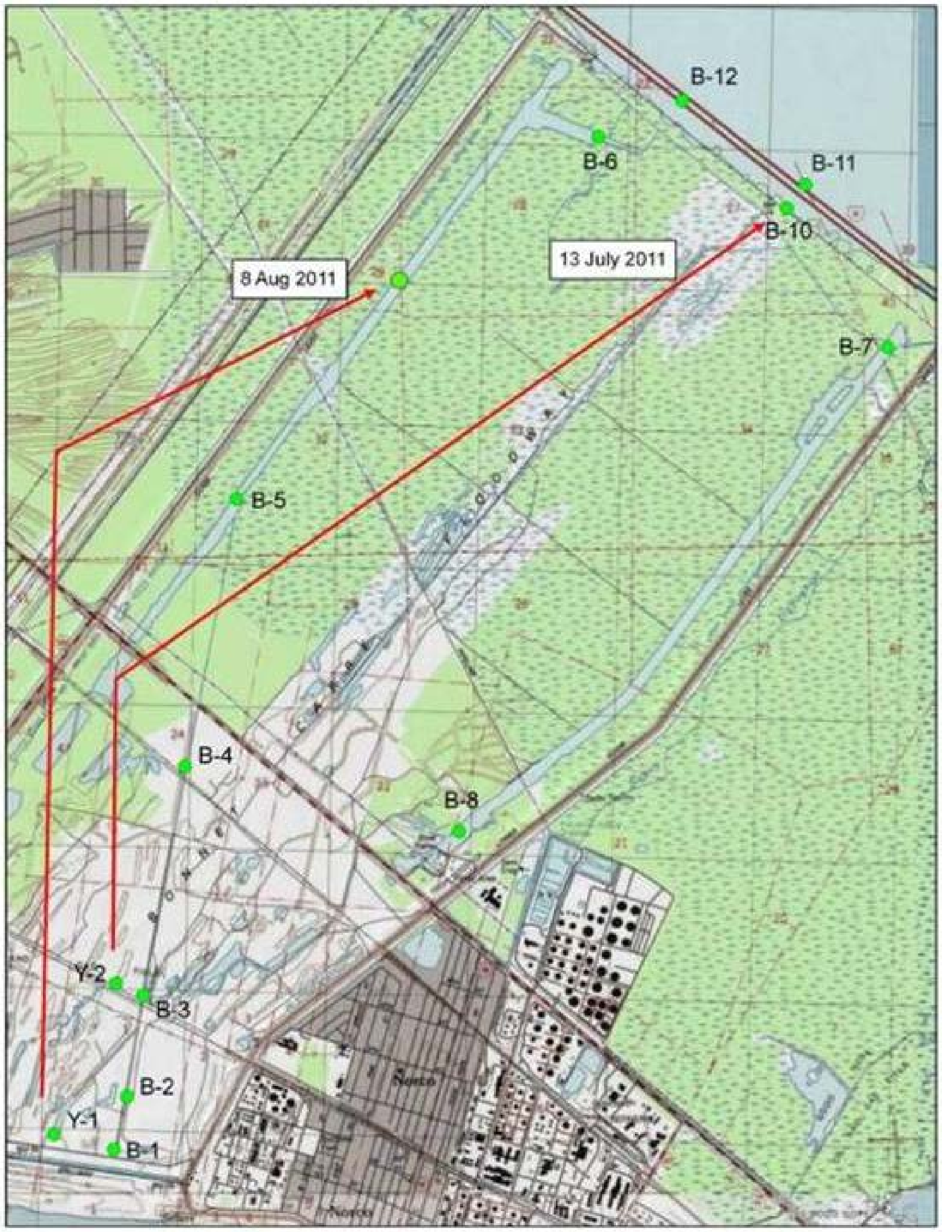


Figure 3.4. Location of 12 VR2Ws (remote receivers, green dots) deployed in the Bonnet Carre Spillway down to Lake Pontchartrain. Red arrows indicate relocation of receivers from waterbodies that became disconnected from primary canals.

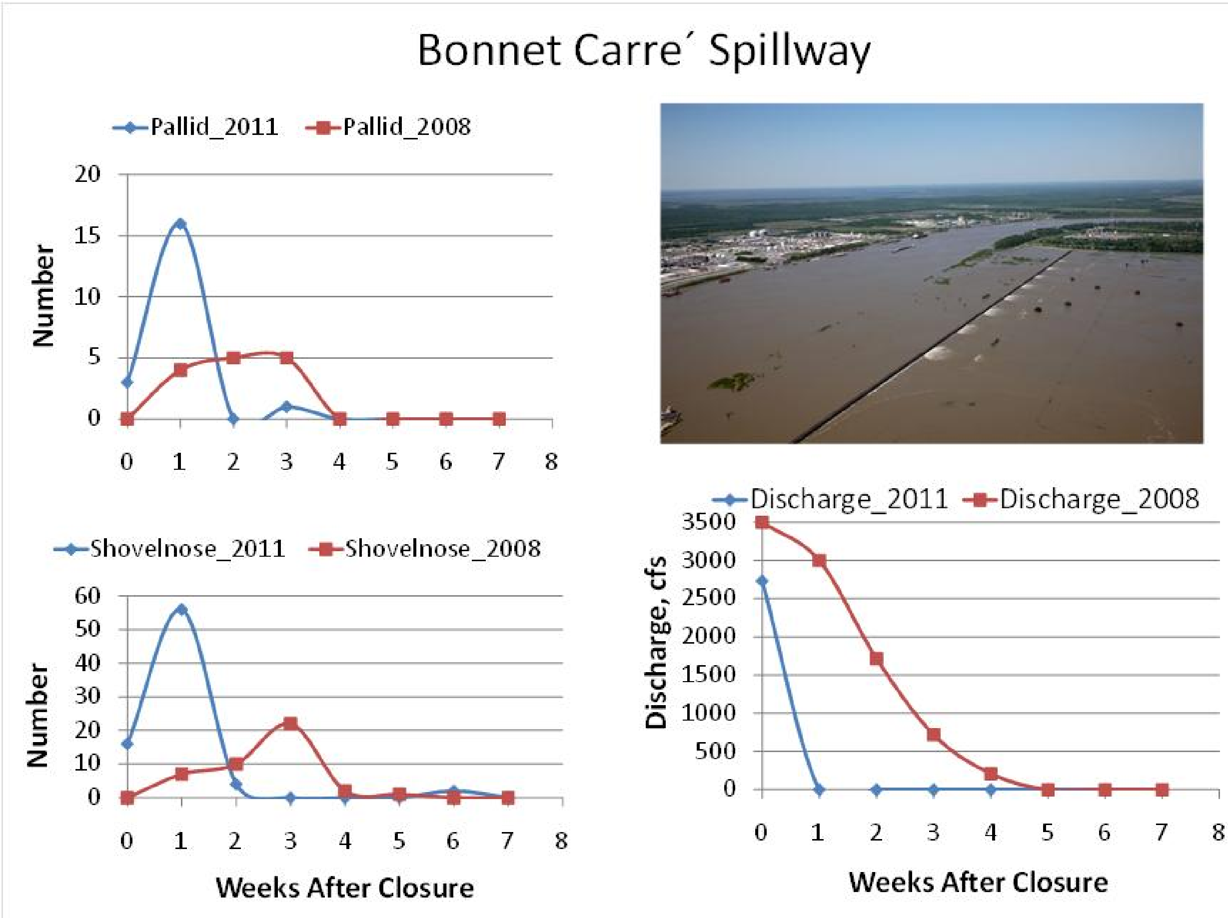


Figure 3.5. A summary of discharge (CFS) in the floodway and sturgeon catch after closure of the Bonnet Carre spillway in 2008 and 2011.

Chapter 4: Evaluation of Asian Carp Entrained through the Muddy Bayou Control Structure

Sand boils at Buck Chute Mississippi River Levee adjacent to Eagle Lake was problematic during the 2011 flood. To prevent potential levee failure, the Muddy Bayou Control Structure was open to direct water from Steele Bayou into Eagle Lake to equalize pressure on the levee. There were concerns about introducing Asian Carp (bighead and silver carp) from a known area infested by these species (i.e., Steele Bayou) into Eagle Lake during the opening and the resulting impacts to the fisheries, as well as potential dangers to water skiers and boaters from jumping silver carp.

Fish Survey After the Opening of Muddy Bayou Control Structure on May 2, 2011. To evaluate the presence of Asian Carp in Eagle Lake, the ERDC Fish Ecology Team and personal from Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) sampled four reaches including: above the structure to Steele Bayou, the vicinity of Steele Bayou upstream and downstream of Muddy

Bayou, below the structure to the mouth of Muddy Bayou, and Eagle Lake near the confluence of Muddy Bayou. Sampling gear included boat electroshocking, gillnets, and transects using visual counts of jumping silver carp disturbed by the boat motor.

While the Muddy Bayou Structure was open, gillnets were not effective due to trash and leaves becoming entangled in the webbing. Only six species of fish were captured, but no Asian Carp. Visual counts and boat electrofishing provided an additional opportunity to detect Asian Carp (Table 4.1).

Fish Survey During the Closure Of Muddy Bayou Control Structure on August 10, 2011. The ERDC Fish Ecology Team and the MDWFP returned to sample the same reaches of Muddy Bayou in search for Asian Carp. Sampling gear and methods were the same as before using boat electroshocking, gillnets and transects using visual counts of jumping silver carp disturbed by the boat motor. No carp were detected in Muddy Bayou or in Eagle Lake near its confluence with Muddy Bayou, but high abundance of silver carp were documented in Steele Bayou above the structure (Table 4.2). With the reduction of water velocities and depths, gillnets were an effective sampling gear. A total of 80 individuals were netted comprised of eight species of fishes. No Asian carp were present in gillnet samples. Boat electrofishing validated the absence of Asian Carp in Muddy Bayou but showed high abundance of silver and bighead carp in Steele Bayou (Figure 4.1, Table 4.3).

Conclusions. It is likely that Asian carp occur in Eagle Lake considering the duration of the opening and the high density of these species found in the source water (i.e., Steele Bayou). However, problematic infestations of these species are not obvious at this time. Our sampling did not detect Asian carp in Eagle Lake after the structure was closed. We are not aware of any reports of jumping silver carp in the Lake. Furthermore, it is doubtful that Asian carp could establish reproductive populations in the Lake because they typically spawn in rivers with flowing water. If a successful spawn did occur, high predation rates on the fry are likely considering that the lake fishery is managed for predator species including largemouth and white bass. Future sampling of Muddy Bayou and Eagle Lake will be conducted to further investigate the occurrence and abundance of Asian carp in the Lake and below the Muddy Bayou Structure.

Table 4.1. Visual Accounts of Silver Carp Leaping Out of the Water Using Boat Electroshocking and Visual Counts on May 2, 2011

Muddy Bayou at Mouth	n=7
Below Muddy Bayou Structure	n=4
Above Muddy Bayou Structure	n=0
Steele Bayou upstream of Muddy Bayou transect distance 0.4 mile	n=3
Steele Bayou downstream of Muddy Bayou transect distance 0.4 mile	n=0

Table 4.2. Visual Accounts of Silver Carp Leaping Out of the Water Using Boat Electroshocking and Visual Counts on August 10, 2011

Muddy Bayou at Mouth	n=0
Below Muddy Bayou Structure	n=0
Above Muddy Bayou Structure	n=0
Steele Bayou upstream of Muddy Bayou transect distance - 1 mile	n=118
Steele Bayou downstream of Muddy Bayou transect distance - 1 mile	n=42

Table 4.3. Fish Species Observed in Boat Electroshocking or Gillnet Samples on August 10, 2011

Species	Muddy Bayou at Mouth	Below Muddy Bayou Structure	Above Muddy Bayou Structure	Steele Bayou Upstream of Muddy Bayou	Steele Bayou Downstream of Muddy Bayou
Family Polyodontidae (Paddlefish)					
Polyodon spathula, paddlefish	*	-	-	-	-
Family Lepisosteidae (Gar)					
Lepisosteus oculatus, spotted gar	**	***	***	***	***
Lepisosteus osseus, longnose gar	**	**	*	*	**
Lepisosteus platyrhincus, shortnose gar	**	**	**	**	***
Family Clupeidae (Herring)					
Dorosoma cepedianum, gizzard shad	***	***	***	***	***
Dorosoma petenense, threadfin shad	***	***	***	***	***
Family Cyprinidae (Minnows)					
Cyprinus carpio, common carp	**	**	**	**	**
Hypophthalmichthys molitrix, silver carp	-	-	-	***	***
Hypophthalmichthys nobilis, bighead carp	-	-	-	*	**
Ctenopharyngodon idella, grass carp	**	**	**	**	**
Family Catostomidae (Suckers)					
Ictiobus bubalus, smallmouth buffalo	***	***	***	***	***
Ictiobus cyprinellus, bigmouth buffalo	**	***	***	**	***
Ictiobus niger, black buffalo	**	***	***	***	***
Family Ictaluridae (Catfishes)					
Ictalurus furcatus, blue catfish	-	*	*	-	-
Ictalurus punctatus, channel catfish	***	***	***	-	-
Percichthyidae (Temperate Basses)					
Morone Hybrid, white bass x stripe bass	*	-	-	-	-
Centrarchidae (Sunfishes)					
Lepomis macrochirus, bluegill	-	*	-	-	-
Micropterus salmoides, largemouth bass	-	*	-	-	-
Sciaenidae (Drums)					
Aplodinotus grunniens, freshwater drum	-	-	-	-	*

Ranking of species other than bighead and silver carp:
Not Observed - Rare *
Common ** Abundant ***

Figure 4.1. A silver carp avoids capture from the MDWFP electroshocking boat in Steele Bayou.

Participants

Name	Affiliation	Project
Joshua Koontz	Memphis District	New Madrid
Mark Smith	Memphis District	New Madrid
Mike Thron	Memphis District	New Madrid
Danny Ward	Memphis District	New Madrid
Dave Herzog	Missouri Department of Conservation	New Madrid
Dave Knuth	Missouri Department of Conservation	New Madrid
David Ostendorf	Missouri Department of Conservation	New Madrid
Russell Beauvais	New Orleans District	Morganza
Joe Harvey	New Orleans District	Morganza
Steve Stone	New Orleans District	Morganza/Bonnet Carré
Richard Boe	New Orleans District	Bonnet Carré
Chris Brantley	New Orleans District	Bonnet Carré
Bill Maus	New Orleans District	Bonnet Carré
Thomas Parker	New Orleans District	Bonnet Carré
Gary Vitrano	Louisiana Wildlife and Fisheries	Bonnet Carré
Matt Duplessis	Louisiana Wildlife and Fisheries	Bonnet Carré
Tim Ruth	Louisiana Wildlife and Fisheries	Bonnet Carré
Jeff Thompson	Louisiana Wildlife and Fisheries	Bonnet Carré
Dave Schultz, PI	Nicholls State University	Bonnet Carré
Stephen Byrne	Nicholls State University	Bonnet Carré
Chris Levron	Nicholls State University	Bonnet Carré
Clint Troxler	Nicholls State University	Bonnet Carré
Paul Hartfield	USFWS, Jackson, MS	Bonnet Carré
Debbie Fuller	USFWS, Lafayette, LA	Bonnet Carré
Monica Sikes	USFWS, Lafayette, LA	Bonnet Carré
Robert Smith	USFWS, Lafayette, LA	Bonnet Carré
David Walther	USFWS, Lafayette, LA	Bonnet Carré
Jerry Brown	Mississippi Wildlife, Fisheries, and Parks	Eagle Lake
Don Henke	Mississippi Wildlife, Fisheries, and Parks	Eagle Lake
Ryan Jones	Mississippi Wildlife, Fisheries, and Parks	Eagle Lake
Brian LaBarre	Vicksburg District	Eagle Lake
Kent Parrish	Vicksburg District	Eagle Lake
Jay Collins	ERDC	All
Steven George[1]	ERDC	All
Jan Hoover [1]	ERDC	All
Alan Katzenmeyer	ERDC	All
Jack Killgore[1]	ERDC	All
Phil Kirk	ERDC	All
Bill Lancaster	ERDC	All
Bradley Lewis	ERDC	All
Todd Slack[1]	ERDC	All

[1] Co-authors of this report

SECTION VI

MISSISSIPPI DEPARTMENT OF MARINE RESOURCES
OFFICE OF MARINE FISHERIES

2011 MISSISSIPPI RIVER/BONNET CARRÉ SPILLWAY FLOOD OPERATION
AUGUST 2011

TABLE OF CONTENTS

Reference: National Marine Fisheries Service. 2010. Fisheries Economics of the United States, 2009. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-118, 172pp. Available at: *https://www.st.nmfs.noaa.gov/st5/publication/index.html*.

INTRODUCTION

The severe and cumulative impacts of sequential natural and manmade disasters which have struck the Gulf of Mexico since 2004, have taken a tremendous biological and economic toll on Mississippi's coastal resources, harvesters, and industry. This report focuses on the Bonnet Carré Spillway opening (and other environmental factors), during the Mississippi River flooding event of 2011.

High snowfall this past winter coupled with excessive spring rainfall throughout the mid-west resulted in record flooding in the U.S. The 2011 Flood waters exceeded most of the records for gauge readings and volumes, even surpassing the 1927 and 1937 floods according to the U.S. Army Corps of Engineers. Rivers experiencing the most severe impact include the Upper Missouri and Souris rivers, the Red River in North Dakota and Minnesota, the Minnesota River, the Upper Mississippi River, the Des Moines River, the Lower Missouri River, the James River, the Big Sioux River, the lower Ohio River, and the Lower Mississippi River. The result of all this water has been greatly increased flows down most of the country's major rivers which forced releases from many of the reservoirs and control structures, straight down the Mississippi River Valley and into the Gulf of Mexico.

Along the Gulf coast, a number of federal flood control structures were opened to handle the load and prevent flooding of communities along the river. The Bonnet Carré Spillway, located approximately 30 miles above New Orleans was opened on May 9, 2011 and not closed again until June 20, 2011. The Bonnet Carré serves to reduce pressure on existing levees by lowering the river stage and decreasing flow velocities to New Orleans and surrounding communities. The 7,000 feet long spillway structure located on the east bank of the Mississippi River, contains 350 concrete bays, of which 330 were opened to release the excess river water into the western end of Lake Pontchartrain. Each bay of the spillway is 20 feet wide. In addition, the Morganza Spillway, located along the western bank of the Mississippi River, some 20 miles north of Baton Rouge, was opened for only the second time since it was completed in the mid-1950s. The Morganza is used to divert water from the Mississippi River into the Atchafalaya Basin to protect communities downriver (Figure1).

The maximum discharge rate of the Bonnet Carré Spillway was estimated at 316,000 cubic feet per second (cfs) (note: 1 cubic foot = 7.48 gallons.) This maximum flow occurred with only 330 out of the 350 bays opened. The design maximum flow of the spillway is 250,000 cfs, which is a difference of some 66,000 cfs; or over 26% greater than the volume the structure was designed to carry. The Bonnet Carré spillway had a discharge rate at or exceeding 250,000 cfs for a total of 21 days (Figure 2). For illustrative purposes, an Olympic sized swimming pool has a volume of approximately 88,229 cubic feet or 660,000 gallons, depending on its depth; and during that 21 day period, the Bonnet Carré spillway was discharging that volume about every two seconds. These numbers and calculations are important to consider because it is a common practice to compare the total number of spillway bays opened during one flood event versus another past event when evaluating the severity of the impact. Even though some 400 feet of the spillway remained closed, the 2011 opening was indeed a major event which exceeded most other full spillway openings.

Coupled with the great inflow of freshwater into the Gulf from the north was the fact that the five Gulf States were under extreme to exceptional drought and record high temperatures (Figures 3 and 4). Rainfall along the coast was minimal if not absent from at least early April 2011. The potential effects of floodwaters were most likely buffered due to the drought conditions and the resulting unusually low local river flows. This reduced the coastal rivers contribution to the flood waters impact.

The air temperatures during that time exceeded 100°F on numerous occasions, setting up high salinity and high temperature waters across most of the Gulf's traditional oyster harvesting grounds. The stage was set for another hardship for the Gulf's oyster fishery.

Salinities in the production reef areas in western-most Mississippi Sound were at normal levels at the beginning of April 2011. However, with the Mississippi River rising and subsequent opening of the Bonnet Carré in early May 2011, the salinities in areas like St. Joseph's reef declined steadily from about 13.0 parts per thousand (ppt) on April 23, 2011 to 1.0 ppt by May 23, 2011 (Figure 5). The freshwater remained over that area until June 17, 2011 and finally reached the 'normal' salinity levels around July 4, 2011.

The Mississippi oyster season for public reefs closed in April 2011. However, one Mississippi oyster farm lease holder; near Waveland, MS, was issued a Lease Harvest Permit, and began harvesting the lease oysters on May 14, 2011, and ceased harvest activities June 2, 2011 due to the oysters beginning to open and die.

In addition to lower salinities, many of the waters in Mississippi Sound as far east as Gulf Shores Alabama have experienced large plankton blooms which have simultaneously driven down the dissolved oxygen and caused fish kills and 'jubilees'. Low oxygen conditions such as these aren't good for sessile organisms like oysters.

DMR staff collected a total of 200 square meter samples during May 2011 (100 samples) and repeated again during July 2011(100 samples) which indicated significant oyster mortalities. Preliminary oyster mortalities estimate for market sized oysters (≥ 3" total length) of the major commercial reefs in the western Mississippi Sound were determined to be in excess of 85%.

The salinity in these areas of the Mississippi Sound was driven well below the five ppt, the threshold which has been shown in past studies to cause extensive oyster mortalities. Biological sampling continues in Mississippi and the full impact of this freshwater event is still unknown.

IMPACTS TO COASTAL HABITATS

During May 2011, the Mississippi Department of Marine Resources (MDMR) conducted a square meter sampling program of oyster reefs located in the western Mississippi Sound. A total of 100 square meter samples were collected by SCUBA divers at 50 randomly chosen sites within 30 second (30") sized grids overlaid onto known western oyster reef boundaries. During July 2011, the MDMR repeated this sampling, with findings and comparisons illustrated in Figures 6 -8.

Living oysters as well as obviously recent dead oysters were measured and recorded. Instantaneous mortality estimates were derived by comparing the numbers of living versus recent dead oysters in the samples. Instantaneous mortality estimates for May 2011 ranged from 7% to 40%, and from 36% to 98.7% for the month of July 2011. Likewise, estimates of the number of sacks (1.98 $ft.^3$) of live market sized (≥ 3" length) oysters present were calculated for each reef area or complex (Figure 7). These ranged from 8.1 to 448 estimated live market oyster sacks per acre for May 2011 (weighted average 249.5), and from 2.7 to 43.8 sacks per acre for July 2011 (weighted average 34.1) Figure 8.

The weighted average estimate of living market oysters as well as mortalities was based on sampling results while taking the total reef area or complex acreages into consideration. This was performed by each reef or complex and for the total western oyster reef acreage of 7,797 acres. May 2011 sampling resulted in an estimate of 1,945,085 sacks of market sized oysters. While in July 2011, these numbers dropped dramatically some 86%, or loss of 1,678,878 sacks to an estimated total of only 266,207 remaining sacks.

The extent and severity of flood waters was effectively monitored through constant recorder instruments, recording YSI data sondes and sampling. Figures 9-21 illustrate low salinity and later; high temperatures and low dissolved oxygen events. Salinity levels on many of the oyster reefs were below two and three parts per thousand (ppt) for a period of approximately two to three weeks. Additionally, water temperatures reached 30°C at many locations in middle to late June 2011. Mississippi Department of Environmental Quality (MDEQ) YSI data sondes were deployed at the request of the MDMR, in the vicinity of various oyster reef locations and later recovered (Figures 21-25). However, two of the MDEQ YSI data sondes are missing, and were not recovered.

The MDMR postponed an ongoing oyster cultch plant in May 2011 due to the opening of the Bonnet Carré spillway. In August 2011, the MDMR restarted restoration activities for oysters. Brood stock oysters were relayed to the hardest impacted areas in the western Mississippi Sound. This work is expected to help re-inoculate other affected benthic organisms as well. Significant oyster cultch plants of several areas were begun in August 2011, and will continue into September 2011. Oyster reef cultivation work will be conducted by the MDMR during the months of August 2011 and September 2011. Cultivation will consist of towing a bagless oyster dredges over existing oyster shells covered with fouling organisms, such as a heavy algae growth or low salinity tolerant hooked mussels, to help expose a clean hard surface which will be conducive to an improved spat set rate.

Several years of recovery are anticipated before the return of a “normal” oyster season. Long term effects are unknown, especially for the larval stages. Ongoing monitoring activities will be required to maximize restoration efforts. A potential exists for multi-species year class losses.

The MDMR Shellfish Bureau conducts two routine phytoplankton samples each month. Data analyses of these samples are compiled in cooperation with the NOAA Phytoplankton Monitoring Network (PMN). These samples are taken from the northern-most and the southern-most boundaries of the Pass Christian oyster reef. In light of the Bonnet Carré’ Spillway opening, additional sampling was added from the St. Joe oyster reef. This sample is taken once each month to monitor for the presence of introduced phytoplankton species from the fresh water influx.

Results from the samplings showed a significant decrease in common phytoplankton and an introduction of a few freshwater species. The freshwater phytoplankton observed included *Pediastrum spp.* and *Scenedesmus spp.*

As the dissolved oxygen and salinity began to return to normal levels, there was an increase in algal blooms in the western Mississippi Sound. On June 27, 2011, a phytoplankton bloom was reported in the western Mississippi Sound. Aerial photographs were taken of this bloom but identification of type was not recorded (Figure 26). On July 27, 2011, a bloom of *Chattonella spp.* was investigated at the Gulfport and Long Beach shorelines. This bloom caused a significant fish kill.

Certain species of *Chattonella* have been shown to produce brevetoxin which will cause fish kills and is harmful for human consumption. No brevetoxins were detected in this *Chattonella* bloom. When an algal bloom begins to crash, the decaying process depletes dissolved oxygen which in turn, causes hypoxic conditions and will suffocate marine animals and plants.

On June 22, 2011 an aerial survey was conducted along the western Mississippi Sound to take some pictures of the influence of freshwater. Figure 27 shows what is believed to be the mixing of the turbid freshwater with the clearer high salinity water of the Gulf of Mexico.
Due to the likely introduction of aquatic invasive species, such as Asian carp, through this year's spillway opening, surveillance monitoring will be conducted to assess the extent and impact of their introduction in order that corrective measures may be taken to limit their further spread to other coastal bays and river systems.

IMPACTS TO MARINE RESOURCES

Impacts to the Mississippi Blue Crab Fishery. When the Bonnet Carré Spillway opened on May 9, 2011 it was anticipated that this freshwater would negatively influence the summer's shrimp and crab harvest in the Mississippi Sound. Immediate fishery impacts were expected to be seen by movement of mobile species to areas of higher salinities. However, shrimp landings data continued stable through May and June 2011 through the present to be normal to slightly higher than normal (source: NOAA). Future Mississippi shrimp landings will continue to be monitored on a monthly basis.

The DMR decided to use 2001-2009 to calculate the historical average of dockside landings and value for both crab and oysters. This decision was based the negative impacts of Hurricane Katrina in 2005 and the BP oil spill in 2010, which greatly misrepresents the historical averages for the last five years.

Mississippi blue crab landings for May 2011 were 46,934 lbs., a 35% decrease compared to average landings for May in the years 2001 through 2009 (73,525 lbs.). Value for Mississippi May 2011 blue crab landings was $38,584.00, a 44% decrease compared to average values for May in the years 2001 through 2009 ($69,824.00).

Mississippi blue crab landings for the period May-August 2011 averaged were 34,688 lbs./month, a 53.5% decrease compared to average landings for May-August in the years 2001 through 2009 (74,563 lbs./month). To date, based on an estimated 53.5% decrease (combined May through August 2011), total damage assessment for 2011 when compared to average annual value for the years 2001-2009 of $603,000 per year it has been determined to have had a total economic impact of $515,200 on the blue crab fishery of Mississippi. It is possible that the freshwater affected the natural migration and life cycle stages of blue crab and will affect future catches in Mississippi. The decreased harvest could warrant the Mississippi blue crab fishery to be considered harmed, disrupted or failed, per the requirements of the National Marine Fisheries Service Policy Guidance for Disaster Assistance Under Magnuson-Stevens Act 312(a) and Interjurisdictional Fisheries Act 308(b) and 308(d). Should that determination be made by NOAA, it would reflect injury to approximately 291 Mississippi resident commercial crab trap license holders and 86 resident commercial crab trawl license holders (Table 1).

An appropriate recovery plan to restore and enhance the fishery will be drafted upon determination of the level of injury is made.

Impacts to the Mississippi Oyster Fishery. The seafood industry has experienced more than its fair share of both natural and man-made disasters since Hurricane Katrina made landfall in 2005. The support that the MDMR received from the Department of Commerce has been a major catalyst in the recovery of Mississippi's commercial and recreational fisheries. In 2010 the deepwater horizon disaster caused major difficulties for the entire northern gulf coast. In the spring of 2011 we had the impact of the opening of the Bonnet Carré Spillway which introduced large volumes of fresh Mississippi River water into the western Mississippi Sound home to 95% of the States oyster reefs.

Mississippi's oyster industry (Table2) is an important component to the entire seafood industry in the State with a total economic impact of $100 million dollars (2003) and after Katrina was reduced to $12.17 million in 2007. The commercial seafood industry in Mississippi had an overall total economic impact of $289 million in 2009 (NMFS 2010).

Fisheries staff conducted an assessment of the public oyster reefs in Mississippi prior to the opening of the Bonnet Carré Spillway in May 2011. This assessment provided an estimate of 1,945,086 sacks of oysters on the public reefs. In July 2011 a post spillway opening assessment was conducted this estimate resulted in 266,207 sacks of oyster. Mortality as a result of excessive fresh water from the Bonnet Carré Spillway opening and other environmental factor caused a loss of 1,678,878 sacks of oysters. Mississippi's oyster resource had approximately 86% mortality in a two month period. Based on these high mortalities it will require a minimum of three years for a full recovery of the oyster resource, given no additional environmental stressors. Figures 28 and 29 depict the poor condition of oyster during the July reef assessment.

With a net loss of 1,678,878 sacks of oysters or 13,431,024 pounds of oyster meat and based on the Mississippi's average annual prices per pound of meat harvested of $2.78 (NOAA 2010). The direct economic impact from the spillway opening on the oyster fishery is estimated at $37,338,246. The economic multiplier was determined using the data for Mississippi in the NOAA publication *Fisheries Economics of the U.S 2009* the most current report. The economic multiplier was calculated using Mississippi's 2009 commercial harvesters sales $60,857,000 divided by the 2009 total landing revenue $37,998,000 the result is an economic multiplier which includes post harvest activities results in an economic multiplier of 1.6. Therefore the one-year economic impact to the oyster industry from the opening of the Bonnet Carré Spillway and other environmental factors is estimated at $59,411,194, a more detailed economic impact report will be put together in the near future.

FIGURES AND TABLES

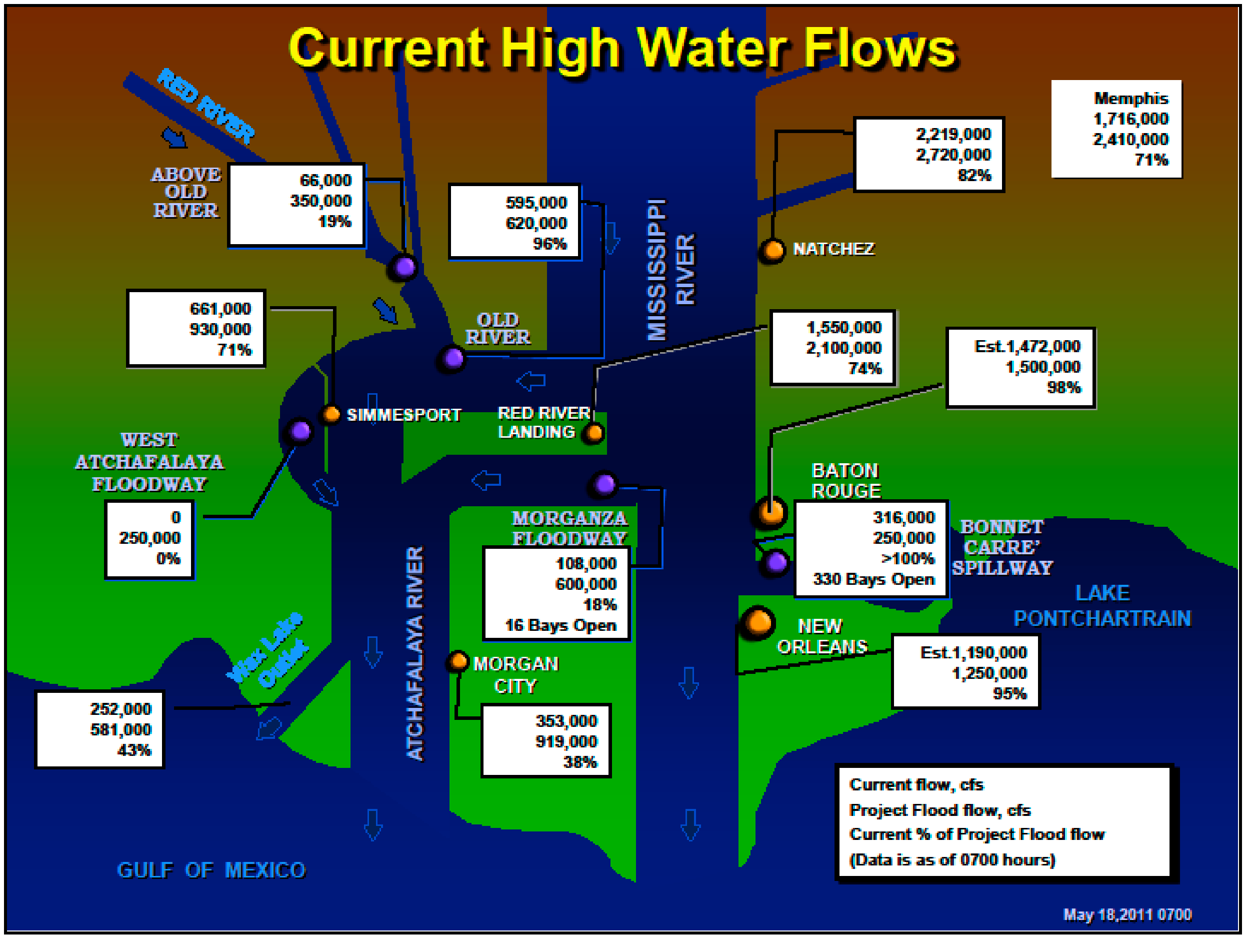


Figure 1. Map of Spillway Locations and Functions

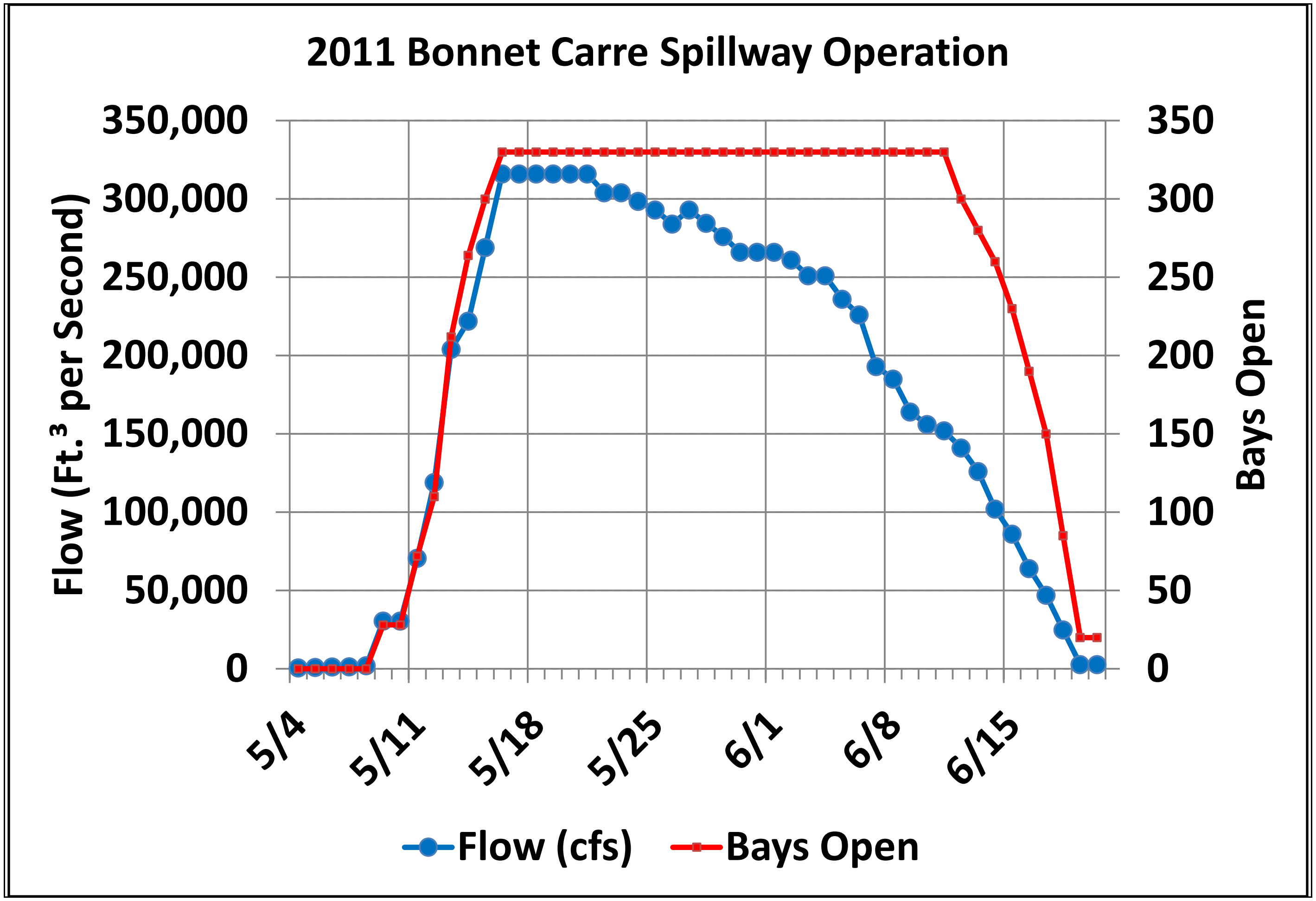


Figure 2. Bonnet Carré' Spillway Operations

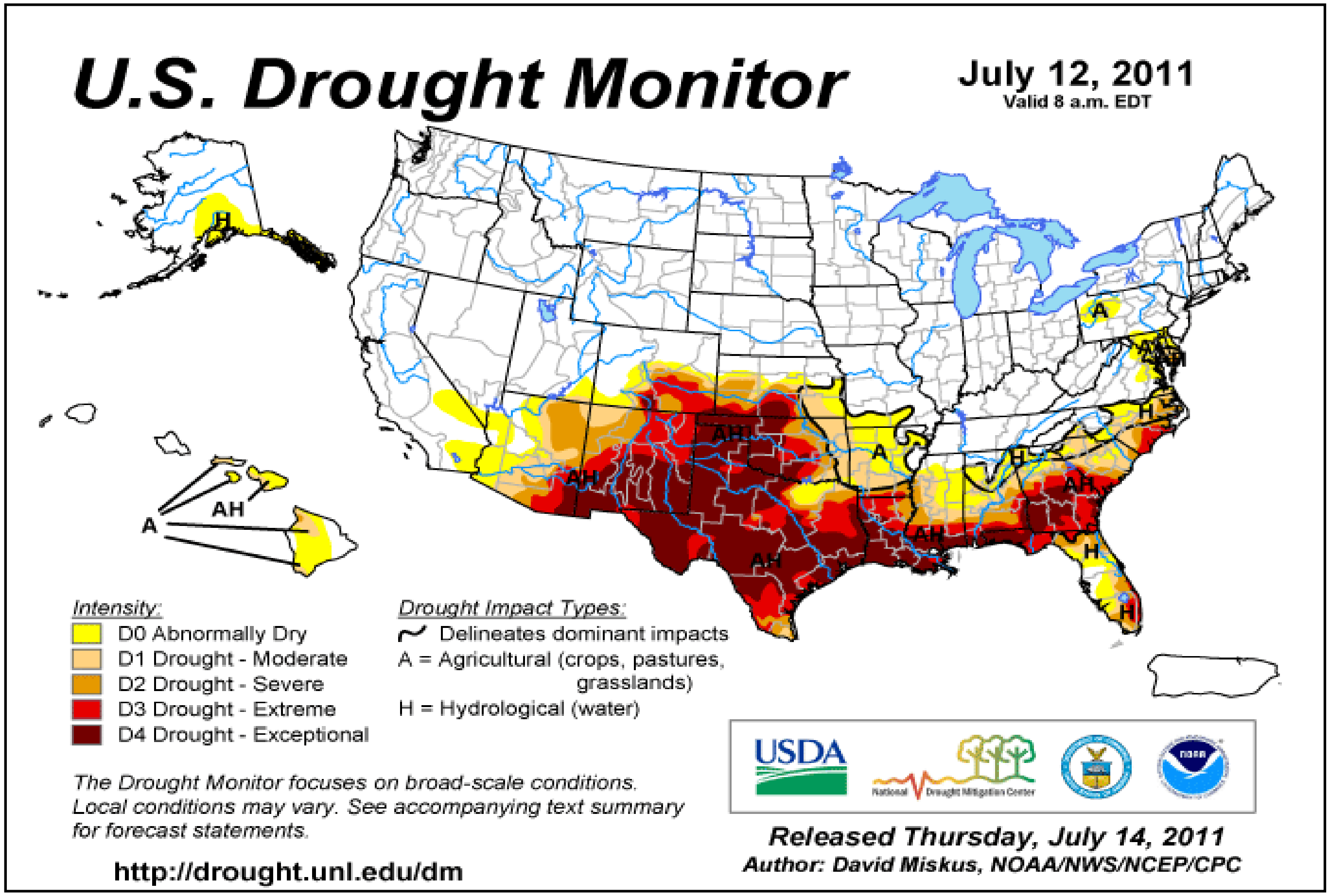
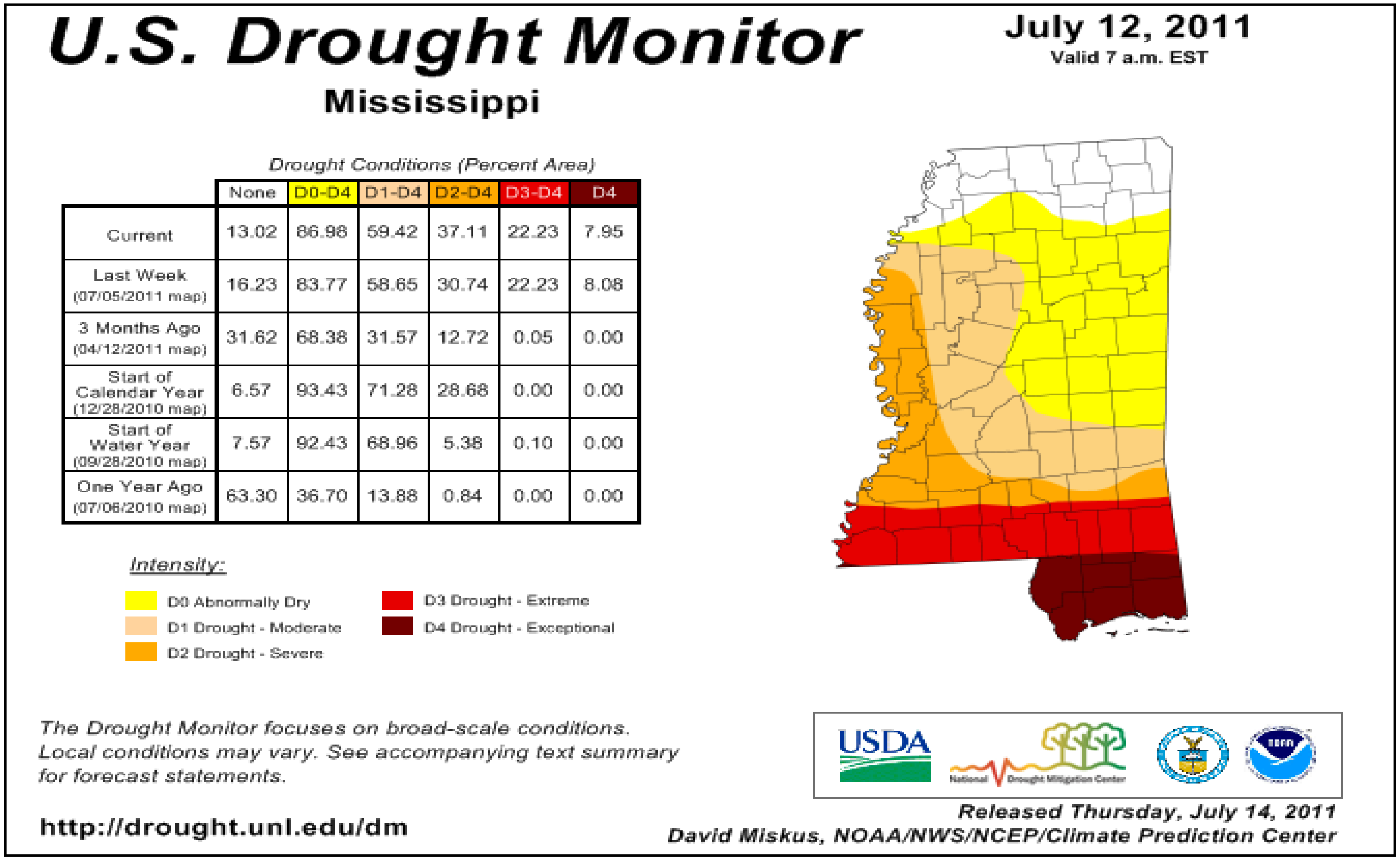


Figure 3. 2011 U.S. Drought Map



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	13.02	86.98	59.42	37.11	22.23	7.95
Last Week (07/05/2011 map)	16.23	83.77	58.65	30.74	22.23	8.08
3 Months Ago (04/12/2011 map)	31.62	68.38	31.57	12.72	0.05	0.00
Start of Calendar Year (12/28/2010 map)	6.57	93.43	71.28	28.68	0.00	0.00
Start of Water Year (09/28/2010 map)	7.57	92.43	68.96	5.38	0.10	0.00
One Year Ago (07/06/2010 map)	63.30	36.70	13.88	0.84	0.00	0.00

Figure 4. 2011 U.S. Drought

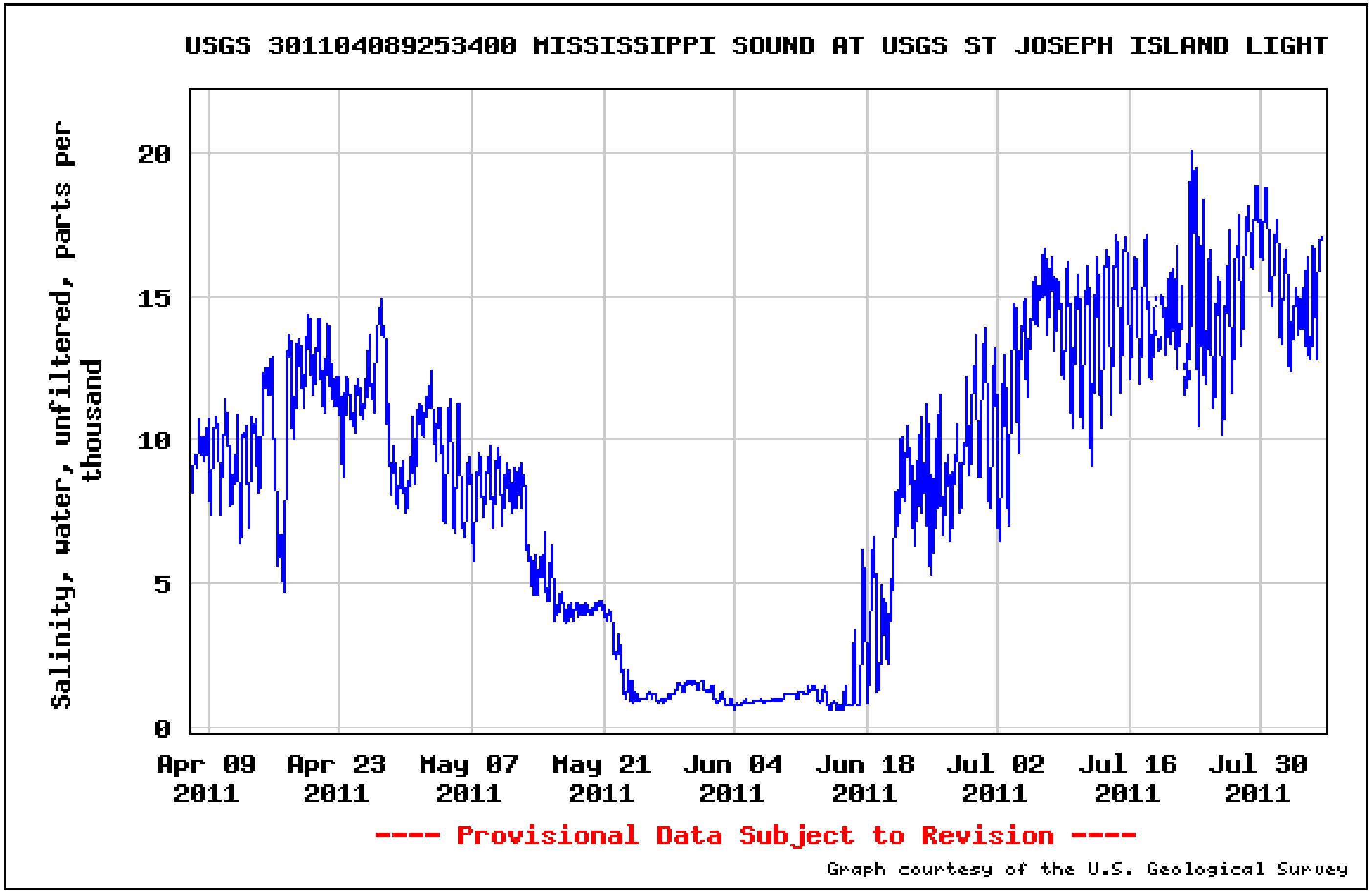


Figure 5. St. Joseph Reef Salinities

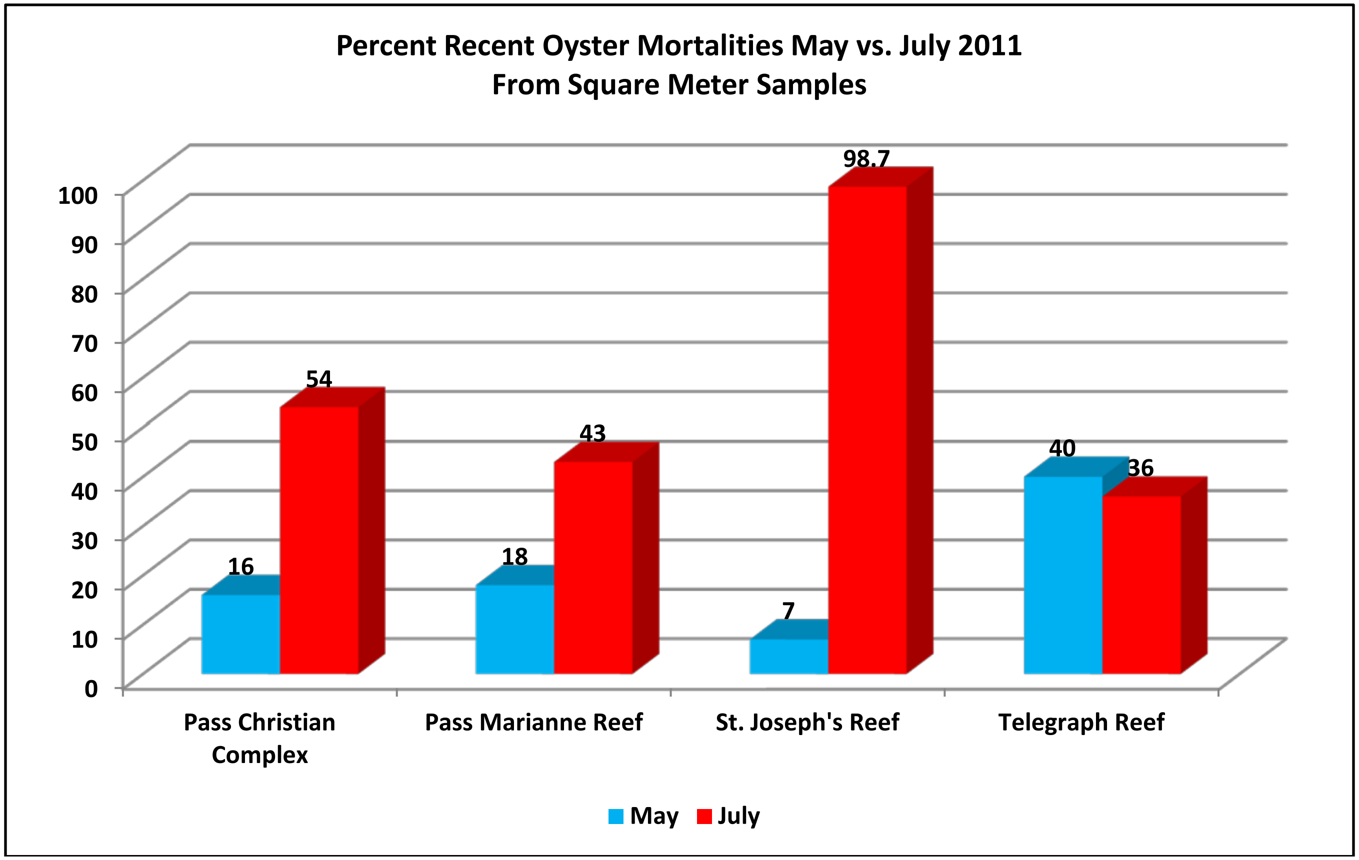


Figure 6. Percent Recent Oyster Mortality

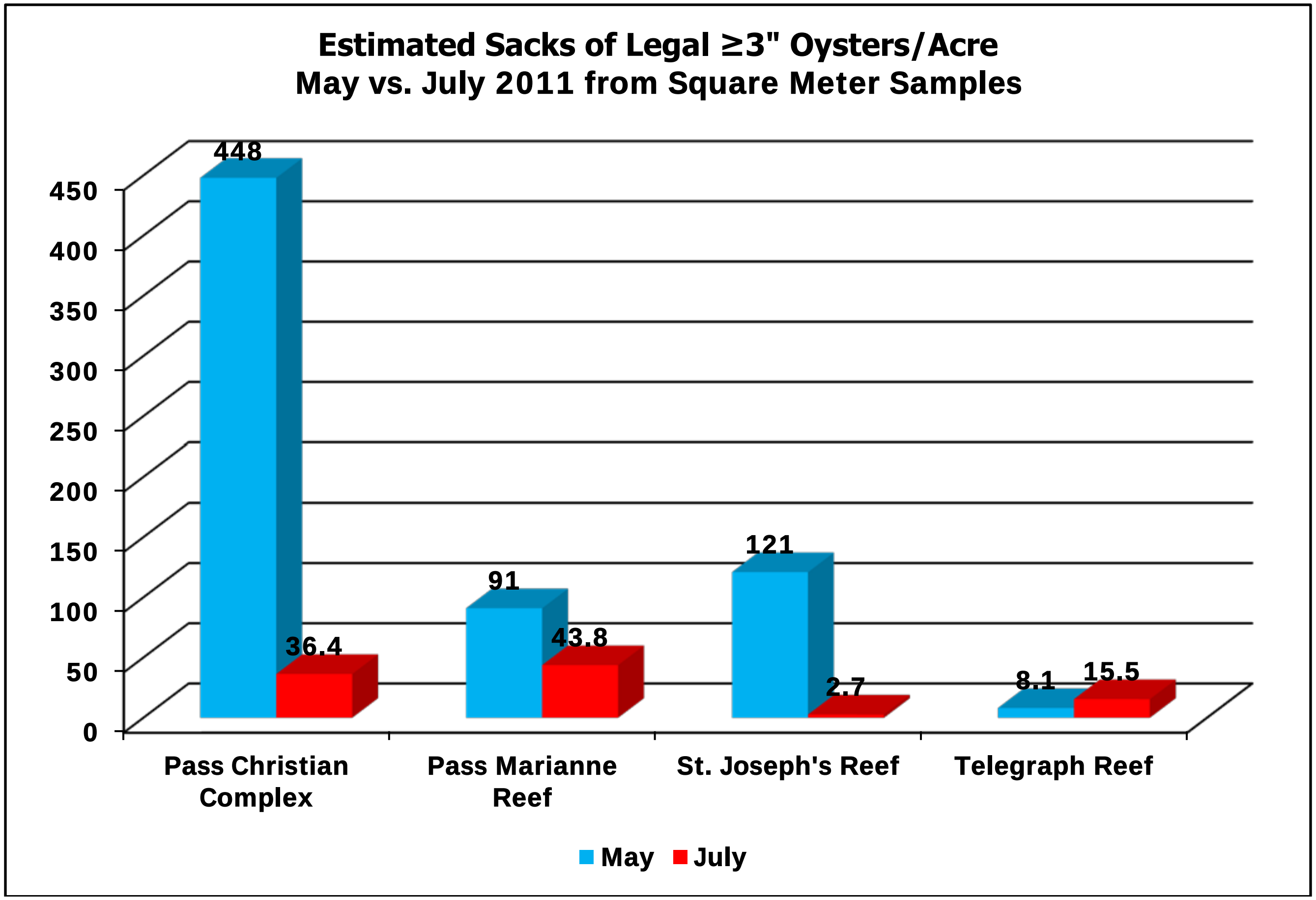


Figure 7. Estimated Sacks of Oysters Per Acre

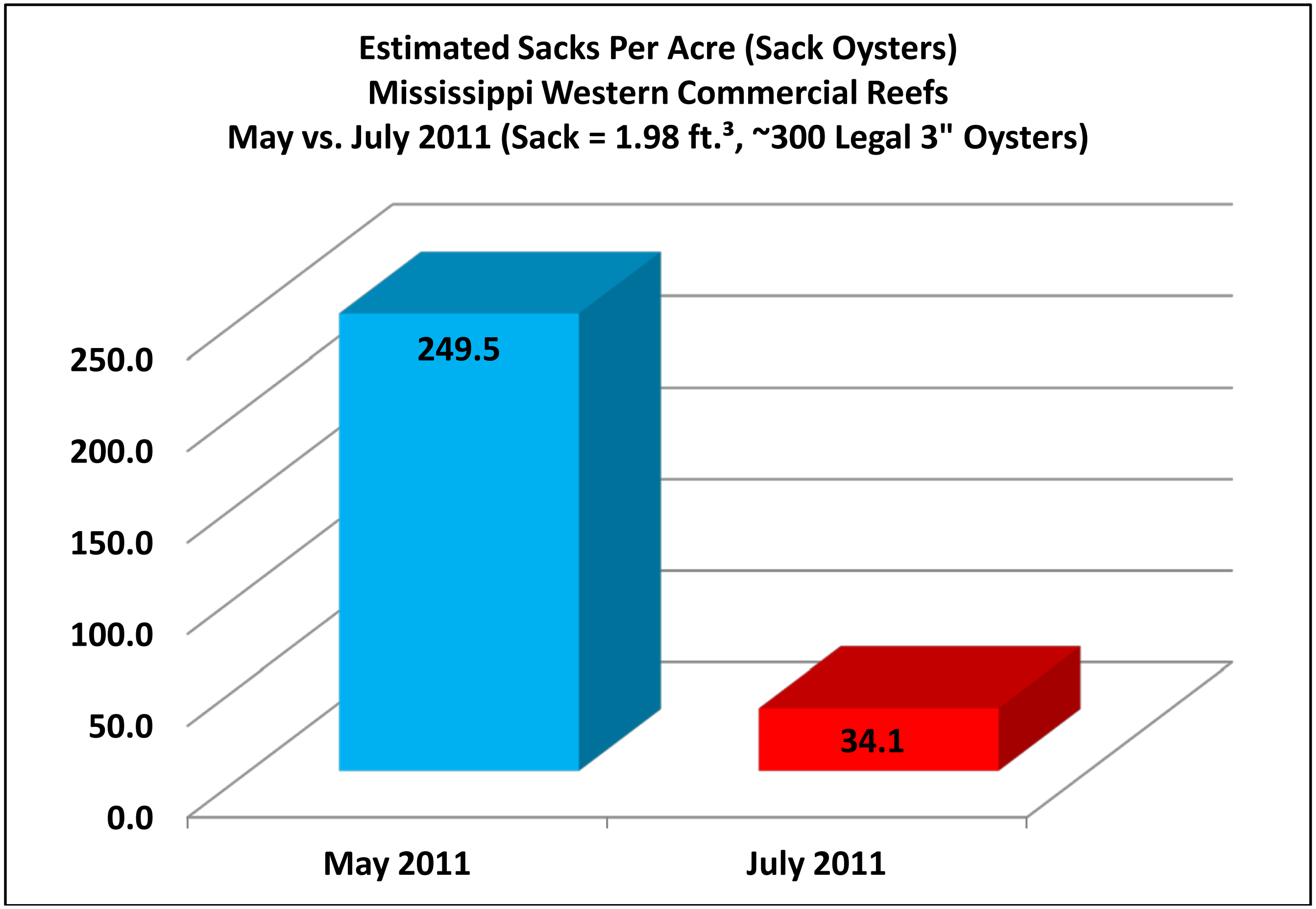


Figure 8. Estimated Sacks Per Acre (Legal Oysters)

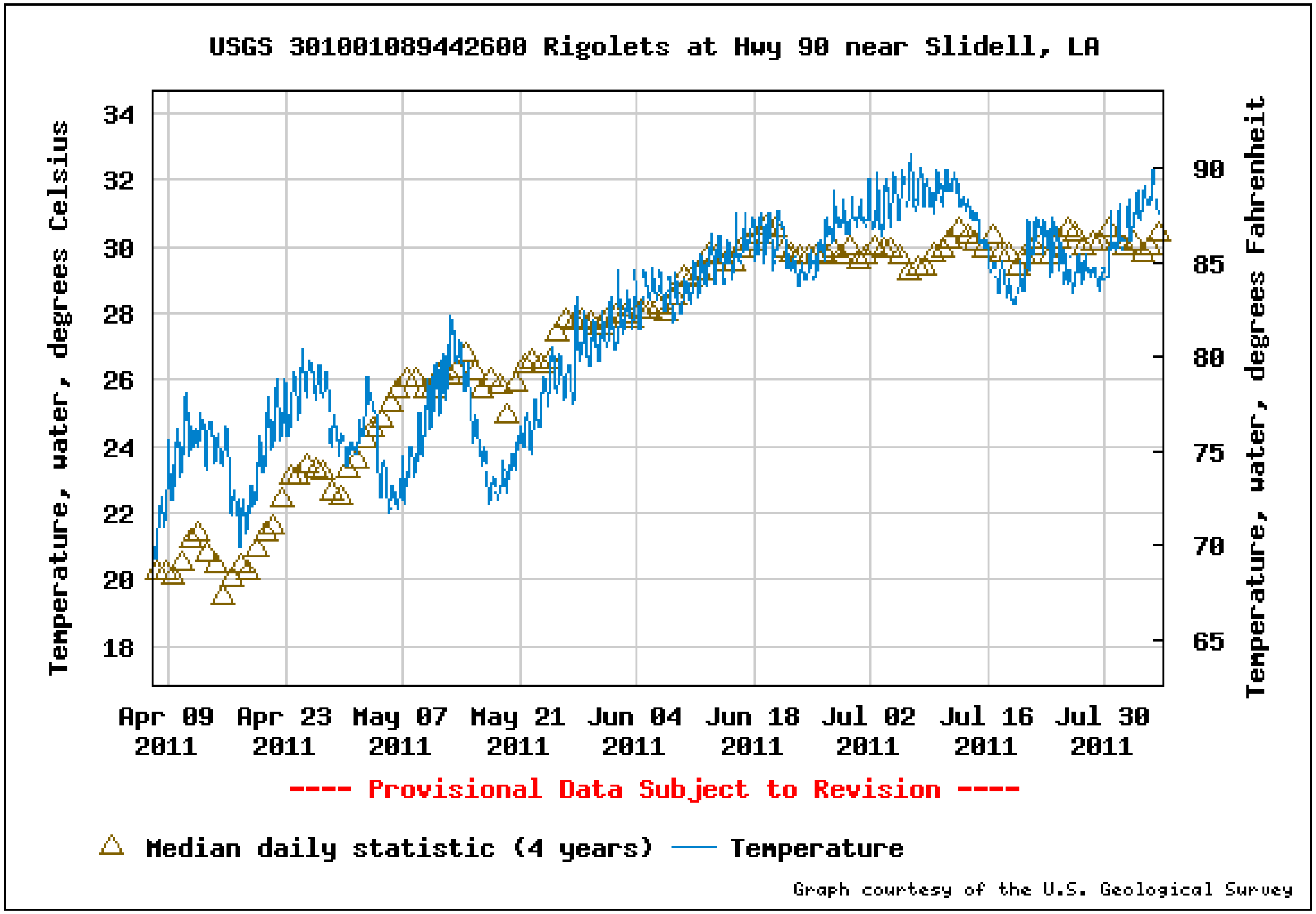


Figure 9. USGS

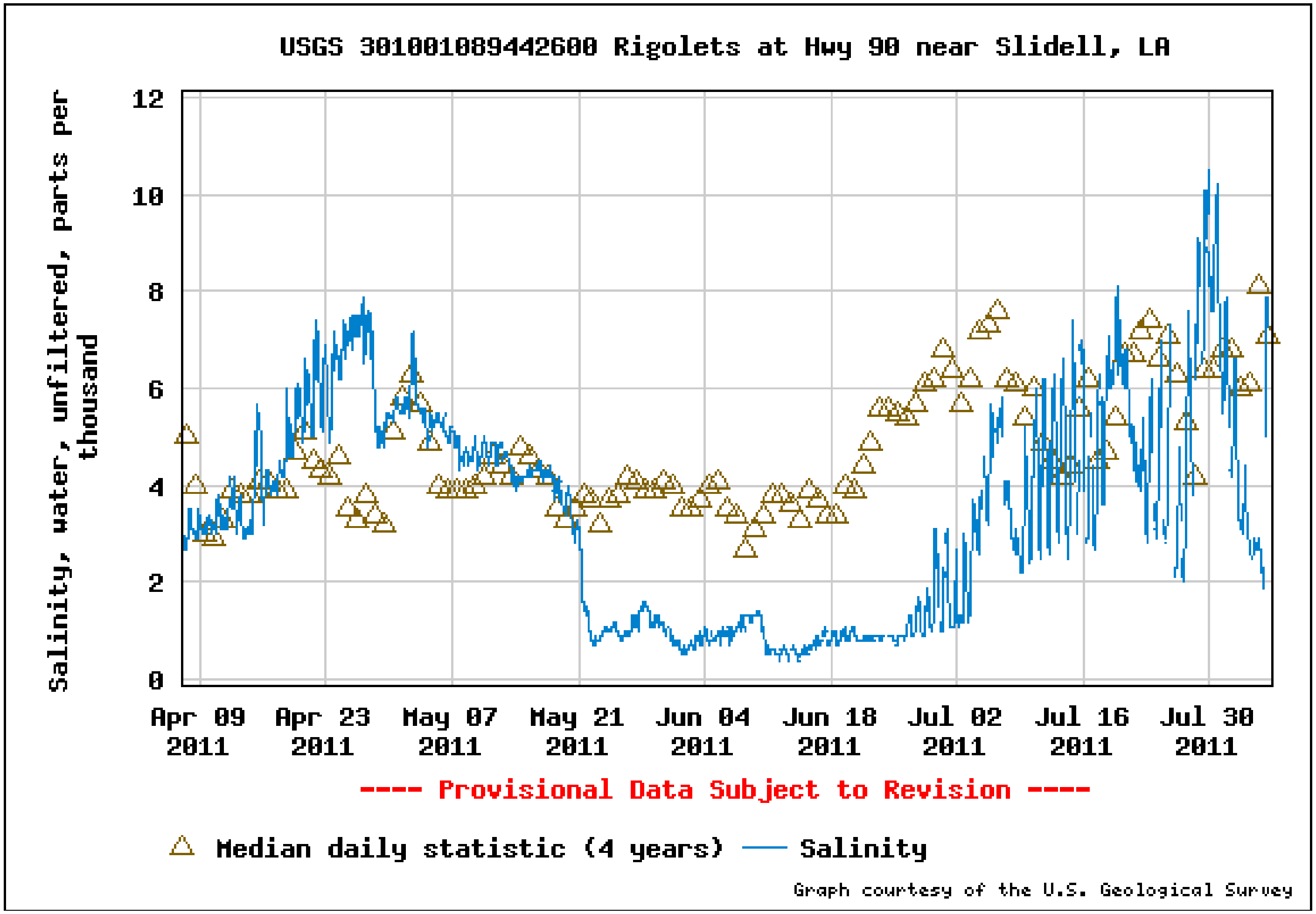


Figure 10. USGS

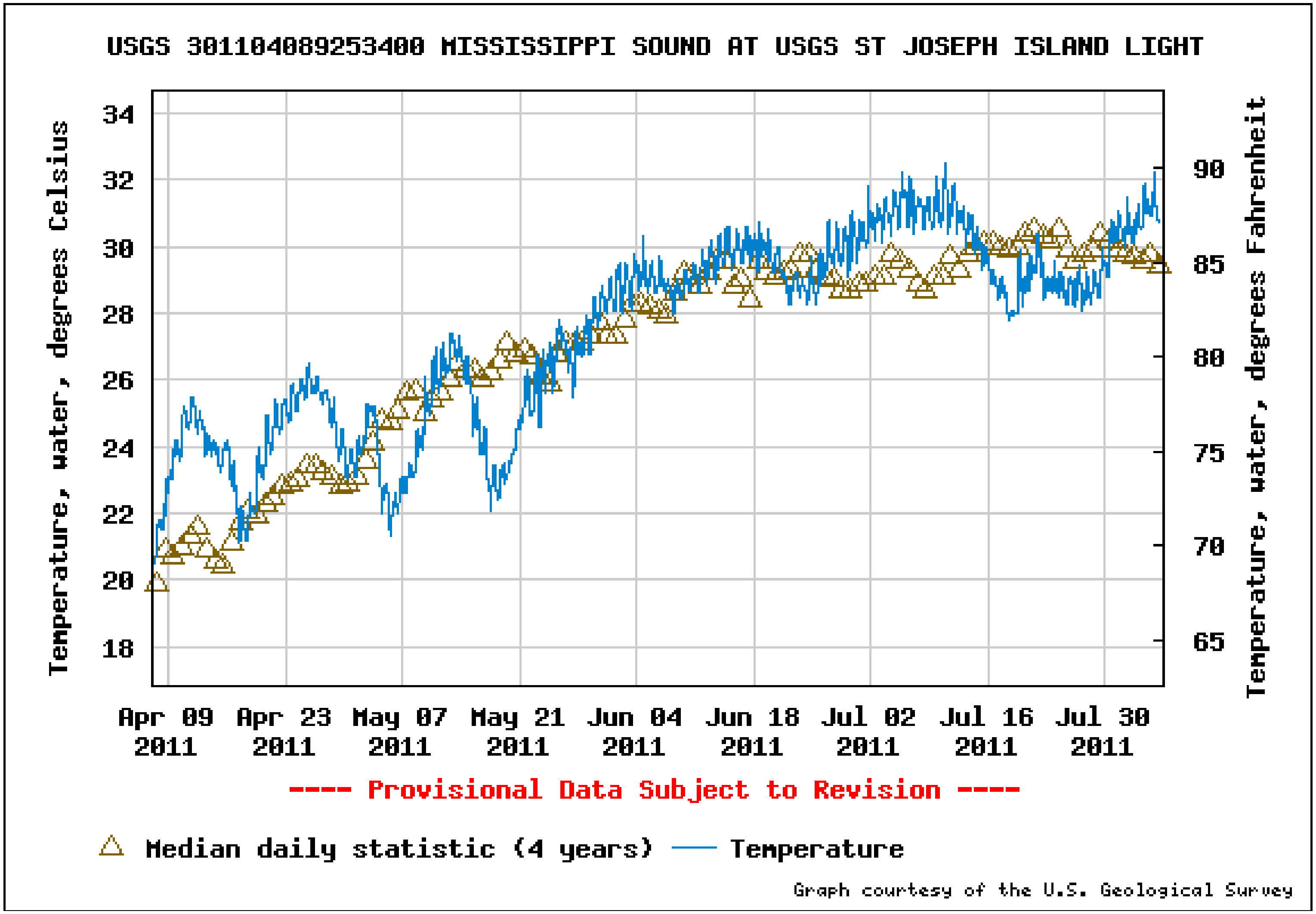


Figure 11. USGS

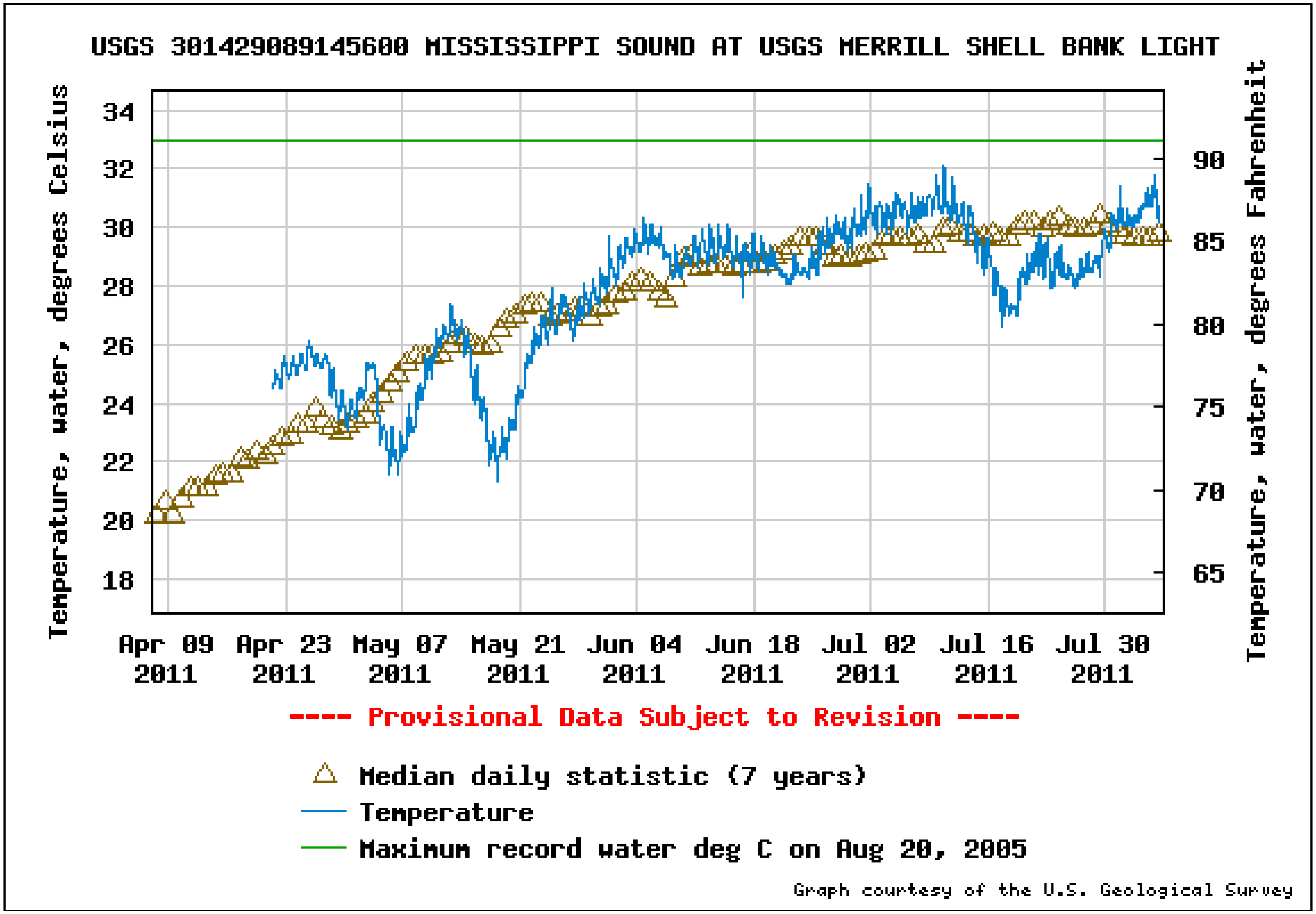


Figure 12. USGS

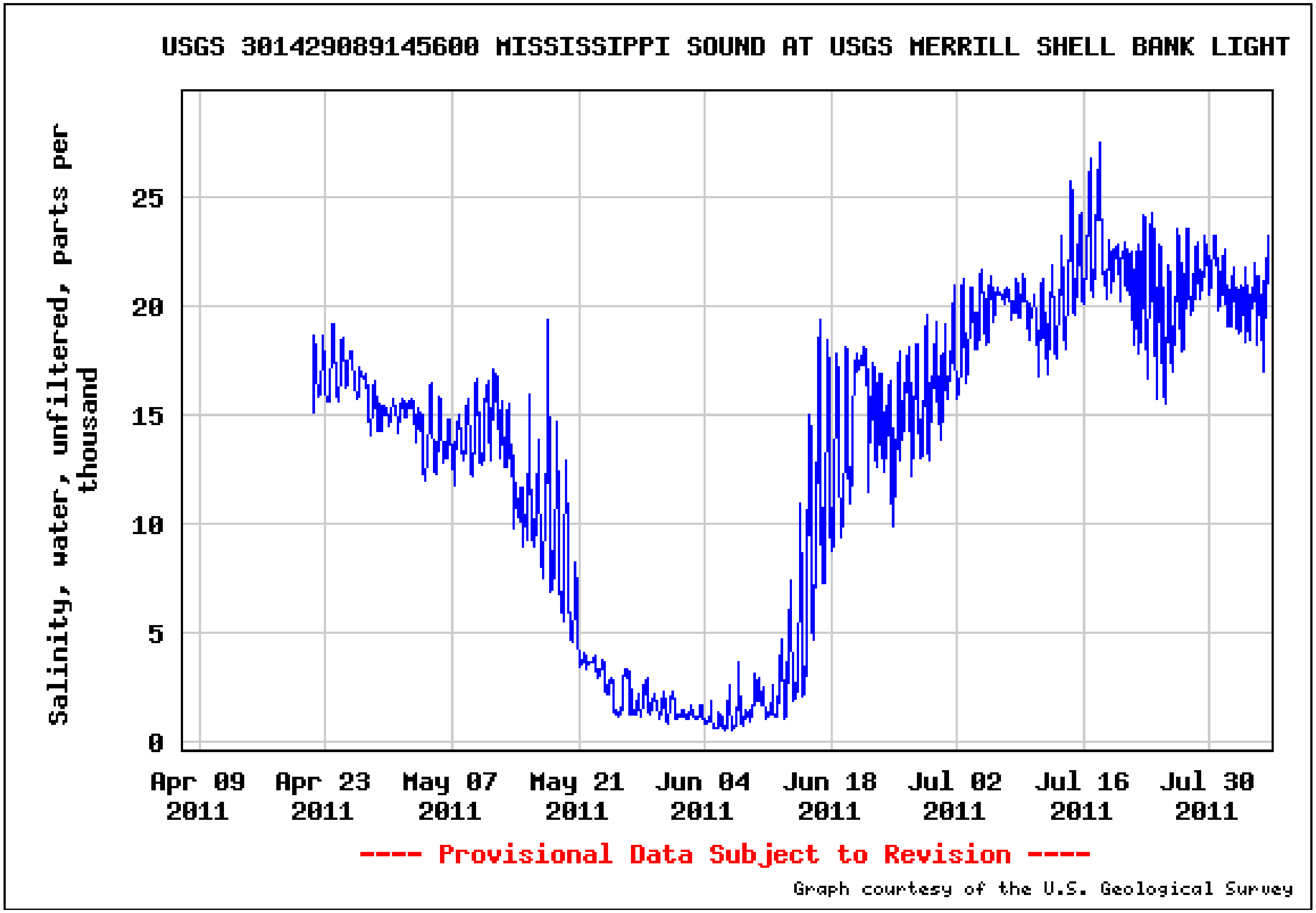


Figure 13. USGS

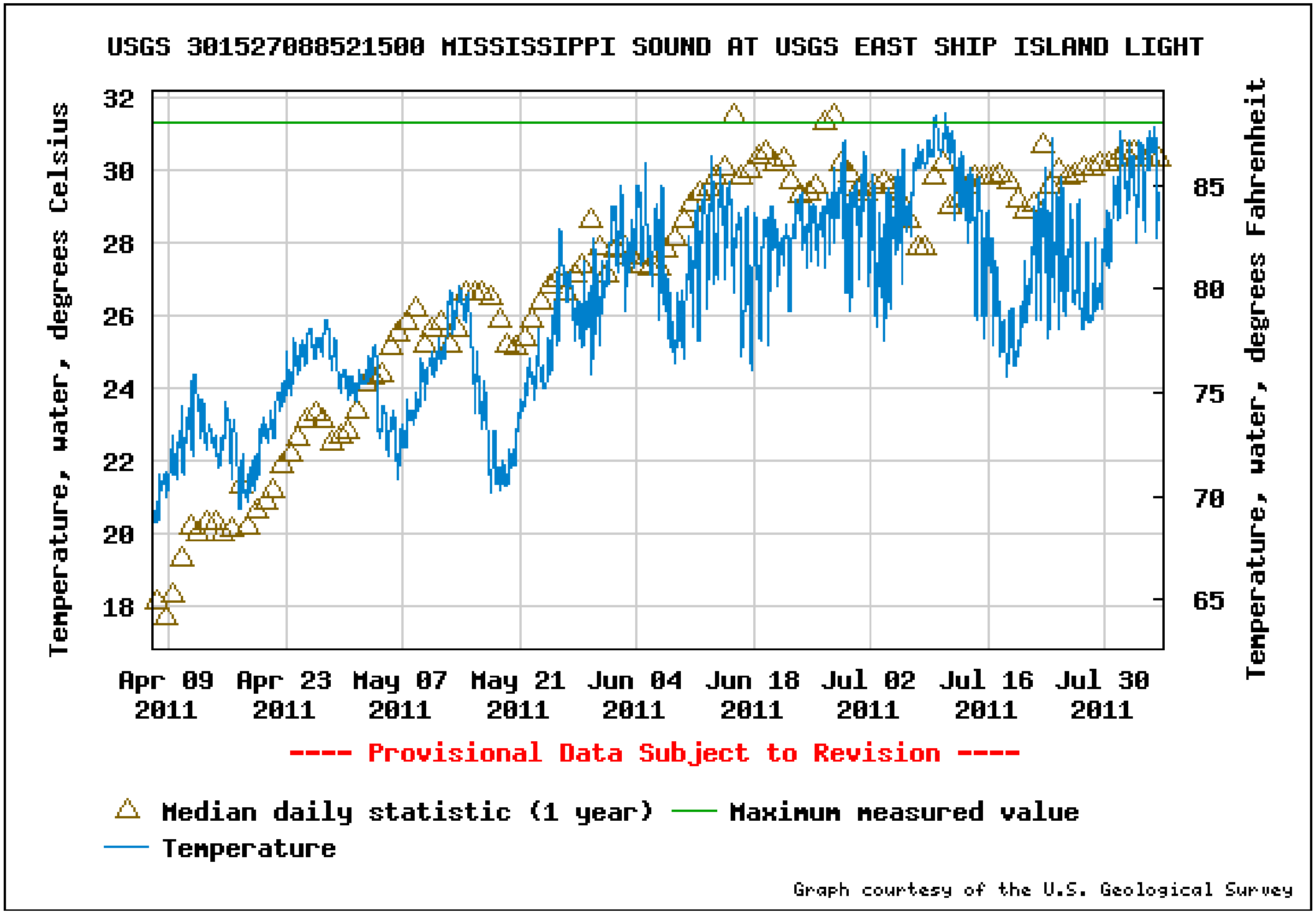


Figure 14. USGS

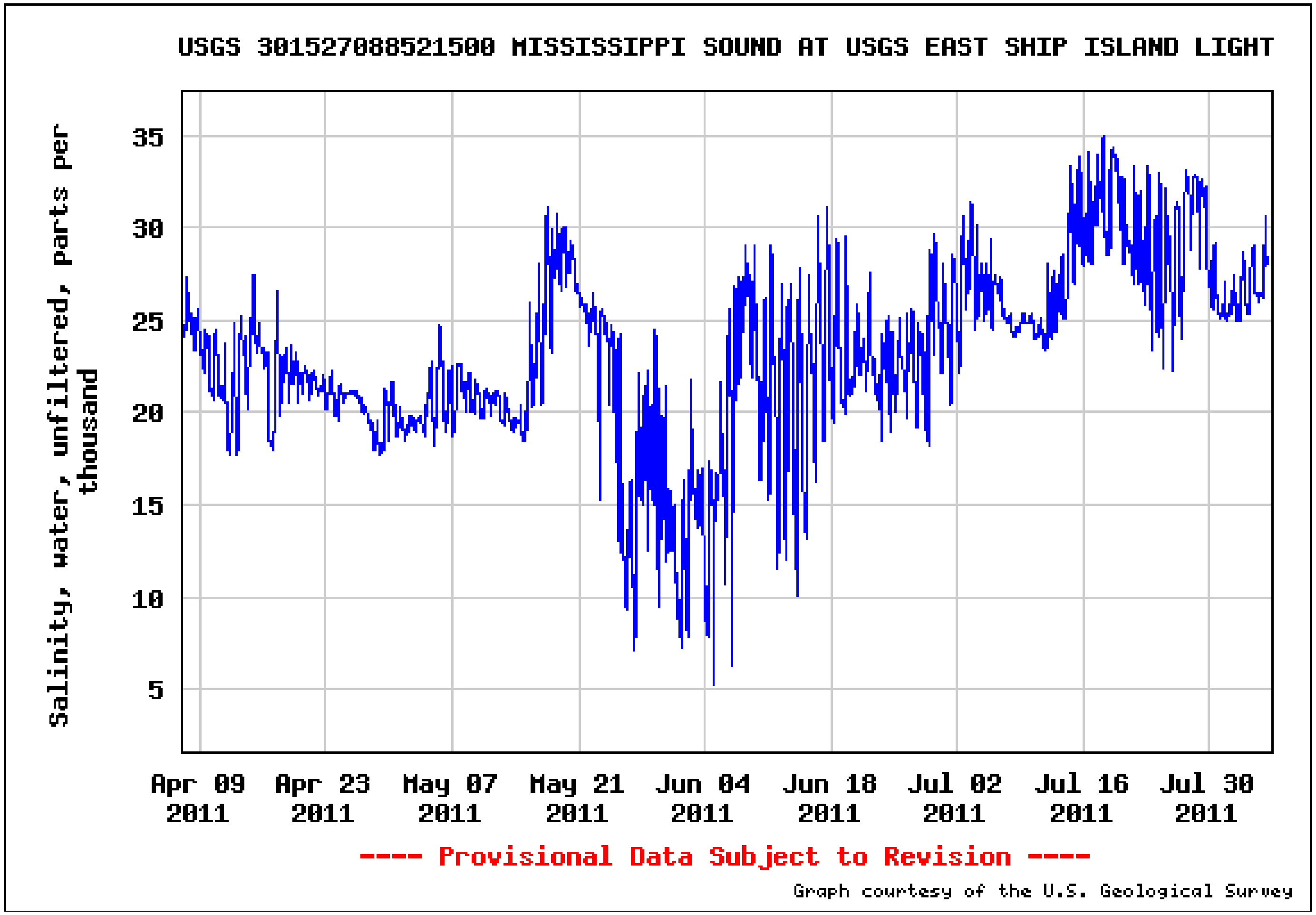


Figure 15. USGS

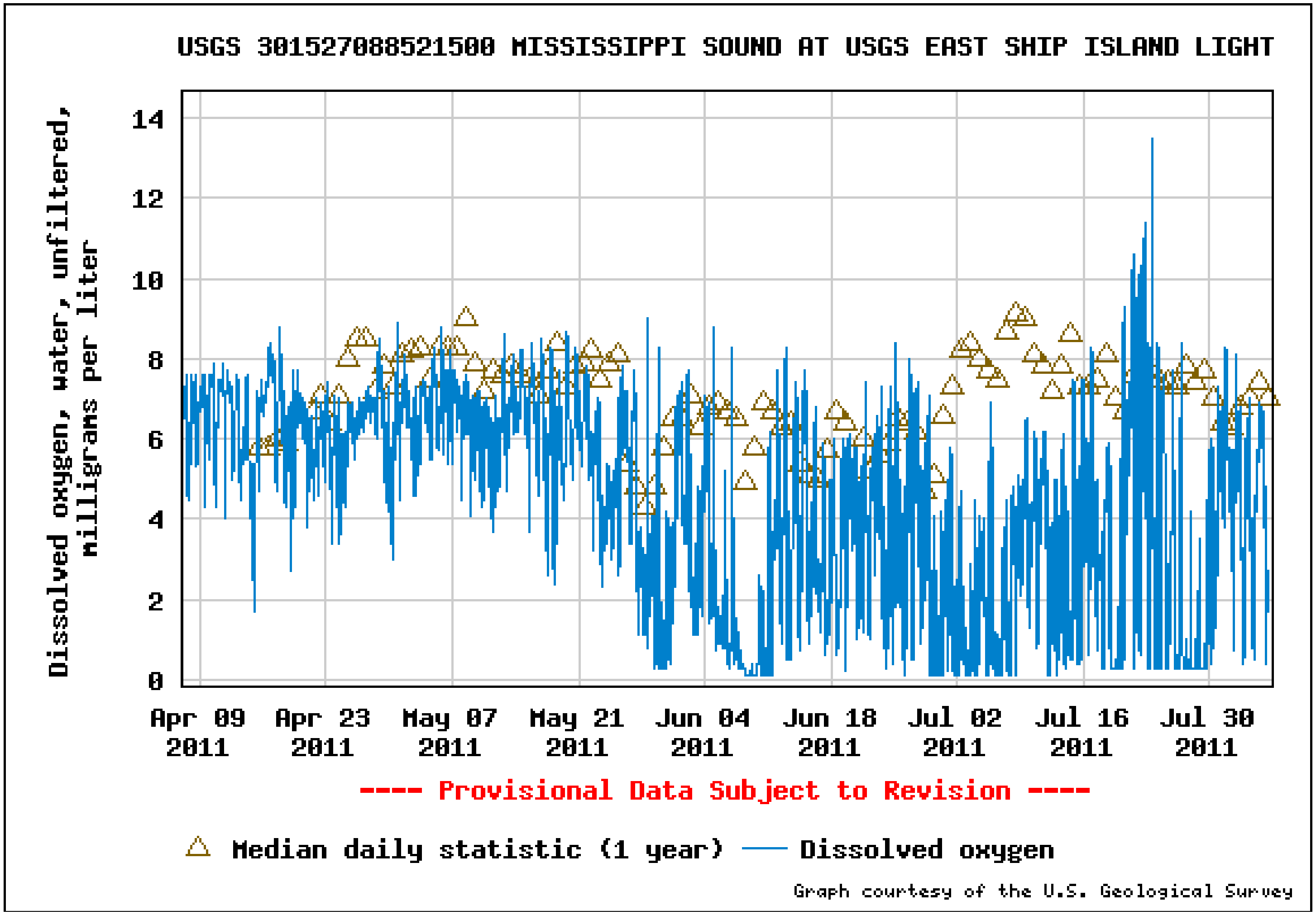


Figure 16. USGS

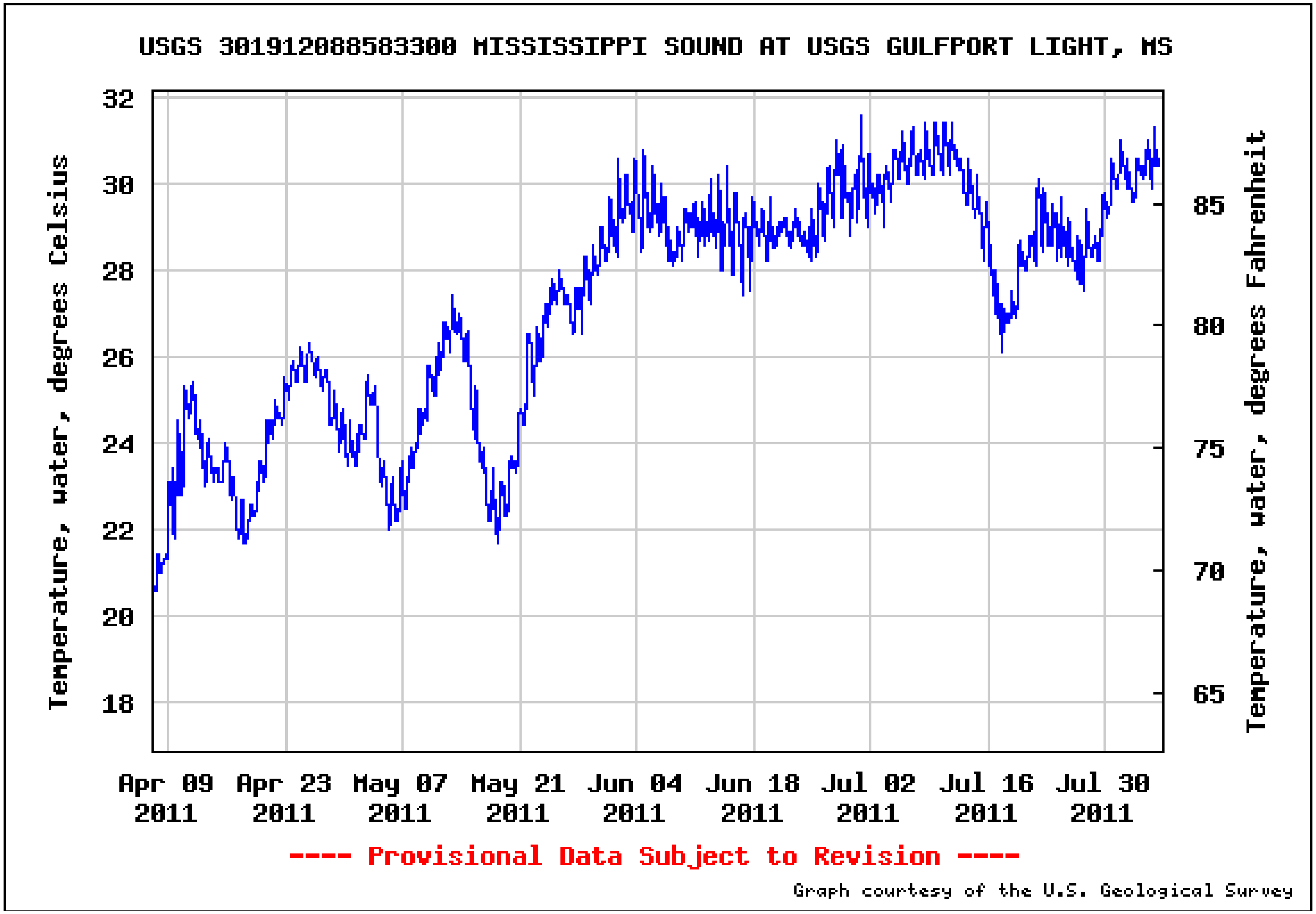


Figure 17. USGS

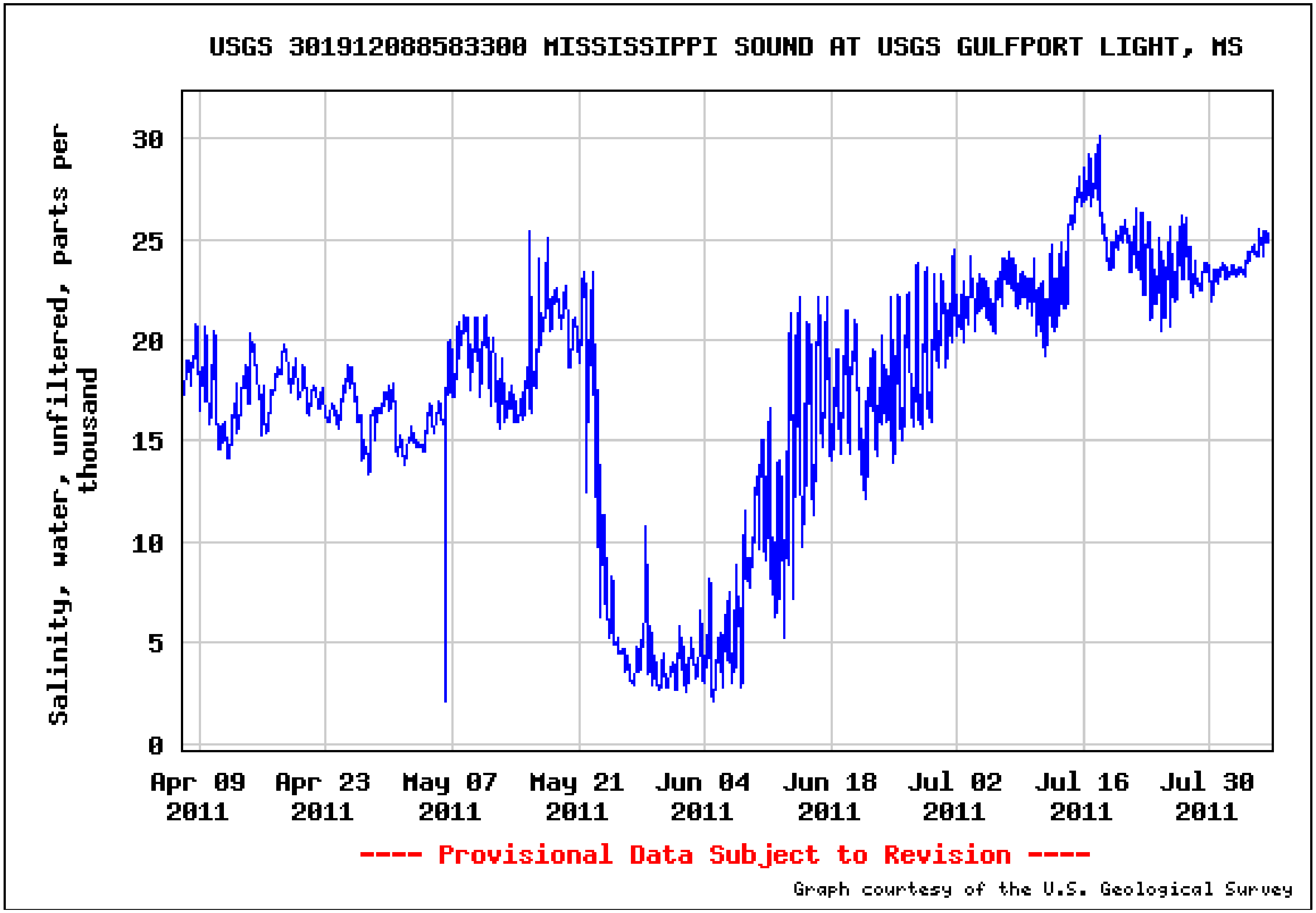


Figure 18. USGS

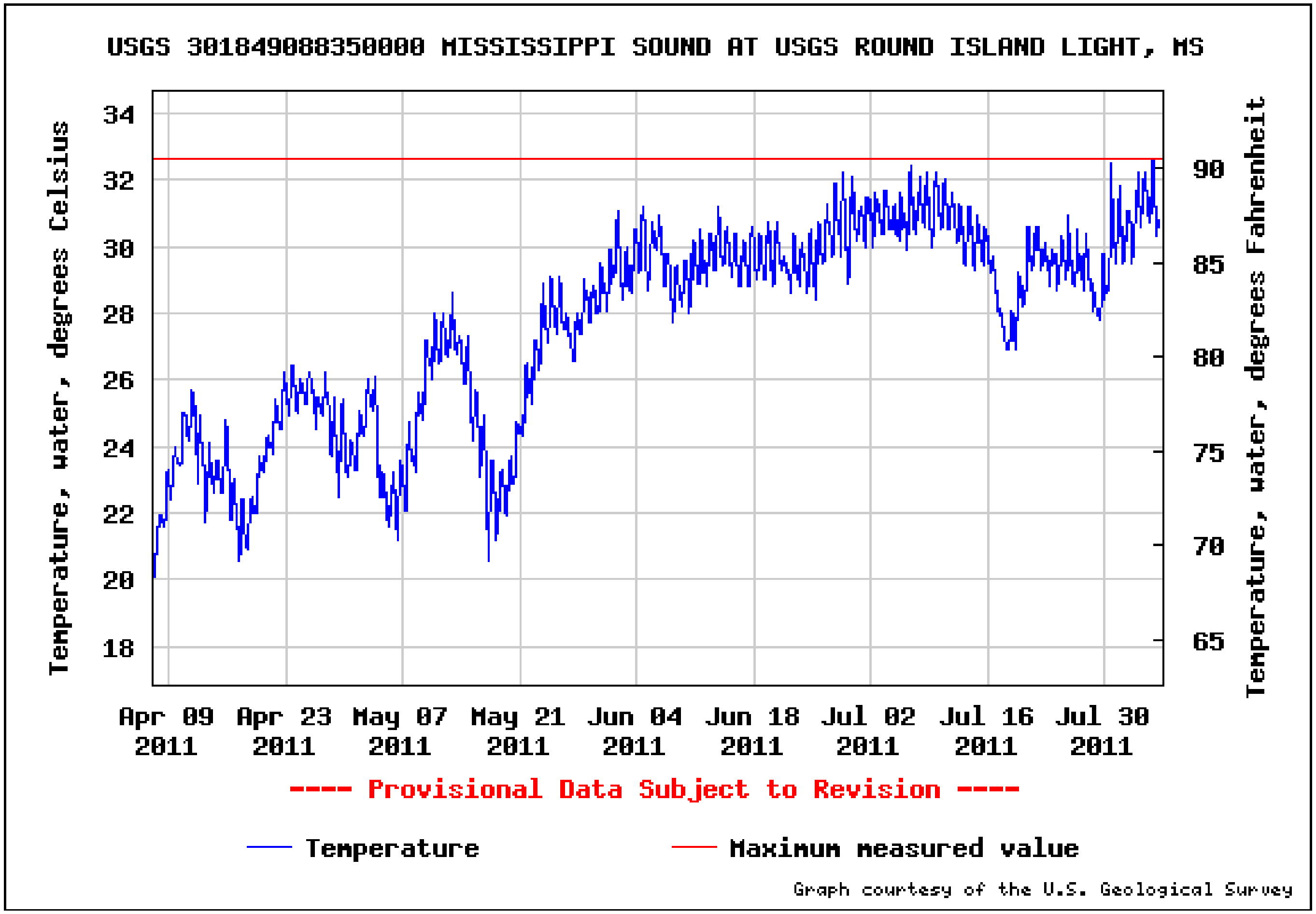


Figure 19. USGS

Figure 20. USGS

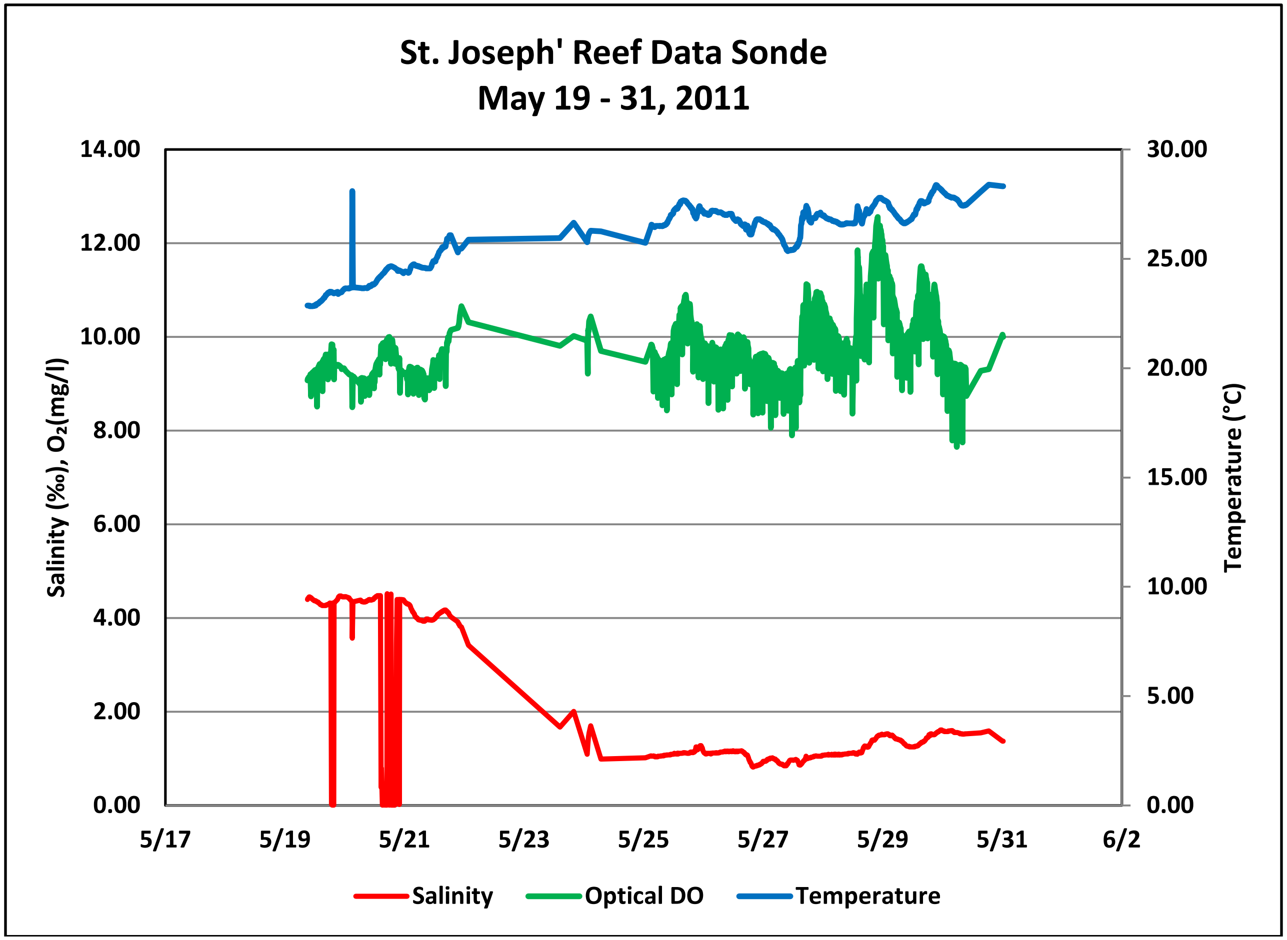


Figure 21. St. Joseph's Reef Hydrology

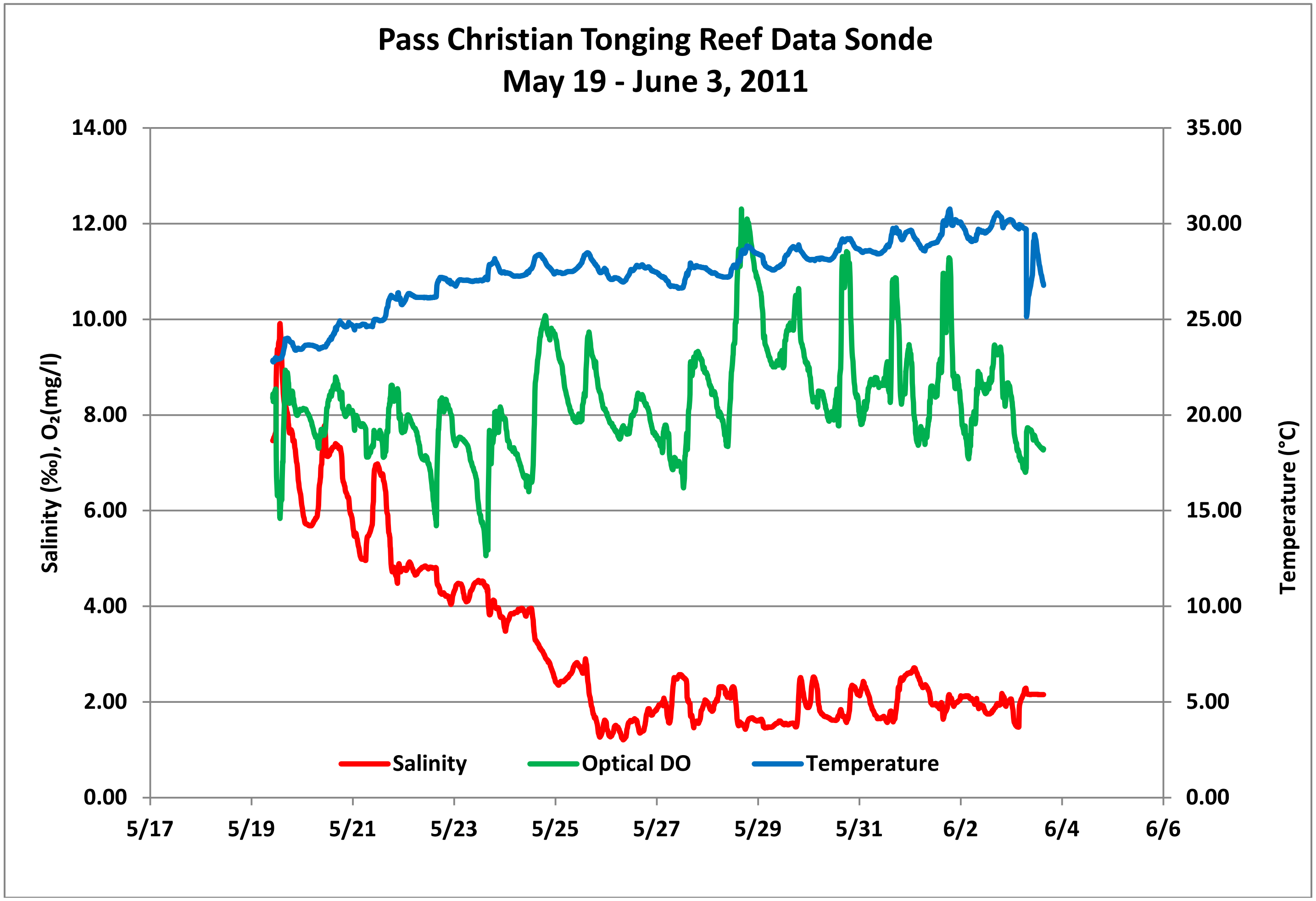


Figure 22. Pass Christian Tonging Reef Hydrology

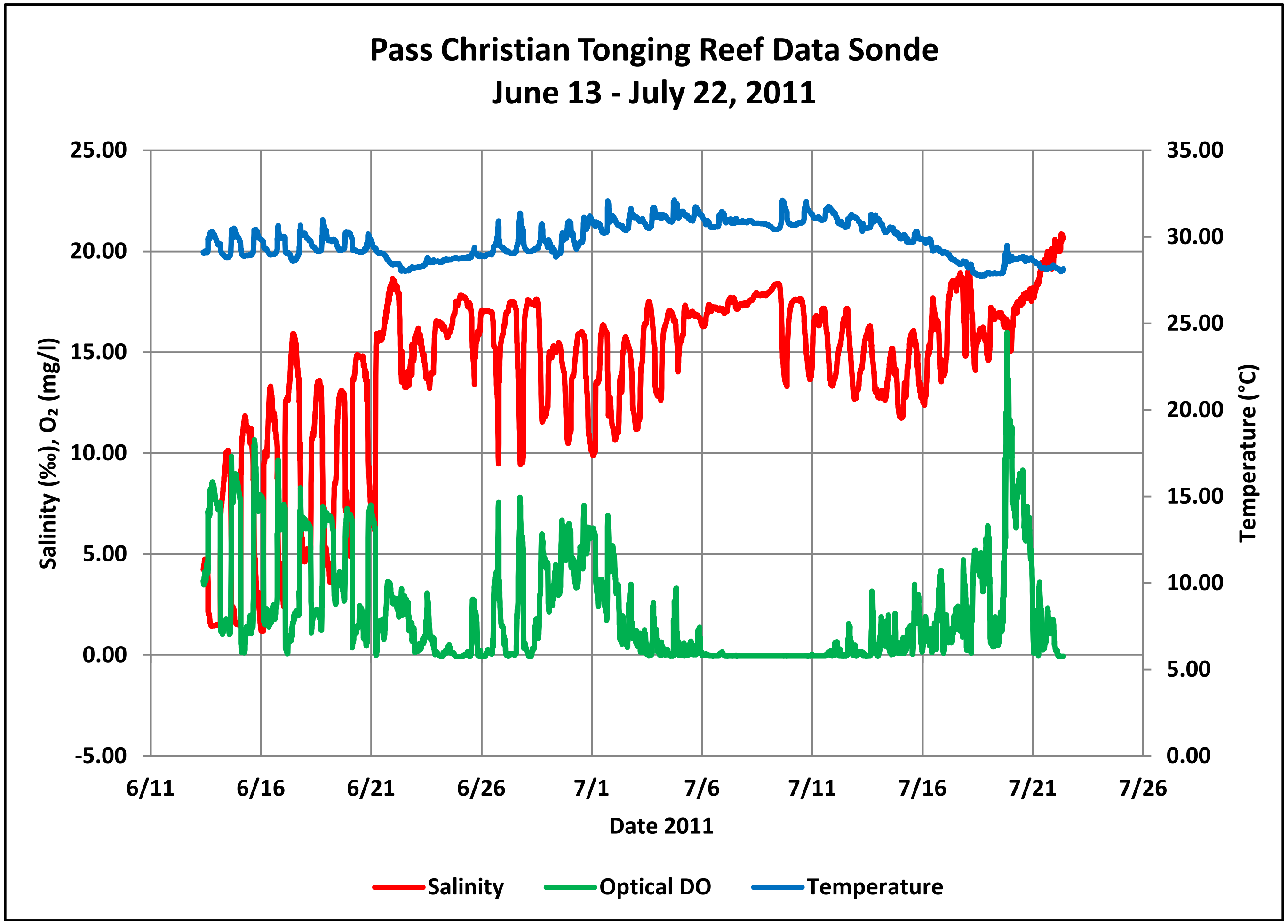


Figure 23. Pass Christian Tonging Reef Hydrology

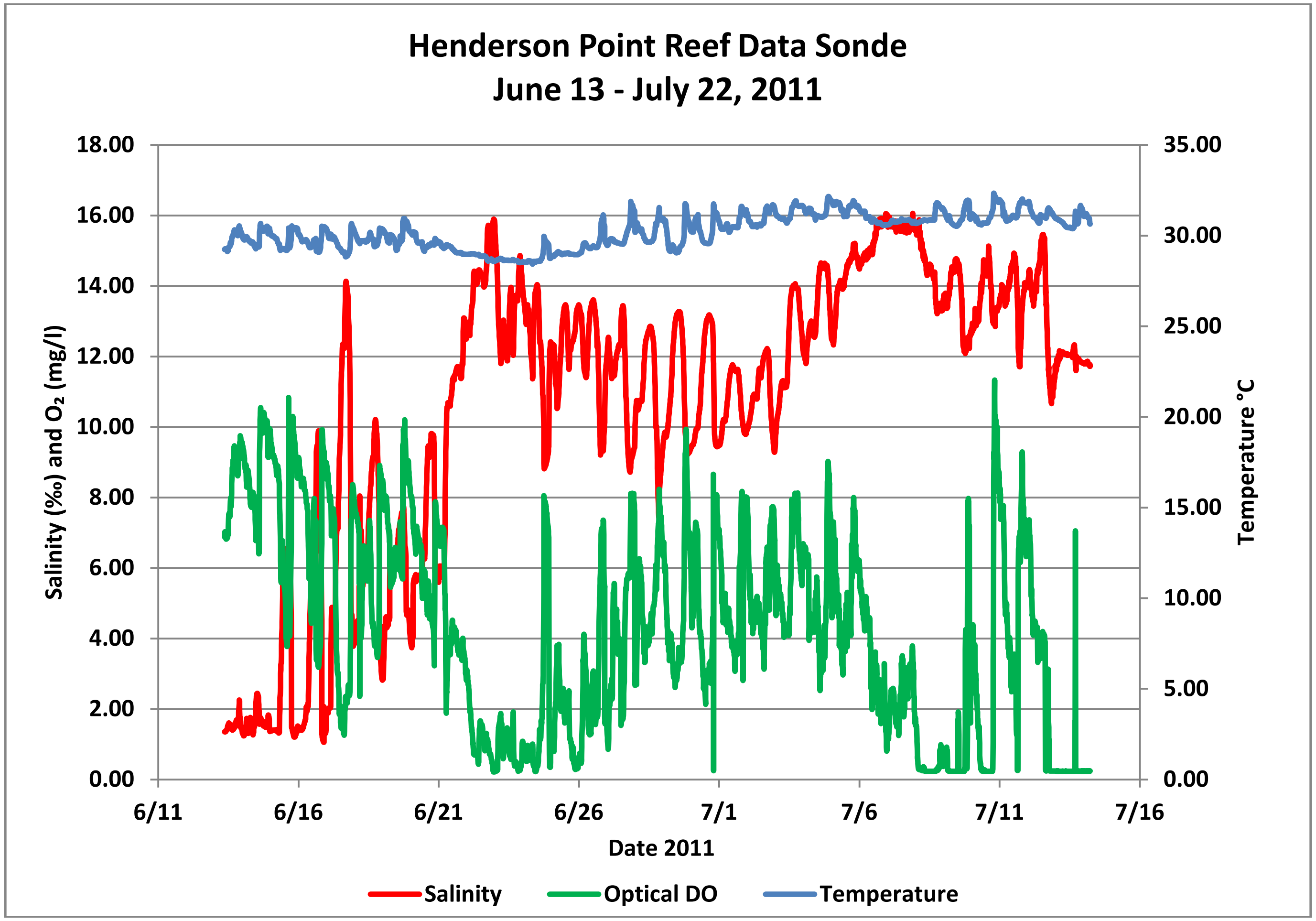


Figure 24. Henderson Point Reef Hydrology

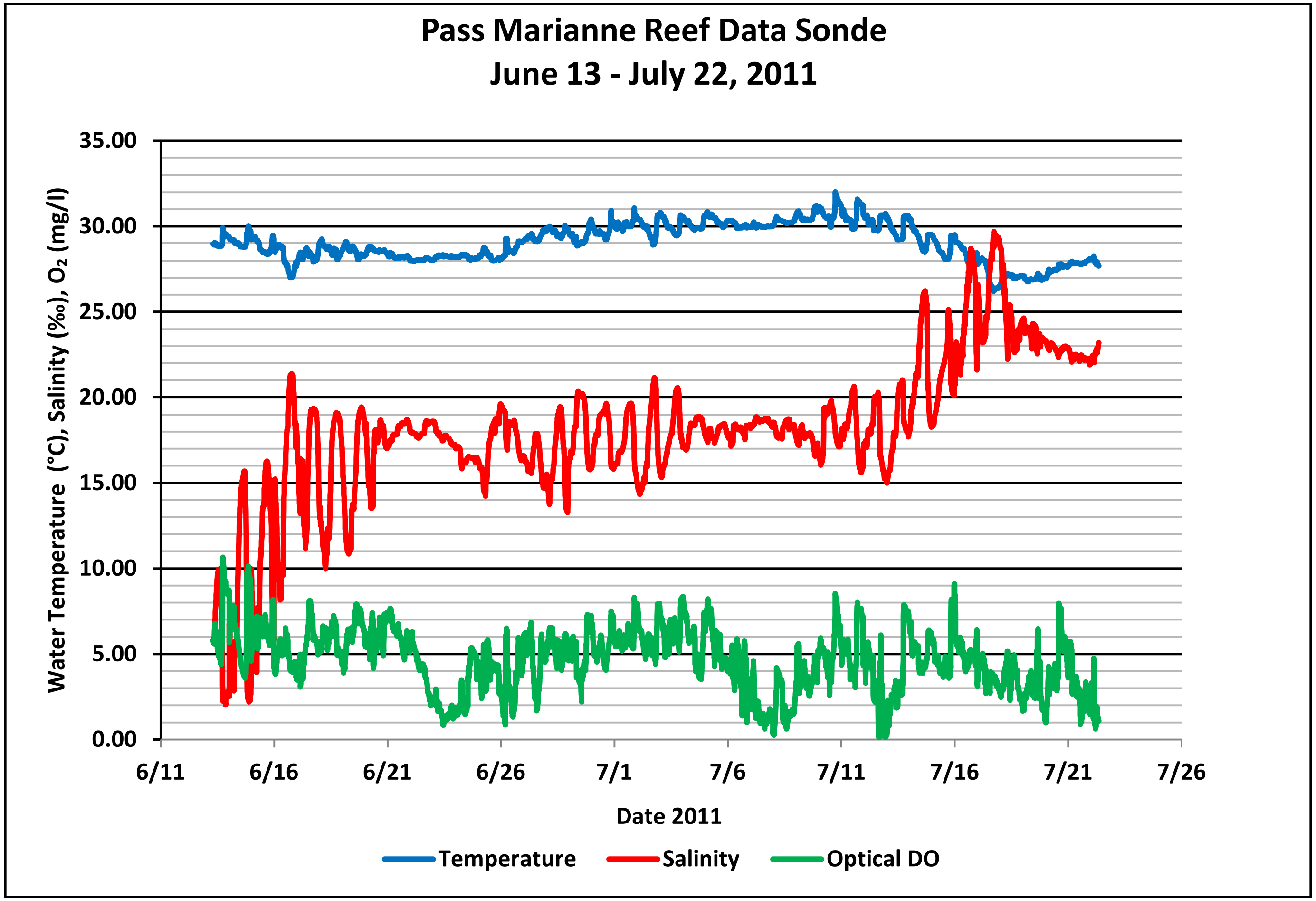


Figure 25. Pass Marianne Reef Hydrology

Figure 26. June 27, 2011 Aerial Photo of Algae Bloom and MDMR Boat Collecting Phytoplankton Sample

Figure 27. Photograph of Turbid Water Around the Western Tip of Deer Island in Biloxi, MS June 22, 2011

Table 1. Mississippi Blue Crab Dockside Landings, Value and Number of Participants

Year	Annual Landings (lbs)	Value ($)	Resident Commercial Crab Trap Licenses	Resident Commercial Crab Trawl Licenses
2001	433,656	390,941	208	No such license yet
2002	716,127	568,419	217	No such license yet
2003	876,521	680,032	253	No such license yet
2004	865,106	705,705	262	No such license yet
2005	429,231	436,003	189	56
2006	1,126,818	927,943	122	45
2007	737,442	741,136	110	58
2008	450,037	446,756	138	53
2009	545,328	572,852	155	64
2010	DWH	DWH	138	67
2011	n/a	n/a	291	86

Table 2. Mississippi Oyster Dockside Landings, Value and Number of Participants

Year	Annual Landings (lbs meat)	Value ($)	Resident Commercial Dredge Licenses	Resident Commercial Tong Licenses	Non-Resident Commercial Dredge Licenses	Non-Resident Commercial Tong Licenses
2001	2,653,270	4,195,464	165	67	33	68
2002	2,737,839	4,455,647	172	51	44	49
2003	4,042,136	7,227,588	207	59	48	71
2004	3,029,391	6,073,242	180	60	32	56
2005	610,384	1,447,132	28	3	0	5
2006	0	0	16	17	0	1
2007	299,088	818,544	139	56	23	33
2008	2,610,349	6,869,160	97	13	19	13
2009	2,191,724	6,100,264	274	66	118	82
2010	DWH	DWH	273	99	111	104
2011	n/a	n/a	278	87	122	98

Figure 28. Stressed and Dead Oyster in the Shell

Figure 29. Gaping "Dead" Oyster