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COMMON BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN LAKE PONTCHARTRAIN, LOUISIANA: 2007 TO MID-2014

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
3209 Frederic Street
Pascagoula, MS 39567 USA

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KEITH D. MULLIN[1], KEVIN BARRY[1], CARRIE SINCLAIR[1], JENNY LITZ[1], KATHERINE MAZE-FOLEY[1], ERIN FOUGERES[2], BLAIR MASE-GUTHRIE[1], RUTH EWING[1], ANTOINETTE GORGONE[1], JEFF ADAMS[3] AND MANDY TUMLIN[4]

[1] Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA

[2] Southeast Regional Office, National Marine Fisheries Service, NOAA

[3] Office of Protected Resources, National Marine Fisheries Service, NOAA

[4] Louisiana Department of Wildlife and Fisheries

U.S. DEPARTMENT OF COMMERCE
Penny Pritzker, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Kathryn Sullivan, Under Secretary for Oceans and Atmosphere

NATIONAL MARINE FISHERIES SERVICE
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Copies may be obtained by writing:

Keith D. Mullin
National Marine Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratory
3209 Frederic Street
Pascagoula, MS 39567
Keith.D.Mullin@noaa.gov

or

National Technical Information Service
5825 Port Royal Road
Springfield, VA 22161
Voice: (703) 487-4650
Fax: (703) 321-8547

PDF version available at www.sefsc.noaa.gov

Cover photograph: Common bottlenose dolphin in Lake Pontchartrain, Louisiana.
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COMMON BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*)
IN LAKE PONTCHARTRAIN, LOUISIANA: 2007 TO MID-2014

Abstract

Lake Pontchartrain (LP) is a brackish lagoon (1,630 km^2) in southeastern Louisiana connected by two passes on the eastern end to open estuarine waters. Salinity in LP varies seasonally and is generally lowest in late spring and highest in summer and fall (*range* ≈ 0–15 ppt). Common bottlenose dolphins (*Tursiops truncatus*; dolphins) are distributed throughout estuarine waters in the northern Gulf of Mexico but records of dolphins in LP were historically rare. In 2007, 30–40 dolphins were reported in eastern LP just to the west of the Norfolk Southern railroad and U.S. Route 11 bridges ("target area") and reports suggested that dolphins had been there since Hurricane Katrina in August 2005. An initial survey in May 2007 confirmed the location and number of dolphins and revealed that most of them had minor to severe skin lesions that were thought to result from exposure to low salinity water. Periodic photo-identification surveys (*n* = 35) were conducted from spring 2007 through spring 2010 in the target area, eastern LP (east of the bridges) and the two passes. Dolphins were sighted in the target area during 90% of the surveys through winter 2010 after which none were sighted. Seventy-four dolphins were identified in the target area and averaged 34.2 dolphins/survey (*n* = 25, *S.D.* = 6.73, *range* 22–45). Dolphins with unmarked dorsal fins, including calves and neonates, averaged 2.0 dolphins/survey (*S.D.* = 1.76, *range* = 0–6). Twenty-three identified dolphins in the target area had more than 700 days from their first to their last sighting and these individuals were sighted during 8 to 11 of the 11 seasons surveyed where dolphins were sighted. Sixty-one dolphin groups were sighted in eastern LP and the passes with 141 individuals identified, but none were sighted more than four times. There were few identified individuals that were sighted in multiple locations (*i.e.*, target area, eastern LP, the two passes). Skin lesions occurred on over 90% of the target area dolphins and on 30–100% of those from other locations. Lesion severity appeared to be seasonal, and worsened and improved with lower and higher salinities, respectively. Twenty-seven dolphin strandings occurred in the LP area in spring 2010. Salinity and water temperatures in the LP area were unusually low in winter 2010. Only one target area dolphin was sighted in another location post winter 2010. While it was presumed that most of the target area dolphins likely died, only one target area dolphin was among the 12 stranded dolphins from the LP area with a dorsal fin photo of sufficient quality to attempt to match to previously identified dolphins. Twenty-four dolphin strandings also occurred in the LP area in 2013 after only three strandings in 2011and 2012. The origin of the 2013 strandings is unknown, due in part to the lack of LP monitoring after 2010.

Keywords: bottlenose dolphin, Lake Pontchartrain, salinity, skin lesions, *Tursiops truncatus*

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Introduction

Lake Pontchartrain (LP) is a brackish lagoon in southeastern Louisiana connected by two passes (Chef Menteur and Rigolets passes) on the eastern side to Lake Borgne and open estuarine waters leading to the Gulf of Mexico (Figure 1). Common bottlenose dolphins (*Tursiops truncatus*; hereafter referred to as dolphins or bottlenose dolphins) are distributed throughout the bays, sounds and estuaries (BSE) of the northern Gulf of Mexico (Mullin *et al*. 1990) but are not thought to regularly inhabit LP. In his classic book on Louisiana mammals, Lowery (1974) does not mention LP in the section on bottlenose dolphins. Hastings (2009) states that bottlenose dolphins occasionally stray into LP, particularly during periods of high salinity. There are few records of bottlenose dolphin strandings in LP prior to 2007 (*e.g*., 6 strandings recorded from 1978 through 2006) (National Oceanic and Atmospheric Administration, Southeast US historical marine mammal stranding database [SEUS] and Marine Mammal Health and Stranding Response Program [MMHSRP] National Database unpublished data). The National Marine Fisheries Service (NMFS) currently designates 31 BSE stocks in the northern Gulf of Mexico. LP is adjacent to, but not included in, the Mississippi Sound, Lake Borgne, Bay Boudreau Stock, which has a bottlenose dolphin population that fluctuates between warm season highs of over 2000 dolphins to cold season lows of 900–1000 dolphins (Waring *et al.* 2014).

In March 2007, the NMFS was notified by the public that approximately 30–40 dolphins were being regularly observed just to the west of the Norfolk Southern railroad and U.S. Route 11 bridges that cross the eastern part of LP (Figures 1 & 2). The NMFS, with logistic support provided by the Louisiana Department of Wildlife and Fisheries (LDWF), conducted a photographic assessment survey on 9 May 2007. The location and number of dolphins were confirmed by the survey. Skin lesions (*e.g*., Burdett Hart *et al*. 2012) that ranged from minor to severe were observed on most of the dolphins and were thought to be a result of exposure to low salinity water (*e.g.*, Colbert *et al.* 1999, Holyoake *et al.* 2010).

Since the height of the Norfolk Southern bridge was relatively low to the surface of the water and the location of both bridges was between the dolphins' location and the passes leading to the Gulf, there was concern that the bridges might be serving as a psychological barrier to the dolphins' access to higher salinity waters. An anecdotal verbal report to the NMFS by a commercial blue crab (*Callinectes sapidus*) fisherman that worked in LP suggested that a large number of dolphins had been in that area since Hurricane Katrina. The hurricane made landfall just to the east of LP on 29 August 2005 and caused catastrophic damage in Mississippi and eastern Louisiana. The storm surge at the eastern end of LP was 4.6 m (FEMA 2006) and may have played a role in the dolphins' presence at that location. The bridges in eastern LP and its passes were damaged or destroyed (*i.e*., I-10 Twin Spans) by Katrina and there was also speculation that bridge construction and repair during 6 years following Katrina may have been an impediment to dolphin movement.

Following the initial survey, the NMFS and LDWF conducted periodic monitoring surveys of bottlenose dolphins from May 2007 to January 2010 in the area just west of the bridges and in eastern LP. An unusually high number of dolphin strandings were reported in and around LP beginning in February 2010. Twenty-seven strandings occurred within LP and in the passes to Lake Borgne from 15 February through 12 May 2010 (MMHSRP unpublished data). The dolphins in the area west of the bridges were not sighted again during similar surveys conducted during March/April 2010. The absence of dolphin sightings and unusually high strandings occurred at about the same time.

Bottlenose dolphin strandings in LP and Mississippi in early 2010 comprised the beginning of an Unusual Mortality Event (UME) that continued into 2015, in which unusually high numbers of cetacean mortalities occurred in the northern Gulf of Mexico, primarily Louisiana, Mississippi, and Alabama (Venn-Watson *et al.* 2015). As of February 2015, over 1300 cetaceans (primarily bottlenose dolphins) have been found dead in the northern Gulf of Mexico (multi-year cetacean UME in the northern Gulf of Mexico declared in 2010[1]) (Litz *et al*. 2014, Venn-Watson *et al.* 2015). In addition to the 2010 LP strandings (n = 28), the UME includes another peak of strandings in LP in 2013 (n = 24) after two years in which few strandings were recorded in LP (2011, n = 2; 2012, n = 0). Similar to the spring of 2010, a survey was conducted in April 2013 following the reports of increased mortalities and dolphins were sighted only in Chef Menteur Pass. The relationships, if any, of the LP mortalities to other northern Gulf cetacean mortalities is one aspect of the investigation into the northern Gulf UME.

Here we describe the results of monitoring efforts of bottlenose dolphins in the LP region from 2007 to mid-2014, including dolphin distribution, group dynamics, skin conditions, physical environment and strandings.

Methods

Study area

Lake Pontchartrain is large (1,630 km^2, 65 km east–west axis, 40 km north–south axis) with a mean water depth of 3.7 m and a maximum depth of 5 m (Figure 1). Tides are diurnal with a mean range of 11 cm. To the east, two tidally-influenced deep water areas (8–13 m), Chef Menteur (11.3 km in length) and Rigolets (14.5 km in length) passes, connect LP to Lake Borgne (Figure 1). The Inner Harbor Navigational Canal (IHNC, "Industrial Canal") on the southeast shore connects LP to the Intracoastal Waterway (IWC) and the Mississippi River Gulf Outlet (MRGO) (Sikora & Kjerfve 1985, McCorquodale *et al*. 2009) (Figure 1). The MRGO was permanently blocked in 2009 because of its role in land loss, shoreline erosion, saltwater

[1] http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm

intrusion and habitat modification (USACOE 2012). Lake Borgne is characteristically higher in salinity (generally >7 ppt) than LP (USEPA 1999) and ultimately leads into the open waters of the Gulf of Mexico via Mississippi Sound.

Generally, the salinity in LP proper varies seasonally and on an east-west gradient. Salinity is generally lowest in late spring due to an increase in river water flowing into the LP basin and highest in summer and fall (Carrillo *et al*. 2001). Higher salinities are found to the east ($\bar{X}$ = 5.4 ppt, *range* ≈ 0–15 ppt) resulting from inflow from the passes that connect to Lake Borgne and the IHNC. Lower salinities are found to the west ($\bar{X}$ = 1.2 ppt, *range* ≈ 0–8 ppt) resulting from freshwater input from rivers and isolation from saltwater sources (Sikora & Kjerfve 1985). The East and West Pearl rivers debouch into Lake Borgne and the Rigolets, respectively, and both affect salinity in LP. Pearl River water goes into LP via the Rigolets, or more importantly, the freshwater plume from the Pearl River acts as a barrier to salt water from the Gulf of Mexico entering LP (Sikora & Kjerfve 1985). Additionally, the Bonnet Carré Spillway (completed in 1931) in the southwestern corner of LP (Figure 1) is opened during periods of unusually high Mississippi River levels to divert river water into LP to prevent flooding in New Orleans, Louisiana. The discharge of large volumes of river water into LP (up to 30.2 billion m^3) can result in lowered salinities throughout LP (Hastings 2009). The spillway has been opened ten times from 1937–2014, including two openings since 2005. The spillway was opened from 11 April to 8 May 2008 (28 d) with 46% of the bays opened (160/350 bays) resulting in a maximum flow of 4500 m^3s^{-1} out of maximum capacity of 7000 m^3s^{-1} (GEC 2009). It was opened again from 9 May to 20 June 2011 (42 d) with 94% of the bays open and at 5900 m^3s^{-1} maximum flow (Welch & Barnes 2013).

In addition to salinity, Bonnet Carré openings impact temperature, turbidity and productivity in LP and the adjacent Gulf of Mexico. While water temperatures in LP generally range from 9°C in winter to 34°C in summer (Darnell 1958), Mississippi River water is 6–10°C cooler than LP water and carries a heavy load of sediment, nutrients and pollutants (Hastings 2009). Openings vary in timing, duration and volume. Impacts, including algal blooms and fish kills from oxygen depletion, vary depending on these factors as well as on LP conditions (*e.g.*, circulation is largely wind driven), and these impacts can also vary locally (White *et al*. 2009).

More than 250 species of fish are known to inhabit LP, ranging from freshwater species such as largemouth bass (*Micropterus salmoides*) and catfish (*Ictalurus* spp.) in very low salinity areas to brackish and saltwater species including Atlantic croaker (*Micropogonias undulatus*), striped mullet (*Mugil cephalus*), Gulf menhaden (*Brevoortia patronus*), seatrout (*Cynoscion* spp.) and flounder (*Paralichthys* spp.) (Darnell 1958, O'Connell *et al*. 2004). While the freshwater species may not be a normal food source for bottlenose dolphins, these saltwater species are known to be bottlenose dolphin prey (Barros & Odell 1990).

Four bridges traverse LP (Figure 1, Table 1). The Lake Pontchartrain Causeway bridge runs north-south through the center of LP. Three bridges run north-south across eastern LP: Norfolk Southern (NS) railroad, U.S. Route 11 (U.S. 11), and Interstate 10 (I-10) bridges (Figures 1 & 2). The NS and U.S. 11 bridges have a low clearance to the water (<2 m and <4 m, respectively) and run parallel to each other, separated by approximately 20 m in the area where dolphins were consistently sighted (*i.e*., Figure 3 – Area A). The original I-10 bridge ("Twin Spans") was severely damaged by Hurricane Katrina and replaced by a new twin span bridge constructed during 2006–2011 and located ~100 m east of the original. In addition, two bridges span each pass connecting LP and Lake Borgne: U.S. Route 90 and the CSX railroad bridges. Katrina caused extensive damage to all these bridges and, except for the original Twin Spans, they were repaired (O'Connor & McAnany 2008, Padgett *et al.* 2008).

Surveys and photo-ID

Surveys were conducted from a 7-m center console boat by 2–3 scientists from 9 May 2007 to 30 April 2013. Because individual dolphins can be identified by notches on the trailing edge of their dorsal fin, photo-identification methods (photo-ID) were used (Würsig & Würsig 1977, Würsig & Jefferson 1990). Photo-ID surveys and photo analysis methods similar to those used here are described in detail by Melancon *et al*. (2011). Whenever a dolphin group was encountered, an attempt was made to obtain a dorsal fin photograph of each animal in the group. Photographs were also taken to document the skin condition of animals with an abnormal appearance. Additional data were recorded for each group including: beginning and ending time of the encounter; latitude and longitude; number of adult/juvenile, calf and neonate dolphins (as defined by McBride & Kritzler 1951, Shane 1990); behaviors; and category of the number of dolphins with skin conditions (none, one, multiple). Salinity and surface water temperature were also measured with a handheld meter (*i.e.*, YSI Model 30) at each group sighting location and at *ad hoc* locations along survey routes.

The Bonnet Carré Spillway opening that began on 11 April 2008 was expected to dramatically reduce the salinity in LP. Because dolphins were known to inhabit the area adjacent to the NS bridge, an intensive monitoring effort of eastern LP was undertaken by the U.S. Army Corps of Engineers (ACOE) and NMFS to document and evaluate potential impacts to dolphins. This included 11 surveys conducted between 28 April and 10 May 2008 (Barry *et al*. 2008). Surveys before and after the 2008 spillway opening (see below) were conducted as time and resources allowed. Because LP was not known to be routinely inhabited by dolphins, the presence of dolphins was thought to be unusual. Since it was not known how long the dolphins would be present in LP, there was not a definitive research plan with dedicated resources, and research surveys evolved with the circumstances and were conducted opportunistically. For many of the surveys, the amount of survey effort was limited due to logistics because the survey team needed to depart and return to the NOAA NMFS laboratory in Pascagoula, Mississippi, on the same day.

On four occasions, the survey team traveled to LP and conducted a survey on the same day, overnighted locally, then conducted a second survey and returned on the second day.

The survey area was divided into subareas A–I *post hoc* (Figure 3) to aid with data analysis. The survey boat was launched from a marina just east of the U.S. 90 bridge at Rigolets Pass. Areas E and D were traversed in route to the area west of the NS bridge, but these areas were usually not systematically surveyed. However, if dolphins were sighted while in transit, they were photographed. Because the dolphins in the area west of the NS bridge were the impetus and main focus of the surveys, it was called the "target area" (Figure 3; Areas A, B & C) and it was surveyed in an *ad hoc* manner until dolphins were encountered. If no dolphins were encountered in Area A and time allowed, Area B and in some cases Area C were surveyed. A large number of dolphins (*i.e.*, >20) were usually found in the target area. These dolphins typically fit the more common definitions of a "group" of dolphins (*e.g.*, Shane 1990) and they were treated as a group for data collection purposes. Once dolphins were encountered west of the NS bridge, other parts of the target area were not typically surveyed. Beginning in April 2008, "non-target" areas that included Chef Menteur Pass (Area G), Rigolets Pass (Area H) and eastern LP (Area F) were typically surveyed. Data were generally analyzed separately for the target area and non-target areas. Seasons were defined as spring (Mar, Apr, May), summer (Jun, Jul, Aug), fall (Sep, Oct, Nov) and winter (Dec, Jan, Feb). The boat survey aspect of the study spanned 13 seasons from spring 2007 to spring 2010. Except for fall 2009, at least one survey was conducted in each season during this period. An additional survey was conducted in December 2010 to assess dolphin presence and condition in eastern LP after an eight-month lapse in surveys. Similarly, a survey was conducted in April 2013 in response to the large number of strandings in LP during spring 2013.

The primary objectives of the surveys were to:

1. determine whether dolphins inhabit
    a. the target area (Areas A, B & C) west of the NS bridge,
    b. non-target areas of eastern LP (Areas E, D & F), Rigolets Pass (Area G) and Chef Menteur Pass (Area H),
2. document and monitor the skin condition of individual dolphins,
3. determine whether the NS and U.S. 11 bridges were potentially a barrier to individual dolphin movements (*i.e.*, were individuals found both east and west of the bridges), and
4. characterize dolphin group size and composition.

Strandings

Litz *et al*. (2014) provide details of marine mammal stranding response in the northern Gulf of Mexico. Briefly, the Southeast U.S. Marine Mammal Stranding Network includes federal, state and local government agencies, non-profit and academic institutions, private businesses and the public. For cetaceans, stranding network organizations and their personnel are authorized by the

NMFS to collect data from stranded marine mammals through Stranding Agreements issued by the NMFS (MMPA Section 112c), or as local, state or federal government employees operating under Section 109h of the Marine Mammal Protection Act (MMPA).

Stranding response in the LP area was primarily conducted by LDWF and Audubon Aquarium of the Americas (New Orleans). For each stranding reported to the network, the responding agency is required to complete a Marine Mammal Stranding Report - Level A data form (NOAA Form 89-864; OMB No. 0648-0178; NMFS OPR Level A, 2013). Level A data are public data and include details of the stranding event such as species, date, location, condition, sex, length, etc. Currently, stranding network members in the southeast U.S. are required to submit their Level A report electronically into the MMHSRP database within 30 days of the stranding. All data on strandings from the LP area to 30 June 2014 were extracted from the MMHSRP database (1996–2014) or SEUS historical stranding database (1978–1995) for this paper.

Stranding responders in the LP area and elsewhere are asked to take photo-ID quality photographs of the left and right side of a stranded dolphin's dorsal fin; however, image utility for comparisons can vary depending on carcass decomposition state, and most of the LP strandings were heavily decomposed. Available photos of acceptable quality from the dolphins stranded in the LP area were compared to the catalog of dolphins from the LP surveys.

Comparison to other catalogs

As part of the Natural Resource Damage Assessment (NRDA) that followed the *Deepwater Horizon* oil spill (*e.g.,* Schwacke *et al*. 2013), photo-ID studies were initiated in Mississippi Sound and Chandeleur Sound in spring 2010. To attempt to determine whether the dolphins from the target area may have dispersed to other areas after January 2010, the dolphins in the LP area catalog (208 identified individuals) were compared to dolphins with distinctive dorsal fins in the DWH NRDA Mississippi Sound (2158 individuals) and Chandeleur Sound (833 individuals) bottlenose dolphin photo-ID catalogs. The closest points to the Mississippi Sound and Chandeleur Sound study areas from the LP areas are over 80 and 30 km, respectively. While the probability of LP dolphins dispersing to those areas and being identified in them is low, these are the photo-ID catalogs nearest to LP for which we had access.

Skin lesion analysis

Many of the dolphins encountered had skin lesions that were thought to be a result of exposure to low salinity water ("freshwater"). Freshwater skin lesions on bottlenose dolphins are generally characterized by diffuse increased pallor with roughening of the skin surface. There can also be multifocal to coalescing irregular circular to "target" lesions of about 2–3 cm in diameter that can increase in size and confluence to affect large areas of the animals' bodies (Mase-Guthrie *et al*. 2005). The damaged skin is then subsequently invaded by various algal species appearing from dark orange to grayish brown and/or green (Southeast Fisheries Science Center [SEFSC]

unpublished data). Multiple individuals in both the target area and non-target area had lesions of varying degrees. A preliminary analysis of the skin lesions on individuals was conducted by examining photos of individuals. For the target area, available photos of each individual were examined and scored for the presence or absence of lesions for each spring season (2007, 2008 & 2009) and January 2010, the last time dolphins were sighted in the target area. The preliminary analysis focused on the spring season because lesions would likely be at their maximum development due to low annual salinity levels beginning in mid-winter. Because most individuals from non-target areas were sighted only one or two times, they were scored regardless of year for any sighting during a spring season (2007, 2008 or 2009) or January 2010. Notes on the types of lesions observed were also made (*e.g.*, Burdett Hart *et al*. 2012, Gonzalvo *et al*. 2015). A full analysis of skin lesions similar to Burdett Hart *et al*. (2012) is the focus of ongoing work.

Environmental conditions

In addition to data collected during surveys, to provide a broader and more continuous context of the conditions in eastern LP, daily water temperature and salinity records were downloaded from the United States Geological Survey (USGS), National Water Information System site "Rigolets at Hwy 90 near Slidell, LA" for the period from 2008 to mid-2014[2]. This site is the only USGS site that provides continuous temperature and salinity data in or near the study area. Additionally, monthly daily average air temperature and precipitation totals recorded at the Slidell [Louisiana] Municipal Airport near LP's north shore and adjacent to the study area were obtained from the NOAA, National Weather Service for the period 2005–2013.

Results

From 9 May 2007 to 30 April 2013, surveys were conducted on 37 days in the eastern LP region (Table 2). The target area was surveyed on each day except on two days when dolphins were located there the previous day. Areas D and E were also routinely transited/surveyed because they were between the boat launch at the Rigolets and the target area. An additional survey was conducted in Lake Borgne (Area I, Figure 3) on one occasion (21 April 2010) to search for identified dolphins that may have dispersed from the target area and to assess the skin condition of any dolphins encountered.

Temperature and salinity

From 2008 to mid-2014, water temperature at the Rigolets USGS station generally varied between summer highs of over 30°C and winter lows of 10°C, and salinity varied from brief periods below 5 ppt to over 15 ppt (Figure 4). Conditions in late 2009 and early 2010 did not appear to be typical. The rainfall total for Slidell, Louisiana, was nearly 50 cm in December

[2] http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=301001089442600

2009 compared to the next highest December total for 1999–2013 of 15 cm in 2002. Additionally, the average air temperature for January and February 2010 was from 5–10°C, while average air temperatures for these months remained above 10°C from 2005–2009 (Figure 5). In early 2010, water temperature at the Rigolets station dropped briefly to under 5°C while the median water temperature for winter months was above 10°C during 2009–2014 (Figure 4). Salinity dropped below median values during early 2010, 2013 and 2014 (Figure 4). The survey data reflect temperature and salinity cycles with the lowest water temperature recorded in January 2010 (Figure 6).

Characteristics of dolphins in the target area

Dolphins were sighted during 26 of 29 surveys of the target area (Areas A, B & C) conducted from 9 May 2007 to 13 January 2010 (Table 2, Figure 3). No dolphins were sighted in the target area during three surveys conducted on 28 and 29 April, and 1 May 2008, following the opening of the Bonnet Carré Spillway on 11 April 2008. No dolphins were sighted in the target area after January 2010 during surveys conducted in spring 2010 (4 surveys), winter 2010 (1 survey) and spring 2013 (1 survey).

Dolphins were sighted 24 times in Area A and once in Areas B and C. The sighting in Area C consisted of four dolphins sighted briefly in very rough conditions and they were not photographed. A total of 74 individual dolphins with uniquely marked fins were identified in the target area. The number of identified dolphins sighted per survey day ranged from 22 to 45 and averaged 34.2 (n = 25, *S.D.* = 6.73). Additionally, dolphins with unmarked dorsal fins were also seen and averaged 2.0 dolphins/survey (*S.D.* = 1.76, *range* = 0–6). Twenty-three identified dolphins in the target area had more than 700 days from their first to their last sighting and these individuals were sighted during 8–11 of the 11 seasons surveyed where dolphins were sighted. Nineteen individuals were sighted in only one of the 13 seasons surveyed (Table 3).

New individuals were sighted throughout the study in the target area and the discovery curve did not level off (Figure 7). For example, five dolphins were sighted for the first time during the last survey in which dolphins were sighted in the target area (13 Jan 2010).

Up to three neonate dolphins were sighted in the target area during individual surveys (Table 4). Neonates were sighted during March, April, May and June. We were unable to link neonates to an identified dolphin. Feeding or probable feeding behavior and social behavior as defined by Shane (1990) were sighted on multiple surveys.

Characteristics of dolphins in non-target areas

Sixty-one bottlenose dolphin groups were sighted in non-target areas (D–I, Figure 3). Average group sizes in these areas were 8 dolphins or less and the largest group sighted contained 15 dolphins (Table 4). Calves were sighted in each area except D and neonates were only observed

in Area H. Neonates were sighted in April and May. The only sighting in Area F was of one dolphin on one occasion. Feeding or probable feeding was recorded multiple times in each area except D. For dolphins that were sighted in the non-target areas only, 141 individuals were identified with the majority located in Area E (n = 53) and Area H (n = 39). None of the dolphins were sighted more than four times in non-target areas (Table 5). The time between the first and last sighting for 21 dolphins sighted in at least two different seasons in areas D, E, G or H averaged 392 days (*S.D.* = 393) with a maximum of 1827 days for a dolphin (ID# 5006) sighted in Area H.

After the dolphins disappeared from the target area on 13 January 2010, only one dolphin was sighted in eastern LP (Areas D, E & F) but dolphins were sighted during multiple surveys of Chef Menteur Pass (Area H) and Rigolets Pass (Area G). However, only one of these dolphins was a recognized target area dolphin. Throughout the study, dolphins were sighted during 50% and 86% of surveys in Rigolets and Chef Menteur passes, respectively (Table 2).

Movements of individual dolphins

Seven individuals that were photographed in the target area were also photographed in non-target areas east of the NS/U.S. 11 bridges on at least one occasion. Of these seven dolphins, only one was photographed after January 2010 when dolphins disappeared from the target area. This dolphin (ID# 6024) was only observed once in the target area on 07 May 2008 and was observed in Rigolets Pass near the entrance to Lake Borgne on 21 April 2010.

Four dolphins (ID#: 1001, 6022, 6023 & 8020) were observed and photographed close to the NS/U.S. 11 bridges on the east side (Area D) on 2 or 3 surveys. On 03 May 2008, these four dolphins and an unmarked dolphin were sighted in a group with two additional dolphins (ID#: 6002 & 8004), which were photographed frequently both before and after this date in the target area. This was the only time that either of these two dolphins was observed east of the bridges. Interestingly, these two dolphins were photographed west of the NS/U.S. 11 bridges, in the target area, the next day (04 May 2008). The four dolphins (ID#: 1001, 6022, 6023 & 8020) from Area D were not observed in the target area until 05 November 2008, at which point they were frequently sighted in the target area and never observed east of the NS/U.S. 11 bridges again. These examples confirm that at least some individuals were able to move back and forth under the bridges between the target and non-target areas.

The only other known movements of individual dolphins between subareas east of the NS/U.S. 11 bridges were one dolphin (ID# 7015) sighted in Areas D and E and one dolphin (ID# 7025) sighted in Areas E and H.

Skin condition

The dolphins in the LP region displayed freshwater skin lesions in different stages and varying degrees of severity (Figure 8). Except for Area F where only one dolphin was observed, individuals with severe skin lesions were photographed in each sub-area where dolphins were sighted (Figure 9). Over 90% of individuals in the target area had lesions each spring and in January 2010 as did non-target area individuals within LP proper (Table 6). Fewer of the total dolphins sighted in Chef Menteur Pass (Area H, 69%) and Lake Borgne (Area I, 32%) had lesions. Each of the six dolphins examined in Rigolets Pass had lesions, most of them severe. Each spring, one or more young of the year (YOY) (*i.e.*, dolphins with visible fetal folds) observed in the target area had lesions. Two of the seven dolphins without lesions in the target area were YOY with visible fetal folds.

The one dolphin (ID# 6024) sighted in both the target area and Rigolets Pass had lesions, particularly on its dorsal fin, when photographed in the Rigolets (21 Apr 2010); however, its skin condition could not be determined from the photos when it was sighted in the target area (07 May 2008) (backlit photograph).

While a formal analysis is pending, the skin condition of bottlenose dolphins observed in LP appeared to worsen during the late winter to early summer months and improve from mid-summer to early winter. This pattern of deteriorating/improving skin appeared to correlate with changing salinities and water temperatures in LP (*e.g.*, Figure 10).

Strandings

Prior to 2007, bottlenose dolphin strandings were seldom reported from LP (Appendix I). From 1978–2006, there are records of six bottlenose dolphin and one unidentified cetacean strandings in the region. However, from 2007 to 30 June 2014 there have been 67 confirmed strandings in and around LP. The majority occurred in 2010 (n = 28; 15♀, 5♂, 8 unk) and 2013 (n = 24; 10♀, 7♂, 7 unk). During both 2010 and 2013, all strandings except one were between January and May. Overall the most strandings occurred in eastern LP (Areas A, B, D, E & F & Lake Saint Catherine) and the passes (Areas G & H, & 1 stranding in MRGO) (Figure 11).

Comparison of strandings to LP photo-ID catalog

Overall, dorsal fins of only 12 stranded dolphins could be compared to the LP catalog due to decomposition, unmarked fins or lack of usable photographs from stranded dolphins (Appendix I). Of these, two were matched to the LP catalog. One was from the target area (ID# 7020) and was sighted 12 times between 09 May 2008 and 13 January 2010. It was found stranded on 12 March 2010 on the north shore near the Lake Pontchartrain Causeway, well west of the target area. The other matched dolphin (ID# 7043) was sighted once on 22 April 2009 in Chef Menteur Pass (Area H) where it was found stranded on 30 April 2013. Additionally, decomposition precluded tissue collection and analysis of most dolphins stranded in 2010 and only two

necropsies were conducted. Analyses of tissues collected during necropsy from 13 dolphins in 2013 and one dolphin in 2014 are pending.

Comparison of LP catalog to other catalogs

The comparison of LP catalog individuals to the NRDA Mississippi Sound and Chandeleur Sound catalogs yielded only two matches. Two dolphins (ID# 6053 & 6049) sighted in the same group in eastern Lake Borgne on 21 April 2010 were sighted separately in Chandeleur Sound 30.8 km (26 May 2010) and 49.3 km (8 Feb 2011) east of their Lake Borgne location.

Discussion

The majority of dolphins that occurred east of the I-10 bridge (Areas E, F, G, H) were seen only one or two times, suggesting that dolphins are transitory in these areas and inhabit LP for only brief periods of time. However, many of the dolphins in the target area west of the NS bridge were observed multiple times and in multiple seasons between May 2007 and January 2010, suggesting that they resided in LP during that time. If the dolphins in the target area were swept into LP during Hurricane Katrina, as anecdotally suggested, then they may have been there for as long as 4.4 years. Dolphins have been known to become displaced inland by hurricanes and tropical storms. For example, Rosel and Watts (2008) reported the details of seven bottlenose dolphins that were stranded alive at different locations as much as 10.9 km inland in western Louisiana after Hurricane Rita made landfall on 24 September 2005.

However, despite the fact that many dolphins lived west of the NS bridge for 2.7 to 4.4 years, if they were swept into LP by Katrina, perhaps they were "psychologically" if not physically trapped. After Katrina, the dolphins may not have had any concept of where they were or how to get back to where they originated. Perhaps the low NS bridge (Figure 2) was enough of a barrier to prevent exploration that might have led some or all of the dolphins out of LP. Because they were finding food and they were with other dolphins, perhaps there was not enough incentive to leave, despite the negative impacts of low salinity water.

Many of the atypical attributes of the dolphins found in the target area (*e.g.*, presence, location, small "home range," site fidelity, group size, and homogenous group membership of a large number of the individuals — discussed below) could potentially be consistent with dolphins displaced into LP by Hurricane Katrina. During Katrina, the storm surge at the Rigolets was 4.6 m and 4.0 m near the NS/U.S. 11 bridges (FEMA 2006). As Katrina approached from the south, winds were from east to west across Mississippi Sound toward Lake Borgne (Ebersole *et al.* 2010). At one point the water level in Lake Borgne was 2.5 m higher than eastern LP and the current in Chef Menteur and Rigolets passes was as much as 3 m s^{-1} (Dietrich *et al.* 2010). It is likely that any dolphins in the Lake Borgne area would have been swept into LP. The dolphins could also have ridden the storm surge over and across land barriers (*e.g.*, the Bayou Sauvage

area directly to the south) and been swept into LP from multiple locations and converged on the target area later for social reasons, food or both.

The dolphins in the target area occurred within a relatively small area and, for each sighting, were considered to constitute a single group. If the occurrence of all dolphins in the target area was only Katrina-related and essentially closed to emigration and immigration, the discovery curve should have leveled off shortly after the initial surveys, however, it did not (Figure 7). During each of the first three seasons of surveys, 31–37 individuals were identified in the target area but by January 2010, 74 dolphins were identified. Therefore, it appears that new dolphins were moving into the target area, probably from the Gulf of Mexico via eastern LP post-Katrina. Additionally, some dolphins identified early in the study were not seen in subsequent seasons (Figure 7) and either died or permanently dispersed prior to spring 2010 when all of the dolphins in the target area disappeared.

The average number of dolphins identified in the target area each season was 36.5 (n = 11, *S.D.* = 8.51, *range* 24–51). Once a large group was located and photographed, the remainder of the target area was not systematically searched. Given the size of the catalog, it appears that a number of dolphins may have been routinely missed. However, if the identified dolphins that were not sighted in subsequent seasons are excluded from the catalog size for that season (Figure 7), the difference between average number of dolphins identified each season and the average number of dolphins still potentially available each season, 42.4 (n = 11, *S.D.* = 7.23), indicates an average of 5–6 dolphins were missed per season.

If dolphins were coming from the Mississippi Sound region to the target area, it means they were passing under a minimum of five bridges including construction of the I-10 Twin Spans to reach the target area. Entrance to LP via the IWC and IHNC is also a possibility, but it is narrow and the clearance of one of the bridges is also very low to the water. The alternative would be for individuals from an unknown, larger, more scattered, Katrina-related LP population to have eventually found the target area. While the latter seems to be less likely, the target area is small but happens to be a very popular recreational fishing area along the NS bridge ("The Trestles"; Davis 1988) which could mean that prey were more abundant in that location.

The dolphins in the target area were located immediately west of the NS/U.S. 11 bridges and few of the identified dolphins were known to pass under the bridges. Whether the bridges served as a barrier or landmark, if either, is not known. Many estuarine bottlenose dolphins in the northern Gulf of Mexico live in areas with bridges and to our knowledge, there are no accounts that bridges serve to restrict their movements. All of the routes that dolphins could take into LP (Rigolets, Chef Menteur, IHNC) require that dolphins pass under bridges (although none are as low as the NS bridge, Table 1). All of the bridges were damaged by Katrina and were either repaired, replaced or demolished (Table 1). Very little is known about the impacts of marine

construction that includes in-air and underwater explosions and pile driving on delphinids, and few studies have been conducted. The studies that have been conducted have not shown definitive and consistent responses, but changes in behavior have been reported (Buckstaff *et al*. 2013). Buckstaff *et al.* (2013) noted that in Sarasota Bay, Florida, bottlenose dolphin density in an area of new bridge construction and adjacent old bridge demolition was higher after all the work was completed than before and during the work. However, some dolphins may have had preferred habitat in the bridge area and did not avoid the area during construction and demolition. During the LP surveys, dolphins were sighted both in Chef Menteur and Rigolets passes between the U.S. 90 and CSX bridges and they certainly moved in and out of those passes. While the sighting of individuals, except in a few cases, did not indicate the movement of individuals between areas, it is reasonable that dolphins were routinely passing under bridges or inhabiting area near bridges with construction activities.

The impact of the spring 2008 opening of the Bonnet Carré Spillway on the dolphins is difficult to assess. There were 45 dolphins identified in the target area during spring 2008 and 33 of these dolphins were sighted in the target area after a year or more. While the severity of skin lesions has not been formally assessed, the percent of individuals with lesions remained similar and high (>90%) across spring 2007, 2008 and 2009 (Table 6). The Mississippi River water during 2008 flowed along the south shore of LP and out the eastern passes and may not have impacted the target area to a large degree (White *et al*. 2009). An analysis of trawl, seine and gillnet data collected by LDWF prior to 2008 and after the opening of the Spillway at locations throughout LP and Lake Borgne indicate that, overall, the 2008 opening had little effect on the distribution of fishes and other aquatic organisms. There were some differences in the catches of some species but bay anchovy (*Anchoa mitchilli*), Atlantic croaker, Gulf menhaden and sand seatrout (*C. arenarius*) made up the majority of finfish captured by trawl both before and after the opening (GEC 2009). Interestingly, both the 2008 and 2011 spillway openings preceded a spike in LP dolphin strandings by 2 years (*i.e*., 2010 and 2013, respectively) although it is not clear what could cause the association with a 2-year lag.

Dolphins inhabiting low salinity environments for an extended period of time (*i.e.*, several weeks) experience a number of negative health conditions. A distinct observable clinical manifestation is severe skin lesions that worsen with prolonged exposure to lowered salinities (*e.g.*, Simpson & Gardner 1972, Greenwood *et al.* 1974, Colbert *et al*. 1999, Gulland *et al*. 2008). In addition to skin degradation and secondary infection, there are electrolyte imbalances in the blood, resulting in changes in blood chemistry. These changes include decreased osmolality, sodium and chloride levels associated with over-hydration (bloated appearance) due to increased water absorption through the skin and solute loss (Hui 1981, Andersen & Nielsen 1983). In addition, increased ocular corneal opacity (corneal edema) has also been observed in out-of-habitat dolphins rescued and repatriated from freshwater systems (Mase-Guthrie *et al.* 2005). The associated physiological stress of prolonged freshwater exposure eventually leads to

mortality if low salinity conditions persist and dolphins remain in low salinity environments (SEFSC unpublished data).

In June 2011, the NMFS was notified that a dolphin routinely inhabited the canals and surrounding waterways around Lakeshore Estates. Lakeshore Estates is a subdivision of homes connected to LP by a series of canals and borders the north shore of LP between I-10 and the Rigolets (*i.e.*, borders Area E). This single male dolphin was observed for 3 years in the Lakeshore Estates area. Residents subsequently told the NMFS that the dolphin first appeared as a calf after Hurricane Katrina; however, the exact age of the dolphin has yet to be determined. Interestingly, its dorsal fin did not match any dolphins in the LP catalog, although identifying notches could have been acquired after the majority of the photos in the LP catalog were taken (prior to spring 2010). Also, if the dolphin always resided in the canals, it would not have been in the other areas where dolphins were photographed during the study period. The dolphin was reported numerous times by the public and was periodically monitored by LDWF. He would routinely approach boats and reportedly bit several people during his tenure. The last time the dolphin was photographed alive, on 3 June 2014 (salinity 2.0 ppt), he had extensive freshwater skin lesions thought to cover ~50% of his body. The dolphin was found dead on 15 June 2014. Although his decomposition state at the time of recovery prevented a determination of cause of death, his extensive freshwater skin lesions and the prolonged low salinity exposure in the canal where he resided are presumed to have contributed to his demise.

Because it is brackish in general and salinity varies temporally and spatially, the LP area is probably marginal bottlenose dolphin habitat (*e.g.*, Kawecki 2008). Routine bottlenose dolphin occurrence in LP is probably restricted to the Rigolets Pass, Chef Menteur Pass and extreme eastern LP, and dolphin occurrence observed in these areas was low compared to other areas such as Mississippi Sound that are inhabited year round (*e.g.*, Hubard *et al.* 2004). Still, dolphins in these areas of LP developed skin lesions. While the impacts of skin lesions are not well understood, as discussed, lesions may make the dolphins more susceptible to infection and absorption of chemicals or contaminants from the water. Why dolphins inhabit these areas and tolerate lesions is not known. The characteristics of individuals such as age, sex, reproductive condition and "social status" that inhabit marginal habitat are also of interest and warrant further investigation. However, a comparison of total length of non-perinate strandings (≥115 cm total length) from 2010 to mid-2014 from the northern Gulf of Mexico UME (Litz *et al*. 2014) excluding LP region strandings to those from LP during 2010 and 2013 reveals no clear differences (Table 7). Of the strandings for which sex was determined, in the larger UME more males stranded (62%), whereas in the much smaller LP sample, more females stranded (58%) (MMHSRP unpublished data).

Compared to bottlenose dolphins from other studies, the group dynamics of the dolphins in the target area were quite interesting. The size of bottlenose dolphin groups in estuarine habitats in

the northern Gulf of Mexico is variable but typically averages <10 dolphins/group (Mullin *et al*. 1990). Groups of over 30 dolphins do occur in estuarine waters, but are usually thought to be temporary and/or feeding aggregations and are commonly found in passes to the Gulf of Mexico. Bottlenose dolphins occur in "fission-fusion" groups where associations are brief (days) and the only long-term bonds (*i.e*., years), other than those of mother-calf pairs, are thought to be between pairs or trios of males (Smolker *et al.* 1992, Connor *et al*. 2000). Many of the individual dolphins that occurred in the dolphin group sighted in the target area did not conform to typical bottlenose dolphin association patterns. While a quantitative analysis of association and the social network is pending (*e.g.,* Daura-Jorge *et al.* 2012), 23 dolphins were seen in eight or more seasons that spanned at least 700 days (1.9 years). Over 90% of dolphin sightings in the target area occurred in an area of about 10 km^2. The home range of bottlenose dolphins in estuarine habitats has been quantified using a variety of methods, and the range sizes are generally larger than this (*e.g*., Gubbins 2002, Mazzoil *et al*. 2008, Urian *et al*. 2009). With an average of 36 dolphins usually inhabiting an area of 10 km^2, dolphin density was at least 3.6 dolphins/km^2. Densities of 1.5–2.0 bottlenose dolphins/km^2 are on the high end of those historically reported for the nearby Mississippi Sound region (Hubard *et al*. 2004, Miller *et al*. 2013).

It appears that the most likely outcome for most of the dolphins that inhabited the target area is that they died. They were last sighted on 13 January 2010 and subsequently there was a dramatic increase in dolphin strandings throughout LP in March and April of 2010. The sharp increase in strandings occurred during a short but sustained period of cold weather coupled with a rapid influx of fresh water. The co-occurrence of these climatic/environmental and stranding events was, with little doubt, directly related. While only two dolphins of those stranded could be matched to the LP catalog, only one dolphin from the target area was seen alive during subsequent surveys. Nevertheless, the 2013 strandings in LP were similar in magnitude and location to 2010, and while the water temperature was not below average in 2013, salinities were lower than normal for an extended period in early 2013 (Figure 4). The origin of the 2013 dolphins is more difficult to speculate about because of the lack of surveys in the LP area after spring 2010.

Conclusions

LP gave scientists an opportunity to observe dolphins as they coped in an environment of reduced salinity for a prolonged period of time. Previously observed freshwater exposure scenarios have resulted in dolphin mortalities in a relatively short period of time, varying from days to weeks (SEFSC unpublished data). The scenario in LP was dramatically and remarkably unusual in its presentation. We assume that most of the dolphins eventually succumbed to the detrimental effects of reduced salinity or some combination of long term effects of reduced salinity combined with low water temperatures. Alternatively, it is also possible that the extreme drop in temperature and salinity in early 2010 finally drove the surviving dolphins out of LP.

These surveys also increased our awareness of the role that LP and its passes serve as habitat for bottlenose dolphins. However, there is still much that is not understood, such as whether dolphins venture farther west into LP and the conditions that cause dolphins to enter and utilize LP habitat (*e.g.*, during periods of increased salinity). Some of these questions should be addressed with future research in the LP and Lake Borgne region. A better understanding of the role that LP and similar environments serve is necessary for effective management of inshore bottlenose dolphin stocks given the ongoing struggles with habitat loss in Louisiana and future impacts to the environment such as hurricanes, climate change and oil spills. In regards to the unusual group of dolphins that remained in LP for over 2.5 years, many questions will unfortunately remain unanswered.

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Literature Cited

Andersen, S.H. and E. Nielsen. 1983. Exchange of water between the harbor porpoise, *Phocoena phocoena* and the environment. Experientia 39:52-53.

Barros, N.B. and D.K. Odell. 1990. Food habits of bottlenose dolphins in the southeastern United States. Pages 309-328 *in* S. Leatherwood and R.R. Reeves (eds). The bottlenose dolphin. Academic Press, San Diego, California.

Barry, K.P., A.M. Gorgone and B. Mase. 2008. Lake Pontchartrain, Louisiana bottlenose dolphin survey summary: 28 April 2008 – 10 May 2008. Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, Florida 33149. PRBD-08/09-01. 62 p.

Buckstaff, K.C., R.S. Wells, J.G. Gannon and D.P. Nowacek. 2013. Responses of bottlenose dolphins (*Tursiops truncatus*) to construction and demolition of coastal marine structures. Aquatic Mammals 39:174-186.

Burdett Hart, L.B., D.S. Rotstein, R.S. Wells, J. Allen, A. Barleycorn, B.C. Balmer, S.M. Lane, T. Speakman, E.S. Zolman, M. Stolen, W. McFee, T. Goldstein, T.K. Rowles and L.H. Schwacke. 2012. Skin lesions on common bottlenose dolphins (*Tursiops truncatus*) from three sites in the Northwest Atlantic, USA. PLoS ONE 7(3): e33081.

Carrillo, A.R., C.R. Berger, M.S. Sarruff and B.J. Thibodeaux. 2001. Salinity changes in the Pontchartrain Basin estuary, resulting from Mississippi River gulf outlet partial closure plans, Rep. ERDC/CHLTR-01-14, U.S. Army Corps of Eng., Washington, D. C.

Chen, G., E.C. Witt III, D. Hoffman, R. Luna and A. Sevi. 2007. Analysis of Interstate 10 twin bridge's collapse during Hurricane Katrina. Pages 35-42 *in* G.S. Farris, G.J. Smith, M.P. Crane, C.R. Demas, L.L. Robbins and D.L. Lavoie (eds). Science and the storms—the USGS response to the hurricanes of 2005: U.S. Geological Survey Circular 1306.

Colbert, A.A., G.I. Scott, M.H. Fulton, E.F. Wirth, J.W. Daugomah, P.B. Key, E.D. Strozier and S.B. Galloway. 1999. Investigation of unusual mortalities of bottlenose dolphins along the mid-Texas coastal bay ecosystem during 1992. NOAA Technical Report NMFS 147. 23 p.

Connor, R.C., R.S. Wells, J. Mann and A.J. Read. 2000. The bottlenose dolphin: Social relationships in a fission-fusion society. Pages 91-126 *in* J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead (eds). Cetacean societies: field studies of dolphins and whales. University of Chicago Press.

Darnell, R.M. 1958. Food habits of fishes and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. Publication of the Institute of Marine Science, University of Texas 5:353-416.

Daura-Jorge, F.G., M. Cantor, S.N. Ingram, D. Lusseau and P.C. Simões-Lopes. 2012. The structure of a bottlenose dolphin society is coupled to a unique foraging cooperation with artisanal fisherman. Biological Letters 8:702-705.

Davis, D. 1988. Frank Davis fishing guide to Lake Pontchartrain and Lake Borgne. Pelican Publishing Company, Gretna, Louisiana. 141 p.

Dietrich, J.C., S. Bunya, J.J. Westerink, B.A. Ebersole, J.M. Smith, J.H. Atkinson, R. Jensen, D.T. Resio, R.A. Luettich, C. Dawson, V.J. Cardone, A.T. Cox, M.D. Powell, H.J. Westerink and H.J. Roberts. 2010. A high-resolution coupled riverine flow, tide, wind, wind wave, and storm surge model for southern Louisiana and Mississippi. Part II: Synoptic description and analysis of hurricanes Katrina and Rita. Monthly Weather Review 138:378-404.

Ebersole, B.A., J.J. Westerink, S. Bunya, J.C. Dietrich and M.A. Cialone. 2010. Development of storm surge which led to flooding in St. Bernard Polder during Hurricane Katrina. Ocean Engineering 37:91–103.

FEMA. 2006. Louisiana Hurricane Katrina inundation and advisory base flood elevation map panel overview, north area: http://www.fema.gov/pdf/hazard/flood/recoverydata/katrina/katrina_la_overview-n.pdf

GEC. 2009. Biological and recreational monitoring of the impacts of the 2008 Bonnet Carré Spillway opening, St. Charles Parish, Louisiana. Contract report prepared for the U.S. Army Corps of Engineers, New Orleans District. Contract No. W912P8-07-D-0008.

Gonzalvo, J., I. Giovos and S. Mazzariol. 2015. Prevalence of epidermal conditions on common bottlenose dolphins (*Tursiops truncatus*) in the Gulf of Ambracia, western Greece. Journal of Experimental Marine Biology and Ecology 463:32-38.

Greenwood, A.G., R.J. Harrison and H.W. Whitting. 1974. Functional and pathological aspects of the skin of marine mammals. Pages 71-110 *in* R. J. Harrison (ed). Functional anatomy of marine mammals. London: Academic Press.

Grenzeback, L.R. and A.T. Lukmann. 2009. Case Study of the transportation sector's response to and recovery from Hurricanes Katrina and Rita. Report prepared for the Transportation Research Board, Washington, D.C. 44 p.

Gubbins, C. 2002. Use of home ranges by resident bottlenose dolphins (*Tursiops truncatus*) in a South Carolina estuary. Journal of Mammalogy 83:178-187.

Gulland, F.M.D., F.B. Nutter, K. Dixon, J. Calambokidis, G. Schorr, J. Barlow, T. Rowles, S. Wilkin, T. Spradlin, L. Gage, J. Mulsow, C. Reichmuth, M. Moore, J. Smith, P. Folkens, S. F. Hanser, S. Jang and C.S. Baker. 2008. Health assessment, antibiotic treatment, and behavioral responses to herding efforts of a cow-calf pair of humpback whales (*Megaptera novaeangliae*) in the Sacramento River Delta, California. Aquatic Mammals 34:182-192.

Hastings, R.W. 2009. The lakes of Pontchartrain: their history and environments. The University Press of Mississippi. 319 p.

Holyoake, C., H. Finn, N. Stephens, P. Duignan, C. Salgado, H. Smith, L. Bejder, T. Linke, C. Daniel, K. Moiler, H.N. Lo, G.S. Ham, S. Allen, K. Bryant and D. McElligott. 2010. Technical report on the bottlenose dolphin (*Tursiops aduncus*) unusual mortality event within the Swan Canning Riverpark, June-October 2009. Report to the Swan River Trust. 234 p.

Hubard, C.W., K. Maze-Foley, K.D. Mullin and W.W. Schroeder. 2004. Seasonal abundance and site fidelity of bottlenose dolphins (*Tursiops truncatus*) in Mississippi Sound. Aquatic Mammals 30:299-310.

Hui, C. 1981. Seawater consumption and water flux in the common dolphin *Delphinus delphis.* Physiological Zoology 54:430-440.

Kawecki, T.J. 2008. Adaptation to marginal habitats. Annual Review of Ecology, Evolution, and Systematics 39:321-342.

Litz, J.A., M.A. Baran, S.R. Bowen-Stevens, R.H. Carmichael, K.M. Colegrove, L.P. Garrison, S.E. Fire, E.M Fougeres, R. Hardy, S. Holmes, W. Jones, B.E. Mase-Guthrie, D.K. Odell, P.E. Rosel, J.T. Saliki, D.K. Shannon, S.F. Shippee, S.M. Smith, E.M. Stratton, M.C. Tumlin, H.R. Whitehead, G.A.J. Worthy and T.K. Rowles. 2014. Review of historical unusual mortality event (UMEs) in the Gulf of Mexico (1990 – 2009): providing context for the multi-year northern Gulf of Mexico cetacean UME declared in 2010. Diseases of Aquatic Organisms 112:161-175.

Lowery, G.H., Jr. 1974. The mammals of Louisiana and its adjacent waters. Louisiana State University Press. 565 p.

Mase-Guthrie, B., F. Townsend, W. McFee, C. Manire, R.Y. Ewing and T. Pitchford. 2005. Cases of prolonged freshwater exposure in dolphins along the Southeast United States. Poster presentation at Society for Marine Mammalogy 16th Biennial Conference, San Diego, California.

Mazzoil, M., J.S. Reif, M. Youngbluth, M.E. Murdoch, S.E. Bechdel, E. Howells, S.D. McCulloch, L.J. Hansen and G.D. Bossart. 2008. Home ranges of bottlenose dolphins (*Tursiops truncatus*) in the Indian River Lagoon, Florida: environmental correlates and implications for management strategies. EcoHealth DOI: 10.1007/s10393-008-0194-9.

McBride, A.F. and H. Kritzler. 1951. Observations on pregnancy, parturition, and post-natal behavior in the bottlenose dolphin. Journal of Mammalogy 32:251-266.

McCorquodale, J.A., R.J. Roblin, I.Y. Georgiou and K.A. Haralampides. 2009. Salinity, nutrient, and sediment dynamics in the Pontchartrain Estuary. Journal of Coastal Research 54:71-87.

Melancon, R.A.S., S. Lane, T. Speakman, L.B. Hart, C. Sinclair, J. Adams, P.E. Rosel and L. Schwacke. 2011. Photo-identification field and laboratory protocols utilizing FinBase Version 2. NOAA Technical Memorandum NMFS-SEFSC-627. 46 p.

Miller, L.J., A.D. Mackey, M. Solangi and S.A. Kuczaj II. 2013. Population abundance and habitat utilization of bottlenose dolphins in the Mississippi Sound. Aquatic Conservation: Marine and Freshwater Ecosystems 23:145-151.

Mullin, K.D., R.R. Lohoefener, W. Hoggard, C.L. Roden and C.M Rogers. 1990. Abundance of bottlenose dolphins, *Tursiops truncatus*, in the coastal Gulf of Mexico. Northeast Gulf Science 11:113-122.

O'Connell, M.T., R.C. Cashner and C.S. Schieble. 2004. Fish assemblage stability over fifty years in the Lake Pontchartrain estuary: comparisons among habitants using canonical correspondence analysis. Estuaries 27:807-817.

O'Connor, J.S. and P.E. McAnany. 2008. Damage to bridges from wind, storm surge and debris in the wake of Hurricane Katrina. MCEER special report series, engineering and organizational issues before, during and after Hurricane Katrina. Volume 5. FHWA Contract Number DTFH61-98-00094. U.S. Department of Transportation, Federal Highway Administration. 158 p.

Padgett, J., P. DesRoches, B. Nielson, M. Yashinsky, O. Kwon, N. Burdette and E. Tavera. 2008. Bridge damage and repair costs from Hurricane Katrina. Journal of Bridge Engineering January/February 2008:6-14.

Rosel, P.E. and H. Watts. 2008. Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico. Gulf of Mexico Science 2008:88-94.

Schwacke, L.H., C.R. Smith, F.I. Townsend, R.S. Wells, L.B. Hart, B.C. Balmer, T.K. Collier, S. De Guise, M.M Fry, L.J. Guillette, Jr., S.V. Lamb, S.M. Lane, W.E. McFee, N.J. Place, M.C. Tumlin, G.M. Ylitalo, E.S. Zolman and T.K. Rowles. 2013. Health of common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the *Deepwater Horizon*, oil spill. Environmental Science and Technology 48:93-103.

Shane, S.H. 1990. Behavior and ecology of the bottlenose dolphin at Sanibel Island, Florida. Pages 245-265 *in* S. Leatherwood and R.R. Reeves (eds). The bottlenose dolphin. Academic Press, San Diego, California.

Sikora, W.B. and B. Kjerfve. 1985. Factors influencing the salinity regime of Lake Pontchartrain, Louisiana, a shallow coastal lagoon: analysis of a long-term data set. Estuaries 8:170-180.

Simpson, J.G. and M.B. Gardner. 1972. Comparative microscopic anatomy of selected marine mammals. Pages 298-418 i*n* S.H. Ridgeway (ed). Mammals of the sea: Biology and medicine. Charles C. Thomas Publishers, Springfield, Illinois.

Smolker, R.A., A.F. Richards, R.C. Connor and J.W. Pepper. 1992. Sex differences in patterns of associations among Indian Ocean bottlenose dolphins. Behaviour 123:38-69.

Urian, K.W., S. Hofmann, R.S. Wells and A.J. Read. 2009. Fine-scale population structure of bottlenose dolphins (*Tursiops truncatus*) in Tampa Bay, Florida. Marine Mammal Science 25:619-638.

USACOE. 2012. Mississippi River Gulf Outlet (MRGO) ecosystem restoration plan. Final feasibility report. Supplemental report to the Chief of Engineers in response to the Water Resources Development Act of 2007. U.S. Army Corps of Engineers New Orleans District 7400 Leake Avenue New Orleans, Louisiana 70118. 285 p.

USEPA. 1999. Ecological condition of estuaries in the Gulf of Mexico. EPA 620-R-98-004. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, Florida. 80 p.

Venn-Watson S., L. Garrison, J. Litz, E. Fougeres, B. Mase, G. Rappucci, E. Stratton, R. Carmichael, D. Odell, D. Shannon, S. Shippee, S. Smith, L. Staggs, M. Tumlin, H. Whitehead and T. Rowles. 2015. Demographic clusters identified within the northern Gulf of Mexico common bottlenose dolphin (*Tursiops truncatus*) unusual mortality event: January 2010 - June 2013. PLoS ONE 10(2): e0117248. doi:10.1371/journal.pone.0117248

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds). 2014. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2013. NOAA Technical Memorandum NMFS-NE-228.

Welch, H.L., and K.K. Barnes. 2013. Streamflow characterization and summary of water-quality data collection during the Mississippi River flood, April through July 2011: U.S. Geological Survey Open-File Report 2013–1106, 29 p., http://pubs.usgs.gov/of/2013/1106/.

White, J.R., R.W. Fulweiler, C.Y. Li, S. Bargu, N.D. Walker, R.R. Twilley and E. Green. 2009. Mississippi River flood of 2008: observations of a large freshwater diversion on physical, chemical and biological characteristics of shallow estuarine lake. Environmental Science and Technology 43:5599-5604.

Würsig, B. and M. Würsig. 1977. The photographic determination of group size, composition, and stability of coastal porpoises (*Tursiops truncatus*). Science 198:755-756.

Würsig, B. and T.A. Jefferson. 1990. Methods of photo-identification for small cetaceans. Reports of the International Whaling Commission Special Issue 12:43-52.

Table 1. Summary of bridges across eastern Lake Pontchartrain and its passes, the damage caused by Hurricane Katrina on 29 August 2005, the status of the bridge in 2014, and the clearance (*i.e.*, the height of the bridge above the water).

Bridge	**Katrina Damage[1] 29 Aug 2005**	**Status[2]**	**Clearance[3]**
Norfolk Southern Railroad Lake Pontchartrain	Bridge survived but sections of track washed off	Reopened 12 Sep 2005	1.2 m
U.S. Route 11 Lake Pontchartrain	Extensive - Functional but moveable span without electricity	Remained open (closed for repairs to Katrina damage Jan-May 2012)	3.8 m
I-10 Lake Pontchartrain Old Twin Span	Most spans displaced or dropped in water	Temporary repairs: Eastbound span opened, 14 Oct 2005; Westbound lane opened, 5 Jan 2006 Demolished in 2011	19.8 m (at bascule) 2.6 m (low deck)
I-10 New Twin Span	NA	Construction started 13 July 2006; Eastbound lane opened 9 July 2009; Westbound lane opened 7 April 2010; Completed 8 Sep 2011	22.3 m (at channel) 9.1 m (low deck)
U.S. Route 90 Rigolets Pass Old Fort Pike Bridge	Extensive - Movable span not functional	Reopened 7 Dec 2005 Demolished Oct 2008	4.54 m
U.S. Route 90 Rigolets Pass New Fort Pike Bridge	Extensive - Under construction	Completed 15 Jan 2008	20.1 m (at channel)
CSX Railroad Rigolets Pass	Closed to traffic	Reopened 31 Jan 2006	3.4 m (through swing bridge)
U.S. Route 90 Chef Menteur Pass	Extensive - Closed to traffic	Reopened 11 Aug 2006	3.1 m
CSX Railroad Chef Menteur Pass	Closed to traffic	Reopened 31 Jan 2006	3.1 m
Causeway Lake Pontchartrain	Some ramps and spans lost	Reopened 24 Sep 2005	4.6–15.2 m

1 - Chen *et al*. (2007), O'Connor and McAnany (2008), Padgett *et al*. (2008), Grenzeback and Lukmann (2009); 2 - Grenzeback and Lukmann (2009) and newspaper reports; 3 - Primary source: http://www.nauticalcharts.noaa.gov

Table 2. Summary of Lake Pontchartrain bottlenose dolphin surveys from May 2007 to April 2013. A letter indicates the sub-area (A–I; Figure 3) was transited or surveyed (dolphins sighted? – Yes/No; nr = not recorded). Barry *et al.* (2008) surveys are shaded.

Survey	Survey Date	Groups Sighted	No. Dolphins	A	B	C	D	E	F	G	H	I
1	5/9/2007	1	nr	N	Y		N	N				
2	5/22/2007	1	20	Y			N	N				
3	6/7/2007	1	25	Y			N	N				
4	6/21/2007	1	22	Y			N	N				
5	11/5/2007	2	30	Y			Y	N				
6	12/19/2007	1	30	Y			N	N				
7	3/28/2008	2	31	Y			Y	N				
8	4/28/2008	0		N	N		N	N				
9	4/29/2008	1	15	N	N		N	N	N	N	Y	
10	4/30/2008	4	27	N		Y	N	N	N	Y	Y	
11	5/1/2008	1	1	N		N	Y	N				
12	5/3/2008	4	52	Y		N	Y	Y				
13	5/4/2008	2	31	Y		N	N	Y				
14	5/5/2008	2	38	Y	N		N	Y				
15	5/6/2008	3	32	Y			N	N	N	N	Y	
16	5/7/2008	2	33	Y	N		N	N		Y		
17	5/9/2008	2	35	Y	N		Y	N	N	N	N	
18	5/10/2008	5	35	Y	N	N	Y	Y		Y		
19	6/6/2008	1	25	Y			N	N				
20	7/16/2008	2	42	Y			Y	N				
21	9/5/2008	1	35	Y			N	N				
22	11/5/2008	5	63	Y			N	Y	N	Y	Y	
23	12/16/2008	3	46	Y			N	Y		Y		
24	3/17/2009	5	59	Y			N	Y	N			
25	3/18/2009	3	13					Y	Y	N	Y	
26	4/22/2009	3	41	Y			N	N	N		Y	
27	4/23/2009	4	49	Y			N	Y		N		
28	8/25/2009	2	35	Y	N	N	N	N	N	N	Y	
29	8/26/2009	3	46	Y			N	Y	N			
30	1/13/2010	1	32	Y			N	N				
31	3/31/2010	2	5	N	N		N	N	N	N	Y	
32	4/1/2010	3	3	N	N		N	N	N	N	Y	
33	4/9/2010	3	5	N		N	N	N	N	Y	Y	
34	4/20/2010	5	6	N			N	Y	N	Y	Y	
35	4/21/2010	4	25							Y		Y
36	12/9/2010	1	6	N	N		N	N	N	Y	N	
37	4/30/2013	4	14	N	N		N	N	N	N	Y	

Table 3. Identified Target Area dolphins (*n* = 74) sighted from spring 2007 to spring 2010 (spring = Mar, Apr, May; summer = Jun, Jul, Aug; fall = Sep, Oct, Nov; winter = Dec, Jan, Feb; *n* = number of surveys). No dolphins were sighted in the Target Area during additional surveys conducted during winter 2010/11 (*n* = 1) and spring 2013 (*n* = 1).

Catalog ID	No. Days First to Last Sighting	No. Seasons Sighted	Spring 2007 *n* = 2	Summer 2007 *n* = 2	Fall 2007 *n* = 1	Winter 2007/08 *n* = 1	Spring 2008 *n* = 12	Summer 2008 *n* = 2	Fall 2008 *n* = 2	Winter 2008/09 *n* = 1	Spring 2009 *n* = 3	Summer 2009 *n* = 2	Fall 2009 *n* = 0	Winter 2009/10 *n* = 1	Spring 2010 *n* = 4
1000	980	11	■	■	■	■	■	■	■	■	■	■		■	
6005	980	10	■	■	■		■	■	■	■	■	■		■	
6007	980	9	■			■	■	■	■	■	■	■		■	
7000	980	10	■	■	■	■	■	■	■		■	■		■	
7001	980	10	■	■	■	■	■	■	■		■	■		■	
7002	980	10	■	■	■	■	■	■	■		■	■		■	
7003	980	10	■	■	■	■	■	■	■		■	■		■	
7011	980	10	■	■	■	■	■	■	■		■	■		■	
8001	980	10	■	■	■	■	■	■	■		■	■		■	
6003	967	9	■	■		■	■	■	■		■	■		■	
7007	967	10	■	■	■	■	■	■	■		■	■		■	
7009	967	10	■	■	■		■	■	■	■	■	■		■	
8004	967	10	■	■	■	■	■	■	■		■	■		■	
8005	967	11	■	■	■	■	■	■	■	■	■	■		■	
8006	967	10	■		■	■	■	■	■	■	■	■		■	
8007	967	10	■		■	■	■	■	■	■	■	■		■	
6006	951	8		■		■	■	■	■		■	■			
2000	840	9	■	■	■	■	■	■	■		■	■			
8003	840	9	■	■	■	■	■	■	■		■	■			
6002	827	9	■	■	■	■	■	■	■		■	■			
12004	811	8		■		■	■	■	■	■	■	■			
7008	796	9		■	■	■	■	■	■	■	■	■			
6001	715	9	■	■	■	■	■	■	■	■	■				
7006	678	8	■	■	■	■	■	■	■		■				
6060	656	7					■	■	■	■		■		■	
7020	614	7					■	■	■	■		■		■	
2001	587	8	■	■	■	■	■	■	■	■					
8002	587	7	■		■	■	■	■	■	■					
12003	558	2		■						■					
6000	546	6	■	■	■		■	■	■						
7005	546	7	■	■	■	■	■	■	■						
8021	546	5						■	■		■	■		■	
2002	533	7	■	■	■	■	■	■	■						
8009	533	5	■	■			■	■	■						
6018	516	5					■	■	■		■	■			
12006	516	6					■	■	■	■	■				
7027	495	3							■		■			■	
12007	491	6				■	■	■	■	■	■				

Catalog ID	No. Days First to Last Sighting	No. Seasons Sighted	Spring 2007 *n* = 2	Summer 2007 *n* = 2	Fall 2007 *n* = 1	Winter 2007/08 *n* = 1	Spring 2008 *n* = 12	Summer 2008 *n* = 2	Fall 2008 *n* = 2	Winter 2008/09 *n* = 1	Spring 2009 *n* = 3	Summer 2009 *n* = 2	Fall 2009 *n* = 0	Winter 2009/10 *n* = 1	Spring 2010 *n* = 4
7022	480	5													
8022	472	5													
1001	434	5													
1002	434	4													
6022	434	6													
6023	434	5													
7034	434	5													
7035	434	5													
8020	434	5													
6019	406	4													
7010	366	4													
8000	324	5													
8008	254	4													
6004	187	3													
7029	132	3													
6016	34	2													
12002	30	2													
3000	1	1													
7061	1	1													
7072	1	1													
7073	1	1													
12019	1	1													
6017	0	1													
6024	0	1													
7021	0	1													
7051	0	1													
7052	0	1													
7068	0	1													
7069	0	1													
8029	0	1													
12015	0	1													
12020	0	1													
12031	0	1													
12032	0	1													
12033	0	1													
12034	0	1													

Table 4. Summary statistics of field estimates of group size, calves and neonates, and physical environment data collected for each dolphin group sighting by sub-area (Figure 3) during Lake Pontchartrain surveys conducted from 2007 to 2013 (nr = not recorded, na = not applicable). (Field estimates were made within the first 10 minutes after sighting a group and before photos were collected.)

		Group Size		**Calves/group**		**Neonates/group**		**Water Temp. (°C)**		**Salinity (ppt)**		**Water Depth (m)**	
	No. Groups	***Mean (S.D.)***	***Range***	***Mean (S.D.)***	***Range***	***Mean (S.D.)***	***Range***	***Mean (S.D.)***	***Range***	***Mean (S.D.)***	***Range***	***Mean (S.D.)***	***Range***
Target Area													
A	24	29.5 (4.49)	20.0-40.0	1.4 (1.10)	0-3.0	1.3 (1.07)	0-3.0	22.6 (5.72)	6.4-30.8	4.8 (2.69)	1.4-9.2	3.8 (1.32)	2.1-6.9
B	1	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr
C	1	4.0 (na)	na	0	na	0	na	23.6	na	3.1	na	3.1	aa
Non-Target Area													
D	8	4.1 (2.23)	1.0-7.0	0	na	0	na	24.5 (3.83)	19.6-31.2	2.8 (1.47)	1.6-5.2	3.6 (0.54)	3.0-4.3
E	17	6.5 (4.68)	1.0-12.0	0.8 (0.86)	0-2.0	0	na	22.4 (3.56)	12.3-28.6	6 .0 (3.65)	1.6-13.6	10.6 (7.84)	2.4-25.3
F	1	1.0	na	0	na	0	na	20.4 (na)	na	6.1 (na)	na	1.9 (na)	na
G	10	2.6 (3.03)	1.0-10.0	0.1 (0.33)	0-1.0	0	na	20.1 (4.95)	10.3-25.2	4.5 (3.77)	1.9-12.7	9.6 (4.09)	10.0-17.0
H	22	4.2 (4.00)	1.0-15.0	0.3 (0.64)	0-2.0	0.1 (0.36)	0-1.0	21.1 (2.67)	17.3-29.0	3.3 (2.85)	1.2-9.5	17.8 (7.03)	9.8-31.0
I	3	8 (6.08)	1.0-12.0	1.3 (1.53)	0-3.0	0	na	22.5 (0.21)	22.3-22.7	4.4 (0.10)	4.3-4.5	2.3 (0.75)	1.5-3.0

Table 5. Summary of the number of individual bottlenose dolphins identified (No. ID) by sub-area (Figure 3) and the number of times individuals were resighted, and the number of individuals sighted in a sub-area only (yellow) or in multiple sub-areas (orange) during Lake Pontchartrain surveys conducted from 2007 to 2013 (na = not applicable). (The sum of the column and row for a sub-area equals the total number of dolphins identified in the sub-area.)

					No. of Resightings				**No. of Dolphins Identified**								
Sub-area	**No. of Surveys**	**First Date**	**Last Date**	**Total No. ID**	**>10x**	**6-10x**	**2-5x**	**1x**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
A	35	5/9/2007	4/30/2013	73	37	15	8	13	48	18	0	6	0	0	1	0	0
B	12	5/10/2007	5/1/2013	19	0	0	0	19		1	0	0	0	0	0	0	0
C	7	4/30/2008	4/9/2010	0	na	na	na	na			0	0	0	0	0	0	0
D	34	5/12/2007	5/3/2013	9	0	0	7	2				2	1	0	0	0	0
E	36	5/13/2007	5/4/2013	53	0	0	18	35					51	0	0	1	0
F	16	4/29/2008	5/5/2013	0	na	na	na	na						0	0	0	0
G	18	4/30/2008	5/6/2013	14	0	0	3	11							13	0	0
H	14	5/1/2008	5/7/2013	39	0	0	9	30								38	0
I	1	4/21/2010	4/21/2010	28	0	0	0	28									28

Table 6. Number of individual bottlenose dolphins with skin lesions sighted in the Target Area during three spring seasons from 2007 to 2009 and January 2010, and for individuals sighted in Non-target Areas (Figure 3) during any of the same seasons (na = not applicable).

	Target Area				Non-target Areas (Spr 2007-09 or Jan 2010)					
	Spr 2007	**Spr 2008**	**Spr 2009**	**Jan 2010**	**D**	**E**	**F**	**G**	**H**	**I**
Individuals Examined	34	51	49	36	2	44	na	6	42	28
No. with Lesions	32	49	47	35	2	42	na	6	29	19
Percentage with Lesions	94%	96%	96%	97%	100%	95%	na	100%	69%	32%

Table 7. Average total length (cm) of non-perinate (≥115 cm) male and female bottlenose dolphins stranded during the 2010–2014 Northern Gulf of Mexico UME (excluding Lake Pontchartrain) and those stranding in the Lake Pontchartrain area during 2010 and 2013 (*n* = number of strandings).

Northern GMx UME	**Females**	**Males**	**Unknown Sex**
mean (cm)	207.5	223.5	209.3
S.D.	37.63	43.11	42.66
Range	115-282	115-323	115-292
n	188	306	113
Lake Pontchartrain			
mean (cm)	217.2	223.9	190.7
S.D.	25.50	38.3	45.40
Range	168-252	152-300	135-244
n	21	15	11

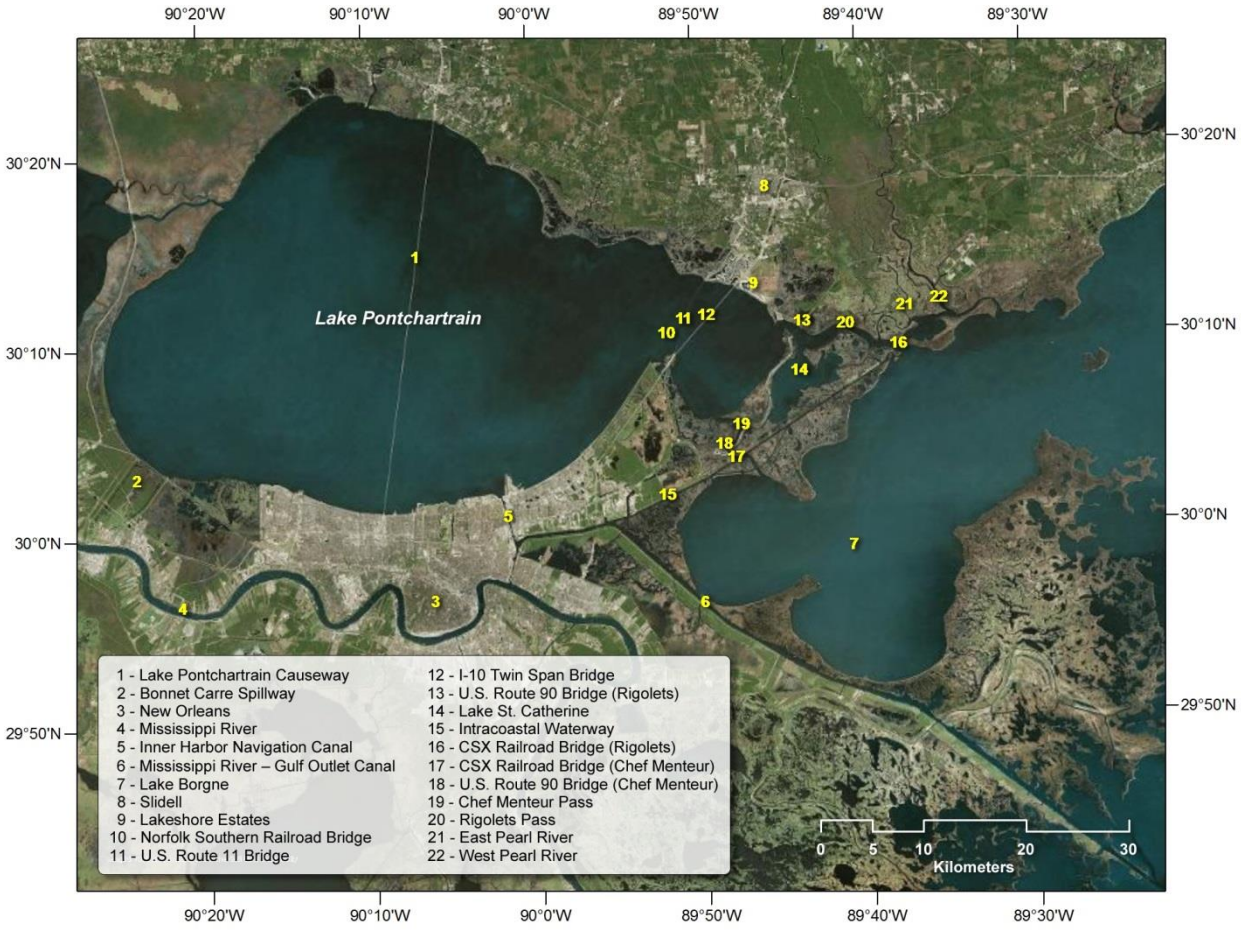

Figure 1. Map of the Lake Pontchartrain, Louisiana, region with locations referred to in the text.

Figure 2. The Norfolk Southern (NS) railroad bridge looking east from the Target Area (Figure 3). The support columns for the U.S. 11 bridge can be seen just beyond the NS bridge and the I-10 bridge is in the background.

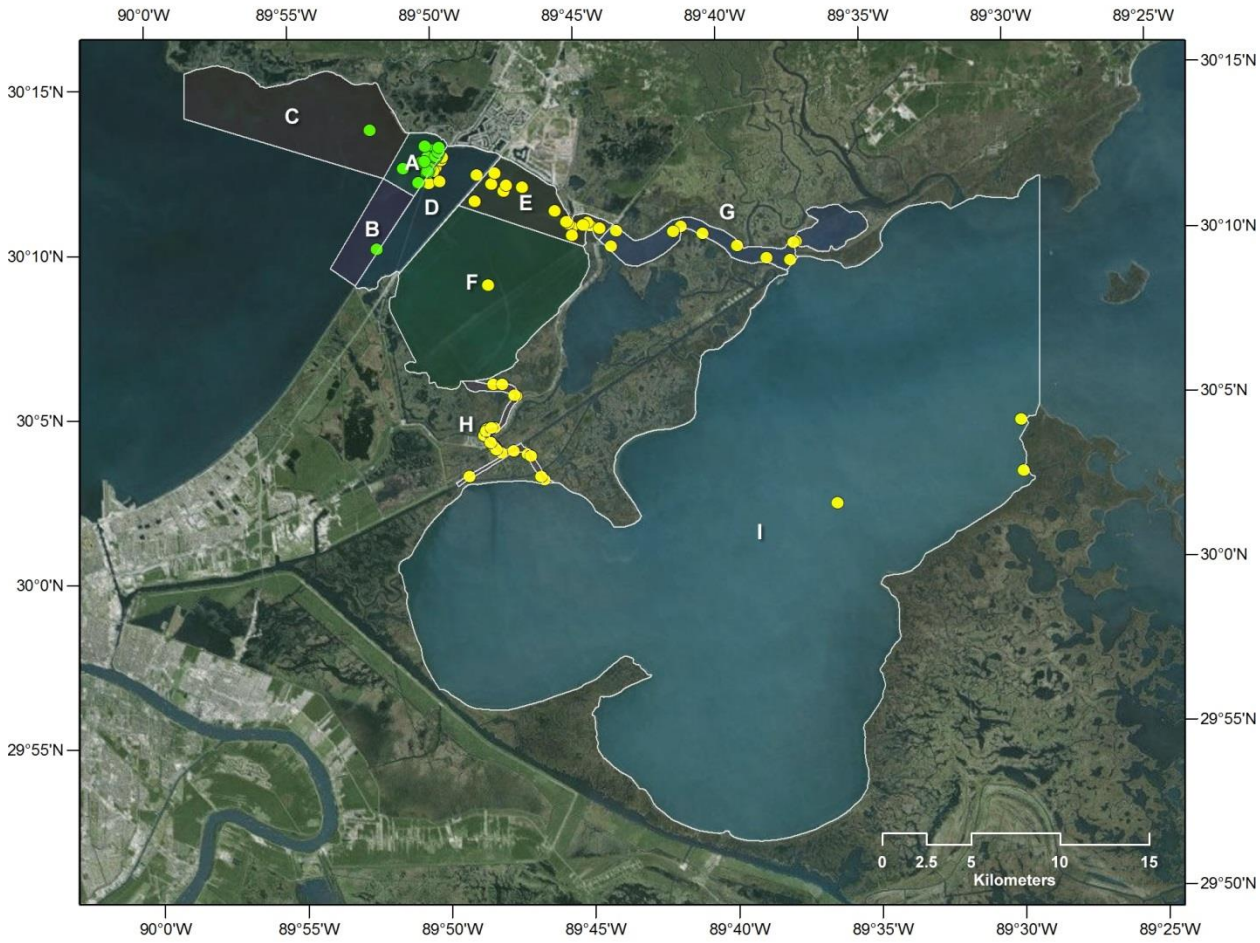

Figure 3. Sub-areas referred to in the text and bottlenose dolphin group sighting locations for the Target Area (green) and non-target areas (yellow) for eastern Lake Pontchartrain bottlenose dolphin surveys conducted from 9 May 2007 to 30 April 2013:

Target Areas

A – north along northwest Norfolk Southern (NS) railroad bridge

B – south along southwest NS railroad bridge

C – west of "A" along north shore

Non-target Areas

D – area between NS/U.S. 11 bridges and I-10 bridge

E – area between I-10 bridge and U.S. 90 bridge at Rigolets Pass

F – area between I-10 bridge and Chef Menteur Pass

G – Rigolets Pass between U.S. 90 bridge and CSX railroad bridge

H – Chef Menteur Pass

I – Lake Borgne

(Lake Saint Catherine - the body of water between F and I, was not surveyed because it is very shallow.)

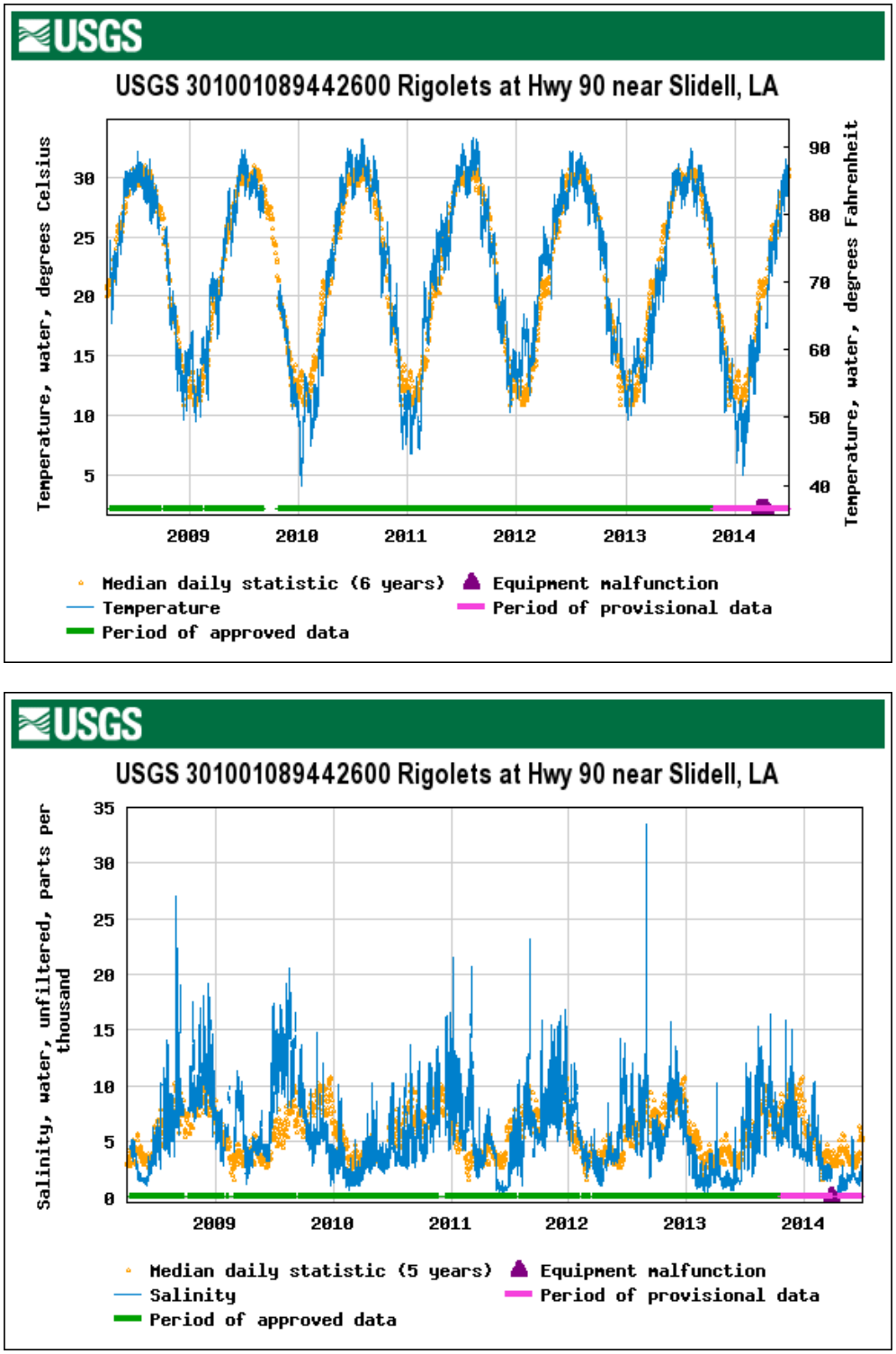

Figure 4. Water temperature (upper) and salinity (lower) at the USGS station in Rigolets Pass near U.S. 90.

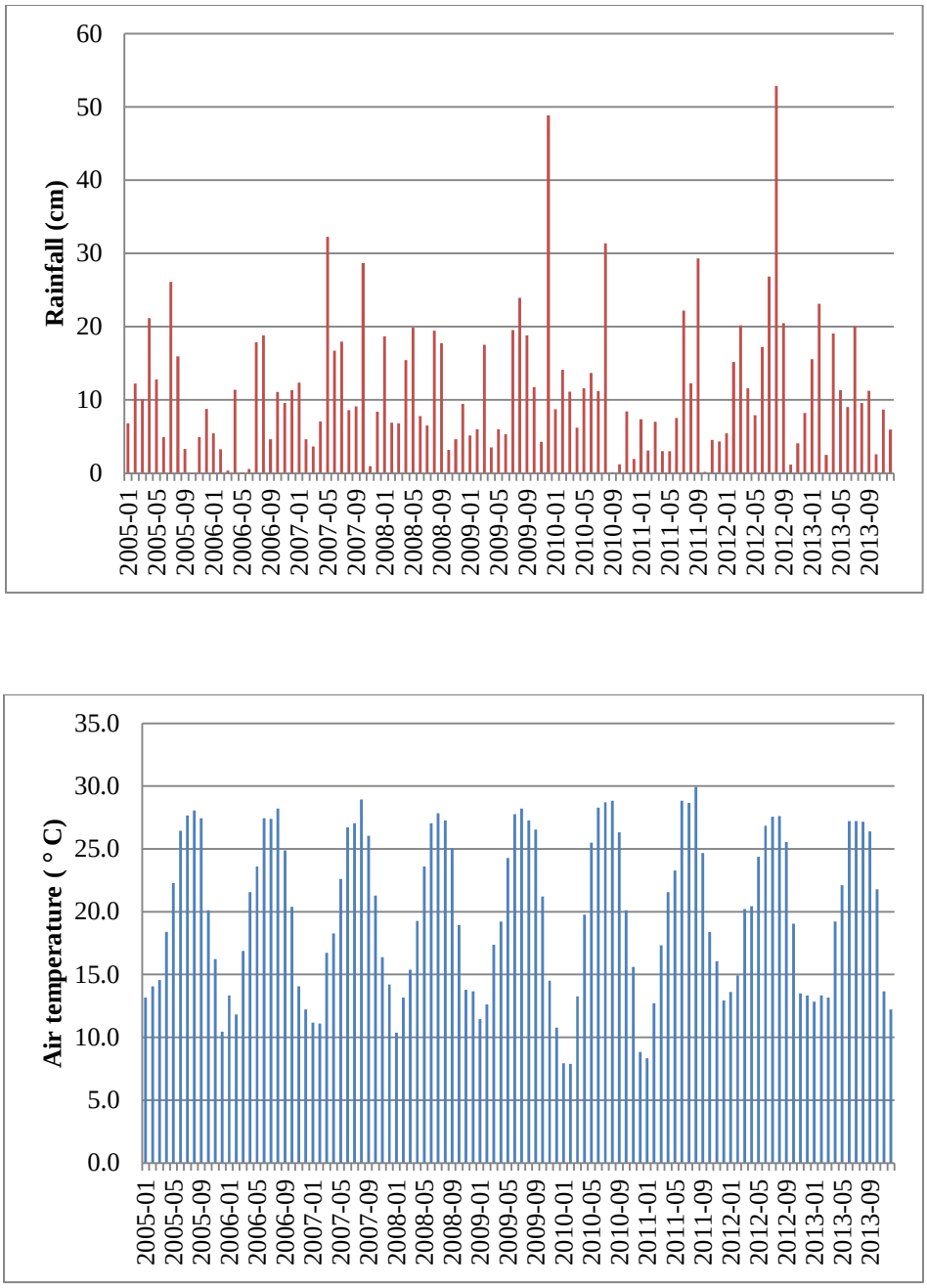

Figure 5. Monthly rainfall total (upper) and average air temperature (lower) at Slidell, Louisiana, from 2005–2013. Slidell is on the northeastern shore of Lake Pontchartrain (Figure 1).

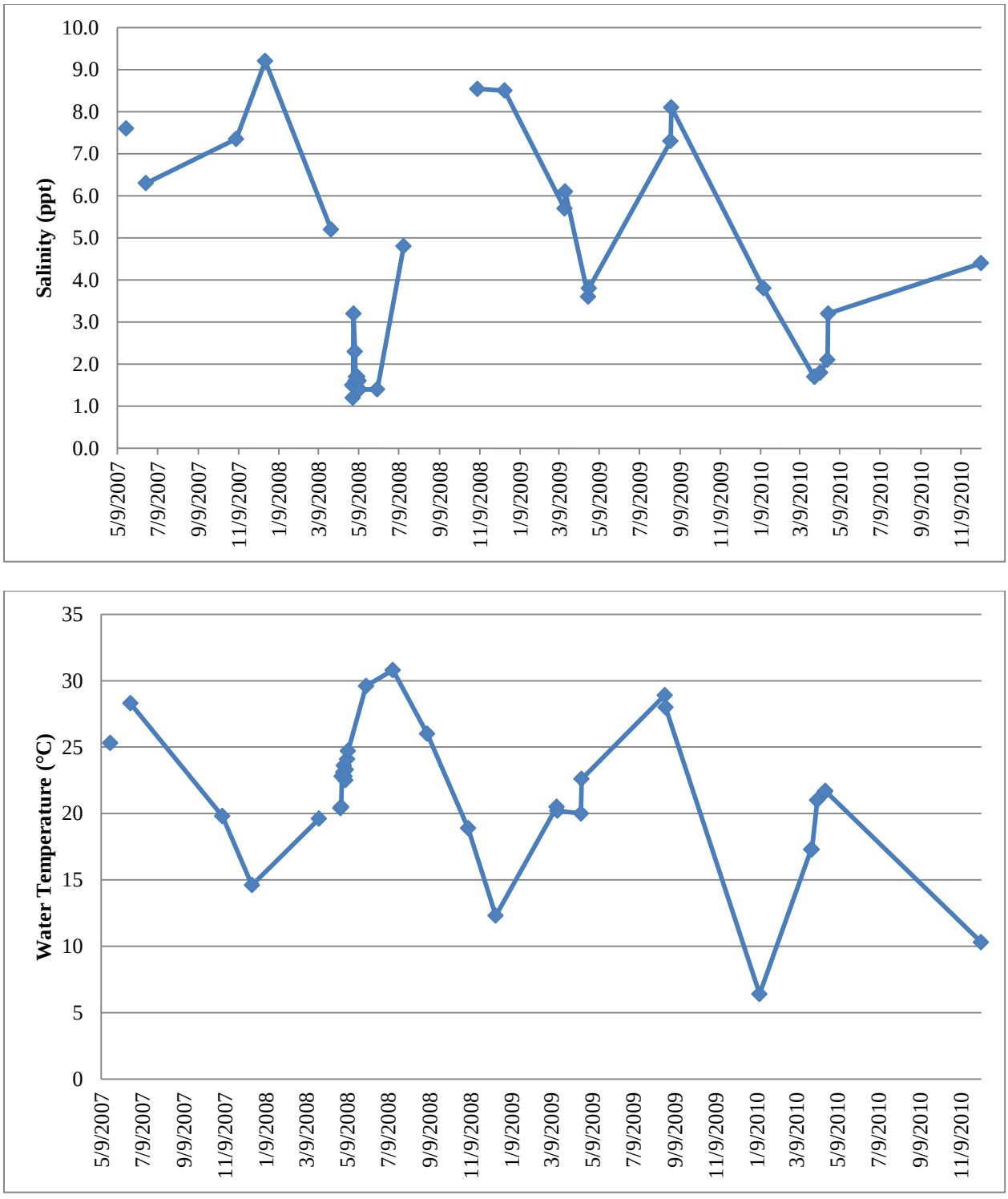

Figure 6. Minimum salinity (upper) and water temperature (lower) recorded during each Lake Pontchartrain bottlenose dolphin survey.

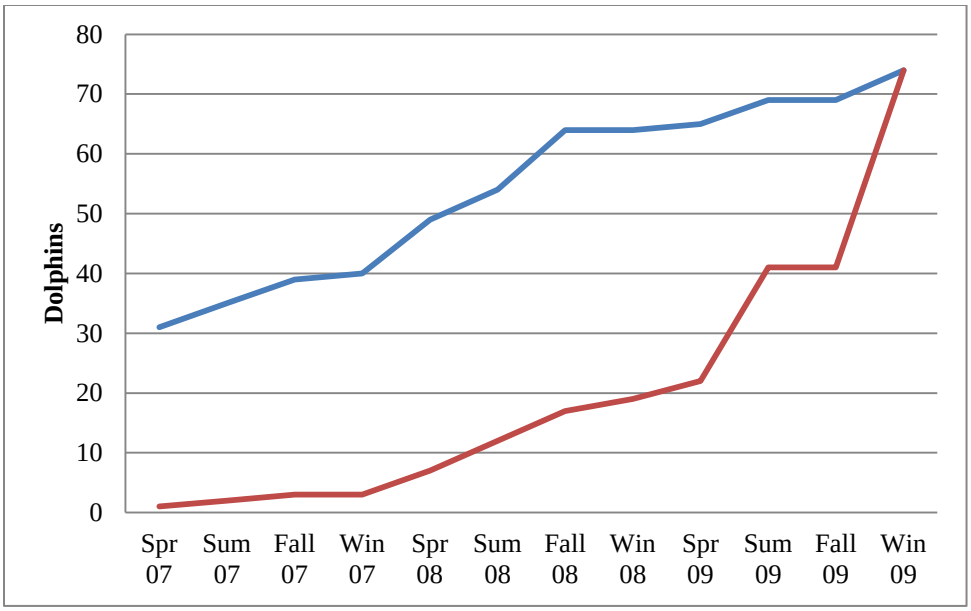

Figure 7. Discovery curve (blue) of identified bottlenose dolphins in the Target Area (Figure 3). A total of 74 individual dolphins were identified in the Target Area. The red (lower) line shows the number of identified dolphins that were not sighted again during subsequent seasons.

Figure 8. Examples of skin lesion types/stages observed on bottlenose dolphins during the Lake Pontchartrain surveys.

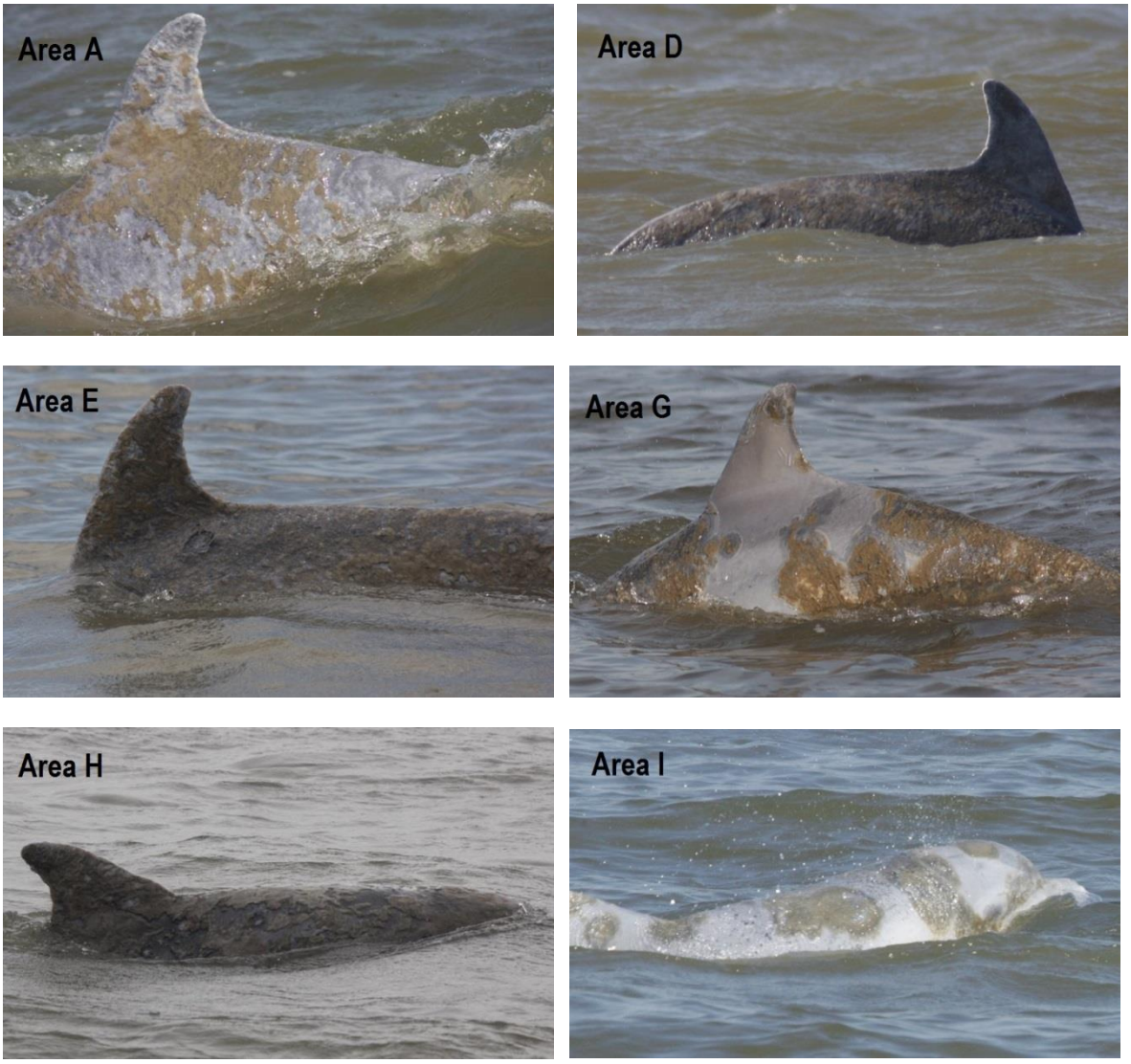

Figure 9. Example of an individual with severe skin lesions from each sub-area (Figure 3) that dolphins were sighted in (except area F) within the Lake Pontchartrain area.

09 May 2007 (not recorded)

10 May 2008 (25.4°C, 1.4‰)

05 November 2008 (19.9°C, 8.5‰)

17 March 2009 (20.5°C, 6.5‰)

Figure 10. Skin condition of bottlenose dolphin #7006 from the Target Area (Figure 3) on various dates, including water temperature and salinity conditions in Lake Pontchartrain, Louisiana.

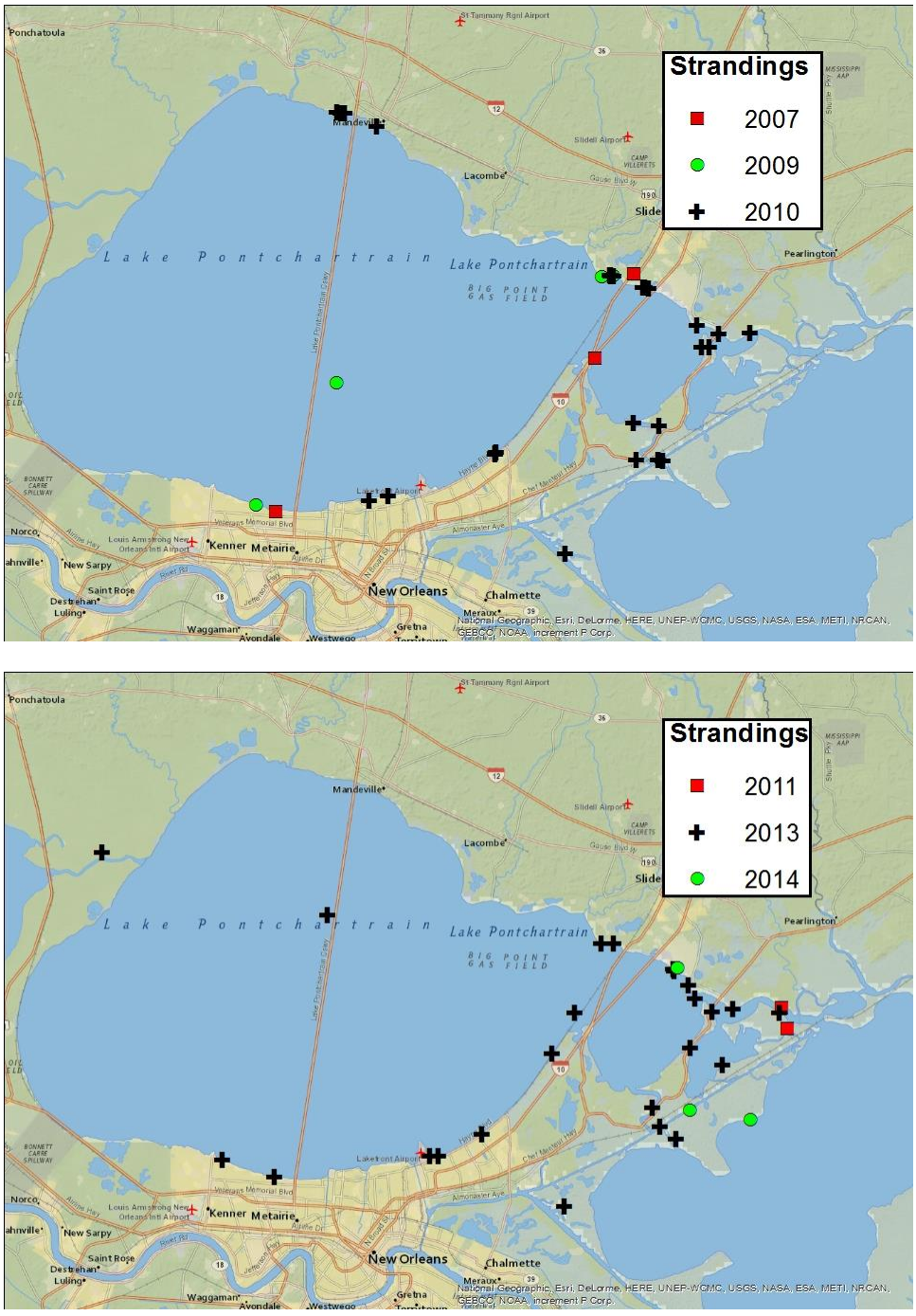

Figure 11. Locations of bottlenose dolphin strandings in the Lake Pontchartrain area from 2007 to 2014.

Appendix I.

Common bottlenose dolphin strandings in the Lake Pontchartrain area from May 1978 through June 2014 (*n* = 73). Unidentified cetaceans and dolphins were assumed to be bottlenose dolphins (M = male, F = female, Unk = unknown, Unid = unidentified, Y = yes, N = no).

Date	NMFS No.	Latitude	Longitude	Species ID	Code	Sex	Total Length (cm)	Necropsy	Date Necropsy	Dorsal Fin Match
5/3/1978	SEAN3233			Tursiops		M	244.0	N		No photo
4/21/1992	SE6866	30.3535	-90.0711	Unid cetacean	4	Unk		N		No photo
2/25/1993	SE7797	30.0368	-90.2287	Tursiops	3	Unk	228.6	N		No photo
11/21/1996	SE11895	30.1863	-89.7589	Tursiops	3	M	168.0	N		No photo
3/15/1997	SE12143	30.3232	-90.0392	Tursiops	3	F	236.0	Y	3/22/1997	No photo
3/18/1997	SE12142	30.2237	-89.8190	Tursiops	3	Unk		N		No photo
7/11/2004	SER04-525	30.1801	-89.5578	Tursiops	2	Unk		N		No photo
4/13/2007	SER07-457	30.0219	-90.1783	Tursiops	3	M	213.4	N		No photo
4/20/2007	SER07-308	30.1547	-89.8561	Tursiops	3	M	202.0	Y	4/20/2007	No photo
4/25/2007	SER07-458	30.2258	-89.8147	Tursiops	4	M	274.3	N		No photo
3/12/2009	SER09-0122	30.2238	-89.8468	Tursiops	3	M	254.0	Y	3/12/2009	No photo
3/18/2009	SER09-0123	30.1914	-89.8156	Tursiops	2	Unk	91.4	Y	3/18/2009	No photo
4/2/2009	SER09-0126	30.2245	-89.8360	Tursiops	2	M	251.5	Y	4/2/2009	No photo
4/16/2009	SER09-0349	30.0255	-90.1941	Tursiops	3	F	208.3	Y	4/16/2009	No photo
4/17/2009	SER09-0391	30.0255	-90.1935	Tursiops	3	M	180.3	Y	4/17/2009	No photo
4/26/2009	SER09-0348	30.1767	-89.6864	Tursiops	2	Unk	134.6	N		No photo
2/15/2010	SER10-0375	30.0336	-90.0613	Tursiops	4	Unk	92.7	N		No photo
3/12/2010	SER10-0377	30.3658	-90.1048	Tursiops	3	F	210.8	Y	3/12/2010	Match #7020
3/12/2010	SER10-0378	30.3658	-90.1048	Unid Cetacean	6	Unk	182.9	N		No photo
3/15/2010	SER10-0379	30.3660	-90.1081	Tursiops	4	F	228.6	N		Poor quality
3/15/2010	SER10-0381	30.3668	-90.1120	Tursiops	4	F	251.5	N		Poor quality
3/16/2010	SER10-0417	30.2141	-89.7996	Tursiops	4	M	257.8	N		Poor quality
3/19/2010	SER10-0386	30.1632	-89.7458	Unid Dolphin	4	Unk	243.8	N/A		No photo
3/22/2010	SER10-0388	29.9835	-89.8836	Tursiops	4	M	243.8	N		No photo
3/22/2010	SER10-0385	30.2150	-89.8047	Tursiops	4	F	210.8	N		No photo
3/22/2010	SER10-0384	30.2244	-89.8372	Tursiops	4	F	236.2	N		Poor quality
3/22/2010	SER10-0387	30.3543	-90.0727	Tursiops	4	F	208.3	N		Poor quality
3/23/2010	SER10-0698	30.0967	-89.8143	Tursiops	3	Unk		N		No photo
3/25/2010	SER10-0393	30.2255	-89.8382	Tursiops	6	F	167.6	N		No photo
3/27/2010	SER10-0395	30.1743	-89.7288	Tursiops	5	F	195.6	N		No photo
3/28/2010	SER10-0396	30.0703	-89.9533	Tursiops	4	M	152.4	N		No photo
3/30/2010	SER10-0394	30.1628	-89.7386	Tursiops	5	F	243.8	N		No photo

Date	NMFS No.	Latitude	Longitude	Species ID	Code	Sex	Total Length (cm)	Necropsy	Date Necropsy	Dorsal Fin Match
3/30/2010	SER10-0392	30.2147	-89.8029	Tursiops	4	M	243.8	N		No photo
4/1/2010	SER10-0412	30.0647	-89.8114	Tursiops	3	M	243.8	N		No photo
4/1/2010	SER10-0709	30.0648	-89.7901	Tursiops	3	F	228.0	N		No photo
4/1/2010	SER10-0413	30.0949	-89.7893	Tursiops	5	F	243.8	N		No photo
4/2/2010	SER10-0846	30.0707	-89.9531	Tursiops	4	Unk	152.4	N		No photo
4/4/2010	SER10-0424	30.2241	-89.8342	Tursiops	4	F	228.6	N		No photo
4/6/2010	SER10-0423	30.1814	-89.7511	Tursiops	4	F	226.1	N		Poor quality
4/7/2010	SER10-0428	30.0644	-89.7850	Tursiops	3	Unk	213.4	N		No photo
4/13/2010	SER10-0696	30.0300	-90.0796	Tursiops	4	Unk	135.0	N/A		No photo
4/16/2010	SER10-0426	30.2252	-89.8375	Tursiops	4	F	243.8	N		No match
5/12/2010	SER10-0684	30.0718	-89.9521	Tursiops	3	Unk	241.3	N		Poor quality
9/4/2010	SER10-0613	30.1754	-89.6974	Tursiops	2	F	212.1	Y	9/8/2010	No match
1/10/2011	SER11-0066	30.1687	-89.6664	Tursiops	4	M	198.1	N/A		No photo
10/5/2011	SER11-2451	30.1509	-89.6608	Tursiops	3	M	170.2	Y	12/8/2011	No photo
3/11/2013	SER13-0100	30.1342	-89.7575	Tursiops	3	M	204.5	Y	3/12/2013	No match
3/17/2013	SER13-1053	30.2243	-89.8349	Tursiops	2	F	233.5	Y	9/23/2013	No match
3/26/2013	SER13-0518	30.3034	-90.3481	Tursiops	4	Unk	228.6	Y	4/5/2013	No match
3/29/2013	SER13-0308	30.1654	-89.7361	Tursiops	3	M	191.5	Y	4/1/2013	No match
4/1/2013	SER13-0309	30.0547	-89.7715	Tursiops	4	F	177.0	Y	4/2/2013	No match
4/2/2013	SER13-0375	30.0403	-90.0103	Unid Cetacean	6	Unk		N/A		Poor quality
4/6/2013	SER13-0519	30.0368	-90.2276	Tursiops	4	F	170	Y	4/9/2013	Poor quality
4/8/2013	SER13-0382	30.0825	-89.7955	Unid Dolphin	3	Unk	137	N/A		No photo
4/8/2013	SER13-0515	30.1675	-89.715	Tursiops	3	F	209.8	Y	4/8/2013	Not distinct
4/8/2013	SER13-0468	30.2246	-89.8474	Tursiops	4	M	182.9	Y	4/9/2013	Poor quality
4/9/2013	SER13-0313	30.1884	-89.7596	Tursiops	4	M	205.8	N		Not distinct
4/10/2013	SER13-0321	30.0404	-90.0194	Tursiops	4	M	260	Y	4/10/2013	Poor quality
4/23/2013	SER13-0385	30.0222	-90.1746	Tursiops	4	M	208.3	N		No photo
4/27/2013	SER13-0405	30.0594	-89.9672	Tursiops	4	M	254.3	Y	4/29/2013	Not distinct
4/28/2013	SER13-0466	30.2006	-89.7739	Unid Dolphin	4	Unk	137	N/A		No photo
4/29/2013	SER13-0471	30.1189	-89.7254	Tursiops	4	F	190.3	N		No match
4/29/2013	SER13-0461	30.1642	-89.8732	Unid Dolphin	3	Unk	243.8	N/A		Poor quality
4/29/2013	SER13-0455	30.1768	-89.7532	Tursiops	2	F	103.8	Y	4/30/2013	Neonate
4/29/2013	SER13-0464	30.202	-89.7745	Tursiops	4	M	186.3	N		No match
4/30/2013	SER13-0406	30.0655	-89.7882	Tursiops	4	F	248.3	Y	4/30/2013	Match #7043
5/8/2013	SER13-0512	30.1289	-89.896	Tursiops	4	M	223.1	Y	5/13/2013	Poor quality
5/20/2013	SER13-0762	30.1642	-89.668	Tursiops	4	M	299.7	N		Poor quality
5/23/2013	SER13-0787	30.2495	-90.1216	Unid Dolphin	3	Unk	182.9	N/A		Poor quality
5/24/2013	SER13-1268	29.9968	-89.8844	Unid cetacean	6	Unk		N/A		No photo

Date	NMFS No.	Latitude	Longitude	Species ID	Code	Sex	Total Length (cm)	Necropsy	Date Necropsy	Dorsal Fin Match
4/23/2014	SER14-00801	30.0717	-89.6975	Tursiops	4	Unk	94			No photo
5/20/2014	SER14-00802	30.0801	-89.7586	Tursiops	2	M	135		5/20/2014	Not distinct
6/15/2014	SER14-00668	30.1996	-89.7663	Tursiops	4	M	224	N		No match