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SHORT PAPERS AND NOTES

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HURRICANE IMPACTS ON BOTTLENOSE DOLPHINS IN THE NORTHERN GULF OF MEXICO.—The impacts of hurricanes on marine mammals are not well described (but see Langtimm and Beck, 2003; Marsh, 1989). However, a variety of long- and short-term effects are possible. In the long term, populations may be impacted by decreased survival probability (Langtimm and Beck, 2003), habitat degradation, decreased prey availability or abundance, damage to critical habitats, and/or potential long-term health effects. Direct, immediate impacts may include injury, displacement, and even death (Langtimm and Beck, 2003; Marsh, 1989), where displacement (or “out of habitat”) refers to an animal that is out of its normal distributional and/or habitat range and would most likely perish because of surrounding environmental factors and resource limitations, e.g., an ice seal in the Caribbean or a bottlenose dolphin in a freshwater canal. In the southeastern United States, there are few records of dolphins displaced out of their typical habitat after hurricanes. A review of the National Oceanic and Atmospheric Association (NOAA) Southeast Regional Marine Mammal Stranding Database (1990–2001) and the NOAA National Marine Mammal Health and Stranding Response Database (2002–2004) found one posthurricane out-of-habitat dolphin event, and this event was attributed to animals caught behind a levy after it was repaired posthurricane. There are reports in the database of dead animals stranded on beaches after hurricanes, but it is not possible to directly correlate those events to hurricanes and none were considered out of habitat. In contrast, the hurricane season of 2005 saw an unprecedented number of displaced, out-of-habitat dolphins along the U.S. Gulf of Mexico coast, particularly in Louisiana.

On 24 Sept. 2005, the southwest Louisiana coast was hit by Hurricane Rita, a Category 3 hurricane on the Saffir–Simpson scale with sustained winds of 193 km/hr at landfall. Prior to landfall this hurricane was one of the most powerful hurricanes on record, reaching Category 5 status on 21 Sept. 2005 and remaining as such for approximately 18 hr (Knabb et al., 2006). Rita was accompanied by a storm surge of approximately 4.6 m above mean sea level (MSL) in Cameron Parish, LA (southwestern-

most coastal county) and 2.4–3.7 m above MSL in adjacent Vermilion Parish, LA (Knabb et al., 2006). Because of the extremely low elevational change and the numerous bayous, canals, and waterways, the storm surge moved inland a considerable distance in southwest Louisiana, reaching Interstate 10 (about 46 km from the Gulf coast) in Lake Charles, LA (Knabb et al., 2006).

During the 4 wk following Hurricane Rita (25 Sept.–23 Oct. 2005), there were six reports of bottlenose dolphins (*Tursiops truncatus*) trapped in inland areas in southwest Louisiana (five in Cameron Parish and one in Vermilion Parish; Fig. 1). A seventh dolphin was reported in March 2006 in Vermilion Parish, more than 5 mo after the hurricane. These out-of-habitat dolphins were found in a variety of locations, including flooded roadside ditches, borrow pits (long narrow ditches dug to provide material for adjacent roadbed), larger canals, shallow flooded fields, and a natural creek area (Fig. 2). After surveying the areas visually accompanying each encounter and through analysis of satellite imagery, we believe that in all cases the animals were carried inland on the storm surge accompanying the hurricane and left stranded in areas that held water longest as waters receded. Although the 3.1–4.6-m surge dissipated as it moved inland, it left behind vast areas of flooded land that were very slow to drain, leaving ditches, canals, channels, and cattle-grazing fields covered in water of depths of 0.6–1.8 m. By Jan. 2006, many of the inland fields and marshes had still not completely drained. Locations of out-of-habitat dolphins ranged from 2.5 to 11 km inland from the coast of the Gulf of Mexico and salinities of the various locations were estimated to be between 10 and 15 parts per thousand (ppt).

All seven out-of-habitat dolphins were alive when originally reported. Stranding personnel from the Texas Marine Mammal Stranding Network and NOAA Fisheries responded to each report. Each live-stranded animal was initially evaluated for condition. At a minimum, the following characteristics were assessed: demeanor (struggling, alert, unresponsive), body condition (poor: muscles concave, visible neck; moderate: muscles slightly rounded/flat; good: muscles convex/rounded), skin condition (smooth, wrinkled, peeling) and tone (firm, spongy, very spongy), breath rate and quality (shallow, weak, explosive), eye condition (open, closed, cloudy, discharge), and obvious trauma or skin damage. In addition, the conditions of

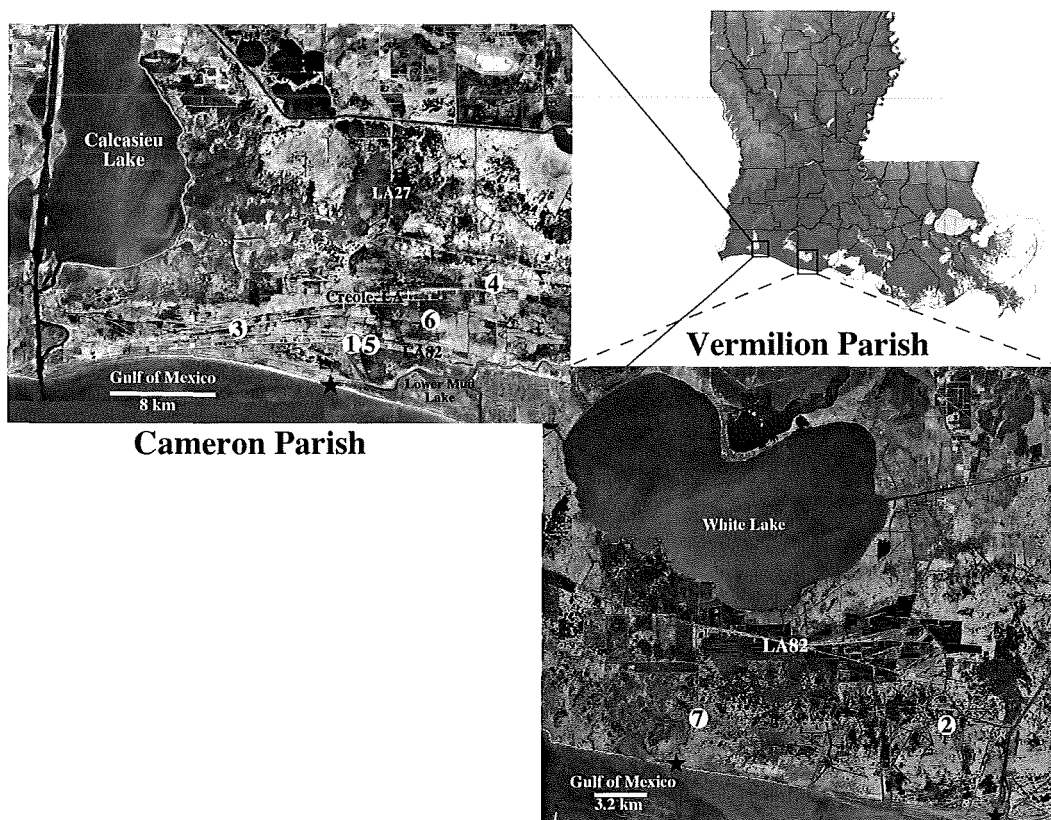


Fig. 1. Locations of the seven bottlenose dolphins stranded in Cameron and Vermilion parishes by storm surge from Hurricane Rita. Numbers refer to dolphins in the order in which they appear in Table 1. Black stars identify release sites.

the habitat each animal was confined to (water depth, salinity, water quality, food availability, and access to the Gulf of Mexico) were also evaluated. All animals were confined (i.e., no direct access to the Gulf of Mexico) in areas of low water quality. All salinities were less than or equal to 15 ppt. In most cases, debris was present in the water, most blown or washed in by the hurricane. Debris included lawn mowers, sections of barbed wire fence, large sections of corrugated metal roofing, and other items that could injure an animal. In addition, waters contained dead, decaying animals (deer, birds, fish) and most had visible sheens of oil on the surface. Natural food availability was deemed poor for all but one animal. As a result of these poor habitat conditions and a low survival probability under these conditions, and the lack of available rehabilitation facilities in the region, the decision was made to capture and release the animals into the Gulf of Mexico. Six were captured and released and one died on site before the capture team was able to respond (Table 1). Captured animals were examined

externally and photographed, and two were fitted with Roto-tags on their dorsal fins. The dolphins were transported to the coast by helicopter, pickup truck, military Humvee, or flat-bottomed boat, where they were then carried in a stretcher out into the water. All animals were released into the Gulf of Mexico in 1 to 1.5 meters of water.

The first dolphin (LA01) was reported 25 Sept. 2005, one day after landfall, in a roadside ditch near Creole, Cameron Parish, LA, 4.0 km from the coastline. The ditch was approximately 18×24 m with a maximum water depth of 1.2 m (Fig. 2). This large male was actively swimming, mainly in circles, and breathing regularly, with respiration rates ranging between 1.2 and 1.8 breaths/min (bpm; estimated by counting the number of breaths over a 5-min period and then dividing by five to obtain number of breaths per minute). Although feeding behavior was not observed, small fish were sighted swimming in the ditch. The animal was in good body condition (as defined above); the skin was firm and smooth and no skin lesions were seen. This

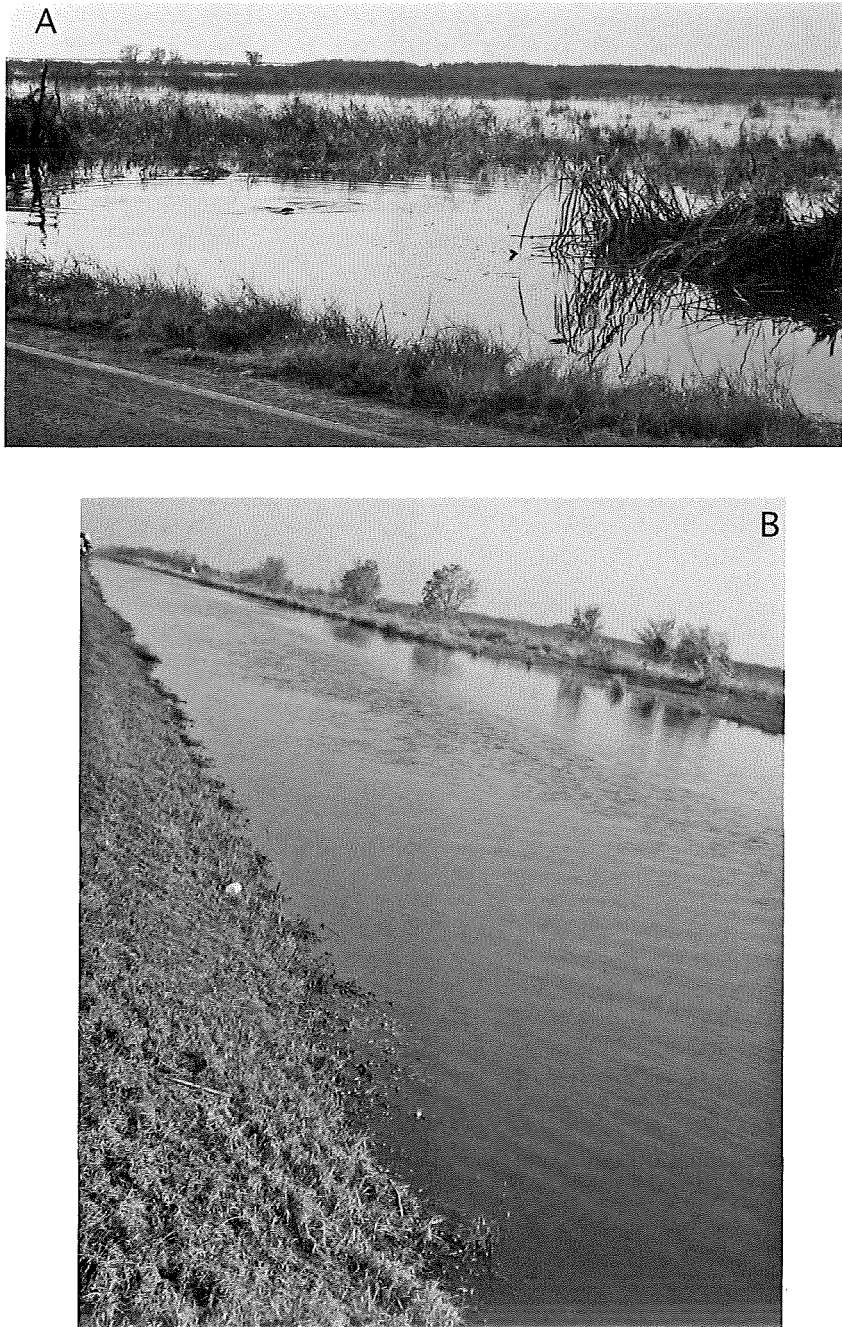


Fig. 2. Examples of areas where out-of-habitat dolphins were trapped: (A) roadside ditch where LA01 was found, and (B) canal-like borrow pit where LA03 was found. In (A) the dolphin could not cross the grassy berm and remained in the open water in the foreground. It can be seen breaking the surface near the center of the ditch.

dolphin was the largest of the six recovered. With the help of a U.S. Coast Guard helicopter and the National Guard, it was airlifted to the coast and released into the Gulf of Mexico. The

animal was observed interacting with a group of bottlenose dolphins within minutes after release. The second dolphin (PER001) was reported on 11 Oct. 2005 and captured and released on 13

TABLE 1. Capture data for seven out-of-habitat dolphins in southwest Louisiana after Hurricane Rita. Numbers in first column correspond to locations in Figure 1. Days out of habitat measured as number of days between hurricane landfall and dolphin release (or death) date. Distance from coastline was approximated as the distance due south (of the capture location) to the Gulf of Mexico shoreline using the Louisiana Department of Natural Resources Strategic Online Natural Resources Information System (SONNRIS) interactive geographic information system website at http://sonnriss-www.dnr.state.la.us/www_root/sonnriss_portal_1.htm. Water depths also approximate. N/A, not applicable.

Animal ID	Date recovered	Gender	Body length (cm)	Capture location	Release location	Days out of habitat	Salinity, ‰	Water depth (m) at deepest point	Distance from coastline (km)
1 LA01	29 Sept. 2005	Male	244	29°46.8'N/93°6.6'W	29°45.6'N/93°7.2'W	6	N/A	1.2	4.0
2 PER001	13 Oct. 2005	Male	199	29°34.8'N/92°19.8'W	29°32.4'N/92°18.6'W	20	15	2.2	5.3
3 LA02	16 Oct. 2005	Male	184	29°47.4'N/93°11.4'W	29°45.6'N/93°7.2'W	23	10.2	0.91	2.4
4 LA03	18 Oct. 2005	Female	199	29°49.8'N/92°59.4'W	29°45.6'N/93°7.2'W	25	10.9	2.0	10.9
5 LA04	18 Oct. 2005	Male	200	29°46.8'N/93°6.0'W	29°45.6'N/93°7.2'W	25	14.2	0.91	4.0
6 LA05	22 Oct. 2005	Male	213	29°47.4'N/93°3.0'W	Deceased	29	N/A	0.91	5.8
7 LA06	13 March 2006	Male	222	29°36.0'N/92°31.8'W	29°34.2'N/92°32.4'W	171	12.3	2.44	3.1

Oct. 2005. This male was found in a borrow pit along a dirt road near Freshwater Bayou, Vermilion Parish, LA, approximately 5.3 km from the coast. The borrow pit was 15 × 100 m in size with a maximum depth of approximately 2.2 m, and it narrowed at each end creating a section of water only 1.8 m wide and 0.6–0.9 m deep before opening back up into another pit. The dolphin would not cross these shallow areas, which facilitated its capture using a net. This animal was observed attempting to feed on either small fish or crayfish and at one point threw a small fish ahead of it on the surface of the water. Despite the observed feeding behavior, this animal was determined to be in poor condition. It was emaciated, exhibiting indentation between the head and body indicative of nuchal fat atrophy (Cox et al., 1998), and breath rates were 3.8 bpm. In addition, the skin on the tail flukes and pectoral fins had been affected; it was granular, slimy, and very spongy (Fig. 3) and would slough off when touched. Skin lesions were not observed elsewhere on the body of the animal.

A male bottlenose dolphin (LA02) was reported on 15 Oct. 2005 in Cameron Parish, LA, approximately 2.4 km inland in a very shallow (deepest point approximately 0.9 m), stagnating ditch alongside a state highway. The stagnant water had an oily substance on its surface. There was no need to use a net to catch the animal, as the area was so small. The animal was slightly emaciated, showing some indentation between the head and body; the breath rate was 3 bpm; and the skin was in good condition (smooth, firm, no lesions). It was recovered and released on 16 Oct. 2005.

On 14 Oct. 2005, a fourth animal (LA03) was reported near Little Chenier, Cameron Parish, LA, 10.9 km inland from the Gulf of Mexico; it was responded to on 18 Oct. 2005. This female was found in a long canal approximately 21 m wide and 1.6 km long (Fig. 2). Water conditions in this canal were poor. The water was turbid, contained many dead fish and other animals (birds, deer), and had a light sheen of oil on the surface. Maximum water depth in the center of the canal was at least 2 m, providing space for this animal to maneuver and feed. The animal was somewhat emaciated and exhibited nuchal fat loss, but otherwise appeared to be swimming strongly with a breath rate of 2 bpm. Skin lesions were not observed and the skin was firm and smooth. The animal was captured using a net and released on 18 Oct. 2005 with a Roto-tag (red 163) placed on the dorsal fin.

On the same day, a male dolphin (LA04) was captured near Creole, Cameron Parish, LA. This



Fig. 3. Dolphin fluke with skin condition. The condition was confined to the flukes and pectoral fins. Note skin on tail stock is not affected.

animal was found in a flooded field several hundred meters square and 4.0 km from the coast. Although the area of water was large, it was shallow, with water depths of less than 0.9 m. This dolphin was having difficulty pushing through some areas, possibly bottoming out as it attempted to swim through the thicker grass clumps. Despite swimming in the shallow area, no skin lesions or abrasions were visible. This water was dark and stagnant with areas of oily sheen on the surface. The shallow nature of this area precluded the use of the capture net and instead the animal was herded towards a grassy bank using a line of people spaced arm-width apart. The animal was alert and had good breathing quality with a respiration rate that ranged between 1.0 and 2.0 bpm throughout the entire capture, transport, and release.

The sixth animal (LA05) was reported on 20 Oct. 2005, nearly one month after Hurricane Rita made landfall. This male dolphin was alive when it was first discovered, but was dead 2 d later when the rescue was attempted. It was found in a canal approximately 12 m wide with a maximum water depth of 0.9 m. The canal was located next to a gravel road in the middle of an oil field and ran approximately 5.8 km. The body condition was one of severe emaciation, indicating that the animal had not been able to feed. It was necropsied on site and buried on the beach.

After 20 Oct. 2005 there were no further reports of out-of-habitat dolphins in Cameron or Vermilion parishes. In addition, no dead animals were reported in ditches or fields after waters receded. However, on 13 March 2006, a bottlenose dolphin (LA06) was reported trapped in a small (<30 m wide) creek draining Rollover Lake in the Rockefeller State Wildlife Refuge in Vermilion Parish, LA, 3.1 km from the coast. The animal would not pass over a water control device that stretched across the creek. Initial observations describe the animal as swimming up to the control device, stopping and then turning around, swimming back up the bayou 30–40 m and then turning around back towards the device, repeatedly. This behavior was observed on the day of the capture as well. The 222-cm male appeared to be in excellent body condition suggesting its ability to feed regularly and had a breath rate of 2 bpm and no skin lesions. In contrast to the previous six dolphins, this animal was found in a natural waterway with daily tidal flushing, although salinity was only 10 ppt at the time of capture (the tide was going out). Although it is possible this animal became trapped more recently than post-Rita, the only way for it to get in was over the metal barricade that it refused to cross to get out, or to have been carried inland by storm surge and subsequently trapped. If the latter, the fact that it was a clean, natural waterway with apparently sufficient prey

resources may have allowed it to survive so much longer than the other animals. This animal was captured using a net, fitted with a Roto-tag (yellow 320) and transported by flat-bottom boat 3.2 km down the waterway to the Gulf of Mexico.

What can we learn from the experiences with these out-of-habitat dolphins? First, although perhaps not a common result of hurricanes in the southeastern United States, these out-of-habitat dolphins provide evidence that hurricanes, and particularly the storm surge which may accompany them, can impact coastal bottlenose dolphins and should not be discounted. Second, despite low salinities and poor water quality, animals were able to survive for as many as 3 wk in these conditions. Mase-Guthrie et al. (2005) list four dolphins surviving in even lower salinity conditions (0 to 5 ppt), including at least one case for 3 wk. None of the animals discussed were described as emaciated although some had skin lesions (Mase-Guthrie et al., 2005), in contrast to the post-Rita dolphins, in which five of the seven exhibited signs of emaciation and only one showed evidence of skin lesions. Interestingly, six of the seven animals were males, and five of those were smaller than the asymptotic length for males estimated from Sarasota Bay, FL (Read et al., 1993), suggesting they were young males.

Given the number of animals affected by storm surge as a result of Hurricane Rita, efforts should be made to prepare for future events. Most reports of out-of-habitat animals were received from support people returning to the area to help restore power, telephone, and other services, because all residents had been evacuated and were not allowed back into the area. Educating service companies and law enforcement personnel involved in posthurricane restoration and enforcement about reporting unusual marine mammal sightings to the appropriate authorities will greatly aid in discovery, rescue, and release of out-of-habitat dolphins back to their natural habitat. In addition, placing a dedicated marine mammal search team out in the field looking for displaced dolphins following a natural disaster such as this, instead of waiting to receive reports from others in the area, would be beneficial. Animals could be located earlier, thereby decreasing the length of time they would be out of habitat. Under the conditions such as those seen after Hurricane Rita, these searches would be best conducted by helicopter. Many roads were impassable for several weeks after the hurricane either because they were covered in water or because bridges were washed out or closed for safety reasons. Given the many small

ditches and canals, sighting from an airplane would likely not be effective.

No postrelease monitoring was conducted after the release of these six dolphins. After the hurricane, the stranding network in southwest Louisiana was defunct and all infrastructure in coastal towns was destroyed. These conditions made such monitoring an unobtainable goal. As a result, we have no further information on their condition. However, there have been no reported sightings from southwest Louisiana of dolphins with Roto-tags. Beach surveys for dead stranded dolphins did not start again in Cameron Parish until Jan. 2006. In 2006, eight dead bottlenose dolphins were reported from Cameron Parish. None had Roto-tags nor showed evidence of having had a Roto-tag. However, postrelease monitoring would have been very informative and should be considered if future situations allow.

Hurricane Rita pushed an unprecedented number of bottlenose dolphins inland into areas where they do not normally occur. Hurricanes Katrina and Wilma, which also hit Gulf states in 2005, are each thought to have resulted in at least one out-of-habitat bottlenose dolphin. Comprehensive planning for future events will enhance response capabilities as well as the speed with which animals may be found and released. Other regions where hurricane- or typhoon-related storm surge might be expected to push inland have the potential to experience the same phenomenon. Although perhaps rare, or simply undocumented, this event illustrates the potential impacts hurricanes may have on coastal marine mammal species.

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