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ASSESSMENT OF THE OVERLAP OF TERREBONNE – TIMBALIER BAY AND BARATARIA BAY COMMON BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) STOCKS BASED ON PHOTO-IDENTIFICATION OF INDIVIDUAL DOLPHINS

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Cover photograph: Terrebonne Bay, Timbalier Bay and Barataria Bay in southeast Louisiana
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Table of Contents

List of Tables

List of Figures

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Introduction

Common bottlenose dolphins (*Tursiops truncatus*) are distributed throughout the U.S. Gulf of Mexico (GoMx) from upper continental slope waters, across the continental shelf, to coastal waters, and throughout the numerous adjacent bays, sounds and estuaries (BSEs) (Vollmer and Rosel 2013). The National Marine Fisheries Service (NMFS) is responsible for assessing and managing cetaceans in U.S. waters. Each cetacean species is divided into one or more stocks and the stock is the unit of protection under the Marine Mammal Protection Act (MMPA). A stock is defined in the MMPA as a group of the same species in a common spatial arrangement that interbreed when mature (MMPA 1972). A more functional definition of a population stock is a group of animals whose dynamics are more a consequence of internal dynamics (births and deaths) within the group than external dynamics (immigration or emigration) (Taylor 2005). There are currently 31 BSE stocks of common bottlenose dolphins managed in the U.S. GoMx (Hayes et al. 2017). These BSE stocks are largely defined based on discrete geographic areas with few waterways connecting them to similar adjacent areas, which might limit dolphin movement between them.

Two BSE stocks, which are adjacent to each other in Louisiana and where common bottlenose dolphin (dolphin) studies have been conducted, are the Terrebonne-Timbalier Bay Estuarine System and the Barataria Bay Estuarine System stocks (Hayes et al. 2017) (Figure 1). Numerous dolphin studies were conducted in Barataria Bay in response to the *Deepwater Horizon* oil spill (DWH) (e.g., Lane et al. 2015, Hohn et al. 2017, Hornsby et al. 2017, Schwacke et al. 2017). Using capture-recapture methods based on photo-identification (photo-ID) sampling, McDonald et al. (2017) estimated Barataria Bay abundance to be as large as ~3,000 dolphins in 2014. Based on similar methods, Litz et al. (2018) estimated 3,000 – 4,000 dolphins inhabit Terrebonne-Timbalier Bay.

While physiography can be the basis for initial insights for delimiting potential stocks, ultimately stock delimitations need to be based on strong lines of evidence of demographic independence (NMFS 2005, Martien et al. 2015). Demographically-independent marine mammal populations are primarily identified based on genetic studies but other information, such as distribution, movements, and demographics, can also be very informative (Dizon et al. 1992, Martien et al. 2015). Genetic studies comparing Barataria Bay and Terrebonne-Timbalier Bay dolphins have yet to be completed. However, 44 dolphins were satellite tagged within Barataria Bay from 2011 to 2014 to study movement and ranging patterns as part of the DWH studies. With a few minor exceptions where dolphins ranged into the Bayou Lafourche boundary between Barataria and Terrebonne-Timbalier Bay, none of the dolphins ranged outside of Barataria Bay and the immediate adjacent coastal waters (Wells et al. 2017).

For a wide variety of reasons, coastal Louisiana is experiencing significant land loss (Barras et al. 2003, Zou et al. 2015). One of the projects proposed to mitigate this land loss is the Mid-

Barataria Sediment Diversion which would divert sediment-laden Mississippi River water into Barataria Bay over a period of years with the goal of restoring coastal marsh (CPRA 2017). Because large volumes of fresh river water would potentially impact a brackish ecosystem which includes common bottlenose dolphins, the National Oceanic and Atmospheric Administration (NOAA) and the State of Louisiana began identifying data gaps and science needs related to the diversion project and dolphins. Dolphin stock structure and connectivity, including the potential use of adjacent habitat, were identified as a data gap for the Barataria Bay Stock.

While the DWH satellite tagging studies provided extensive ranging data on 44 Barataria Bay dolphins, this is a small number compared to the number of dolphins found in each area. As a result of multiple studies in these areas where dolphin photographs were collected (e.g., Lane et al. 2015, Sinclair et al. 2017), large photo-ID catalogs of individual dolphins associated with both Terrebonne-Timbalier Bay (1,678 marked individuals) and Barataria Bay (1,914 marked individuals) have been created. These large numbers of identified dolphins provided an opportunity to further study the extent of overlap between these adjacent stocks. Therefore, we compared the Terrebonne-Timbalier Bay and Barataria Bay catalogs to identify dolphins that occur in both catalogs, and evaluated the spatial and temporal characteristics of the co-occurrence.

Methods

Study Areas

Terrebonne-Timbalier Bay (TTB) and Barataria Bay (BB) (Figure 1) are interdistributary basins located in the north-central Gulf of Mexico (GoMx) between the Mississippi and Atchafalaya rivers. They are separated by Bayou Lafourche, the last major distributary of the abandoned Lafourche Delta of the Mississippi River (Reyes et al. 2000) which enters the GoMx at Belle Pass. Belle Pass and Bayou Lafourche serve as major thoroughfares for commercial and recreational vessel traffic. Dredging for oil and gas extraction and the attending infrastructure installed since the mid-1900s have significantly impacted both areas (Houck 2015). The average water depth and salinity of both areas is 2 m and 13 – 18 ppt (USEPA 1999). Salinity varies widely from south to north with more saline waters to the south and freshwater to the north (Steyer et al. 2008, Hornsby et al. 2017).

Terrebonne-Timbalier Bay (~1,761 km^2) - The interior of TTB is surrounded by salt marsh. To the south, TTB is bordered by a series of barrier islands (e.g., Isles Dernieres, Timbalier and East Timbalier islands) and several passes to the GoMx (e.g., Whiskey, Cat Island and Little passes). Port Fourchon, Louisiana, a major port for the oil industry, is on the eastern side of TTB. To the west, the Houma Navigation Canal is a major route for commercial and recreational vessel traffic.

Barataria Bay (~1,673 km^2) – Similar to TTB, the interior of BB is surrounded by salt marsh with numerous bayous and marsh islands. BB includes Caminada Bay, Bayou Rigaud, Bay des Ilettes and Bay Ronquille among many others. BB is bordered by barrier islands to the south (e.g., Grand Isle, Grande Terre islands, Cheniere Ronquille) and passes to the GoMx (e.g., Barataria Pass, Caminada Pass, Quatre Bayou Pass). The Barataria Waterway navigation channel runs north from the GoMx at Barataria Pass near the eastern side of the bay. Grand Isle is inhabited and the town has a population of about 1,300 people.

Photo-ID Data and Survey Effort

Photo-ID dorsal fin images of common bottlenose dolphins were collected primarily during capture-recapture surveys conducted from small boats in TTB and BB (McDonald et al. 2017, Sinclair et al. 2017) (Table 1). Details of photo-ID field methods and photo-analysis are described in Melancon et al. (2011) but are summarized below.

Photo-ID data were collected in TTB during 51 surveys (photo-ID, n = 38; remote biopsy sampling, n = 13) in summer 2016 and winter 2017 (Sinclair et al. 2017). The area surveyed included Bayou Lafourche, small lakes (e.g., Lakes Barre, Felicity, Old Lady, Raccourci and Pelto) and man-made canals (e.g., Havoline Canal, Houma Navigation Canal). A total of 371 survey hours were conducted wherein 5,928 km of survey tracks were covered and 38,189 digital photographs of dorsal fins were collected from 467 dolphin group sightings (Table 1, Figure 2).

For BB, 355 surveys related to DWH impacts and dolphin health were completed as part of ongoing research since 2010 (e.g., Lane et al. 2015, McDonald et al. 2017, Schwacke et al. 2017). Survey types include photo-ID (n = 137), biopsy sampling (n = 21), live-capture and subsequent tracking efforts (n = 51 and 16, respectively), fecundity (n = 49), dolphin strandings (n = 41) and other surveys where photo-ID images were taken (n = 40). A total of 2,067 dolphin groups were encountered where 142,704 digital photographs were collected during 1,746 survey hours that covered 18,586 km of survey tracks (Table 1, Figure 2). Surveys were conducted in BB during all four seasons.

Photo Analysis

Digital dorsal fin images from all surveys were processed using standardized methods [e.g., Melancon et al. (2011), McDonald et al. (2017), Mullin et al. (2017)] and cataloged in FinBase, a customized dorsal fin matching program (Adams et al. 2006). To summarize, sighting images were sorted to find the best right and/or left image of each unique dolphin from each sighting. Sorted images were rated independently for image quality (Q1 = excellent, Q2 = average, Q3 = low) based on a weighted scale detailed in Urian et al. (2014) and overall distinctiveness (D1 = high, D2 = average, D3 = low, D4 = not distinct) similar to Speakman et al. (2010). Sorted and rated images were compared to images of cataloged individuals collected on previous surveys to search for matches. Images for both matched individuals and new individuals were added to the catalog and verified by two trained technicians.

Catalog Comparison

finFindR - To identify individual dolphins that occurred in both TTB and BB, custom finFindR computer software [Western Ecosystems Technology (WEST), Inc., Laramie WY] was used to identify potential dorsal fin matches. The process began with a dorsal fin trailing edge tracing algorithm programmed in finFindR which autonomously collects two radian measurements of nick and notch features on an individual dorsal fin. One radian measurement estimated angles from the relative pixel coordinates as estimated from pixels traversed by the edge tracing algorithm. These measurements quantified overall shape. The second radian measurement computed the angles along the trailing edge of the dorsal fin by first calculating the x and y gradients via fast Fourier transform on each color channel, then returning the angle of greatest color change in the image. These measurements quantified the location and severity of individual nicks and notches.

Radian measurements obtained from 26,498 images of 4,158 individuals in three photo-ID catalogs (TTB, BB, and Mississippi Sound) were used to train an automated matching algorithm. The matching algorithm consisted of a deep convolutional neural network based on the ResNet architecture, which generated a large-margin nearest neighbor metric. The network was trained for 50,000 epochs using a k-neighbors soft-triplet loss objective function.

The neural network defines a mapping from the raw input data to an embedding where the distances between instances of a given individual are closer to each other than to instances of other individuals. The nearest neighbor metric produced by the neural network discriminates and matches dorsal fins by computing a "distance" on the embedding from the characteristics of one fin to characteristics of other fins. Shorter "distances" represent fin pairs with similar nick and notch characteristics, and therefore express putative matches. The finFindR app was used to generate the edge tracings for each image in a catalog; using the edge tracings, the trained network generates an embedding representing the distinct features for all individuals in each catalog. The catalogs were then matched using a sorting algorithm. The distances between every pairing of individuals between the two catalogs were calculated which is used to sort individuals by proximity of features. The app provided a table with each row representing an image in a query catalog and its top 50 possible matches from the reference catalog. The spreadsheet with the top 50 matches was sent to trained technicians who, using FinBase, conducted visual comparisons to determine whether any actual matches existed.

For this comparison, TTB was the query catalog (4,683 images; 1,678 distinct individuals) and BB was the reference catalog (18,565 images; 1,914 distinct individuals). Images used were of excellent or average quality rating (Q1 & Q2) containing high or average fin distinctiveness (D1 & D2) to minimize false negatives.

Validation and Error Rate - A performance validation of finFindR was conducted to estimate the accuracy and reliability of the matching software. The objective was to test the matching

capabilities of the program and calculate an error rate for the TTB-BB catalog comparison. For the validation, 662 photos from BB photo-ID surveys conducted in 2017 were used. Manual matching was previously completed using FinBase (n = 1,914 distinct individuals), hence, catalog matches were used as a baseline to test finFindR. Only images containing fins with high or average fin distinctiveness (D1 & D2) and of excellent or average photographic quality (Q1 & Q2) were used for the validation. The set of 662 images were provided to WEST, Inc. without knowledge of FinBase catalog ID's in order to maintain a blind study. WEST, Inc. traced all images using finFindR and returned a file containing the top 50 most likely matches of each image for trained technicians to conduct visual comparison of the results using FinBase. FinFindR found 532 matches (80%) with an average rank (within the top 50) of 5.13 and average distance of 0.63. Of the 532 matches, 60% were found as the number one ranked fin, 86% were found within the top 10, and 92% of matches were within the top 20 fins. Another 80 matches were found with finFindR but those matches were outside of the top 50 and were not included in the error rate calculations. Based on the 0.80 (95% binomial CI = 0.77-0.83) matching success from the finFindR validation, an error rate of 0.20 (95% binomial CI = 0.17-0.23) was predicted for the TTB-BB catalog comparison.

Match Categories

Ranging patterns of matched animals between the TTB-BB catalogs were evaluated and animals were assigned to the following match categories:

1) Intra-stock - dolphins with all sightings completely within either the TTB or BB stock boundaries, but which also had sightings within Bayou Lafourche, the boundary between the two stocks;

2) Inter-stock - dolphins with sightings within both TTB and BB stock boundaries;

3) Coastal – dolphins with sightings in both catalogs that were outside the BSE stock boundaries and occurred in the adjacent coastal area; and

4) Other – dolphins with sightings recorded in both catalogs whose ranging pattern could not be defined, e.g., sightings that occurred only in Bayou Lafourche or between the estuary and the coastal area.

Results

The TTB and BB catalogs contained 1,678 and 1,914 distinctive individuals (i.e., D1 or D2 distinctiveness rating), respectively. Twenty-eight matches were found between the TTB catalog and the BB catalog (Figure 3, Appendix 1) where an individual dolphin was seen at least once in each study area. The 28 matches represent < 2% of the individuals in each catalog. Nineteen of these 28 matches were found by finFindR (68%), and the additional 9 matches (32%) were found opportunistically. The opportunistic matches included five dolphins that were easily identified because they had been previously freezebranded or tagged, and four fins that were recognized by one of the photo-analysts but not as part of a systematic search.

The majority of matches (*n* = 18) were intra-stock dolphins (Figure 4). Most of the intra-stock matches were Barataria Bay Stock individuals (*n* = 17, 61%). These animals ranged from Bayou Lafourche in the west to the southwestern portions of the BB study area, in close proximity to Grand Isle or in Caminada Bay (Appendix 1 A – Q). Only one intra-stock dolphin was considered a Terrebonne-Timbalier Bay Stock individual (4%) (Appendix 1 R), and was sighted in Bayou Lafourche, Timbalier Bay and Raccourci Bay.

Four animals (14%) were inter-stock estuarine dolphins (Appendix 1 S – V). Three of these animals were sighted in the easternmost part of TTB close to Bayou Lafourche and in southwestern BB near Grand Isle. One animal was sighted in BB near Grand Isle and in north-central Timbalier Bay.

Four matches (14%) between catalogs were a combination of estuarine and coastal sightings or lacked a definitive match category (Appendix 1 W – Z). Two animals were sighted in estuarine TTB toward the center of the survey area and coastal BB south of Elmer's Island. One animal was only sighted in Bayou Lafourche, precluding a definitive match category. The last animal (R9 - "Octavius"), live stranded on 26 October 2015 on Grand Isle. R9 was rehabilitated and released in BB in 28 April 2016, then sighted twice inside TTB on 2 and 7 June 2016. It is unknown from where R9 originated prior to stranding (e.g., TTB, BB, coastal waters or other); therefore, we did not include R9 in other match categories.

Two dolphins (7%) sighted in both study areas were coastal dolphins (Appendix 1 AA & BB). Both animals were sighted approximately 1 km south of the western tip of Timbalier Island in the west and near the western tip of Elmer's Island in the east. These animals were sighted together on two occasions.

Seven matches (25%) between catalogs were of known sex (5 ♀, 2 ♂) (Table 2) from examinations during health assessments or genetic data collected from remote biopsy samples. Three animals were classified as probable females due to association with a calf on one or more occasions. Many male bottlenose dolphins (*Tursiops* spp.) form long-term bonds consisting of two or three individuals (Connor et al. 1992), including those inhabiting the northern GoMx (Wells 1991). Therefore, two animals were classified as probable males because they were always sighted together and not associated with calves.

The number of sightings of matched individuals ranged from 1 to 4 in TTB and 1 to 28 in BB (Appendix 1). In TTB, seven matched individuals were sighted in both summer and winter, and 14 and seven were sighted only in summer or winter, respectively (Table 2). In BB, seasonal sightings of matched individuals ranged from seven (fall) to 18 (summer).

While there were dolphin sightings throughout the BB study area (Figure 2), BB individuals matched to the TTB catalog were only seen in the southwestern part of the study area nearest to TTB. TTB individuals matched to the BB catalog were more widely distributed but

predominately sighted in the eastern third of the TTB study area (Figure 3). With the exception of two sightings (one estuarine and one coastal), TTB matched individuals from winter were confined to Bayou Lafourche, whereas TTB matches in summer were more widely distributed (Figure 3).

Discussion

The small number of dolphins (n = 28) that were identified in both TTB and BB and their generally limited inter-stock ranging patterns were not surprising given previous research in the northern GoMx that show that dolphins display long-term site fidelity to specific BSE habitats (Hayes et al. 2017). Dolphins in BSEs are geographically bounded by land to varying degrees but even the adjacent coastal waters seem to be a barrier in some form, possibly due to habitat and/or prey differences. Genetic studies indicate that dolphins inhabiting a BSE and the adjacent few kilometers of coastal waters, and those inhabiting the more distant coastal waters, constitute different stocks (Sellas et al. 2005). Telemetry studies in BB and elsewhere indicate that even dolphins tagged very close to the coast within a BSE, display restricted use of coastal waters. Satellite tags deployed on dolphins in BB primarily just north of Grand Isle during 2011– 2014 provided location data for 48 to 260 days. In general, these tagged dolphins remained in BB or within 1.75 km of shore. Some of the dolphins ranged in Bayou Lafourche but none traveled into TTB (Wells et al. 2017). Given dolphin mobility, BSE dolphins do not have large ranges in general and tend to use areas smaller than the total area available to them within a BSE (Wells et al. 2017). For example, in Mississippi Sound (north-central GoMx), dolphins that were satellite-tagged close to the mainland had restricted east-west ranges even though unbounded similar habitat was available to them for tens of kilometers (Mullin et al. 2017).

The reasons that common bottlenose dolphins in estuarine waters of the northern GoMx have restricted ranges are probably similar to those suggested for other areas where more in-depth studies have been conducted on the same or similar species. Tsai and Mann (2013) describe bottlenose dolphins (*Tursiops* sp.) in Shark Bay, Australia, as displaying strong bisexual locational philopatry where both sexes remain close to their natal range into adulthood. This apparently has two advantages: knowledge of local social networks, and knowledge of the local prey resources and how to obtain them. Long-term male-male bonds are common to varying degrees in *Tursiops* spp., which is assumed to facilitate mating opportunities. Females appear to benefit from familiarity with matrilineal relatives. Female dolphins in particular probably benefit from knowledge of local prey resources given the energetic burden of reproduction. *Tursiops* spp. display a wide variety of specific feeding behaviors that are location- or region-specific (reviewed in Ronje et al. 2017). One unique feeding behavior seen in BB is drill feeding. Here, individuals presumably drill into the bottom substrate searching for prey creating visible mud plumes and sidesweeping with their flukes at the surface. Drill feeding appears to be a non-

cooperative feeding event involving several individuals sweeping in the same general area but often with ten or more meters separation between foraging individuals.

While there were very few matches between the two catalogs, there are likely additional matches that were not detected by our search. During validation of finFindR, only 80% of the known matches were found, leading to an estimate that 20% (95% CI = 17-23%) of actual matches would be missed during the finFindR TTB-BB comparison. However, 32% of our matches were not detected by finFindR but rather were opportunistically identified, suggesting that the error rate of the automated comparison could have actually been higher than we predicted.

When considering the matches as a proportion of the total catalog size, the difference in survey period for the two catalogs must also be considered. The TTB catalog was not established until 2016, while the BB catalog was established six years earlier (2010) as part of the response to the DWH oil spill. Therefore, some of the dolphins in the BB catalog likely died before 2016, and had no chance of being detected in the TTB surveys. As the current BB catalog size over represents the number of dolphins alive when the comparison was made, our estimate of the proportion of the BB catalog dolphins detected in TTB is also likely an underestimate.

While the total number of dolphins using both stock areas was underestimated, for the majority of matches that were found (18/28), a sighting in Bayou Lafourche was one component of the match. Because Bayou Lafourche is the boundary between TTB and BB stocks and individuals occurred in both catalogs, these matches provide little information on the question of stock overlap. Only four dolphins (< 1% the catalog size of TTB and BB) were found that used estuarine areas exclusive to each stock, i.e., to the east of Bayou Lafourche (exclusively BB stock area) and west of Bayou Lafourche (exclusively TTB stock area). Four additional dolphins used coastal (2) or a mix of estuarine and coastal areas (2) east and west of Bayou Lafourche. While the biases in this study are hard to quantify, except for Bayou Lafourche, this study indicates that there is very little overlap in these stocks in terms of both the number of individuals and their ranges, similar to the findings from the BB satellite tagging (Wells et al. 2017).

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Literature Cited

Adams, J., T. R. Speakman, E. Zolman, and L. Schwacke. 2006. Automating image matching, cataloging, and analysis for photo-identification research. Aquatic Mammals **32**:374-384.

Barras, J., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, and J. Porthouse. 2003. Historical and projected coastal Louisiana land changes: 1978-2050. USGS Open File Report 03-334, 39 pp. (revised January 2004).

Connor, R. C., R. A. Smolker, and A. F. Richards. 1992. Two levels of alliance formation among male bottlenose dolphins (*Tursiops* sp.). Proceedings of the National Academy of Sciences **89**:987-990.

CPRA. 2017. (Coastal Protection and Restoration Authority of Louisiana) Louisiana's 2017 comprehensive master plan for a sustainable coast. 92 pp. Available from: http://coastal.la.gov/resources/library/reports/.

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. Demaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conservation Biology **6**:24-36.

Hayes, S. A., E. Josephson, K. Maze-Foley, and P. E. Rosel. 2017. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2016. NOAA Technical Memorandum NMFS-NE-241. 274 pp.

Hohn, A., L. Thomas, R. Carmichael, J. Litz, C. Clemons-Chevis, S. Shippee, C. Sinclair, S. Smith, T. Speakman, and M. Tumlin. 2017. Assigning stranded bottlenose dolphins to source stocks using stable isotope ratios following the *Deepwater Horizon* oil spill. Endangered Species Research **33**:235-252.

Hornsby, F. E., T. L. McDonald, B. C. Balmer, T. R. Speakman, K. D. Mullin, P. E. Rosel, R. S. Wells, A. C. Telander, P. W. Marcy, and L. H. Schwacke. 2017. Using salinity to identify common bottlenose dolphin habitat in Barataria Bay, Louisiana, USA. Endangered Species Research **33**:181-192.

Houck, O. A. 2015. The reckoning: oil and gas development in the Louisiana coastal zone. Tulane Environmental Law Journal **28**:185-296.

Lane, S. M., C. R. Smith, J. Mitchell, B. C. Balmer, K. P. Barry, T. McDonald, C. S. Mori, P. E. Rosel, T. K. Rowles, T. R. Speakman, F. I. Townsend, M. C. Tumlin, R. S. Wells, E. S. Zolman, and L. H. Schwacke. 2015. Reproductive outcome and survival of common bottlenose dolphins sampled in Barataria Bay, Louisiana, USA, following the *Deepwater Horizon* oil spill. Proceedings of the Royal Society B **282**:20151944.

Litz, J., C. Sinclair, and L. P. Garrison. 2018. Terrebonne-Timbalier Bay, Louisiana, common bottlenose dolphin abundance estimate 2016. Southeast Fisheries Science Center Report PRBD-2018-03. 9 pp.

Martien, K. K., A. R. Lang, and B. L. Taylor. 2015. Report of the meeting on the use of multiple lines of evidence to delineate demographically independent populations. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-538. 10 pp.

McDonald, T. L., F. E. Hornsby, T. R. Speakman, E. S. Zolman, K. D. Mullin, C. Sinclair, P. E. Rosel, L. Thomas, and L. H. Schwacke. 2017. Survival, density, and abundance of common bottlenose dolphins in Barataria Bay (USA) following the *Deepwater Horizon* oil spill. Endangered Species Research **33**:193-209.

Melancon, R. A. S., S. M. 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 pp.

MMPA. 1972. 16 USC §§ 1361 *et seq.*

Mullin, K. D., T. McDonald, R. S. Wells, B. C. Balmer, T. Speakman, C. Sinclair, E. S. Zolman, F. Hornsby, S. M. McBride, and K. A. Wilkinson. 2017. Density, abundance, survival, and ranging patterns of common bottlenose dolphins (*Tursiops truncatus*) in Mississippi Sound following the *Deepwater Horizon* oil spill. PloS one **12**:e0186265.

NMFS. 2005. Revisions to Guidelines for Assessing Marine Mammal Stocks. 24 pp. Available at: http://www.nmfs.noaa.gov/pr/pdfs/sars/gamms2005.pdf.

Reyes, E., M. L. White, J. F. Martin, G. P. Kemp, J. W. Day, and V. Aravamuthan. 2000. Landscape modeling of coastal habitat change in the Mississippi Delta. Ecology **81**:2331-2349.

Ronje, E. I., K. P. Barry, C. Sinclair, M. A. Grace, N. Barros, J. Allen, B. Balmer, A. Panike, C. Toms, and K. D. Mullin. 2017. A common bottlenose dolphin (*Tursiops truncatus*) prey handling technique for marine catfish (Ariidae) in the northern Gulf of Mexico. PloS one **12**:e0181179.

Schwacke, L. H., L. Thomas, R. S. Wells, W. E. McFee, A. A. Hohn, K. D. Mullin, E. S. Zolman, B. M. Quigley, T. K. Rowles, and J. H. Schwacke. 2017. Quantifying injury to common bottlenose dolphins from the *Deepwater Horizon* oil spill using an age-, sex-and class-structured population model. Endangered Species Research **33**:265-279.

Sellas, A. B., R. S. Wells, and P. E. Rosel. 2005. Mitochondrial and nuclear DNA analyses reveal fine scale geographic structure in bottlenose dolphins (*Tursiops truncatus*) in the Gulf of Mexico. Conservation Genetics **6**:715-728.

Sinclair, C., K. Barry, E. Ronje, A. Gorgone, A. Martinez, Speakman, and M. K. D. 2017. Terrebonne Bay – Timbalier Bay, Louisiana common bottlenose dolphin (*Tursiops truncatus*) stock photo-ID capture-recapture and biopsy field summary. NOAA Technical Memorandum NMFS-SEFSC-717. 21 pp. doi:10.7289/V5/TM-SEFSC-717.

Speakman, T. R., S. M. Lane, L. H. Schwacke, P. A. Fair, and E. S. Zolman. 2010. Mark-recapture estimates of seasonal abundance and survivorship for bottlenose dolphins (*Tursiops truncatus*) near Charleston, South Carolina, USA. Journal of Cetacean Research and Management **11**:153-162.

Steyer, G. D., C. Sasser, E. Evers, E. Swenson, G. Suir, and S. Sapkota. 2008. Influence of the Houma navigation canal on salinity patterns and landscape configuration in coastal Louisiana: an interagency collaboration. U.S. Geological Survey Open-File Report 2008-1127, 190 pp.

Taylor, B. L. 2005. Identifying units to conserve. Pages 149-164 *in* J. E. Reynolds III, W. F. Perrin, R. R. Reeves, S. Montgomery, and T. J. Ragen, editors. Marine mammal research: Conservation beyond crisis The John Hopkins University Press, Baltimore, MD.

Tsai, Y. J. J., and J. Mann. 2013. Dispersal, philopatry, and the role of fission-fusion dynamics in bottlenose dolphins. Marine Mammal Science **29**:261-279.

Urian, K. W., D. M. Waples, R. B. Tyson, L. E. Hodge, and A. J. Read. 2014. Abundance of bottlenose dolphins (*Tursiops truncatus*) in estuarine and near-shore waters of North Carolina, USA. Journal of North Carolina Academy of Science **129**:165-171.

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 pp.

Vollmer, N. L., and P. E. Rosel. 2013. A review of common bottlenose dolphins (*Tursiops truncatus truncatus*) in the northern Gulf of Mexico: Population biology, potential threats, and management. Southeastern Naturalist **13**:1-43.

Wells, R. S. 1991. The role of long-term study in understanding the social structure of a bottlenose dolphin community. Pages 199-225 *in* K. Pryor and K. S. Norris, editors. Dolphin societies: Discoveries and puzzles. University of California Press.

Wells, R. S., L. H. Schwacke, T. K. Rowles, B. C. Balmer, E. Zolman, T. Speakman, F. I. Townsend, M. C. Tumlin, A. Barleycorn, and K. A. Wilkinson. 2017. Ranging patterns of common bottlenose dolphins *Tursiops truncatus* in Barataria Bay, Louisiana, following the *Deepwater Horizon* oil spill. Endangered Species Research **33**:159-180.

Zou, L., J. Kent, N. S.-N. Lam, H. Cai, Y. Qiang, and K. Li. 2015. Evaluating land subsidence rates and their implications for land loss in the Lower Mississippi River Basin. Water **8**:10.

Table 1. Summary of survey effort in Terrebonne-Timbalier Bay (TTB) and Barataria Bay (BB).

Survey Area	Survey Type	Survey Days	Survey Distance (km)	No. of Group Sightings	No. of Photographs
TTB	Photo-ID	38	4,675	378	32,965
	Biopsy	13	1,253	89	5,224
	Total	**51**	**5,928**	**467**	**38,189**
BB	Photo-ID	137	11,290	1,055	75,216
	Biopsy	21	1,250	149	8,900
	Fecundity	49	4,067	479	24,373
	Capture	51	1,980	220	13,894
	Tracking	16	-	66	7,754
	Stranding	41	-	41	-
	Other	40	-	57	12,567
	Total	**355**	**18,586**	**2,067**	**142,704**

Table 2. Sexes of Terrebonne-Timbalier Bay (TTB) and Barataria Bay (BB) matches and season(s) sighted (Sp – spring; Su – summer; F – fall; W – winter).

TTB Catalog ID	BB Catalog ID	Sex	TTB		BB			
			Su	W	Sp	Su	F	W
1018	1031	Unknown	X			X		
2038	2254	Unknown	X		X	X	X	
2098	2086	Probable Female	X	X	X		X	
3025	2479	Unknown	X				X	
6015	3158	Probable Male	X		X	X		
6016	6790	Probable Male	X		X	X		
6511	6808	Unknown		X	X			
7080	7845	Unknown	X			X		
7282	2288	Probable Female	X	X				X
8051	7817	Unknown	X		X			
8076	8181	Unknown	X	X	X			
8126	6022	Probable Female		X	X	X		
8129	12947	Unknown		X	X	X		X
13000	R9	Male	X					
13002	2002	Female	X	X	X	X	X	X
13003	13035	Male		X		X		
13004	13032	Female		X	X	X		X
13005	6123	Female		X	X	X	X	X
13006	7091	Female		X	X	X		X
2018	2291	Unknown	X	X	X		X	X
3029	3166	Unknown	X			X		
7348	7497	Unknown	X					X
8037	8180	Unknown	X		X			
13001	7171	Female	X		X	X	X	X
2086	2542	Unknown	X	X		X		
8036	2539	Unknown	X			X		
7400	7827	Unknown	X			X		
7265	7828	Unknown	X	X		X		

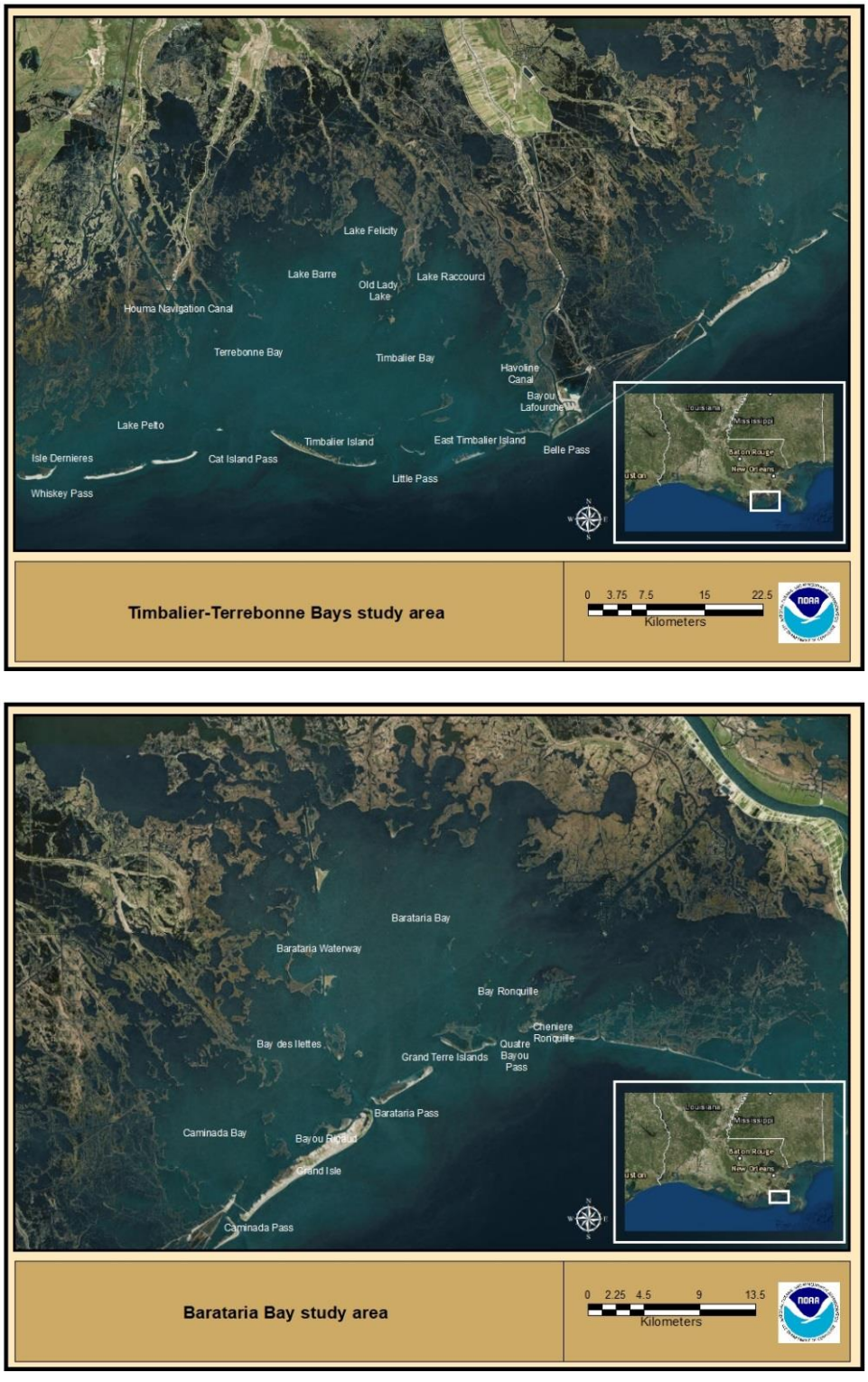


Figure 1. Terrebonne-Timbalier Bay (upper) and Barataria Bay (lower) in southeastern Louisiana with geographic names referenced in the text.

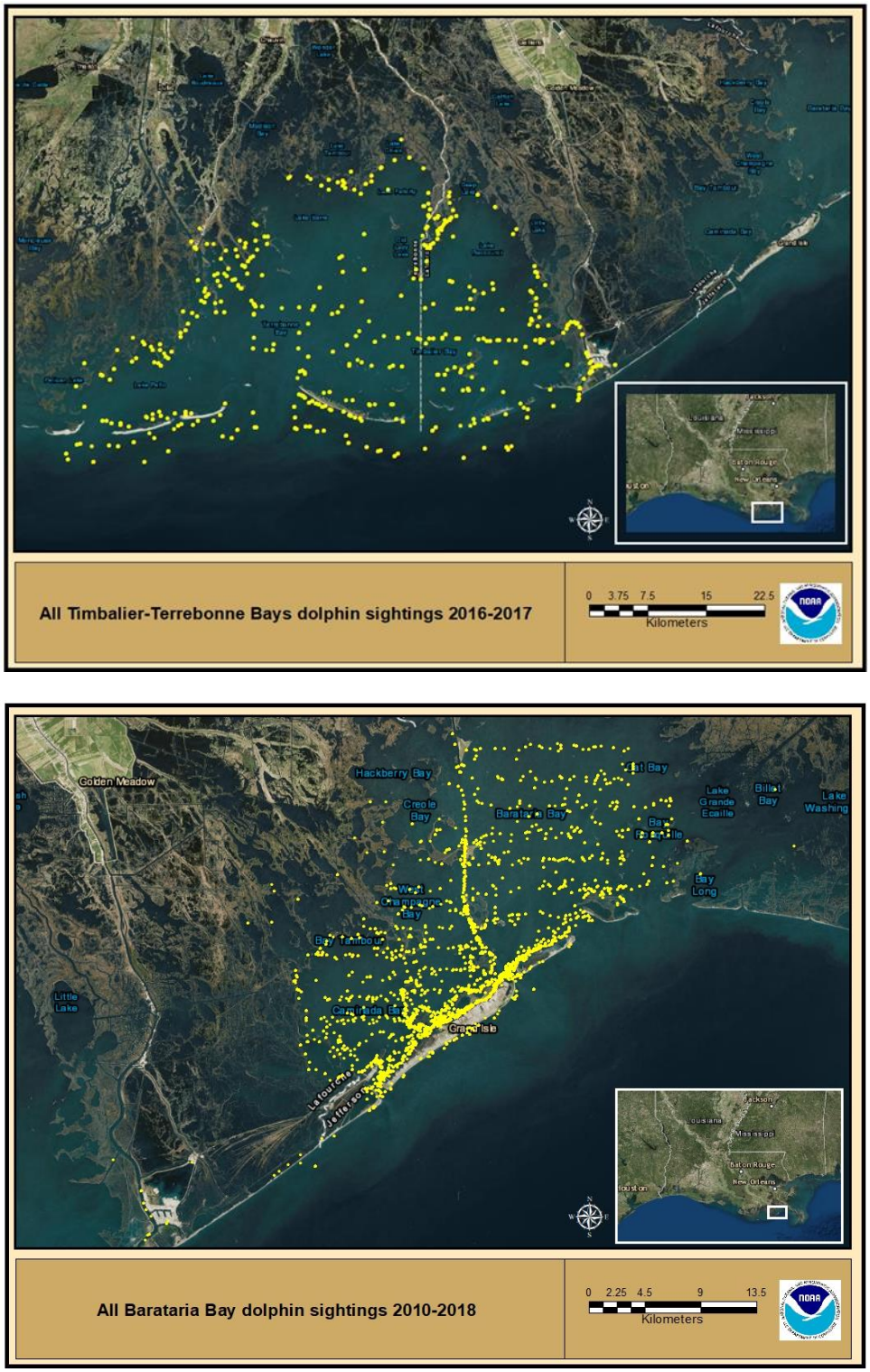


Figure 2. Locations of common bottlenose dolphin groups sighted in Terrebonne-Timbalier Bay (upper) (n = 467) and Barataria Bay (lower) (n = 2,067) during research surveys.

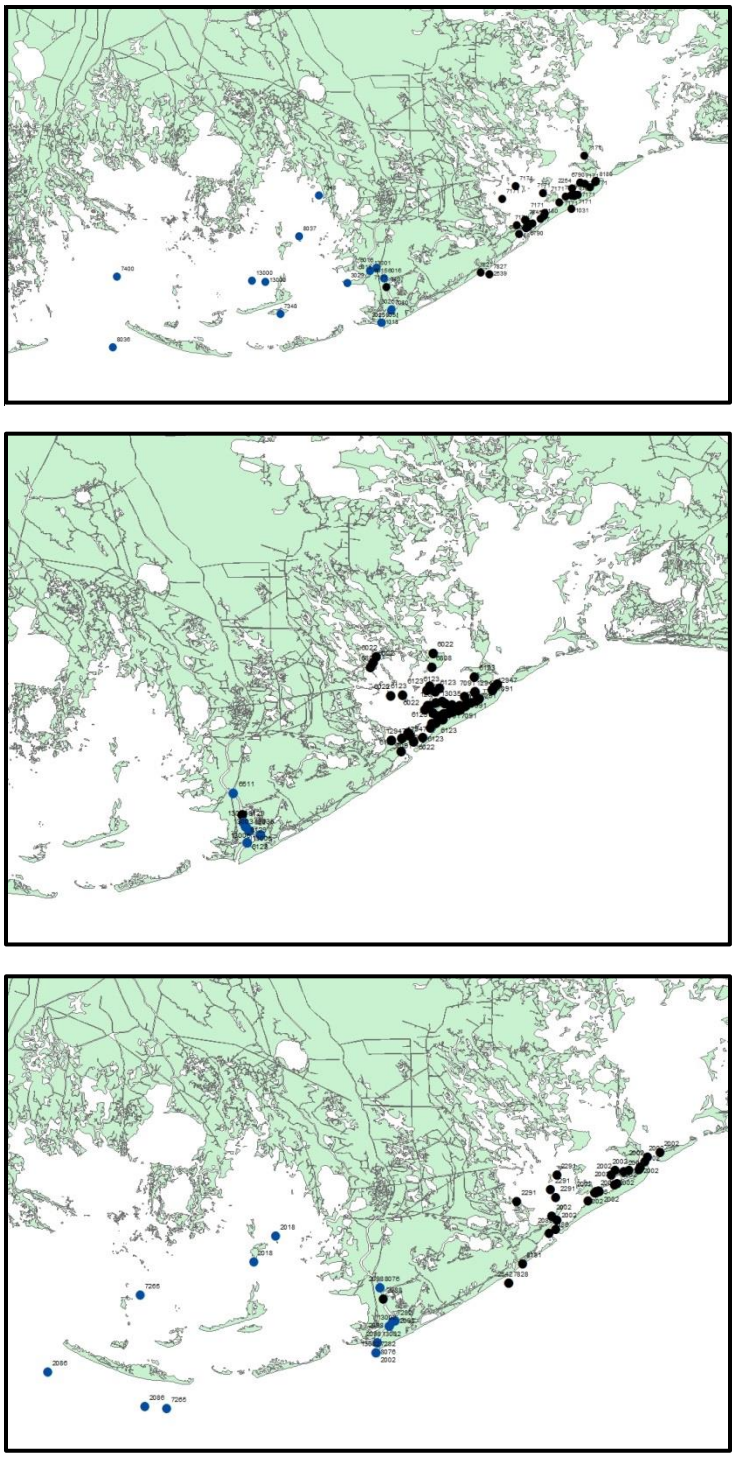


Figure 3. Individual dolphin locations from Terrebonne-Timbalier Bay (TTB) (blue) sighted during TTB surveys in summer (upper), winter (middle), and both summer and winter (lower) that matched individuals from Barataria Bay (BB) (black) during all BB surveys.

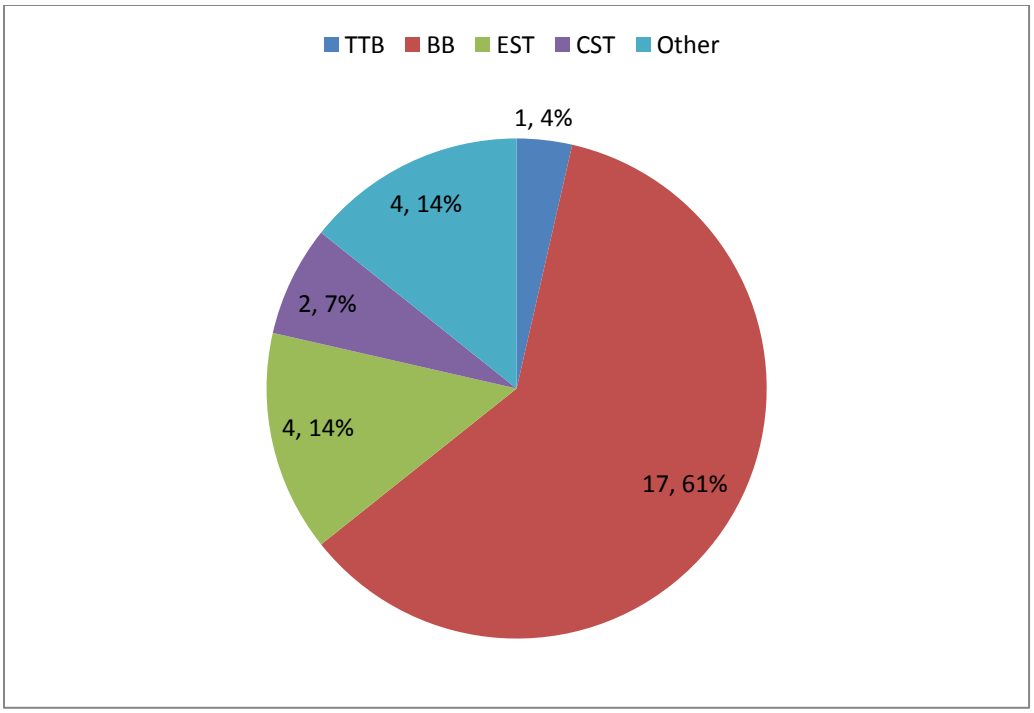


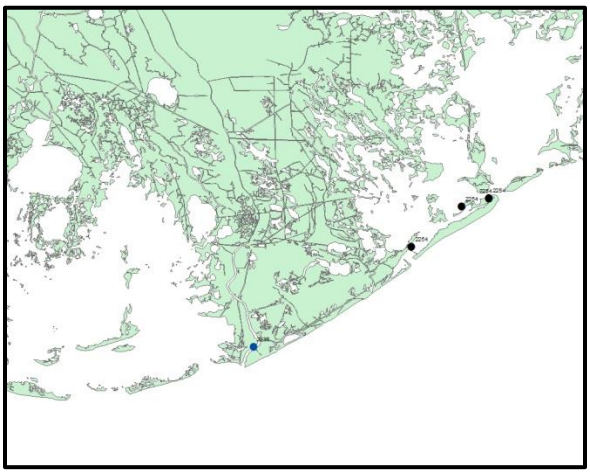
Figure 4. Total number and percentage of dolphins sighted between the Terrebonne-Timbalier Bay (TTB) and Barataria Bay (BB) catalogs were assigned to the following categories: TTB – intra-stock TTB; BB – intra-stock BB; EST – inter-stock estuarine; CST – coastal; and Other. (*Intra-stock* – dolphins with all sightings completely within either the TTB or BB stock boundaries, but which also had sightings within Bayou Lafourche, the boundary between the two stocks; *Inter-stock* – dolphins with sightings within both TTB and BB stock boundaries; *Coastal* – dolphins with sightings in both catalogs that were outside the BSE stock boundaries and occurred in the adjacent coastal area; and *Other* – dolphins with sightings recorded in both catalogs whose ranging pattern could not be defined, e.g., sightings that occurred only in Bayou Lafourche or between the estuary and the coastal area.)

Appendix 1

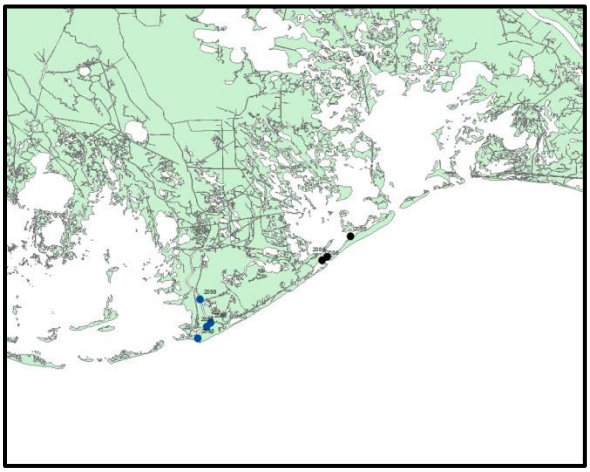
Plot of sightings for each individual common bottlenose dolphin with photo-ID matches between Terrebonne-Timbalier Bay (blue) and Barataria Bay (black) catalogs.

A	TTB	BB
Catalog ID	1018	1031
First Sighting	6/11/2016	6/26/2012
Last Sighting	-	-
No. of Sightings	1	1

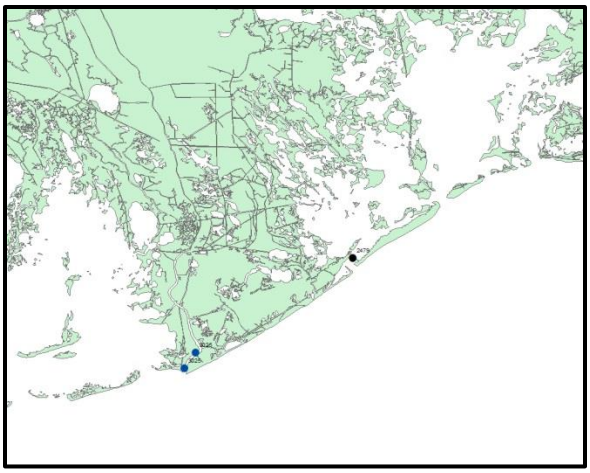
B	TTB	BB
Catalog ID	2038	2254
First Sighting	6/5/2016	11/11/2011
Last Sighting	-	6/30/2012
No. of Sightings	1	4



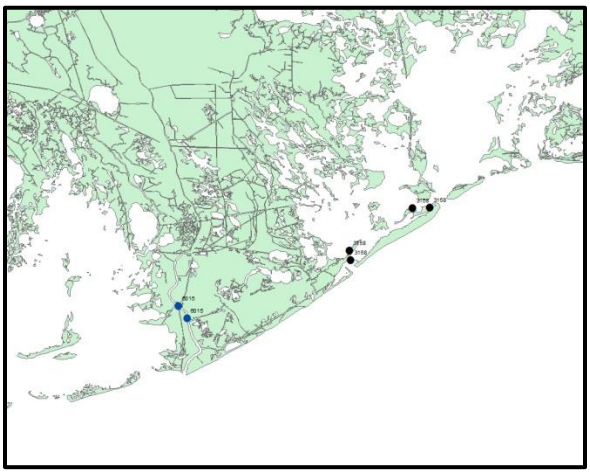
C	TTB	BB
Catalog ID	2098	2086
First Sighting	6/8/2016	11/10/2010
Last Sighting	1/15/2017	9/21/2017
No. of Sightings	4	3



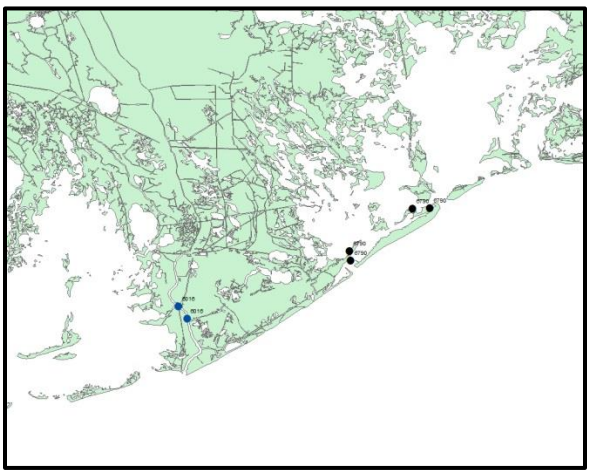
D	TTB	BB
Catalog ID	3025	2479
First Sighting	6/8/2016	11/9/2013
Last Sighting	6/11/2016	-
No. of Sightings	2	1



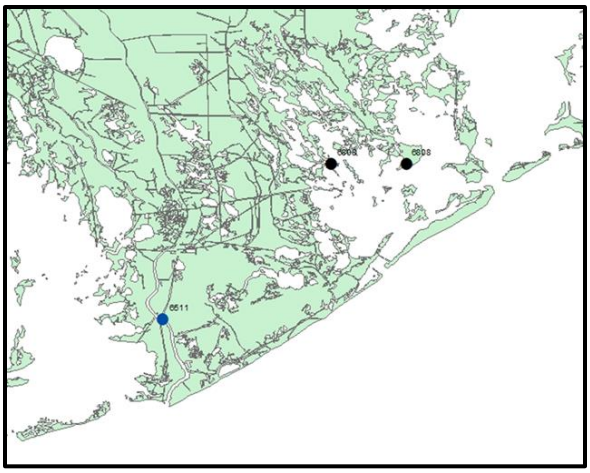
E	TTB	BB
Catalog ID	6015	3158
First Sighting	6/1/2016	4/23/2014
Last Sighting	6/11/2016	6/11/2017
No. of Sightings	2	4



F	TTB	BB
Catalog ID	6016	6790
First Sighting	6/1/2016	4/23/2014
Last Sighting	6/11/2016	6/11/2017
No. of Sightings	2	4

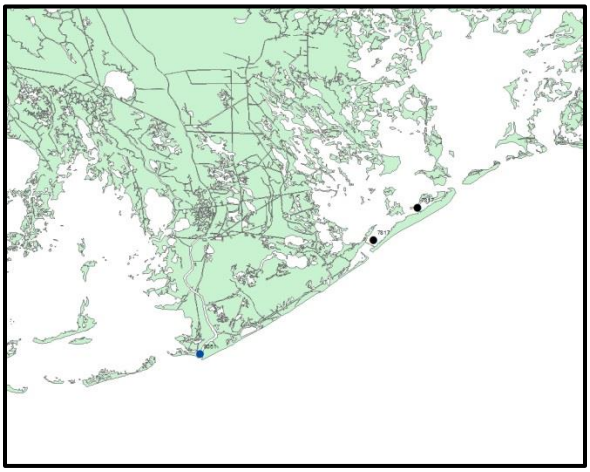


G	TTB	BB
Catalog ID	6511	6808
First Sighting	1/13/2017	4/23/2014
Last Sighting	-	4/10/2015
No. of Sightings	1	2

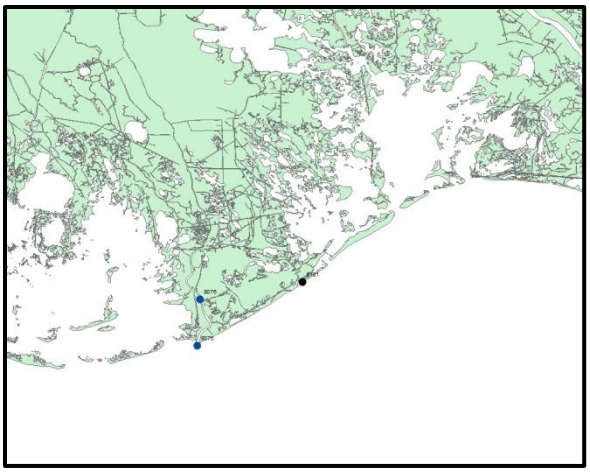


H	TTB	BB
Catalog ID	7080	7845
First Sighting	6/5/2016	6/10/2017
Last Sighting	-	-
No. of Sightings	1	1

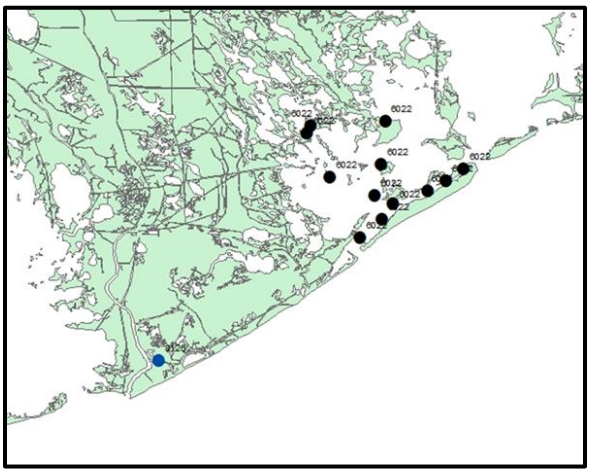
I	TTB	BB
Catalog ID	8051	7817
First Sighting	6/8/2016	4/8/2015
Last Sighting	-	4/10/2015
No. of Sightings	1	2



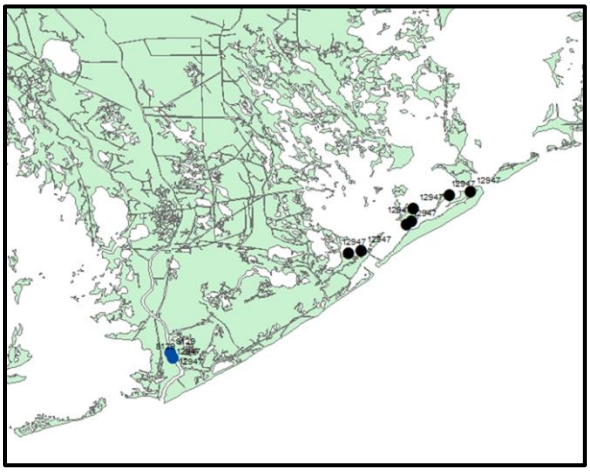
J	TTB	BB
Catalog ID	8076	8181
First Sighting	6/11/2016	5/21/2015
Last Sighting	1/15/2017	-
No. of Sightings	2	1



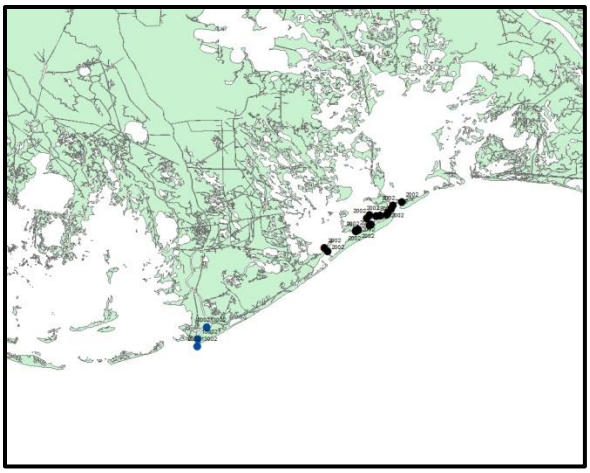
K	TTB	BB
Catalog ID	8126	6022
First Sighting	1/26/2017	6/19/2010
Last Sighting	-	4/26/2014
No. of Sightings	1	12



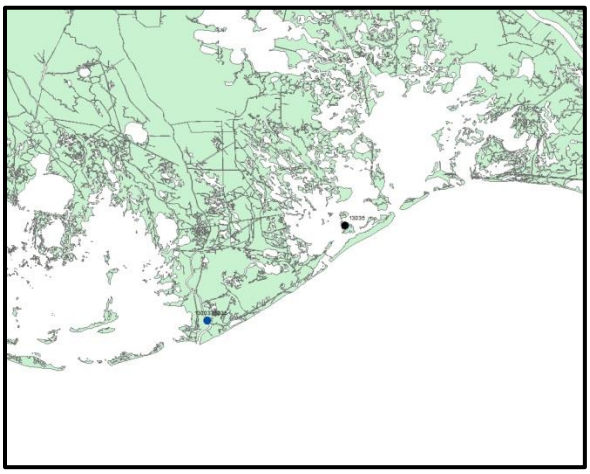
L	TTB	BB
Catalog ID	8129	12947
First Sighting	1/17/2017	5/21/2015
Last Sighting	1/26/2017	5/25/2017
No. of Sightings	2	7



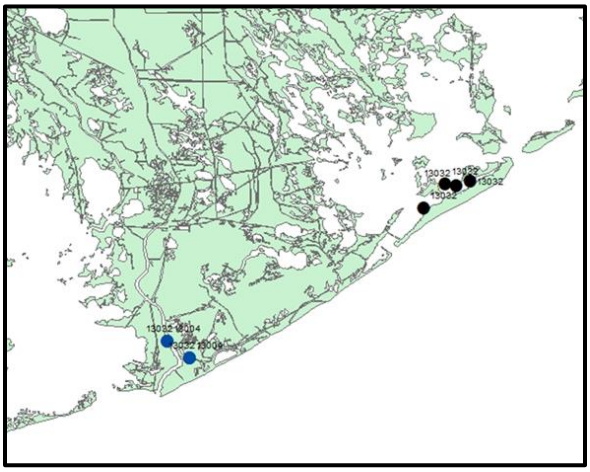
M	TTB	BB
Catalog ID	13002	2002
First Sighting	6/8/2016	6/18/2010
Last Sighting	1/15/2017	9/21/2017
No. of Sightings	3	21



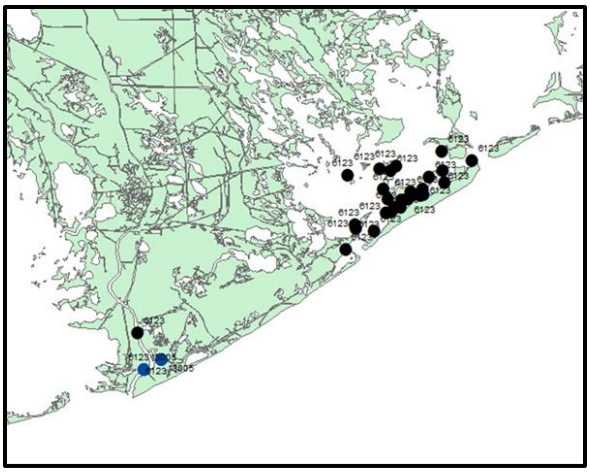
N	TTB	BB
Catalog ID	13003	13035
First Sighting	1/13/2017	7/22/2016
Last Sighting	-	-
No. of Sightings	1	1



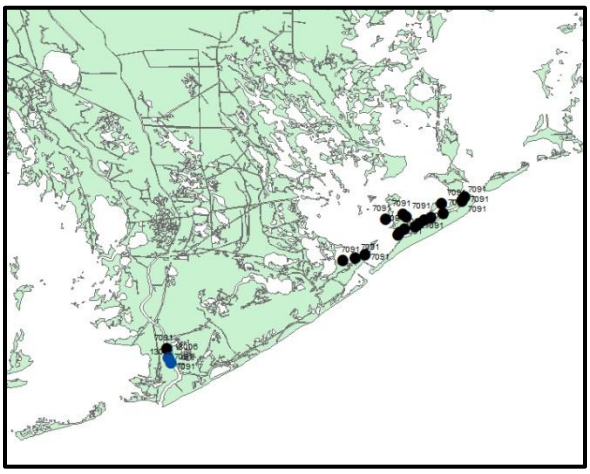
O	TTB	BB
Catalog ID	13004	13032
First Sighting	1/26/2017	4/6/2015
Last Sighting	-1/26/2017	7/18/2016
No. of Sightings	2	4



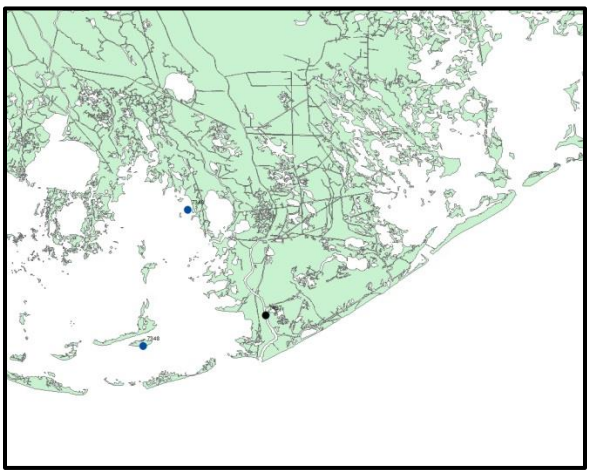
P	TTB	BB
Catalog ID	13005	6123
First Sighting	1/26/2017	5/12/2010
Last Sighting	1/26/2017	3/8/2018
No. of Sightings	2	28



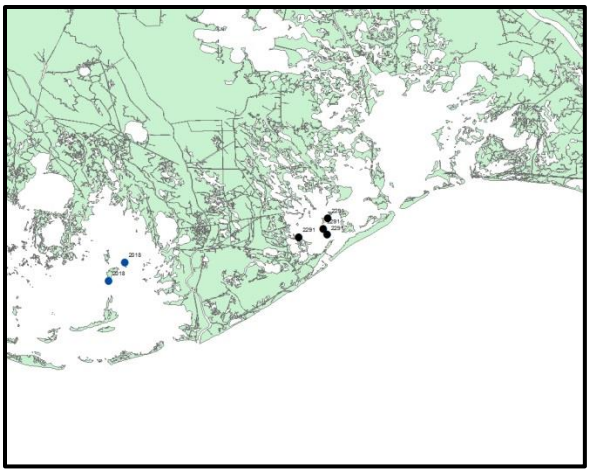
Q	TTB	BB
Catalog ID	13006	7091
First Sighting	1/17/2017	5/11/2010
Last Sighting	1/26/2017	5/25/2017
No. of Sightings	2	20



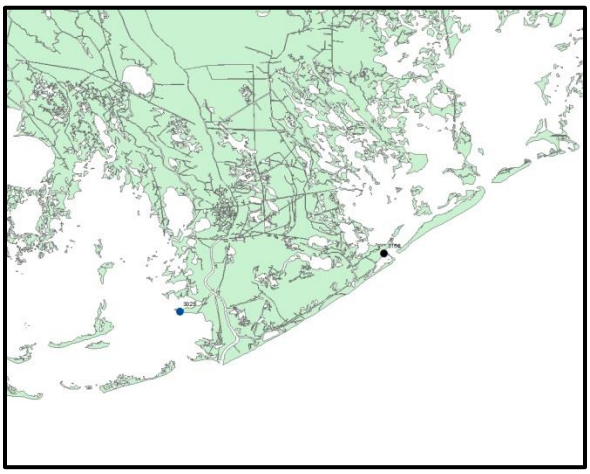
R	TTB	BB
Catalog ID	7348	7497
First Sighting	6/18/2016	2/10/2012
Last Sighting	6/22/2016	-
No. of Sightings	2	1



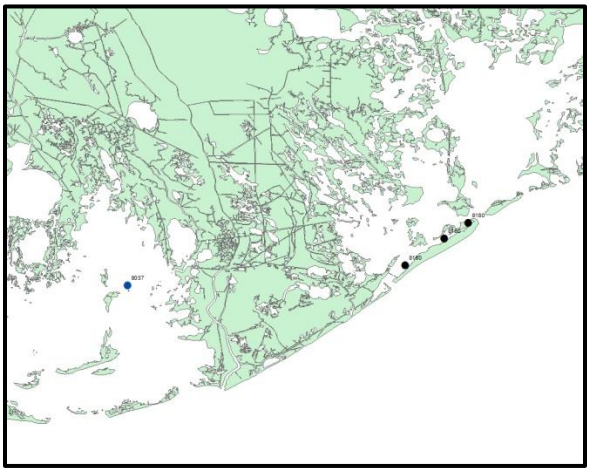
S	TTB	BB
Catalog ID	2018	2291
First Sighting	6/2/2016	11/11/2011
Last Sighting	1/25/2017	4/20/2012
No. of Sightings	2	4



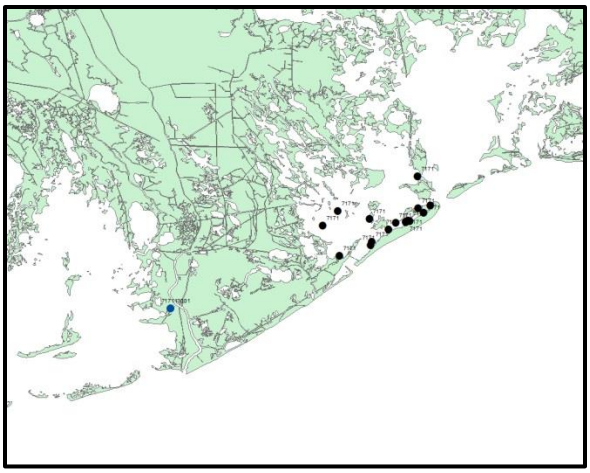
T	TTB	BB
Catalog ID	3029	3166
First Sighting	6/10/2016	7/14/2015
Last Sighting	-	-
No. of Sightings	1	1



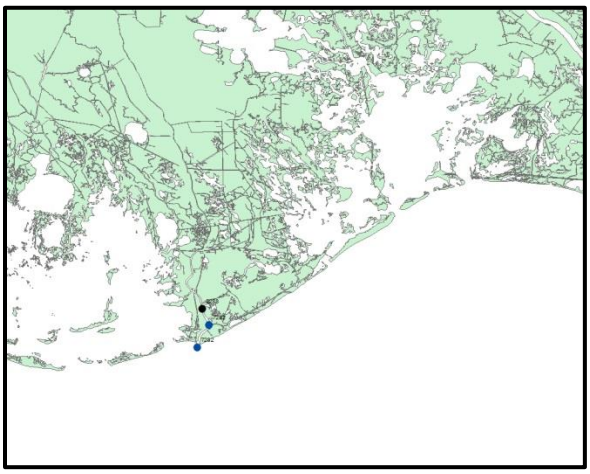
U	TTB	BB
Catalog ID	8037	8180
First Sighting	6/2/2016	5/19/2015
Last Sighting	-	5/19/2015
No. of Sightings	1	3



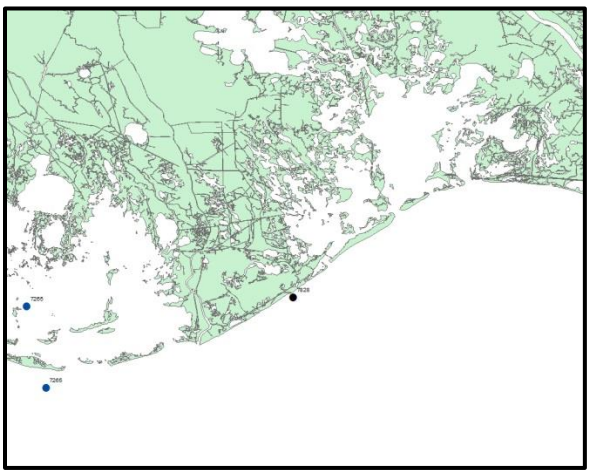
V	TTB	BB
Catalog ID	13001	7171
First Sighting	6/5/2016	11/13/2010
Last Sighting	-	9/19/2017
No. of Sightings	1	17



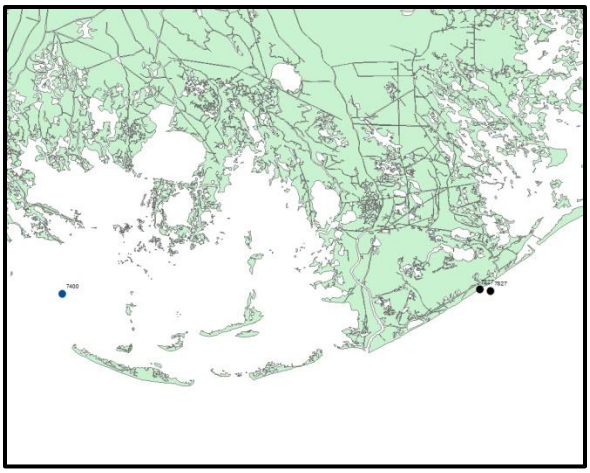
W	TTB	BB
Catalog ID	7282	2288
First Sighting	6/11/2016	2/10/2012
Last Sighting	1/15/2017	-
No. of Sightings	2	1



X	TTB	BB
Catalog ID	7265	7828
First Sighting	6/11/2016	7/13/2015
Last Sighting	1/14/2017	-
No. of Sightings	2	1

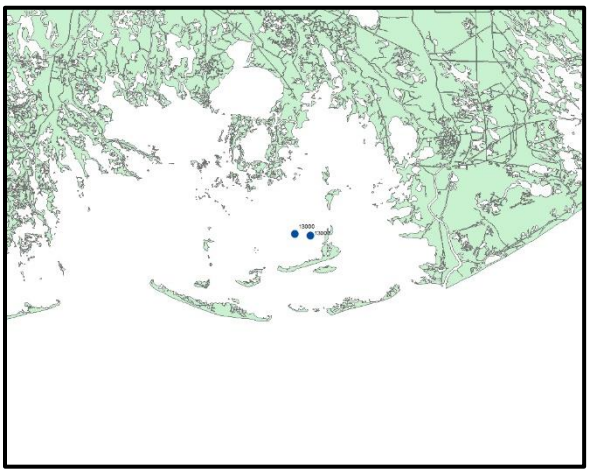


Y	TTB	BB
Catalog ID	7400	7827
First Sighting	6/26/2016	7/13/2015
Last Sighting	-	7/13/2015
No. of Sightings	1	2



Z	TTB	BB
Catalog ID	13000	R9
First Sighting	6/2/2016	10/26/2015*
Last Sighting	6/7/2016	-
No. of Sightings	2	-

*stranding date on Grand Isle



AA	TTB	BB
Catalog ID	2086	2542
First Sighting	6/7/2016	7/13/2015
Last Sighting	1/17/2017	-
No. of Sightings	2	1

BB	TTB	BB
Catalog ID	8036	2539
First Sighting	6/7/2016	7/13/2015
Last Sighting	-	-
No. of Sightings	1	1