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Ranging patterns of common bottlenose dolphins *Tursiops truncatus* in Barataria Bay, Louisiana, following the *Deepwater Horizon* oil spill

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ABSTRACT: Common bottlenose dolphins *Tursiops truncatus* were present in Barataria Bay, Louisiana, USA, before, during, and after the 2010 *Deepwater Horizon* oil spill. Health assessments conducted on dolphins in Barataria Bay in 2011, 2013, and 2014, after the capping of the well, found disease conditions consistent with petroleum hydrocarbon exposure and toxicity. Satellite-linked transmitters were affixed to dolphins during these health assessments for assessing the potential for continued exposure to petroleum-associated products, estimating survival rates, and planning potential restoration. In total, 44 tags were deployed, transmitting for 48 to 260 d. The dolphins exhibited multi-year site fidelity to small home ranges. Most tagged dolphin locations were inside the bay. On average, the dolphins that entered the Gulf coastal waters remained within 1.75 km of shore. No dolphins were documented more than 14 km beyond their 95% utilization distribution (UD) overall home ranges. Individual variation in the use of specific regions and habitats of Barataria Bay suggests the occurrence of community structure. All but 3 of the dolphins (93%) were tracked or observed during more than 1 yr in Barataria Bay, with 20 (45%) recorded each year from 2010 to 2014. All but 6 dolphins (86%) were tracked during multiple seasons. Home range sizes were comparable to those reported for bottlenose dolphins elsewhere. These findings suggest the occurrence of long-term, year-round residency. Residency patterns suggest potential for continued exposure to petroleum-associated products that may have remained in Barataria Bay after the spill.

KEY WORDS: Bottlenose dolphins · Satellite-linked telemetry · Ranging patterns · *Deepwater Horizon* oil spill · Home ranges · Site fidelity

INTRODUCTION

Barataria Bay, Louisiana, (BAR) was one of the heaviest oiled coastal regions of the Gulf of Mexico (GoM) following the 2010 *Deepwater Horizon* (DWH) oil spill (Barron 2012, Michel et al. 2013). Common bottlenose dolphins *Tursiops truncatus* were observed in BAR during and after the spill. Capture-release health assessments of bottlenose dolphins conducted in BAR 1 yr after the flow from the wellhead ended

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found medical conditions of concern. These findings are consistent with exposure to petroleum products, including indications of unusually low levels of adrenal hormones and a high prevalence of moderate to severe lung disease (Schwacke et al. 2014). About half of the sampled dolphins were given a guarded or worse prognosis for survival, and 17% were given a poor or grave prognosis.

In order to understand potential impacts to a population, it is desirable to evaluate survival rates. Measurement of survival rates requires efforts to account for individuals repeatedly over time, and the ability to evaluate the probability that a lack of contact with an individual through signals or observations indicates mortality, as opposed to movement out of a limited study area. Because transmissions can be received from anywhere in the world, satellite-linked telemetry has become an effective tool for defining dolphin ranging patterns and determining if ranges are contained within the bounds of study areas (e.g. Balmer et al. 2014a). The findings from satellite-linked telemetry can also help with the design of follow-up dolphin surveys for resighting targeted identifiable individuals.

Knowledge of ranging patterns of dolphins sampled during health assessments in BAR is also of interest for assessing potential exposure to petroleum-associated products that remained in the environment after the spill, or exposure to other threats. Information on the extent to which individuals use BAR or other waters, and the timing of their use of specific areas, can aid in understanding exposures. Ranging data can also be used to inform potential restoration plans in regions adversely impacted by the DWH oil spill. It would be beneficial to be able to relate habitat restoration plans to specific population units of dolphins, as determined from their ranging and habitat use patterns.

Limited pre-DWH research in BAR suggests that dolphin residence patterns are consistent with those observed elsewhere in the northern GoM (NGoM). Photographic identification (photo-ID) research conducted in a portion of BAR from 1999 to 2002 by Miller (2003) found dolphins were present year-round, and the population appeared to be closed, with some evidence of site fidelity. For management purposes, NOAA Fisheries has tentatively identified relatively discrete stocks of bottlenose dolphins in 32 NGoM bays, sounds, and estuaries, including BAR (Waring et al. 2013). For most of these stocks, evidence exists for residency of at least some of the dolphins, ranging from the multi-decadal, multi-generational, year-round residency of a community of dolphins in Sarasota Bay, Florida (Wells et al. 1987, Wells 2014), to St. Joseph Bay, Florida, where long-term, year-round residents are supplemented seasonally by large numbers of non-resident dolphins (Balmer et al. 2008).

Where site fidelity in the NGoM has been identified and observed over time, it appears to be strong. In Sarasota Bay, as many as 5 concurrent generations of resident dolphins of up to 66 yr of age can be identified at any given time, with some individuals observed in the region for more than 4 decades (Wells 2014). The resident Sarasota Bay dolphins maintained their established community home range, with some temporary shifts in core areas, through major ecological challenges, such as instances when severe harmful algal blooms (*Karenia brevis* red tides) have resulted in more than 90% reductions in their primary prey fish (Wells 2010). Just south of Sarasota Bay, 94% of resident Charlotte Harbor dolphins were re-identified within the same ranging area after the tremendous habitat destruction and pollution caused by Category 4 Hurricane Charley in 2004, followed by a severe red tide (Bassos-Hull et al. 2013).

Findings extrapolated from other NGoM sites and preliminary pre-DWH spill data suggest that site fidelity should occur in BAR. To examine site fidelity and ranging patterns of bottlenose dolphins in BAR, we attached satellite-linked transmitters to dolphins captured, sampled, and released there during health assessments conducted in August 2011, June 2013, and June 2014. The satellite-linked transmitters provided information on daily movements of individuals over periods of up to 8 mo.

MATERIALS AND METHODS

Bottlenose dolphins were tagged with satellite-linked transmitters during capture-release health assessments in BAR, Louisiana. This estuary is located south and west of the Mississippi River, and is separated from the GoM by a series of barrier islands (Fig. 1). The bay system is dominated by saltmarsh vegetation around the fringes and on numerous small marsh islands. The waters are turbid and shallow, on average less than 2 m deep, and experience a tidal excursion of less than 0.32 m (Miller & Baltz 2009). During August 2011, 25 dolphins were tagged, with 8 more in June 2013, and another 11 in June 2014 (Schwacke et al. 2014). In 2011 and 2014, tag deployment occurred primarily in the western portion of BAR, around the barrier islands of Grand Isle and the Grand Terre Islands, as well as marsh islands

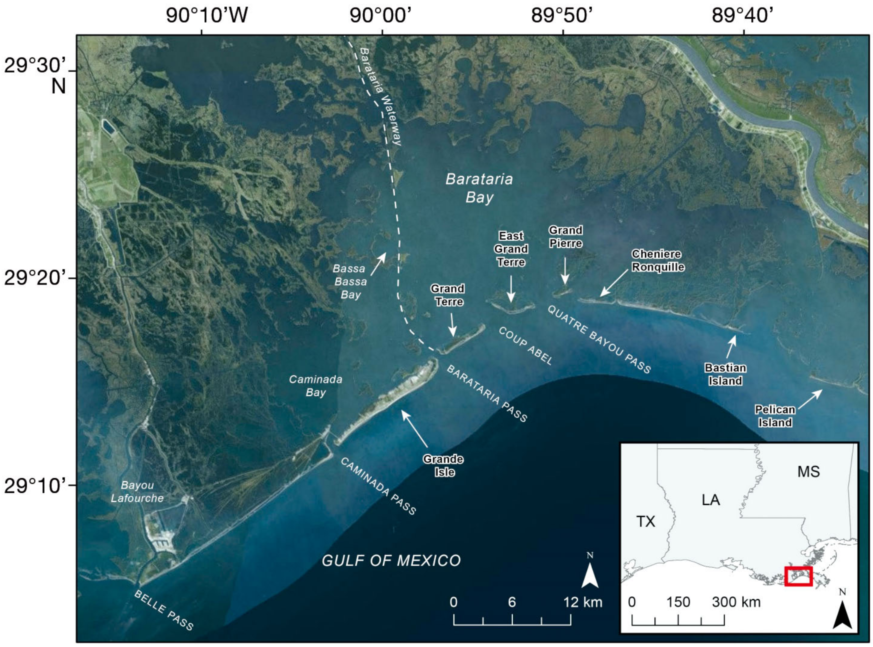

Fig. 1. Barataria Bay (LA, USA) study area for bottlenose dolphin (*Tursiops truncatus*) tagging and tracking

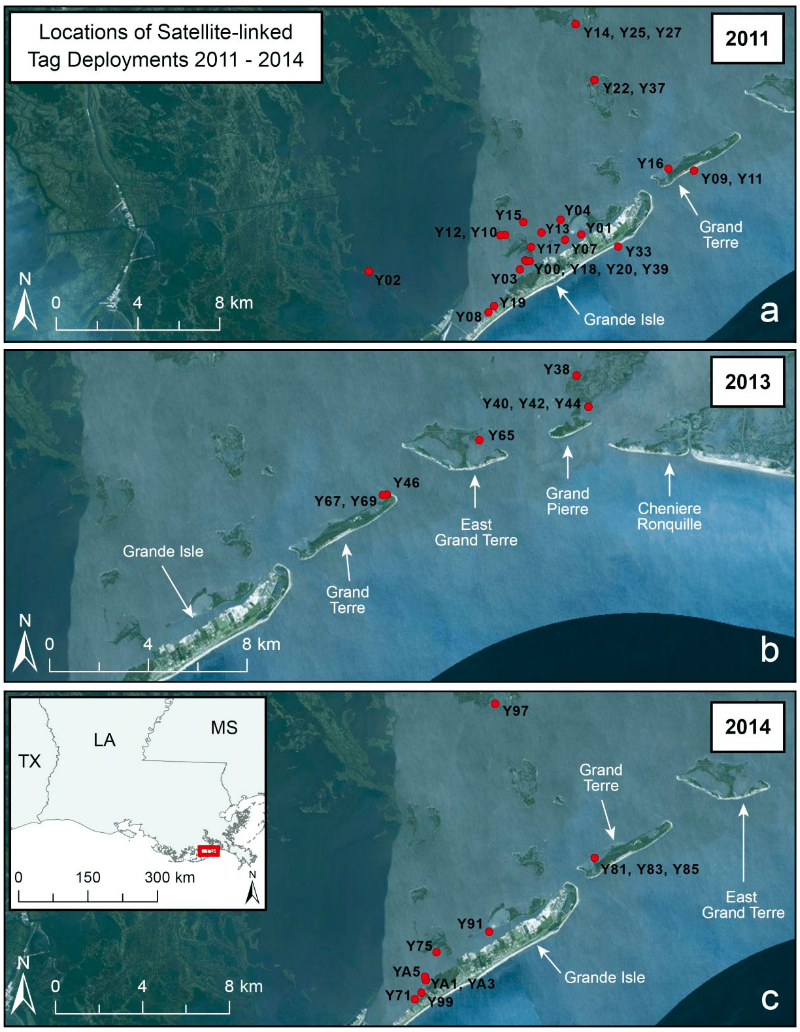

Fig. 2. Locations of deployments of satellite-linked tags during 2011 to 2014. Capture, tagging, and release locations for each dolphin (*Tursiops truncatus*) in each year are indicated by a red dot alongside the identification number of each dolphin tagged at that site

to the north, as far as Bassa Bassa Bay (Fig. 2). In 2013, tags were deployed around barrier and marsh islands farther to the east, to include dolphins in the eastern portion of BAR.

The tags were variants of the SPOT tag produced by Wildlife Computers, and provided location and tag status data. In 2011, SPOT-100 tags were deployed. In 2013 and 2014, SPOT-299B tags, slightly modified from the SPOT-100, were deployed. The SPOT-100 (Single-point, Finmount, 281A, 2-Lay) tags were 8.5 cm long, 2.0 cm wide, 2.5 cm high, weighed 54 g, and had a flexible 18 cm long antenna (Fig. 3a). Plastic wings, 4.5 cm long × 1.5 cm tall, extending forward from the tag body, were positioned on each side of the trailing edge of the dorsal fin, with a matching 0.8 cm diameter hole in each for attaching the tag 3.5 cm cranial to the fin's trailing edge. The basic shape of the tag built on recent design developments where single pin attachments were used and follow-up observations were possible (Balmer et al. 2011, 2014b, Wells et al. 2013a).

The SPOT-299B (Single-point, Finmount, 2-Lay, Custom) tags used in 2013 were 10.5 cm long, 2.0 cm wide, 2.5 cm high, weighed 62 g, and had a flexible 17.3 cm long antenna (Fig. 3b). Plastic wings, 6.5 cm long × 2.0 cm tall, extending forward from the tag body were positioned on each side of the trailing edge of the dorsal fin, with a matching 0.8 cm diameter

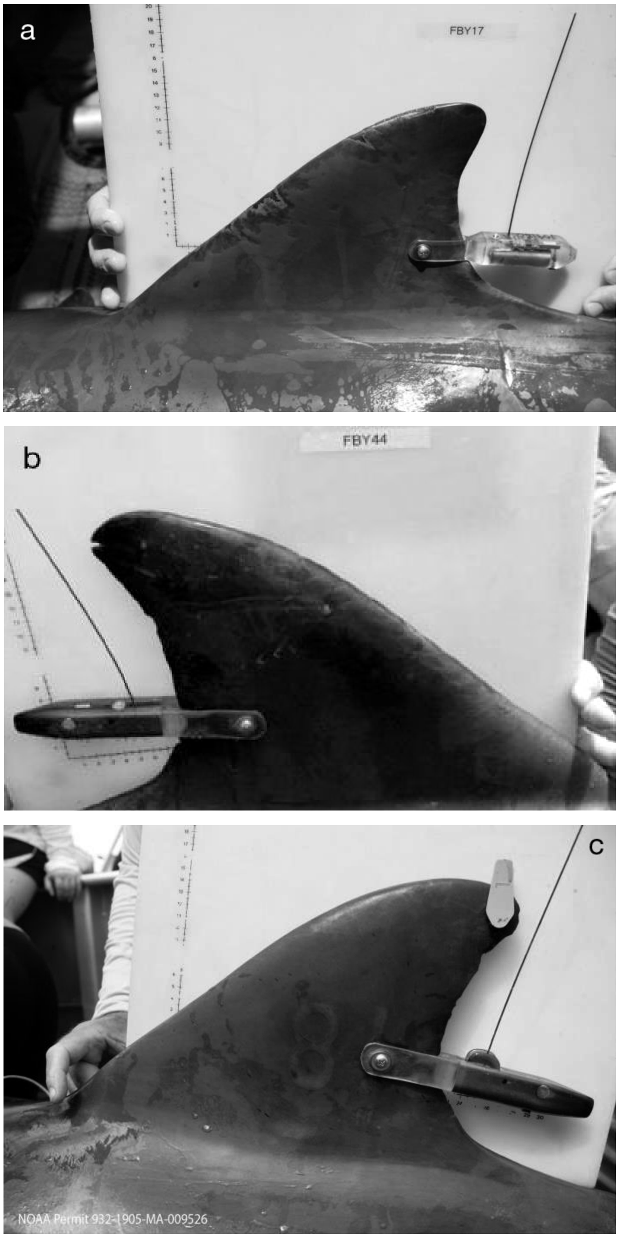

Fig. 3. Satellite-linked tags used in Barataria Bay. Numbered markings on board behind fins indicate cm. (a) SPOT-100 tag deployed on bottlenose dolphin (*Tursiops truncatus*) Y17 in Barataria Bay, LA, in 2011. (b) SPOT-299B tag deployed on bottlenose dolphin Y44 in Barataria Bay, LA, in 2013. (c) SPOT-299B tag deployed on bottlenose dolphin Y81 in Barataria Bay, LA, in 2014. Note the semicircular protective structures added on each side of the antenna base. Photos by NOAA

hole in each for attaching the tag 3.5 cm cranial to the fin's trailing edge. The basic shape of the tag was slightly different from that used in 2011. Computational fluid dynamics (CFD) tests performed (L. Howle, Duke University) prior to production of tags for the 2013 project resulted in shape and configuration refinements leading to significant reduction in drag as compared to previous designs (Wells et al. 2013b). In 2014, parallel ridges were added on each side of the base of the antenna to provide protection (Fig. 3c). Additional CFD tests indicated that these modifications did not add significantly to tag drag. Each tag was coated with Propspeed™ to reduce biofouling (Wells et al. 2013b).

All tags were attached by means of a single plastic pin positioned about 3.5 cm from the trailing edge of the dorsal fin (e.g. Balmer et al. 2014b). The tag was positioned against the trailing edge, while the location for the pin was marked on the fin. The marked site was cleaned with Dermachlor™, and then methanol, scrubs. Lidocaine with epinephrine was injected at the marked site as an analgesic. After several minutes, a sterilized stainless steel 0.8 cm coring tool was centered over the mark, and pushed by hand through the fin into a rubber sanding block held against the opposite side of the fin. A 0.8 cm Delrin™ pin of appropriate length, machine-bored to accept a zinc-plated steel flathead screw in each end, and beveled on 1 end to facilitate fin penetration, was selected from pins of different lengths soaking in Dermachlor, and inserted through the hole in the dorsal fin. The screws were 0.95 cm thread-forming screws for plastic, with 10 to 14 threads. A stainless steel washer was inserted between the screw head and the tag attachment wing. The wings of the tag were placed over the ends of the pins, and the screws and washers were attached by hand-tightening with screw drivers, to the point where a playing-card-thick space remained between each wing and the fin. The tag was tested for function, the serial number was recorded, and photos were taken of the attachment and fin. By design, the screws in the ends of the Delrin attachment pins corrode, allowing the tags to fall off the fins after the end of the tag's battery life.

The SPOT-299B tags used in 2013 and 2014 were designed to both send transmissions to satellites for remote tracking and to produce a signal that could be tracked directly in real time. Each tag included a UHF beacon that sent out low-power, very short, unmodulated pings at the same frequency as the data transmissions, in the 400 MHz range. These signals were designed to be located in the field by a direction-finding receiver and antenna.

Tag transmission windows (duty cycles) varied each year, and were selected to: (1) optimize satellite availability, (2) distribute transmission windows temporally for independence, and (3) make remote tracking data available at the beginning of a field day to facilitate searching for specific individuals in real time. Within years, all tags were set to the same duty cycles. The tags were programmed to transmit up to 250 times each day, yielding a maximum estimate of up to 240 tracking days based solely on battery life.

Location data and home range analyses

Satellite-linked locations were received and processed by the Argos Data Collection and Location System. Argos uses multiple, polar-orbiting satellites to receive data from tags, and transmits these data to ground-based processing centers (CLS 2011). Tag locations were calculated using the Doppler effect on transmission frequency and a location-processing algorithm.

Each individual's ranging patterns were described as overall home (95% utilization distribution [UD]) and core (50% UD) ranging areas, calculated using a kernel interpolation method while accounting for shoreline barriers. A UD represents a probability of finding a given individual in a plane and describes an animal's use of space (White & Garrott 1990). UDs measure areas of intense use; therefore, the resulting ranging areas may not be continuous, but rather broken in space (Powell 2000). Kernel densities are used to calculate specified UDs (Worton 1989).

Data selection for mapping and home range analyses involved filtering tag data for location plausibility. Argos classifies location quality relative to an estimated error radius. The best quality data, LC3, has an estimated error of <250 m. LC2 has an estimated error of <500 m. LC1 locations are estimated to be accurate to within 1500 m. Only location data of qualities LC3 and LC2 were used as input data to calculate UDs.

Home range size measures for bottlenose dolphins in bays, sounds, and estuaries have been found to vary with the numbers of locations used to define the ranges and with sex (Urian et al. 2009). Urian et al. (2009) determined that fixed kernel home range sizes for bottlenose dolphins in bays on the west coast of Florida changed little with >150 locations, based on sighting data. For BAR tag location data, we established a lower threshold of 150 locations for statistical analyses; however, all animals received a home and core range calculation. To remove the potential for autocorrelation, 1 randomly selected location per day was retained for home range analysis.

Previous studies of dolphin home ranges have typically used kernel density methods assuming animals could move anywhere in space. These methods were not ideal for species which encountered a strong barrier, such as land (Benhamou & Cornélis 2010), and often overestimated home range size (MacLeod 2013). While kernel density methods that account for barriers may underestimate home range size, as this method highlights areas of intense use and may not indicate the connectivity between areas of use (Powell 2000, Kie et al. 2010), accounting for barriers improves descriptions of home range shape and estimates of size.

Home and core range calculations are sensitive to a smoothing parameter (*h*) or bandwidth that determines the size and shape of spatial use (Wand & Jones 1995, Kie 2013). A rule-based ad hoc method was applied to estimate the appropriate smoothing parameter for each individual home range (Kie et al. 2010, Rodgers & Kie 2011, Kie 2013). Analysis of estimated smoothing parameters was completed using the Home Range Tools for ArcGIS (HRT) extension for ArcGIS 9.0 (ESRI 2004). Analyses for kernel interpolation while accounting for barriers were completed using the Geostatistical Analyst & Spatial Analyst toolboxes in ArcGIS 10.2 (ESRI 2014), following methods suggested by MacLeod (2013). Land areas were subtracted from the final home and core range areas to ensure resulting range areas represented only usable water resources.

Three parameters were used to describe home range size: (1) overall home range (95% UD), (2) core area (50% UD), and (3) largest dimension of the range (longest distance between 2 locations). Home range analyses were stratified by sex, and a *t*-test was used to determine if significant differences existed between male and female ranging behavior. A chi-square test was used to test for seasonal differences in ranging areas. Statistical tests employed a value of $p < 0.05$ for assignment of significance.

RESULTS

Satellite-linked tags were deployed on 44 dolphins of both sexes (28 F, 16 M), and all ages except dependent calves during 2011 to 2014. In 2011, 14 females were tagged versus 11 males; in 2013, 3 females versus 5 males; and 11 females in 2014. In 2014, only females received tags, to better document ranging patterns of pregnant dolphins and to facilitate reacquisition to determine reproductive outcome.

All tags transmitted post-deployment, from 48 to 260 d (Table 1). The span of dates over which signals of any kind were received varied from year to year, with a mean of 163 d for 2011 deployments (range:

Table 1. Tag deployment and performance summary for dolphins *Tursiops truncatus* tagged in Barataria Bay, LA during 2011, 2013 and 2014. Days to final location/signal: no. of days from deployment to a final location/signal. FB: Freeze-brand; PTT ID: platform transmitter terminal identification number

Dolphin: FB	Tag: PTT ID	Sex	Deployment Date	Deployment °N	Deployment °W	No. of locations	Final location received	Days to final location	Most recent signal	Days to final signal	First date seen without tag	Final tag status
2011 deployments												
Y00	109138	M	Aug 04, 2011	29.23808	−90.01253	544	Nov 22, 2011	110	Nov 22, 2011	110	Apr 20, 2012	Sensor values indicate a healthy tag
Y01	109141	F	Aug 03, 2011	29.25018	−89.98474	1.067	Mar 30, 2012	240	Mar 30, 2012	240	Apr 20, 2012	Low battery voltage
Y02	109148	M	Aug 04, 2011	29.23138	−90.09095	423	Nov 09, 2011	97	Nov 09, 2011	97	Nov 19, 2011	Sensor values indicate a healthy tag
Y03	109143	F	Aug 03, 2011	29.23396	−90.01516	323	Dec 11, 2011	130	Dec 12, 2011	131	Feb 25, 2012	Low battery voltage; heavy biofouling
Y04	109146	M	Aug 07, 2011	29.25637	−89.99531	381	Oct 11, 2011	65	Jan 02, 2012	148	Feb 07, 2012	Heavy biofouling; sensor values indicate a healthy tag
Y07	109134	F	Aug 05, 2011	29.24759	−89.99290	843	Feb 01, 2012	180	Feb 01, 2012	180	May 18, 2012	Low battery voltage; heavy biofouling
Y08	109152	M	Aug 09, 2011	29.21477	−90.03036	332	Oct 12, 2011	64	Jan 31, 2012	175	Oct 27, 2011	Sensor values indicate a healthy tag
Y09	109135	F	Aug 05, 2011	29.27959	−89.92883	272	Sep 22, 2011	48	Sep 22, 2011	48	Apr 11, 2012	Sensor values indicate a healthy tag
Y10	109145	M	Aug 09, 2011	29.24895	−90.02306	737	Mar 22, 2012	226	Mar 26, 2012	230	Apr 24, 2012	Low battery voltage
Y11	109144	F	Aug 05, 2011	29.27959	−89.92883	342	Sep 26, 2011	52	Sep 28, 2011	54	Nov 14, 2011	Sensor values indicate a healthy tag
Y12	109155	M	Aug 10, 2011	29.24877	−90.02535	218	Dec 02, 2011	114	Jan 12, 2012	155	Jan 31, 2012	Carcass recovered with tag; low battery voltage
Y13	109149	F	Aug 07, 2011	29.25050	−90.00472	825	Jan 25, 2012	171	Jan 25, 2012	171	Apr 19, 2012	Low battery voltage
Y14	109136	M	Aug 11, 2011	29.34291	−89.99031	941	Mar 09, 2012	211	Mar 16, 2012	218	Apr 19, 2012	Low battery voltage
Y15	109161	F	Aug 07, 2011	29.25487	−90.01404	265	Jan 01, 2012	147	Jan 22, 2012	168	Mar 30, 2012	Low battery voltage; heavy biofouling
Y16	109137	M	Aug 12, 2011	29.28017	−89.94176	284	Jan 05, 2012	146	Jan 09, 2012	150	Feb 13, 2012	Low battery voltage; moderate biofouling
Y17	109160	F	Aug 08, 2011	29.24386	−90.00973	945	Apr 11, 2012	247	Apr 24, 2012	260	Jun 26, 2012	Heavy biofouling
Y18	109157	M	Aug 15, 2011	29.23771	−90.01183	956	Feb 27, 2012	196	Feb 27, 2012	196	May 17, 2012	Low battery voltage
Y19	109139	F	Aug 09, 2011	29.21759	−90.02750	260	Jan 18, 2012	162	Feb 07, 2012	182	Mar 27, 2012	Sensor values indicate a healthy tag
Y20	109150	M	Aug 15, 2011	29.23771	−90.01183	639	Dec 10, 2011	117	Dec 10, 2011	117	Feb 07, 2012	Sensor values indicate a healthy tag
Y22	109162	M	Aug 16, 2011	29.31840	−89.98014	845	Feb 22, 2012	190	Feb 24, 2012	192	Apr 19, 2012	Low battery voltage; heavy biofouling
Y25	109158	F	Aug 11, 2011	29.34291	−89.99031	789	Jan 21, 2012	163	Jan 21, 2012	163	Feb 14, 2012	Low battery voltage
Y27	109147	F	Aug 11, 2011	29.34291	−89.99031	960	Mar 19, 2012	221	Mar 19, 2012	221	Aug 22, 2012	Low battery voltage
Y33	109133	F	Aug 12, 2011	29.24518	−89.96605	593	Jan 17, 2012	158	Jan 17, 2012	158	Apr 20, 2012	Low battery voltage
Y37	109154	F	Aug 16, 2011	29.31840	−89.98014	790	Jan 28, 2012	165	Jan 29, 2012	166	Feb 14, 2012	Low battery voltage
Y39	109142	F	Aug 16, 2011	29.23788	−90.01040	722	Dec 31, 2011	137	Dec 31, 2011	137	Feb 11, 2012	Moderate biofouling
2011 Deployment summary: 25 tags deployed; duration: mean = 163 d; median = 166 d; min = 48 d; max = 260 d												

Table 1 continued on next page

Table 1 (continued)

Dolphin: FB	Tag: PTT ID	Sex	Deployment Date	Deployment °N	Deployment °W	No. of locations	Final location received	Days to final location	Most recent signal	Days to final signal	First date seen without tag	Final tag status
2013 deployments												
Y38	129996	M	Jun 25, 2013	29.34182	–89.83232	940	Nov 19, 2013	147	Nov 19, 2013	147	May 13, 2014	Sensor values indicate a healthy tag
Y40	130024	M	Jun 25, 2013	29.33051	–89.82697	893	Nov 07, 2013	135	Nov 07, 2013	135	No resight without tag	Low battery voltage
Y42	130028	M	Jun 25, 2013	29.33051	–89.82697	887	Jan 07, 2014	196	Jan 08, 2014	197	No resight without tag	Low battery voltage
Y44	130015	M	Jun 25, 2013	29.33051	–89.82697	597	Sep 19, 2013	86	Sep 19, 2013	86	No resight without tag	Sensor values indicate a healthy tag
Y46	130025	M	Jun 27, 2013	29.29663	–89.91016	498	Sep 21, 2013	86	Dec 26, 2013	182	Apr 08, 2015	Sensor values indicate a healthy tag; seen with missing antenna Nov 17, 2013
Y65	129998	F	Jun 27, 2013	29.31742	–89.87219	511	Sep 15, 2013	80	Sep 15, 2013	80	Apr 25, 2014	Sensor values indicate a healthy tag, but voltage may be trending down prematurely
Y67	130006	F	Jun 27, 2013	29.29645	–89.91178	497	Sep 21, 2013	86	Dec 29, 2013	185	Apr 23, 2014	Low battery voltage; seen with missing antenna Nov 11, 2013
Y69	130005	F	Jun 27, 2013	29.29645	–89.91178	805	Oct 14, 2013	109	Oct 14, 2013	109	Nov 10, 2013	Sensor values indicate a healthy tag; seen with missing tag body Nov 10, 2013; tag completely gone May 14, 2014
2013 Deployment summary: 8 tags deployed; duration: mean = 140 d; median = 141 d; min = 80 d; max = 197 d												
2014 deployments												
Y71	130021	F	Jun 10, 2014	29.22010	–90.02553	313	Nov 14, 2014	157	Nov 18, 2014	161	Apr 06, 2015	Sensor values indicate a healthy tag
Y75	129994	F	Jun 12, 2014	29.23976	–90.01583	441	Sep 11, 2014	91	Sep 11, 2014	91	Apr 06, 2015	Sensor values indicate a healthy tag
Y81	129993	F	Jun 16, 2014	29.28056	–89.94211	204	Oct 19, 2014	125	Oct 19, 2014	125	May 20, 2015	Low battery voltage
Y83	130012	F	Jun 16, 2014	29.28056	–89.94211	134	Oct 05, 2014	111	Oct 18, 2014	124	Jul 15, 2015	Sensor values indicate a healthy tag
Y85	130022	F	Jun 16, 2014	29.28056	–89.94211	189	Sep 13, 2014	89	Sep 25, 2014	101	May 18, 2015	Sensor values indicate a healthy tag
Y91	130018	F	Jun 17, 2014	29.24874	–89.99117	655	Nov 18, 2014	154	Nov 21, 2014	157	Apr 06, 2015	Sensor values indicate a healthy tag
Y97	130026	F	Jun 18, 2014	29.34362	–89.99118	379	Nov 10, 2014	145	Nov 10, 2014	145	Apr 09, 2015	Sensor values indicate a healthy tag
Y99	130020	F	Jun 19, 2014	29.22289	–90.02250	290	Sep 27, 2014	100	Oct 07, 2014	110	Apr 06, 2015	Sensor values indicate a healthy tag
YA1	129995	F	Jun 19, 2014	29.22804	–90.02049	551	Oct 08, 2014	111	Oct 05, 2014	108	May 18, 2015	Sensor values indicate a healthy tag
YA3	130016	F	Jun 19, 2014	29.22804	–90.02049	545	Oct 15, 2014	118	Oct 15, 2014	118	May 19, 2015	Sensor values indicate a healthy tag
YA5	130001	F	Jun 20, 2014	29.22959	–90.02103	131	Jul 20, 2014	30	Aug 09, 2014	50	No resight without tag	Sensor values indicate a healthy tag
2014 Deployment summary: 11 tags deployed; duration: mean = 117 d; median = 118 d; min = 50 d; max = 161 d												

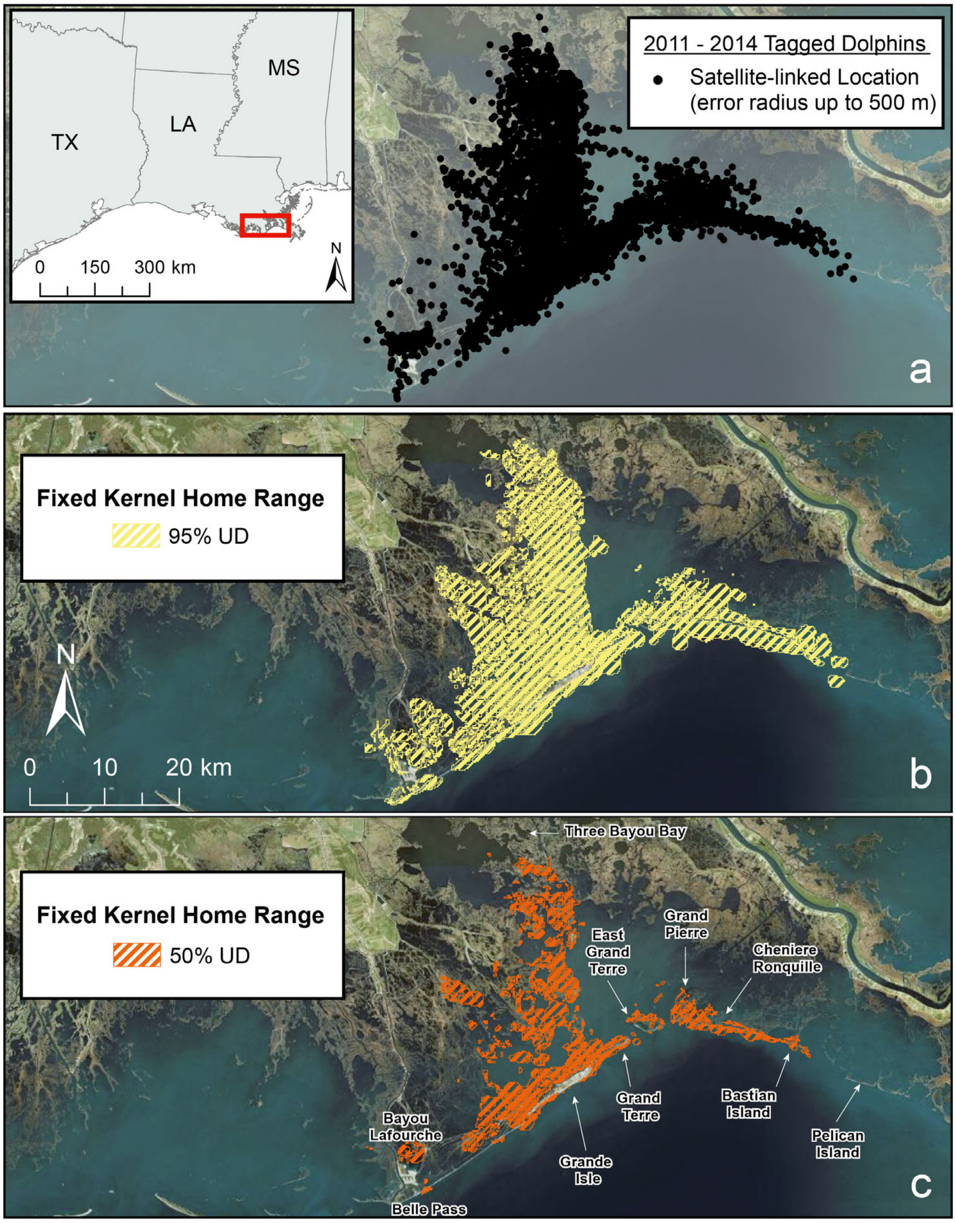

Fig. 4. Composite maps of all of the 44 dolphins (*Tursiops truncatus*) tagged during 2011 to 2014. (a) Satellite-linked locations for each tagged individual (<500 m error radius locations only); (b) fixed kernel home range (95% utilization distribution [UD]) for each tagged dolphin; (c) fixed kernel core areas (50% UD) for each tagged dolphin

48–260 d), 140 d for 2013 (range: 80–197 d), and 117 d for 2014 (range: 50–161 d). The total numbers of locations of all qualities received from each tag varied substantially within and between years. On average, 2011 tags produced 612 locations (range: 218–1067), 2013 tags produced 704 locations (range: 497–940), and 2014 tags produced 348 locations (range: 131–655).

All high quality location data (<500 m error radius) from all 44 dolphins tagged from 2011 to 2014 indicated that tagged dolphins remained in BAR throughout the tracking period (Fig. 4). The locations occurred within an area extending about 65 km east to west, from Bayou Lafourche/Belle Pass to Pelican Island, and about 70 km north to south, from Three Bayou Bay to the barrier islands, and encompassing the capture-release sites of the tagged animals (Fig. 2). Most (85.9%) of the locations were inshore (north) of the barrier islands, while the remainder were in the GoM, but within 4.24 km of shore.

The distributions of tracking locations by capture year were similar for dolphins tagged in 2011 (Fig. 5) and 2014 (Fig. 6), and both were different from those for dolphins tagged in 2013 (Fig. 7), reflecting differences in geographical distribution of capture efforts across years (Fig. 2). Efforts in 2013 included the coastal marshes on the eastern side of BAR where no captures had occurred in 2011; efforts in 2014 fo-

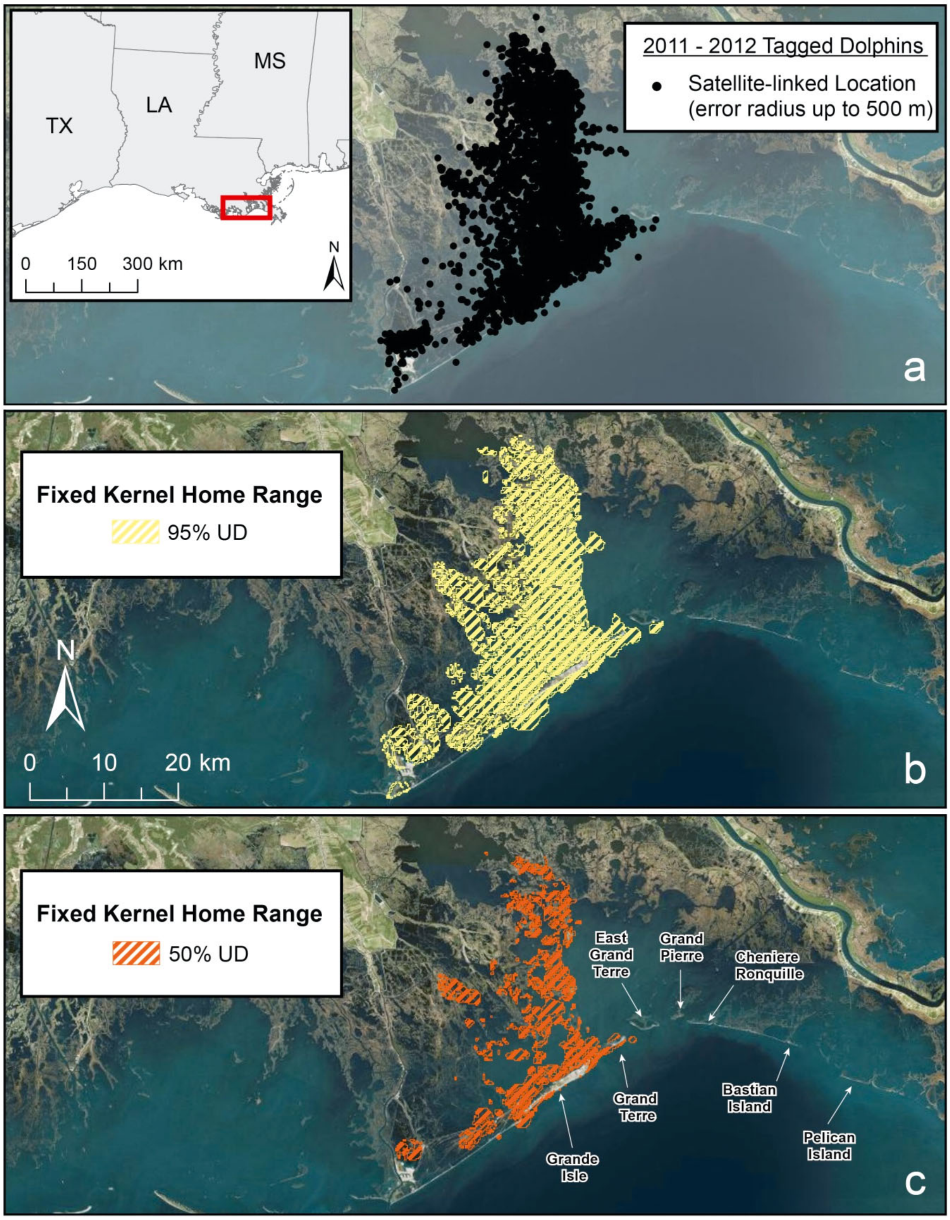

Fig. 5. Composite maps of all of the 28 dolphins (*Tursiops truncatus*) tagged during 2011, and tracked during 2011 to 2012. (a) Satellite-linked locations for each tagged individual (<500 m error radius locations only); (b) fixed kernel home range (95% utilization distribution [UD]) for each tagged dolphin; (c) fixed kernel core areas (50% UD) for each tagged dolphin

cused on trying to recapture 2011 dolphins for follow-up health examinations, in western BAR.

Tagged dolphins were year-round, multi-year residents of BAR. Transmissions were received from tagged animals during all months of the year except May (there were no active tags during any May), and all locations were within BAR, regardless of month (Table 2). All but 3 of the 44 dolphins were tracked and/or documented during NOAA photo-ID surveys (T. Speakman unpubl. data) in multiple years (Table 2). The 3 exceptions were subadult males (Y40, Y42, Y44) caught and tagged in coastal marshes on the eastern side of BAR, beyond the survey study area (Fig. 2). These individuals were each observed only once during photo-ID surveys. On average, tagged dolphins were documented in BAR during tracking and/or photo-ID surveys during 79% of the years 2010 to 2014.

Ranging patterns

Typically, individuals used only a portion of the entire survey region in which the combined tracking locations occurred. Three cases that exemplify general ranging patterns for BAR dolphins are as follows: (1) Y18 represents animals that mainly use waters west of the Barataria Waterway, including Grand Isle

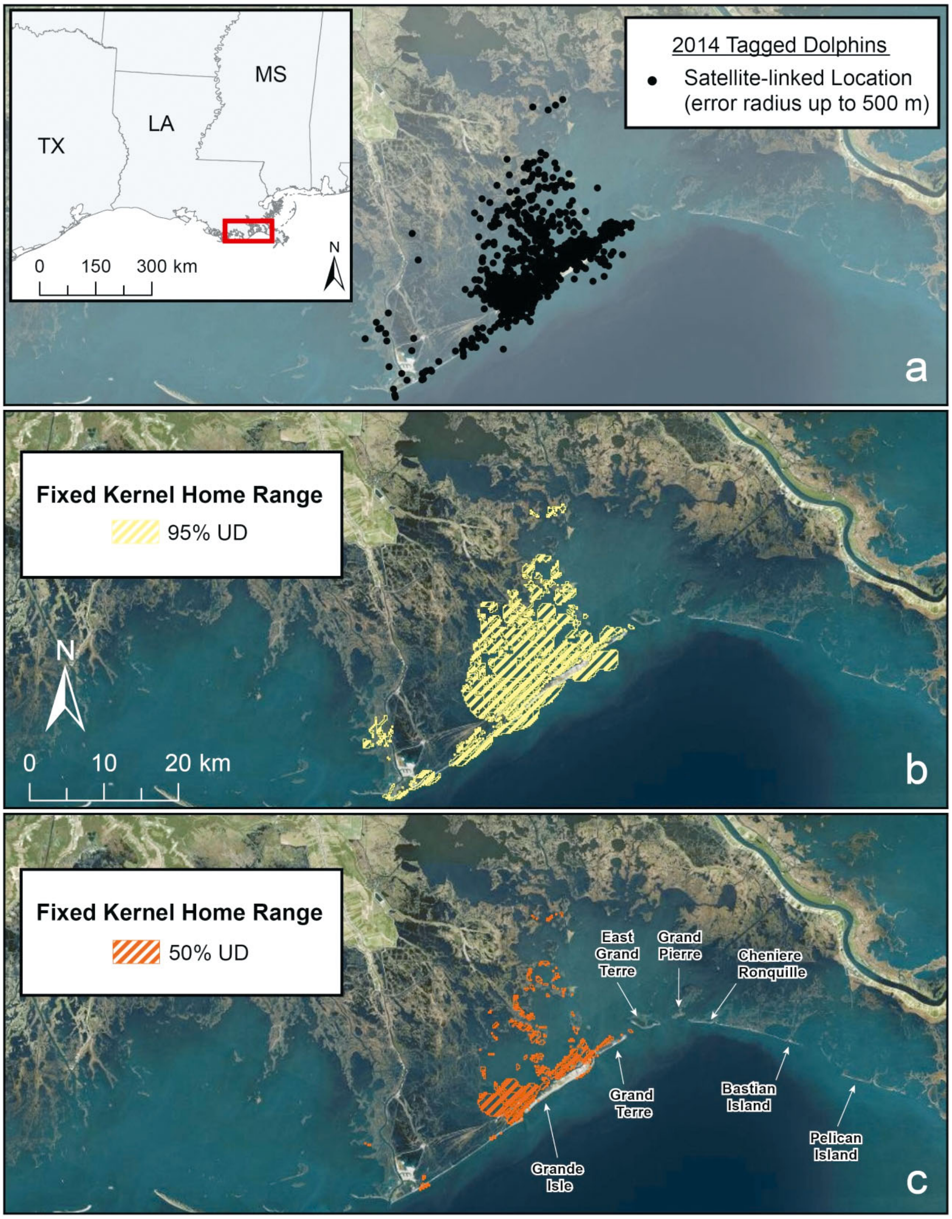

Fig. 6. Composite maps of all of the 11 dolphins (*Tursiops truncatus*) tagged and tracked during 2014. (a) Satellite-linked locations for each tagged individual (<500 m error radius locations only); (b) fixed kernel home range (95% utilization distribution [UD]) for each tagged dolphin; (c) fixed kernel core areas (50% UD) for each tagged dolphin

and nearby Gulf waters along with western BAR areas such as Caminada Bay, West Champagne Bay, and Bassa Bassa Bay (West), (2) Y39 exemplifies the typical pattern of movements near the western barrier islands from Grande Terre, westward, including Grand Isle and nearby Gulf waters (Islands), and (3) Y38 represents movements of dolphins around the barrier islands East of Grand Terre, including coastal marshes in eastern BAR (East).

(1) West: Dolphin Y18, an adult male, was tagged on 15 August 2011 (Fig. 8). His movements occurred over a broader area than those of the other 2 groups, extending further into western BAR, while still using the waters inshore of Grand Isle and the surrounding passes and near-shore GoM. Sighting locations corresponded with tracking location data. Similar movement patterns were observed for other dolphins tagged during 2011 and 2014, including Y00, Y01, Y02, Y03, Y04, Y10, Y12, Y13, Y15, Y20, Y22, Y25, Y27, Y37, Y69, Y71, Y75, Y91, Y97, YA1, and YA3. On average, 5.7% (±6.5% SD) of locations for this group were in Gulf waters (range: 0.4–19.9%). The average maximum distance from shore for Gulf locations was 0.98 km (±0.93 km, range: 0.03–3.11 km). No significant seasonal changes in movements within the Bay were documented.

(2) Islands: Dolphin Y39, an adult female, was tagged on 16 August 2011 (Fig. 9). Her movements were

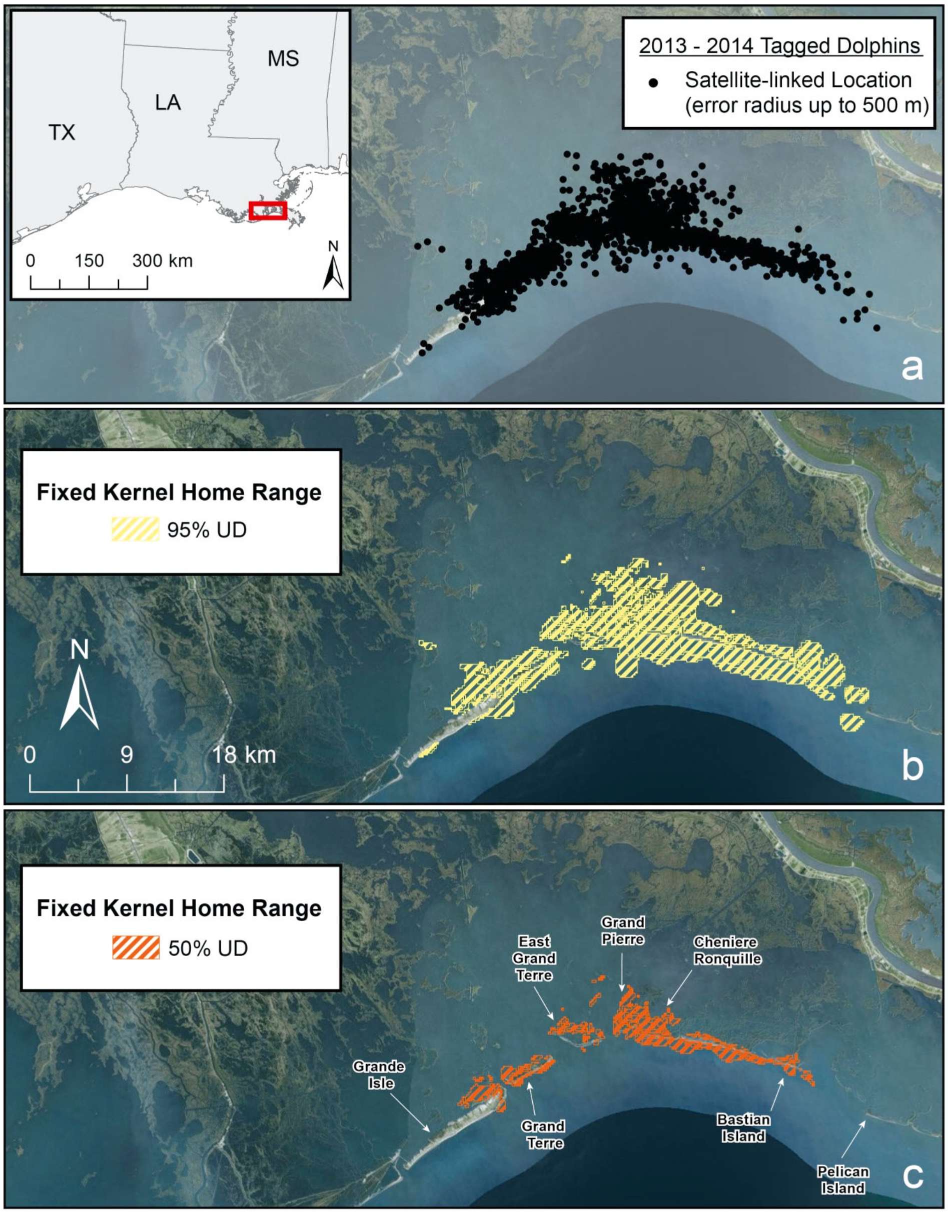

Fig. 7. Composite maps of all of the 8 dolphins (*Tursiops truncatus*) tagged during 2013, and tracked during 2013 to 2014. (a) Satellite-linked locations for each tagged individual (<500 m error radius locations only); (b) fixed kernel home range (95% utilization distribution [UD]) for each tagged dolphin; (c) fixed kernel core areas (50% UD) for each tagged dolphin

concentrated inshore of Grand Isle, and in the surrounding passes and near-shore GoM waters. Sighting locations corresponded with tracking location data. Similar movement patterns were observed for dolphins tagged each year, including Y07, Y08, Y09, Y11, Y16, Y17, Y19, Y33, Y46, Y81, Y83, Y85, Y99, and YA5. On average, 24.0% (±17.5%) of locations for this group were in Gulf waters (range: 2–64%). The average maximum distance from shore for Gulf locations was 1.75 km (±0.98 km, range: 0.47–4.24 km).

(3) East: Dolphin Y38, a subadult male, was tagged on 25 June 2013 (Fig. 10). His movements differed from those of the previous groups in that they were concentrated in eastern BAR, around the coastal marshes and islands, with a few locations in the GoM. Sighting locations corresponded with tracking location data. Similar movement patterns were observed for other dolphins tagged during 2013, including Y40, Y42, Y44, Y65, and Y67. On average, 36% (±25.3%) of locations for this group were in Gulf waters (range: 3.3–64.2%). The average maximum distance from shore for Gulf locations was 2.33 km (±1.15 km, range: 0.86–3.76 km).

The ability to describe different groupings based on habitat use suggests the occurrence of population structure within BAR. Overlays of home ranges (95% UD) and core areas (50% UD), combined within habitat groups for each of the individuals listed above,

Table 2. Dolphin (*Tursiops truncatus*) presence in Barataria Bay, LA. Month columns showing BB indicate when a high quality location (<500 m error radius estimate only) was received from a tagged dolphin in Barataria Bay (no locations were obtained from outside of the study area). Year columns indicate when an individual was documented to be in Barataria Bay at least once, from tracking data (T) or from photo-ID surveys (P) (T. Speakman unpubl. data). PTT ID: platform transmitter terminal identification number

Dolphin: FB	Tag: PTT ID	Deployment date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Present in 2010	Present in 2011	Present in 2012	Present in 2013	Present in 2014
2011 deployments																		
Y00	109138	Aug 04, 2011			BB	BB	BB	BB						P	T,P	P	P	P
Y01	109141	Aug 03, 2011			BB	BB	BB	BB	BB	BB	BB	BB		P	T,P	T,P	P	
Y02	109148	Aug 04, 2011			BB	BB	BB	BB						P	T,P	P	P	
Y03	109143	Aug 03, 2011			BB	BB	BB							P	T,P	P	P	P
Y04	109146	Aug 07, 2011			BB	BB	BB							P	T,P	P		P
Y07	109134	Aug 05, 2011			BB	BB		BB	BB	BB	BB			P	T,P	T,P	P	P
Y08	109152	Aug 09, 2011			BB	BB	BB							P	T,P	P	P	P
Y09	109135	Aug 05, 2011			BB	BB								P	T,P	P		
Y10	109145	Aug 09, 2011			BB	BB	BB	BB	BB	BB	BB	BB			T,P	T,P	P	
Y11	109144	Aug 05, 2011			BB	BB								P	T,P	P		
Y12	109155	Aug 10, 2011			BB	BB									T,P	Stranding		
Y13	109149	Aug 07, 2011			BB	BB	BB	BB	BB	BB				P	T,P	T,P	P	P
Y14	109136	Aug 11, 2011			BB	BB	BB	BB	BB	BB	BB	BB		P	T,P	T,P		P
Y15	109161	Aug 07, 2011			BB	BB									T,P	P	P	P
Y16	109137	Aug 12, 2011			BB	BB	BB	BB						P	T,P	P		
Y17	109160	Aug 08, 2011			BB	BB	BB		BB	BB	BB		BB	P	T,P	T,P	P	P
Y18	109157	Aug 15, 2011			BB	BB	BB	BB	BB	BB	BB				T,P	T,P	P	P
Y19	109139	Aug 09, 2011			BB	BB	BB								T,P	P	P	P
Y20	109150	Aug 15, 2011			BB	BB	BB	BB	BB					P	T,P	P	P	P
Y22	109162	Aug 16, 2011			BB	BB	BB	BB	BB	BB	BB			P	T,P	T,P		P
Y25	109158	Aug 11, 2011			BB	BB	BB	BB	BB	BB				P	T,P	T,P	P	P
Y27	109147	Aug 11, 2011			BB	BB	BB	BB	BB	BB	BB	BB			T,P	T,P		
Y33	109133	Aug 12, 2011			BB	BB		BB	BB	BB					T,P	T,P		
Y37	109154	Aug 16, 2011			BB	BB	BB	BB	BB	BB					T	T,P		
Y39	109142	Aug 16, 2011			BB	BB	BB	BB	BB					P	T,P	P	P	P
2013 deployments																		
Y38	129996	Jun 25, 2013	BB	BB	BB	BB	BB	BB							P	P	T	P
Y40	130024	Jun 25, 2013	BB	BB	BB	BB	BB	BB									T	
Y42	130028	Jun 25, 2013	BB	BB	BB	BB	BB	BB	BB								T	
Y44	130015	Jun 25, 2013	BB	BB	BB	BB											T	
Y46	130025	Jun 27, 2013	BB	BB	BB	BB								P	P	P	T,P	
Y65	129998	Jun 27, 2013	BB	BB	BB	BB								P	P	P	T,P	P
Y67	130006	Jun 27, 2013	BB	BB	BB	BB									P	P	T,P	P
Y69	130005	Jun 27, 2013	BB	BB	BB	BB	BB							P	P	P	T,P	P
2014 deployments																		
Y71	130021	Jun 10, 2014	BB	BB	BB	BB								P	P	P	P	T, P
Y75	129994	Jun 12, 2014	BB	BB	BB	BB								P	P	P	P	T, P
Y81	129993	Jun 16, 2014	BB	BB										P	P	P	P	T, P
Y83	130012	Jun 16, 2014	BB	BB		BB								P	P	P	P	T, P
Y85	130022	Jun 16, 2014	BB	BB	BB									P	P	P	P	T, P
Y91	130018	Jun 17, 2014	BB	BB	BB	BB	BB	BB						P	P	P	P	T, P
Y97	130026	Jun 18, 2014	BB	BB	BB		BB	BB						P		P		T, P
Y99	130020	Jun 19, 2014	BB	BB	BB									P	P	P	P	T, P
YA1	129995	Jun 19, 2014	BB	BB	BB	BB	BB								P	P	P	T, P
YA3	130016	Jun 19, 2014	BB	BB	BB	BB	BB							P	P	P	P	T, P
YA5	130001	Jun 20, 2014	BB	BB										P	P	P	P	T, P

are depicted in Fig. 11. While the 2 western habitat groups overlap inshore of the barrier islands, there appears to be a clear separation between the 2 western groups and the eastern group. The proportion of overlap of core areas between the eastern group and the 2 western groups ranged from 0.005 to 0.013, whereas the overlap of the 2 western groups was 0.116 (Table 3).

Tagged dolphins were present in BAR and vicinity, and nowhere else, during all months of the year

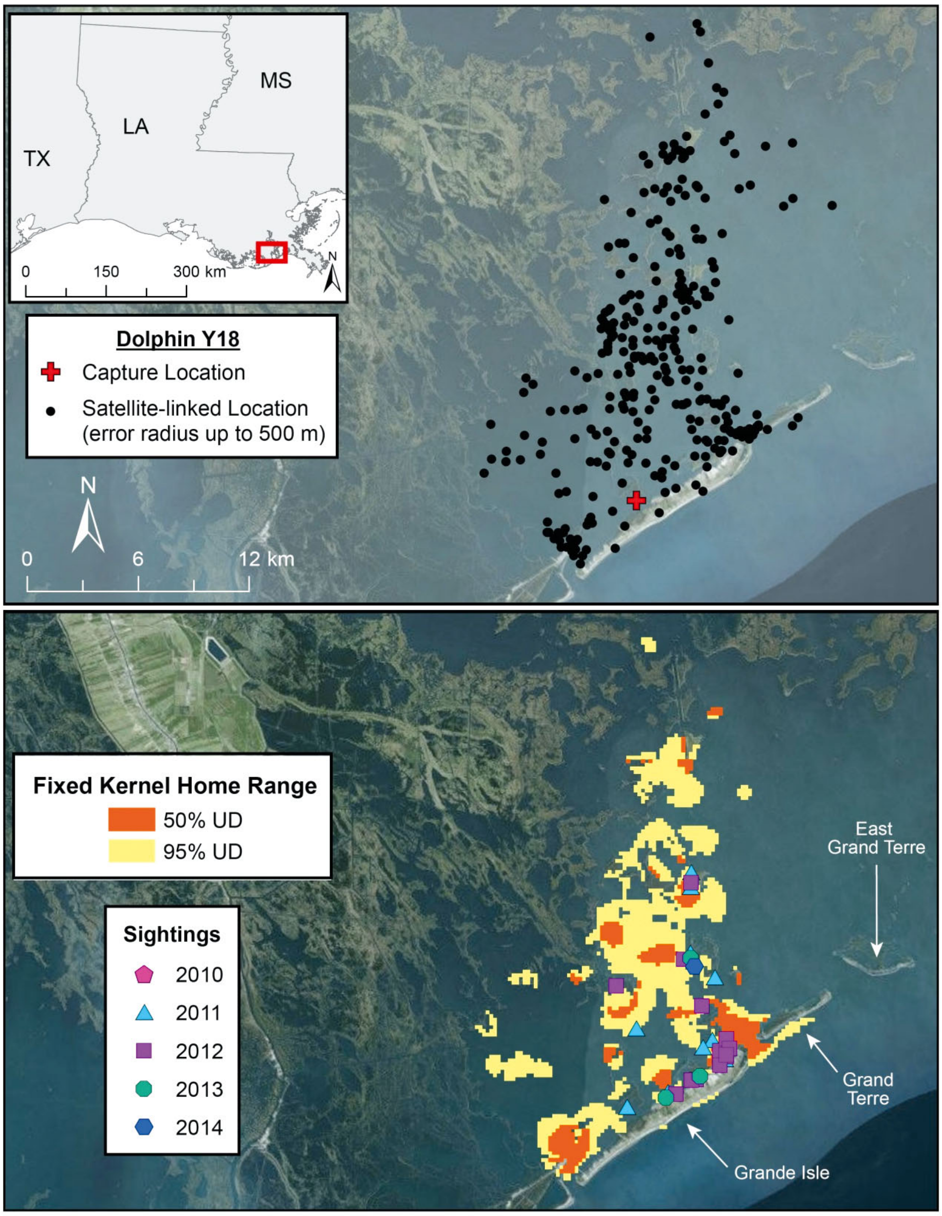

Fig. 8. Tracking location data (<500 m error radius locations only) for dolphin (*Tursiops truncatus*) Y18, captured and tagged in August 2011, with calculated resulting fixed kernel home range (95% utilization distribution [UD]) and fixed kernel core area (50% UD) indicated. Sighting locations during photo-ID surveys are overlaid onto the calculated ranging areas in the bottom panel

when tags were active (Table 2). Comparisons of the proportion of tagged dolphin locations in BAR versus that in adjacent GoM waters showed no significant differences between summer (June to November) and winter (December to April) (Friedman chi-square = 0.0909, df = 1, p = 0.763, n = 16 dolphins; these were the only dolphins tracked in both summer and winter).

Home range size

Home range size parameters were measured strictly from location data from the satellite-linked tags, using only locations with an estimated error radius of <500 m. These measures would not differ appreciably with the inclusion of sighting data from photo-ID surveys. Overall, 46% of sightings were within the calculated 95% UDs for each dolphin. The mean distance from the sightings outside of the 95% UD was only 2.0 km, with a maximum of 13.7 km (Table 4). Most of the sightings occurred within the areas that would be defined by minimum convex polygons enclosing the locations from the satellite-linked tags.

Home range area comparisons among dolphins in BAR involved filtering the home range data to include only dolphins with at least 150 locations with error radius estimates of <500 m. This resulted in 23

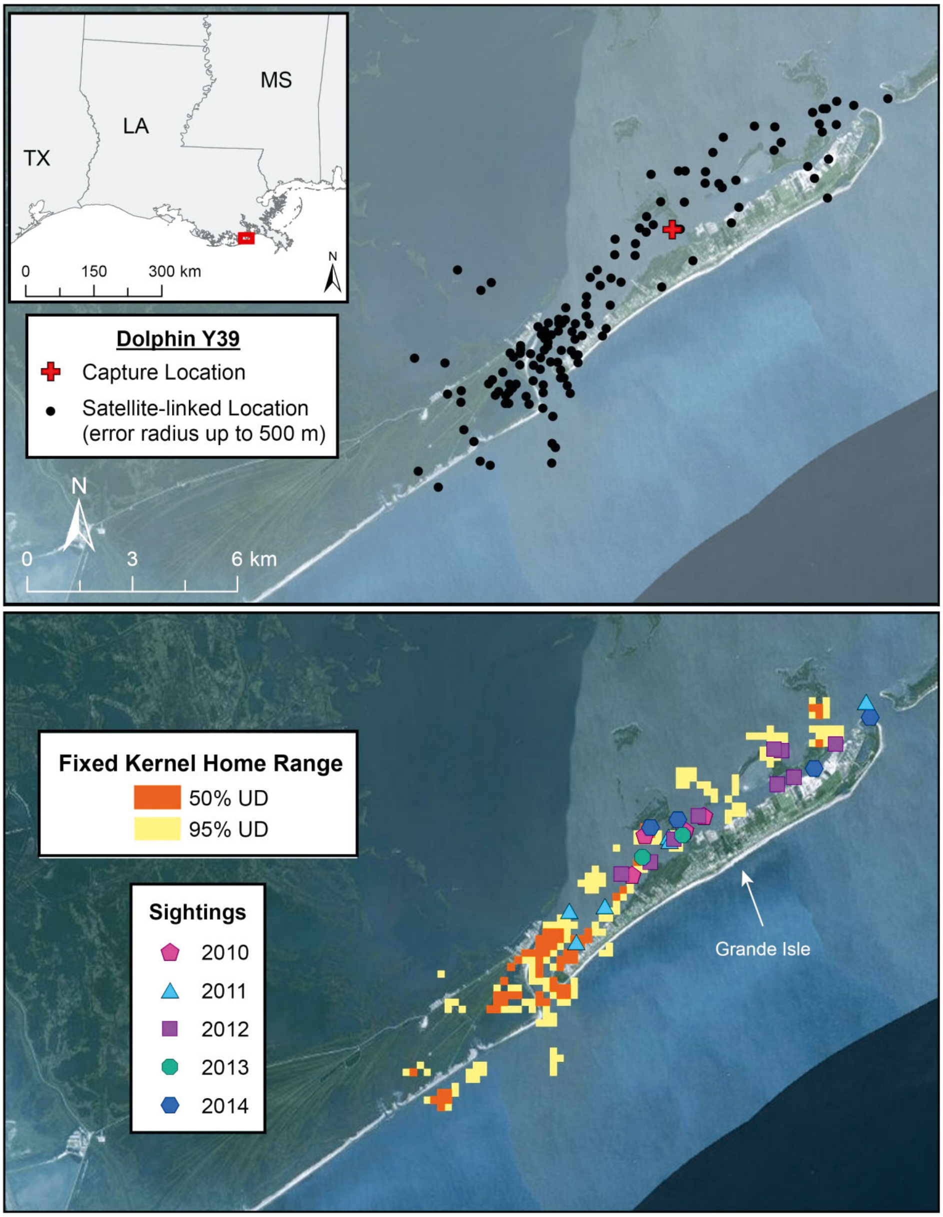

Fig. 9. Tracking location data (<500 m error radius locations only) for dolphin (*Tursiops truncatus*) Y39, captured and tagged in August 2011, with calculated resulting fixed kernel home range (95% utilization distribution [UD]) and fixed kernel core area (50% UD) indicated. Sighting locations during photo-ID surveys are overlaid onto the calculated ranging areas in the bottom panel

dolphins (13 F, 10 M) with sufficient home range size data for further statistical analyses (Table 5). A significant difference (*t*-test, p = 0.043) was found between sexes in BAR in overall home range size, with males having larger 95% UDs (mean: 69.4 km^2 ± 30.79 vs. 43.2 km^2 ± 27.55). No significant sex-related differences were found for core area size (female mean: 10.0 km^2 ± 6.01; male: 13.4 km^2 ± 6.49), or largest range dimension (female mean: 22.1 km ± 9.30; male: 26.5 km ± 6.66).

Home range sizes for females tagged in 2011 were compared to those for females tagged after 2011 (Fig. 12). No significant inter-annual differences were found for mean overall home range size (2011: 45.7 km^2 ± 21.62; 2013–14: 39.2 km^2 ± 37.76), mean core area size (2011: 11.2 km^2 ± 5.69; 2013–14: 7.9 km^2 ± 6.59), or mean maximum distance between locations across the home range (2011: 23.2 km^2 ± 7.84; 2013–14: 20.2 km^2 ± 12.04). To control for potential confounding effects from emphasizing different capture regions in different years, overall home range size for females caught around Grand Isle and Grande Terre were compared for individuals tagged in 2011 versus 2014 (all dolphins were caught to the east of Grand Isle in 2013). No significant inter-annual differences were found for mean overall female home range size (2011: 20.6 km^2 ± 17.10; 2014: 41.9 km^2 ± 37.43).

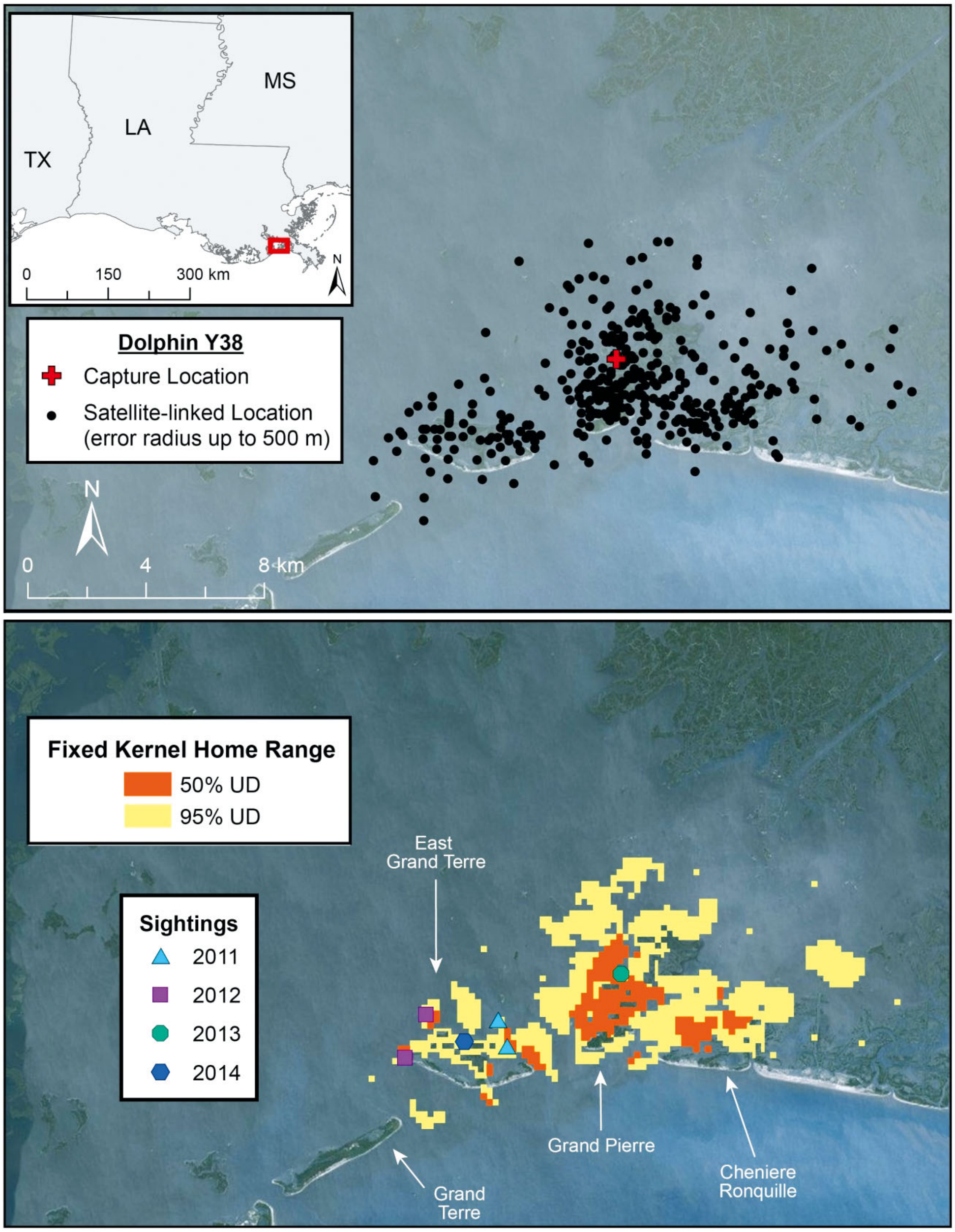

Fig. 10. Tracking location data (<500 m error radius locations only) for dolphin (*Tursiops truncatus*) Y38, captured and tagged in June 2013, with calculated resulting fixed kernel home range (95% utilization distribution [UD]) and fixed kernel core area (50% UD) indicated. Sighting locations during photo-ID surveys are overlaid onto the calculated ranging areas in the bottom panel

Home range sizes for males tagged in 2011 were compared to those for males tagged in 2013 (no males were tagged in 2014) (Fig. 13). Mean overall home range was not significantly different in 2011 (87.4 km^2 ± 25.29) from that for males tagged in 2013 (51.4 km^2 ± 26.09). Mean core area was significantly larger in 2011 (17.5 km^2 ± 6.11) than that for males tagged in 2013 (9.2 km^2 ± 3.80) (*t*-test, $p = 0.033$). There were no significant inter-annual differences in maximum distance between locations across the home range (2011 mean: 28.3 km ± 5.64 vs. 2013 mean: 24.7 km ± 7.74).

DISCUSSION

Dolphins tagged in BAR exhibited a high degree of multi-year site fidelity to relatively small home ranges in the bay. Although some individuals made forays into GoM coastal waters up to a maximum of 4.24 km from shore, most locations of tagged dolphins were north of the barrier islands and coastal marshes. None of the tagged dolphins were tracked or sighted more than 14 km outside of their 95% UD overall home ranges. All but 3 of the 44 tagged dolphins (93%) were tracked or observed over multiple

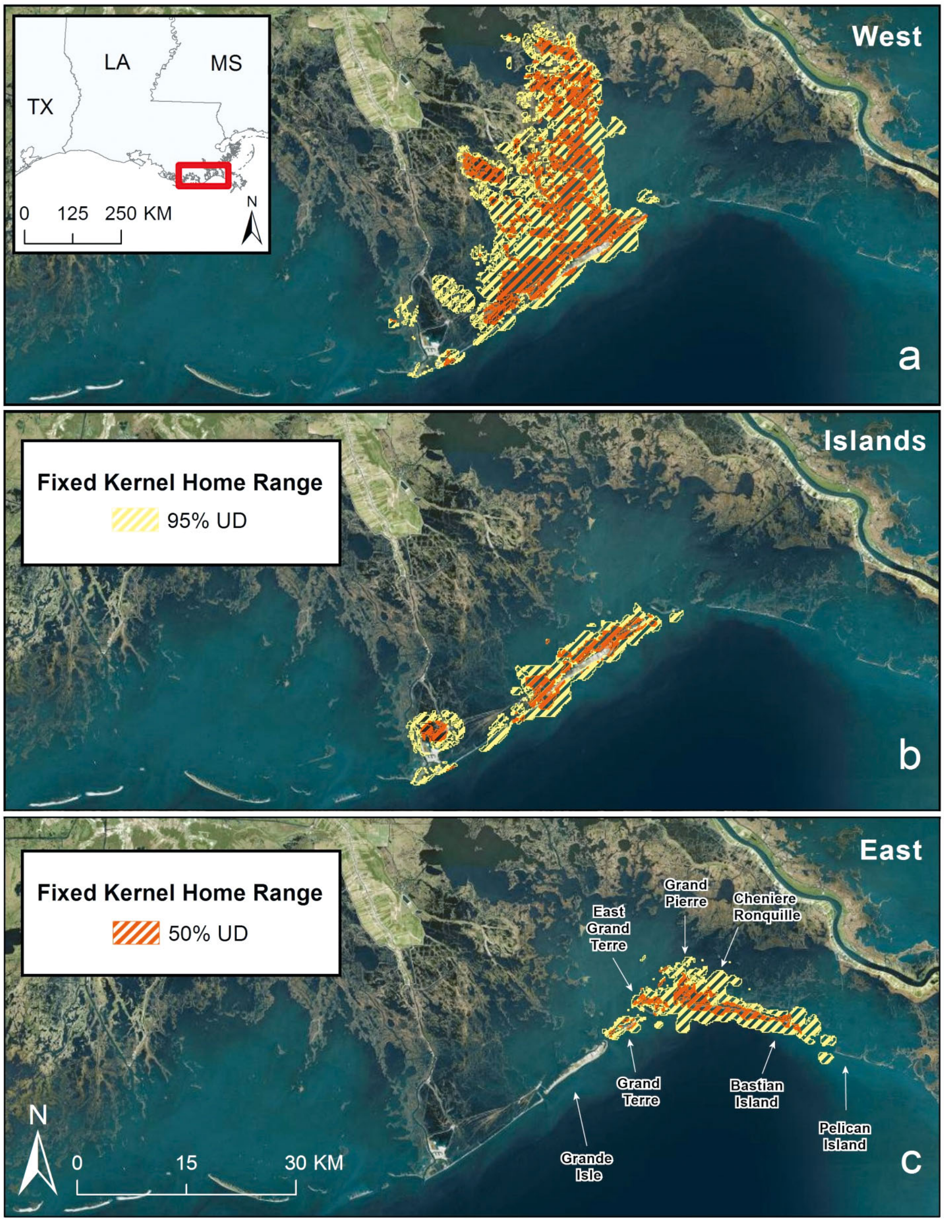

Fig. 11. Composite maps of home ranges of all dolphins (*Tursiops truncatus*) grouped by similar ranging patterns: (a) West; (b) Islands; (c) East

years in BAR, with 20 (45%) recorded from each year during 2010 to 2014. All but 6 tagged dolphins (86%) were documented in BAR during more than 1 season. These findings suggest the occurrence of long-term, year-round residence, as documented at many other sites in the GoM (Wells & Scott 1999, Balmer et al. 2008, Waring et al. 2013).

Data supporting these conclusions were derived from a large-scale data collection effort. Satellite-linked telemetry provides opportunities to collect large quantities of high quality location data remotely, day and night, regardless of weather. The greatest number of high quality locations obtained for a BAR dolphin was 399, compiled over 147 d, for Y38 (Table 1). For perspective, 12 to 26 yr of photo-ID survey data were required for 2 long-term resident bottlenose dolphins in Sarasota Bay with similar numbers of locations (F149, F232, authors' unpubl. data).

Table 3. Proportion of overlapping core areas (50% utilization distribution [UD]) for dolphins (*Tursiops truncatus*) using different combinations of Barataria Bay habitats

	Island	East	West
Island	–	–	–
East	0.013	–	–
West	0.116	0.005	–

Table 4. Home range size measures for dolphins (*Tursiops truncatus*) tagged in Barataria Bay, LA, including overall home range (95% utilization distribution [UD]), core area (50% UD), and longest dimension across home range. Sighting data are compared to overall home ranges for tagged dolphins. For a description of location classes (LC2, LC3) see 'Location data and home range analyses'. Maximum distance is measured from the closest edge of the UD

Dolphin: FB	Sex	No. LC2+ LC3 locations	95% UD (km^2)	50% UD (km^2)	Maximum distance between locations (km)	% sightings within 95% UD	Maximum distance of sightings outside 95% UD (km)
2011 deployments							
Y01	F	289	46	9	18.8	79.0	2.3
Y03	F	70	12	4	15.5	25.0	1.7
Y00	M	131	35	8	22.4	70.3	3.4
Y02	M	85	71	10	20.8	16.7	1.8
Y07	F	196	44	8	32.5	64.7	2.9
Y09	F	67	7	2	9.4	80.0	0.7
Y11	F	62	20	4	15.2	77.8	0.9
Y04	M	102	45	15	16.4	43.8	1.5
Y13	F	279	56	17	23.6	69.2	2.4
Y15	F	19	20	6	15.8	8.0	2.5
Y17	F	222	15	3	10.7	78.6	0.3
Y08	M	67	24	4	27.5	50.0	1.4
Y10	M	155	85	21	26.8	40.0	2.4
Y19	F	24	1	0	7.4	14.3	9.7
Y12	M	56	23	7	14.0	50.0	1.1
Y14	M	266	72	16	27.2	21.4	7.8
Y25	F	201	40	13	20.2	25.0	0.9
Y27	F	267	91	21	35.7	50.0	0.0
Y16	M	76	4	1	12.2	4.3	2.6
Y33	F	164	34	7	22.0	33.3	0.2
Y18	M	312	86	18	29.9	59.3	0.5
Y20	M	188	130	25	36.7	44.8	1.3
Y22	M	162	64	8	21.2	60.9	3.0
Y37	F	301	40	11	22.0	0.0	2.5
Y39	F	143	9	3	17.1	36.0	0.9
2013 deployments							
Y38	M	399	38	8	18.5	66.7	0.0
Y40	M	311	49	9	31.7	0.0	0.0
Y42	M	246	66	10	27.3	0.0	0.5
Y44	M	239	86	15	31.5	0.0	0.8
Y46	M	177	18	4	14.7	77.8	1.8
Y65	F	244	14	3	14.6	66.7	0.1
Y67	F	182	9	2	6.8	100.0	0.0
Y69	F	176	33	7	17.9	85.7	0.3
2014 deployments							
Y71	F	68	15	4	16.3	0.0	5.1
Y75	F	122	44	10	17.2	47.8	0.7
Y81	F	67	6	1	11.7	81.8	0.1
Y83	F	40	8	3	12.6	70.0	4.6
Y85	F	33	48	11	32.4	78.6	1.3
Y91	F	173	38	8	22.8	81.8	13.7
Y97	F	67	22	7	18.1	22.2	1.6
Y99	F	86	29	4	26.2	73.7	0.2
YA1	F	170	103	19	39.1	33.3	0.1
YA3	F	146	111	23	37.3	16.7	3.1
YA5	F	42	16	3	20.9	25.0	0.8

Satellite-linked telemetry also provides opportunities to locate animals should they move beyond the range of other research approaches, such as photo-ID surveys, which are limited in geographic scope by logistical considerations. None of the BAR dolphins were tracked substantially outside of the ranges documented by photo-ID surveys.

Opportunities to deploy large numbers of satellite-linked tags to define movement patterns for dolphins within a given region have been rare, due to expense, logistical challenges for deployment, and the fact that the current level of safety for the animals and reliability of tags and attachments has only been achieved in recent years (Balmer et al. 2011, 2014b, Wells et al. 2013b). From 1998 to 2006, A. A. Hohn et al. (pers. comm.) deployed 34 satellite-linked tags to define the ranging patterns of bottlenose dolphins along the mid-Atlantic coast of the USA. Bordino et al. (2008) deployed 16 satellite-linked tags on franciscanas *Pontoporia blainvillei* in 2 Argentine bays (Wells et al. 2013c). Baird et al. (2012) deployed 27 satellite-linked tags on false killer whales *Pseudorca crassidens*, and 10 on bottlenose dolphins (R. Baird pers. comm.), in Hawaiian waters. Sveegaard et al. (2011) deployed 64 tags on harbor porpoises from the North Sea to the Baltic Sea. The deployment of 44 satellite-linked tags on 1 species of dolphin in a single bay system exceeds the level of any previous effort in such habitats, and the information resulting from tracking these animals, combined with data from photo-ID surveys, provides a precise and detailed picture of the movements of dolphins in BAR.

Residency patterns of BAR dolphins are consistent with those observed elsewhere in the GoM. In nearly every NGoM bay, sound, or estuary where photo-ID or tagging research has occurred, at least some individuals have been identified as long-term

Table 5. Summary home range size data of dolphins *Tursiops truncatus* by sex. UD: utilization distribution

Sex	95% UD (km^2)	50% UD (km^2)	Maximum distance between locations (km)
Females			
Mean	43	10	22
SD	27.5	6.0	9.3
n	13	13	13
Min	9	2	7
Max	103	21	39
Males			
Mean	69	13	27
SD	30.8	6.5	6.7
n	10	10	10
Min	18	4	15
Max	130	25	37

(year-round, multiple years) residents (Wells & Scott 1999, Vollmer & Rosel 2013, Waring et al. 2013). Until now, few published reports of dolphin ranging patterns for the Louisiana-Mississippi area impacted by *Deepwater Horizon* oil have been available, beyond Miller's (2003) suggestion of site fidelity in BAR. Hubard et al. (2004) reported site fidelity across seasons and years for bottlenose dolphins in Mississippi Sound, along with seasonal changes suggesting patterns of both year-round and seasonal residency.

Elsewhere in the NGoM, bottlenose dolphins inhabiting coastal waters of the Florida panhandle and Big Bend region exhibited a variety of residency patterns. Shippee (2014) identified 3 resident communities of dolphins in the connected Choctawhatchee Bay and Pensacola Bay estuaries, and indicated that 22.9% of the dolphins identified were seen only once and thus were considered transients. In St. Joseph Bay, Balmer et al. (2008) described the occurrence of a year-round resident population, with seasonal transients in spring and autumn. In the northeastern GoM, from St. Vincent Sound to Alligator Harbor, Tyson et al. (2011) identified 2 year-round, parapatric communities of dolphins, differing in the degree of site fidelity of individuals (28.3 vs. 45.7% transients). Quintana-Rizzo & Wells (2001) examined resighting patterns for dolphins in the open estuarine system of Cedar Keys over a single year, and reported that 19% of dolphins were observed over 5 mo or more, while others were seen less frequently.

Long-term residency by most of the dolphins inhabiting bays, sounds, and estuaries along Florida's central and southwest coast has been a common finding. In Sarasota Bay, Irvine & Wells (1972) first documented the occurrence of bottlenose dolphin

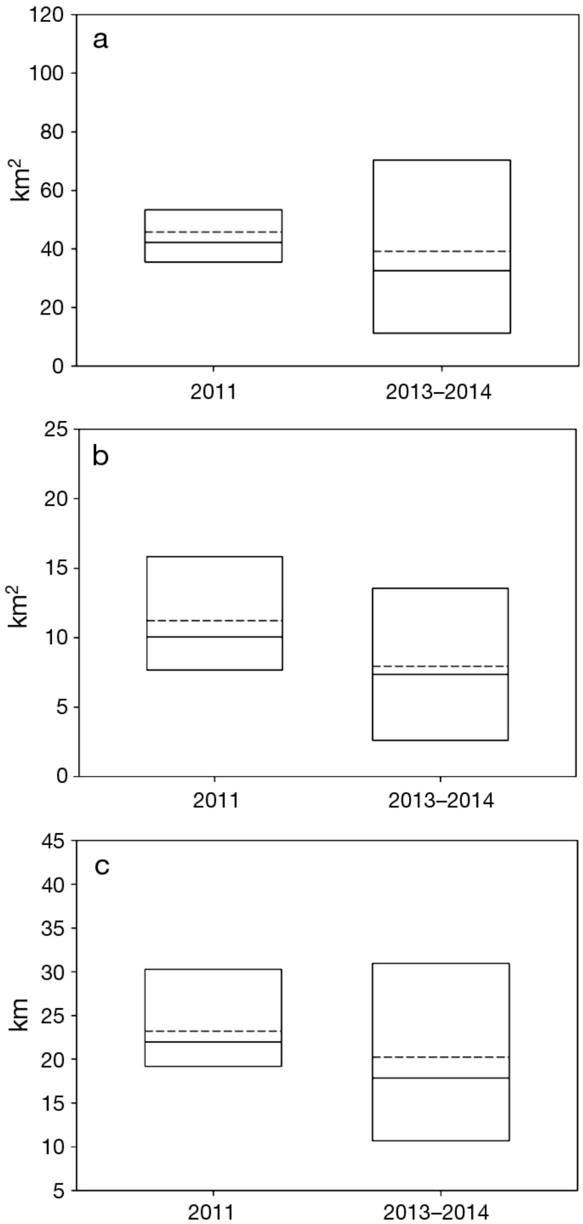

Fig. 12. Inter-annual comparisons of home range parameters for female dolphins (*Tursiops truncatus*) tagged in Barataria Bay, LA, in 2011 (n = 8) versus those tagged after 2011 (n = 5). Shown are the 25th to 75th percentile (boxes); median (solid line); and mean (dashed line). (a) 95% utilization distribution (UD), (b) 50% UD, (c) maximum distance across range

residency to a bay, and subsequent research has demonstrated year-round, multi-decadal, multi-generational residency of most of the dolphins observed in these waters (Wells 2014). Long-term, year-round residency has also been defined for dolphins in Tampa Bay (Wells et al. 1987, Urian et al. 2009). In Charlotte Harbor and Pine Island Sound, Bassos-Hull et al. (2013) identified 81% of dolphins in multiple

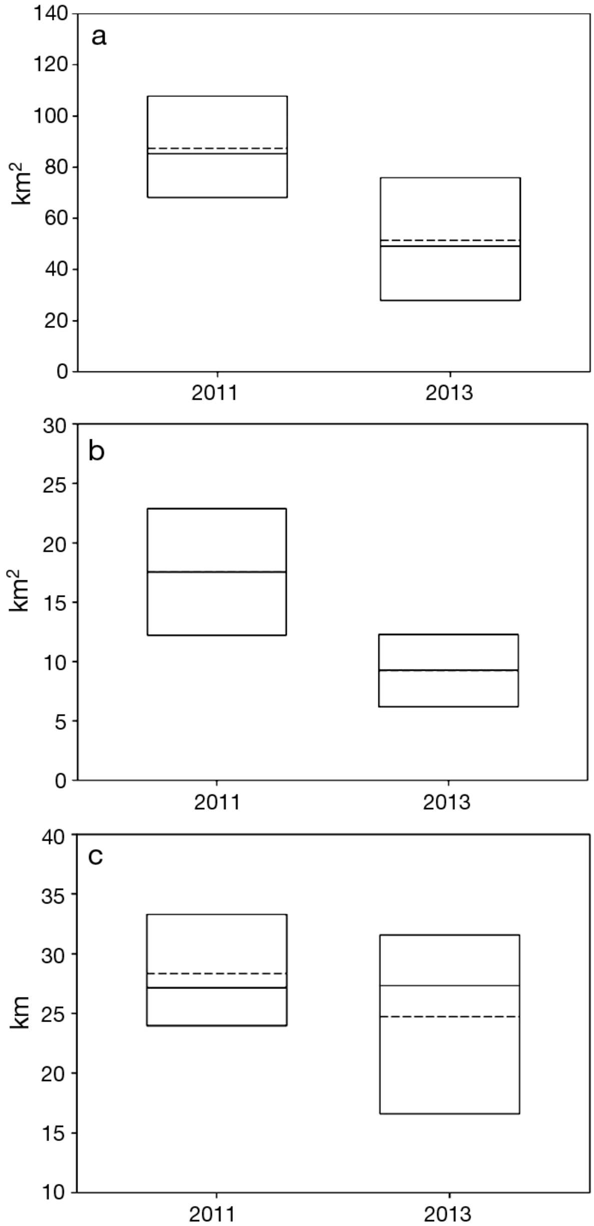

Fig. 13. Inter-annual comparisons of home range parameters for male dolphins (*Tursiops truncatus*) tagged in Barataria Bay, LA, in 2011 (n = 5) versus. those tagged in 2013 (n = 5). No males were tagged in 2014. Shown are the 25th to 75th percentile (boxes); median (solid line); and mean (dashed line). (a) 95% utilization distribution (UD), (b) 50% UD, (c) maximum distance across range

years, 30% over 10 yr or more, and 83% were never identified outside of the study area. Further south, in the Florida Everglades, satellite-linked tracking during July to November 2014 of a bottlenose dolphin rescued from a lake showed movements limited to 36 km of coastline, including bays and creeks (R. Wells unpubl. data).

Numerous research projects involving identifiable dolphins have been conducted in Texas, and all have reported some degree of residency. Shane (1980) identified year-round and seasonally resident dolphins in Port Aransas. Nearby, Gruber (1981) identified resident dolphins in the Pass Cavallo area of Matagorda Bay. Lynn & Würsig (2002) radio-tracked and observed dolphins in Matagorda Bay, and suggested that some individuals were likely multi-year residents, while others were transient. Irwin & Würsig (2004) reported strong site fidelity with seasonal variation in habitat use for dolphins residing in western Galveston Bay. Fertl (1994) reported multi-year residency for some dolphins in the Galveston Ship Channel. Maze & Würsig (1999) reported that 52% of dolphins identified in the San Luis Pass area of Galveston Bay were residents, with some of these documented as multi-year residents. In a 2 yr study, Bräger (1993) estimated that about 20% of dolphins in Galveston Bay and associated GoM waters were residents.

Across the GoM, use by dolphins of a variety of habitats, including coastal waters classified as bay, sound, or estuary residents is not uncommon. At many sites, bay-, sound-, and estuary-resident dolphins venture short distances into the GoM on occasion, as was seen for BAR dolphins (e.g. Shane 1980, Gruber 1981, Irvine et al. 1981, Maze & Würsig 1999, Lynn & Würsig 2002, Fazioli et al. 2006, Shippee 2014). The occurrence of at least 3 different types of home ranges with different defining suites of physiographic and habitat features raises questions about whether there is more than 1 management unit, or stock, of bottlenose dolphins residing in BAR. In particular, the clear separation of dolphins into eastern versus western BAR suggests the occurrence of discrete, resident units within the bay. More detailed analyses of relationships among ranging patterns, genetics, social association patterns, and stable isotopes may lead to the identification of multiple biologically meaningful resident population units, or communities, as has been done on the west coast of Florida (Wells et al. 1987, Duffield & Wells 2002, Sellas et al. 2005, Urian et al. 2009, Barros et al. 2010).

Home range sizes for BAR dolphins were comparable to those reported for bottlenose dolphins elsewhere (Wells & Scott 1999, Balmer et al. 2008, Urian et al. 2009). Table 5 summarizes the measures for BAR dolphins, by sex. The mean longest distance between locations across a home range for BAR dolphins was 22 km for females, and 27 km for males. These measures fall within the range reported for bottlenose dolphins in St. Joseph Bay, FL (Balmer et al. 2008), Indian River Lagoon, FL (Mazzoil et al. 2008), Gulf of Guayaquil, Ecuador (Felix 1997), and Gulf of California, Mexico (Ballance 1992), while smaller than those for bottlenose dolphins living in open water habitats near Cedar Keys, FL (Quintana-Rizzo & Wells 2001) and the Southern California Bight (Defran et al. 1999).

The method for measuring UDs used in this study has only been used previously with bottlenose dolphins from Sarasota Bay, FL. Wilkinson (2014) calculated mean 90% UDs of 50 km^2 for females and 68 km^2 for males. These values are comparable to the mean 95% UDs calculated for BAR females (43 km^2) and males (69 km^2) (Table 5). The method used here likely produces estimates of home range size that would tend to be smaller than those calculated in most previous studies because it is intended to provide a more specific measure of the areas used by the animal to the greatest extent, with reduced emphasis on connections between heavily used areas.

Other fixed kernel estimates of UDs have been calculated for bottlenose dolphins elsewhere, and the results tend to be very similar across methods. Using the same calculation methods as for other published studies, mean 95% UDs were 104 to 106 km^2 for BAR females, and 151 to 155 km^2 for males. The BAR means are larger than those reported for the Lower Florida Keys (Lewis et al. 2013), but are within the range reported for Sarasota Bay, FL (Owen et al. 2002, McHugh et al. 2011) and the Indian River Lagoon, FL (Gibson et al. 2013). The BAR ranges are slightly smaller than those reported for Tampa Bay (Urian et al. 2009), and much smaller than those reported from the open waters surrounding the Azores (Silva et al. 2008).

Within BAR, the differences between male and female overall home range sizes were consistent with patterns observed elsewhere, with male ranges being significantly larger than those of females (Table 5) (Urian et al. 2009). No inter-annual differences in overall home range size or maximum distance between locations were found for BAR dolphins of either sex, and no inter-annual difference in core area size was found for females. The only significant inter-annual difference was observed for males in core area size. This is likely related to the different habitat focus in each year. In 2011, tagging of males primarily occurred in western BAR and around Grand Isle, while in 2013, tagging efforts were focused on the coastal marsh areas in the southeastern portion of BAR. The consistency from year to year and across sex of the overall home range provides another indication of the stability of BAR dolphin home ranges.

The residency patterns exhibited by dolphins in BAR fit within the spectrum of ranging patterns seen elsewhere in the GoM, and match well with those from areas where site fidelity is strongest, where dolphins are resident year-round and across multiple years. Of the 258 Sarasota Bay dolphins that were captured/released since 1980 and observed for at least 2 yr, 89% were also observed for at least 5 yr. If Sarasota Bay dolphins were defined as multi-year residents, they tended to be long-term residents. In BAR, 93% of the tagged dolphins were present in the bay for at least 2 yr. Given the relatively small sizes of the home ranges, the lack of tracking locations or sightings substantially outside of the home ranges, the multi-year and multi-season presence of individuals, and the similarity of these patterns with long-term residency patterns elsewhere in the NGoM, it is reasonable to conclude that the BAR stock is predominantly comprised of long-term residents that were therefore exposed to the oil that entered the bay, in addition to prolonged exposure to residual oil and clean-up chemicals and byproducts in the sediments and prey subsequent to the spill, as well as the anthropogenic disturbances associated with spill response and remediation.

The strong site fidelity of BAR bottlenose dolphins as described from this telemetry research provides a solid underpinning for management action in response to the *Deepwater Horizon* oil spill, both for assessing losses to the bottlenose dolphin stock(s) residing in the bay and for planning restoration activities. The lack of movement of the tagged animals outside of BAR strengthens estimates of survival rates, as emigration can be ruled out as a potential complicating factor (Lane et al. 2015). Documentation of habitat-use patterns can help to guide restoration activities, to focus efforts in places where dolphins will receive optimal benefits. The well-defined residency patterns of these dolphins will also facilitate the design of programs for continued monitoring of these dolphins to allow assessment of long-term impacts from the *Deepwater Horizon* oil spill.

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