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Short Note

Dolphin Sightings Near the Coast of Bimini, The Bahamas, 2003-2013

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Many dolphin species use coastal habitats (e.g., bottlenose dolphins [*Tursiops* sp., Scott et al., 1990], Atlantic spotted dolphins [*Stenella frontalis,* Melillo et al., 2009], Hector's dolphins [*Cephalorhynchus hectori,* Bräger et al., 2002], and humpback dolphins [*Sousa* sp., Parra et al., 2006]), and given their close proximity to human population centers, it is unsurprising that coastal dolphins are often well studied (Scott et al., 1990; Acevedo & Burkhart, 1998; Carillo et al., 2010; Bearzi & Saylan, 2011). Understanding habitat choice, site fidelity, movement patterns, group composition, and behaviors of dolphins on a regional level can contribute to the overall conservation of individual species (Martinho et al., 2014) and to most delphinids as a whole. Pollution, bycatch, and prey depletion by fisheries, marine ecotourism, and boat traffic are all human activities that negatively impact dolphins and tend to be concentrated near the coast (Martien et al., 2012). Given the additional threat posed by coastal development, it is clear that a more detailed understanding of how dolphins use coastal areas continues to be warranted, especially since dolphins' use of these areas can vary considerably both within and between species, in addition to between coastlines. The waters off Bimini, The Bahamas, have been relatively isolated from generally negative human activity, despite their close proximity (i.e., approximately 85 km between Miami and Bimini) to Florida. The area has been an active study site for research into Atlantic spotted and bottlenose (*T. truncatus*) dolphin behavior, communication, and acoustics ongoing since 1997 by the Dolphin Communication Project (DCP) (Melillo et al., 2009; Greene et al., 2011; Dudzinski et al., 2012, in press; Melillo-Sweeting et al., 2014). DCP maintains photo-identification catalogs for both species in the area and documents their sighting locations during research effort onboard local ecotour vessels. A portion of DCP's overall study area (see Figure 2.1 in Melillo, 2008) is immediately adjacent to the western shore of Bimini between the shoreline and the northerly flowing Gulf Stream. Herein, we present details of single and mixed species (spotted and bottlenose dolphins) sightings off this stretch of coastline from 2003 to 2013. These sighting details serve as baseline information for how two species of dolphin have used this coastal area prior to commencement of the construction of a cruise ship terminal. This construction included additional underwater and surface noise from dredging, pile driving, vessels, etc.; increased suspended silt (i.e., decreased underwater visibility and potential impacts to prey species near the construction site); and increased vessel traffic—all of which are currently ongoing in this area (Melillo-Sweeting, pers. obs., 2014).

The coastal area used in this study, a subset of the overall DCP study area near Bimini, was marked by a north/south limit of N25° 40.130 and N25° 47.976. This is the western edge of the Great Bahama Bank with depths ranging from shore to 30 m, with most search effort conducted in depths of 8 to 12 m and within 5 km of shore (Figure 1). The sea floor is generally sandy, with scattered reefs running parallel to shore. Data were collected from a total of four local dolphin swim/watch vessels (inboard and outboard, all mono-hulls). Data recorded included environmental conditions (e.g., cloud cover, Beaufort sea state, wind direction), dolphin sighting location (via handheld GPS) and water depth (when available from the vessel depth sounder), dolphin species and group size, and dolphin behavior. A group was defined as the total number of dolphins within close proximity to one another before going out of view (i.e., a sighting). Dolphins were considered to be traveling if all members of the group were moving steadily in one direction, not varying their positions relative to one another (when more than one dolphin was present) by more than 45° (Shane, 1990; Dudzinski, 1998). Dolphins were considered feeding if they were observed crater-feeding or

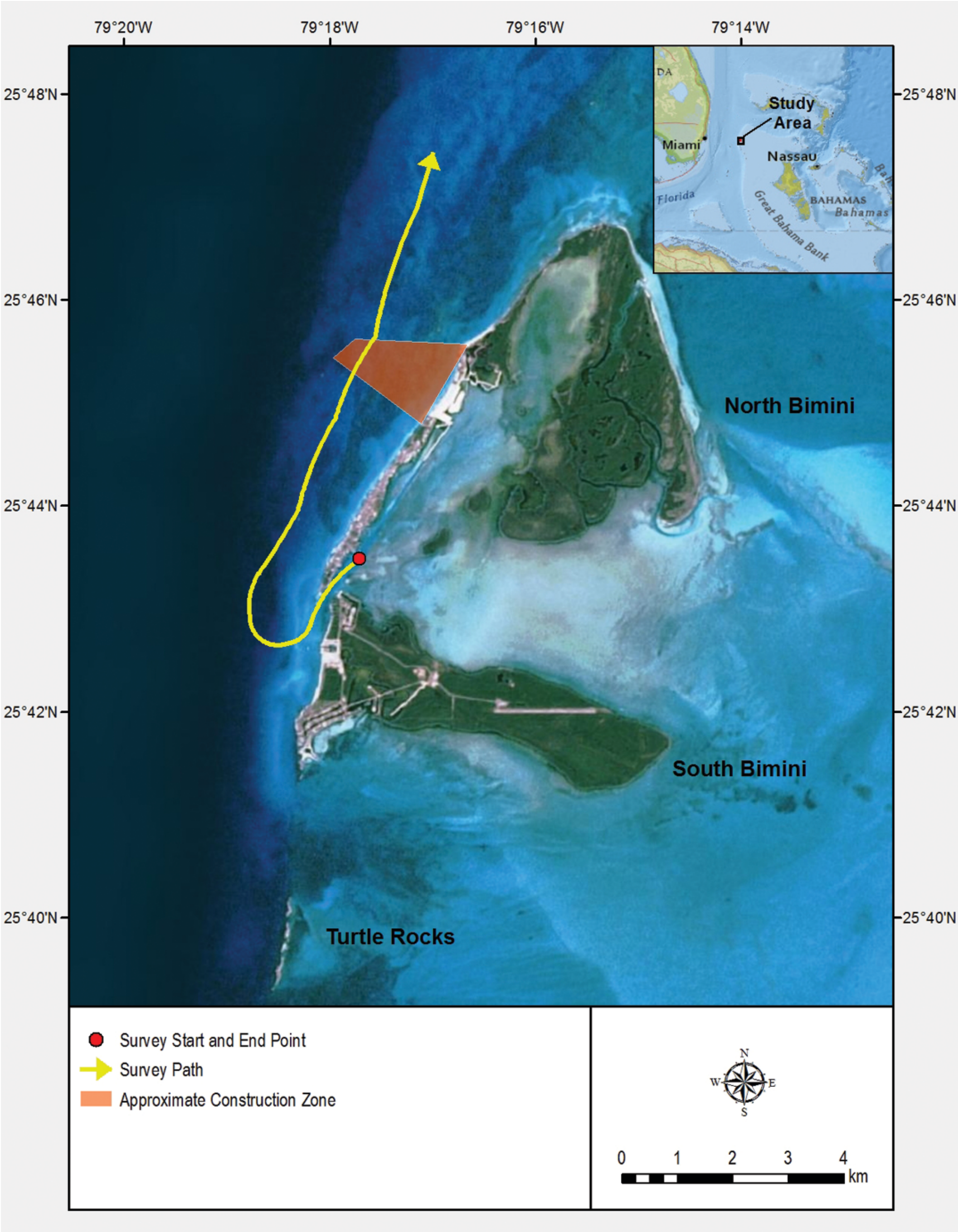

Figure 1. General coastal survey zone with 2014 construction zone noted as shaded area; the survey path was followed out and back as part of a larger study area.

actively chasing known prey items (e.g., houndfish [*Tylosurus* spp.] and mackerel [*Scomberomorus* spp.]). These behavior definitions are broad and, as such, are applicable to both species. In this 11-y study period, 654 dolphin surveys were completed, all of which included, at minimum, two on-effort passes (i.e., researchers actively looking for dolphins) through the identified coastal study area as part of more extensive surveys regularly conducted in the region, resulting in approximately 1,400 h of effort. Surveys were conducted predominantly between April and September, with only occasional surveys (n = 24) completed in the off-season (October through March), due to weather and sea conditions. Most surveys were conducted in dry conditions with calm seas (Beaufort sea state, median = 2, min = 1, max = 5). Most surveys were completed in the 4 to 5 h prior to sunset, although some morning effort (n = 32) was included. At least one DCP researcher was searching for dolphins at all times, in addition to trained boat crew and untrained guests. Details on species, group size, and behavior were logged by DCP researchers.

Overall, dolphins were documented in this coastal zone on 35.8% (n = 234) of all surveys, resulting in 339 sightings within this area (Figure 2). Dolphins were observed on 35.7% of all afternoon surveys and 37.5% of morning surveys. The drastic difference in sample size prohibits a statistical comparison, but these limited data suggest use of this coastal zone throughout the day. Dolphins were observed on 34.7% of April-September surveys and 62.5% of October-March surveys. This seemingly large difference in sighting rate by season may be an artifact of the limited off-season effort (n = 24). More off-season effort would facilitate a better understanding as to how dolphins use this area seasonally. When depth was recorded, dolphins were observed in a mean depth of 9.47 m (min = 2.74 m, max = 29.57 m). Spotted dolphins were observed in an average depth of 10.36 m (min = 6.01 m, max = 29.57 m), bottlenose dolphins in 9.05 m (min = 2.74 m, max = 24.08 m), and mixed species groups in 8.53 m (min = 6.40 m, max= 10.36 m). It should be noted that very few surveys extended to or over the continental shelf in water deeper than 14 m; therefore, this study cannot speak to the dolphins' use of deeper waters or farther than 5 km perpendicular to Bimini's shoreline. In addition, preliminary temporal analysis, using Esri GIS, did not reveal any shifts in the spatial distribution of observations throughout the study area for either species individually or when grouped together. Spotted dolphins did exhibit a presence nearshore in 2003 along the northwestern and northern coasts that it did not repeat in subsequent years, but, overall, both species were observed consistently throughout the study area.

Spotted dolphins comprised 40.1% of all sightings, 46.6% were bottlenose dolphins, 2.9% were mixed species groups (spotted and bottlenose), and 10.3% were unconfirmed species sightings (Table 1). When unconfirmed species sightings were removed, there was no significant difference in the species group type (spotted-only, bottlenose-only, mixed species) sighted by year (χ^2 = 13.808, df = 20, p = 0.840). A Kruskal-Wallis H test showed a significant difference in the mean number of sightings between the different species (χ^2 [2] = 21.900, $p < 0.001$), with the following mean ranks: 21.45 (spotted), 23.55 (bottlenose), and 6.00 (mixed species). Mann-Whitney post-hoc tests, with the Bonferroni correction applied, indicated significant differences ($p < 0.01$) in mean number of sightings between spotted and mixed species and bottlenose and mixed species. However, there was still no significant difference between mean sighting numbers for spotted and bottlenose groups (p = 0.449), indicating that, ultimately, both species use this coastal area with similar frequency.

The average spotted dolphin group size was 6 ± 4.27, bottlenose dolphin group size was 5 ± 3.45, and mixed species group size was 14 ± 9.24. Combining all years and all species group types, 46.9% of sightings were of groups with up to 5 individuals, 39.8% contained 6 to 19 dolphins, 2.4% included 20 or more individuals, and 10.9% of the groups were too brief in sighting duration to get an accurate group size estimate (Tables 2 & 3). Group sizes were clustered in this way in order to assess the regularity of particularly small (i.e., < 5 animals) and large (i.e., > 20 animals) groups (Herzing et al., 2003; Melillo et al., 2009). When groups with no count were removed, and all species group types were combined, there was a significant difference in group size between years (χ^2 = 40.569, df = 6, $p < 0.001$) (Table 2). Group size clusters were also significantly different when examined by species (χ^2 = 134.75, df = 9, $p <$ 0.001) (Table 3). A Kruskal-Wallis H test showed a significant difference in the mean number of sightings between the group sizes (χ^2 [2] = 21.430, $p < 0.001$) with mean ranks of 22.64 (1 to 5), 22.32 (6 to 19), and 6.05 (20+). Mann-Whitney post-hoc tests, with the Bonferroni correction applied, indicated that mean sighting numbers for groups with 20+ individuals were significantly different ($p < 0.001$) than group sizes of 1 to 5 and 6 to 19. Mean sighting numbers for groups with 1 to 5 individuals or 6 to 19 individuals were not significantly different (p = 4.488), indicating that smaller group sizes (groups with less than 20 animals) are most likely to be observed in this coastal area. The largest standardized residual in this case was for mixed species groups with 20+ individuals. Mixed species groups are atypical in their own right near Bimini, comprising only 8.87% of all dolphin sightings during a previous study (Melillo et al., 2009).

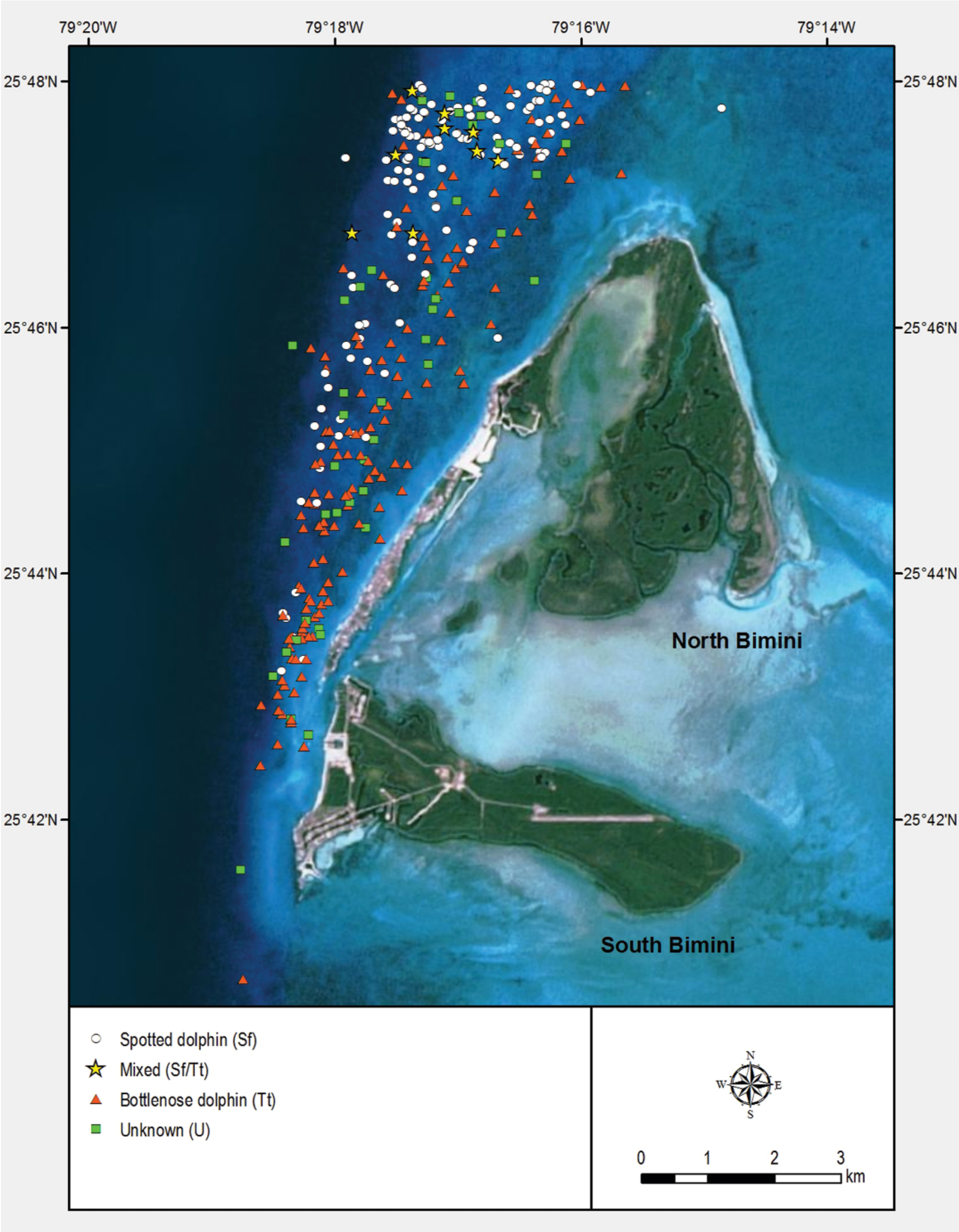

Figure 2. All dolphin sightings from 2003 to 2013 within the coastal area of the Dolphin Communication Project's larger dolphin research project, where Sf = *Stenella frontalis*, Tt = *Tursiops truncatus*, and Sf/Tt = mixed species group

The lack of significant differences in the mean number of sightings between species (spotted vs bottlenose dolphins, single-species groups) and all group sizes up to 19 individuals indicates that these dolphins consistently used this coastal area during this 11-y period. Combining all years and

Table 1. Number of sightings by year and species, where Sf = *Stenella frontalis*, Tt = *Tursiops truncatus*, Sf/Tt = mixed species group, and U = unconfirmed species; number of surveys in parentheses follows each year

	2003 (33)	2004 (40)	2005 (44)	2006 (55)	2007 (61)	2008 (58)	2009 (66)	2010 (86)	2011 (94)	2012 (78)	2013 (39)	Mean	SD
Sf	5	7	6	13	14	13	7	23	16	15	17	12.36	5.31
Tt	5	7	12	8	17	16	14	21	19	26	13	14.36	6.03
Sf/Tt	0	1	0	1	1	0	2	1	2	1	1	0.91	0.67
U	3	0	1	0	4	2	5	3	8	6	3	3.18	2.37
Total	13	15	19	22	36	31	28	48	45	48	34	30.82	12.14

Table 2. Number of sightings by year and group size

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Mean	SD
≤ 5	9	7	5	13	15	11	13	27	25	22	12	14.46	6.89
6-19	3	8	10	7	15	14	10	17	15	16	20	12.28	4.83
20+	0	0	0	0	0	0	1	2	2	3	0	0.73	1.05
N/A	1	0	4	2	6	6	4	2	3	7	2	3.36	2.14

Table 3. Number of sightings by species and group size

	Sf	Tt	Sf/Tt	Unconfirmed	Mean	SD
≤ 5	66	79	1	13	14.46	6.89
6-19	60	67	6	2	12.28	4.83
20+	5	0	3	0	0.73	1.05
N/A	5	12	0	20	3.36	2.14

all species group types, dolphins used the area for travel 22.4% of the time, feeding for 8.8%, and other or unconfirmed activity for 68.7% of the time. With no significant difference found within these broad behavior categories over time ($\chi^2 = 21.48$, $df = 20$, $p = 0.37$), the dolphins clearly engage in multiple behaviors in the study area. This is unlike some other studies that have shown dolphins to use coastal areas primarily for specific activities or behaviors such as resting (Norris et al., 1994; Lammers, 2004). With nearly one-quarter of all dolphin groups sighted near Bimini confirmed to be traveling, this shallow, nearshore area is, at least some of the time, a natural corridor. Bottlenose dolphins elsewhere may use corridors as they respond to prey availability (Defran et al., 1999), just as many cetacean movements may be dictated by food resources (Norris & Dohl, 1980).

During a large portion (68.7%) of our coastal sightings, group activity could not be confirmed. Various factors contributed to this limitation, including other boat traffic, limited visibility during boat-based observations, and the occasional brevity of the sightings. Thus, our sample size of groups identified as engaged in feeding or travel activity is likely an underestimate for how this particular coastal area is presumably used by these dolphins. Although a full analysis of group composition (e.g., age classes and sexes) is beyond the scope of this study, it should be noted that all age classes (i.e., calf through adult) and both sexes of both species were observed in this study area. Neonate sightings from both species were rare, with only a single sighting of a neonate bottlenose dolphin confirmed in the study area (DCP, unpub. data, 2003-2013).

This study provides an 11-y baseline dataset on the occurrence of two dolphin species, allowing future work to assess possible changes in their use of Bimini's coastline in response to anthropogenic impacts. Compared to other coastal areas (e.g., 40 km of Sarasota Bay coastline; Scott et al., 1990), Bimini's coastline is small (approximately 16 km). This may limit the dolphins' access to shoreline benefits such as calm water and shallow protected areas. However, Bimini is considered remote and relatively under-developed commercially, which may have limited most anthropogenic impacts. Still, the coastal area described in this study has been utilized by humans for decades, whether for sport and subsistence fishing, snorkeling, and SCUBA diving or for general recreational boating. The year 2014 brought the first large-scale development with pile driving and dredging along the west coast of Bimini (Melillo-Sweeting, pers. obs., 2014; Figure 1). Research surveys for dolphins will continue through construction activity and into the new-use phases of this coastal area: a new, manmade barrier (a pier extending to a multi-acre artificial island) and large-vessel (e.g., 200 m) traffic and noise along with silt plumes, possibly on a daily basis.

Studies assessing the dolphins' habitat use, dolphin abundance, and individual associations within DCP's entire study area are currently in progress. Additional future research will focus on possible difference(s) in shoreline habitat use between dolphin sexes and age classes as well as potential seasonal differences. Construction activities (e.g., pile driving, dredging; Tougaard et al., 2009; Bailey et al., 2010, Pirotta et al., 2013), with associated increased noise, silt, and vessel traffic, are known to influence dolphin habitat use and behavior. Management, conservation, and legal implications will require consideration for any construction project that might affect the environment and its inhabitants (Blickley & Patricelli, 2010). As such, future research should also include an assessment of anthropogenic impacts on these dolphins from the increased human activity in the coastal study area. At a time when humans' development of coastal regions shows no signs of slowing, managers and permit issuers must have reliable information about dolphins' use of to-be-developed coastlines.

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