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Site Fidelity of Coastal Bottlenose Dolphins (*Tursiops truncatus*) off Southeast Florida, USA

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Abstract

The coastal bottlenose dolphin is well studied throughout its natural range, though most research focuses on wide, well-protected habitats such as bays and estuaries rather than on narrow coastal sand banks. This study identifies a residential group of coastal bottlenose dolphins utilizing the northwestern Atlantic waters off the coast of Palm Beach County, Florida. From 2014 to 2020, 313 boat surveys were conducted, and 585 individual dolphins were identified using photo-identification. Using seasonal and annual resighting ratios, 24 dolphins were considered full-time residents, 66 dolphins were considered part-time residents, and 478 dolphins were transient. The presence of individuals with high site fidelity indicates that the region is used as a permanent habitat for some individuals, while the presence of transient animals may indicate a possible bridge between populations living to the north and south of the region.

Key Words: site fidelity, coastal, Florida, bottlenose dolphin, *Tursiops truncatus*

Introduction

The Common Bottlenose Dolphin

Common bottlenose dolphins (*Tursiops truncatus*) are some of the most widespread and well-studied marine mammals (Rice, 1998; Goodall et al., 2011; Chen et al., 2017). Their range extends across all tropical and temperate oceans, with genetically unique populations documented from the southern coast of Australia and South America to the northern latitudes of Europe (Goodall et al., 2011; Louis et al., 2018; Van Aswegen et al., 2019). Across the global range, a substantial amount of genetic and phenotypic diversity occurs within the species (Guidarelli et al., 2018), with one of the greatest differences observed between coastal and offshore populations (Tezanos-Pinto et al., 2009; Zaeschmar et al., 2020). Coastal bottlenose dolphins tend to be smaller and lighter in color, with a pink or white underside, while offshore individuals are larger and darker in color, with distinct capes below the dorsal fin (Rossbach & Herzing, 1999; Simões-Lopes et al., 2019). These two ecotypes may even represent two distinct subspecies or species in some parts of their range (Wickert et al., 2016; Costa et al., 2021, 2022).

While common bottlenose dolphins have no natural predators in the northwest Atlantic, they face a myriad of threats today. In coastal regions with large fisheries, interactions with fishing boats are common and can result in entanglement, hooking, and boat strikes, all of which can be fatal for dolphins. A substantial increase in the frequency of dolphin entanglement in south Florida has occurred since 1997. This trend is due in part to the increasing size of the fisheries industry in this region (McHugh et al., 2021). South Florida also experiences annual red tide events, often caused by a eutrophic production of the dinoflagellate *Karenia brevis*, which can impact local dolphin populations. Dolphins living in areas with regular *K. brevis* blooms exhibit a higher body burden of brevetoxin, the respiratory toxin released by *K. brevis*, than other populations, which may lead to either direct mortality or weakened immune systems (Fire et al., 2007). The blooms regularly coincide with large-scale mortality events in local dolphin populations, and both the dolphins and prey fishes involved in the die-off show high levels of brevetoxins (Twiner et al., 2011). Though this most often affects the Gulf Coast on the western side of Florida, the length and size of these red tide blooms has increased in the last few years, expanding into the waters of southeast Florida and putting the dolphins in this area at even higher risk (Tominack et al., 2020).

The South Florida Coastal Ecosystem

Along the eastern coast of South Florida, the deepwater Gulf Stream current approaches shore closer than at any other point in the country (Avent et al., 1977). The coastline in this region has a steep drop-off nearshore, with depths of 20 m common within 5 km of shore (Kajiura & Tellman, 2016; Figure 1). The area off Palm Beach County is composed primarily of a narrow sand bank and hard reef systems; however, this sand bank makes up only 30% of the area within 6 km of shore. The remainder is made up of a combination of hard corals, bedrock, and granite continental shelf (Finkl et al., 2005). Many sunken vessels and artificial reefs in the region provide habitat for an increased number of fish. While the shallow water bank in this part of Florida is small, it supports an exceedingly high level of biodiversity, with over 177 fish species found on the reefs in this region (Arena et al., 2007).

The combination of narrow bank and high biodiversity makes this area a hotspot for large predators. One of the largest aggregations of blacktip reef sharks (*Carcharhinus melanopterus*) in the world moves through this area annually, and other shark species are common year-round (Kajiura & Tellman, 2016). Beyond the continental shelf, in over 200 m of water, cetaceans, including offshore bottlenose dolphins, Risso's dolphins (*Grampus griseus*), pilot whales (*Globicephala macrorhynchus*), and false killer whales (*Pseudorca crassidens*), have been recorded. Nearshore, however, there have only been opportunistic reports of Atlantic spotted dolphins (*Stenella frontalis*; Herzing & Elliser, 2016). Even with the abundance of prey and the presence of other large predators, no research has been published on residential dolphins in the coastal oceans of Palm Beach County and the surrounding coastline.

Tursiops *Stocks in the Northwest Atlantic*

The coastal ecotype of the bottlenose dolphin has been well documented along the northwestern Atlantic Ocean coast of the United States. A pilot study by the National Oceanic and Atmospheric Association (NOAA) suggested that one large migratory stock of coastal bottlenose dolphins extended from South Carolina to mid-Florida, with an estimated population of about 13,000 individuals (Blaylock, 1995). Studies since then have determined that this population consists of smaller, unique stocks. Little to no genetic crossover exists between coastal bottlenose dolphins sampled in Georgia and in northern Florida (Rosel et al., 2009), and dolphins in Florida, Georgia, and South Carolina showed significantly different susceptibilities to skin lesions (Hart et al., 2012). This larger region of coastline is now thought to have four genetically distinct coastal stocks: (1) the South Carolina/Georgia Stock, (2) Northern Florida Coastal Stock, (3) Central Florida Coastal Stock (CFCS), and (4) Florida Keys Stock (Torres et al., 2005; Bills & Keith, 2012; Taylor et al., 2016; NOAA, 2018). It should be noted that the Florida Keys Stock shows large behavioral differences from other Atlantic coast stocks and may be more closely related to the stocks of western Florida and the Caribbean Sea (Lewis & Schroeder, 2003; Caballero et al., 2012). There is also some evidence of a transient migratory stock spanning a large portion of the U.S. east coast, but this group is poorly understood (Gubbins et al., 2003; NOAA, 2010).

While the CFCS has been given substantial attention, almost all studies have focused on the dolphins residing permanently in the Indian River Lagoon, with little focus on the oceanic population (Mazzoil et al., 2011, 2020; McFee et al., 2012; Richards et al., 2013; Durden et al., 2017, 2019; Nekolny et al., 2017). Between Fort Pierce and Vaca Key, Florida (the northern limit of the Florida Keys Stock), the lack of wide, shallow shelf and the proximity of the Florida Current to shore may act as a boundary inhibiting coastal bottlenose dolphins from residing in this area (NOAA, 2018). Coastal bottlenose dolphins tend to reside in areas with a wide sand bank in depths between 1 to 15 m as the sand banks are protected from ambush predators who may attack young dolphins and are full of potential prey (Rossbach & Herzing, 1999). At least one report exists in the literature of opportunistic sightings of offshore bottlenose dolphins off the coastal shelf of this region (Herzing & Elliser, 2016), and Haria et al. (2023) estimated the likely abundance of coastal bottlenose dolphins in this area, but no study to this point has investigated the site fidelity of dolphins or the possibility of a permanent residential group in the coastal waters off southeast Florida. While this region is technically considered part of the range of the CFCS, it is not surveyed during NOAA stock analysis due to the assumption that no residential or frequent dolphins inhabit this area (NOAA, 2018).

This study is the first population study of site fidelity in small cetaceans off the coast of Palm Beach, Florida. While much attention has been given to the bottlenose dolphins of the Indian River Lagoon to the north and Biscayne Bay to the south, the area between these two regions is not represented in the literature. While all other bottlenose dolphin population studies in the U.S. occur in relatively shallow, naturally protected areas like estuaries and bays, this study occurs on a narrow sand bank directly adjacent to the deep-water Florida Current. Understanding the site fidelity of a bottlenose dolphin population living in a unique and understudied habitat type could give insight into the behavioral flexibility and evolution of the species.

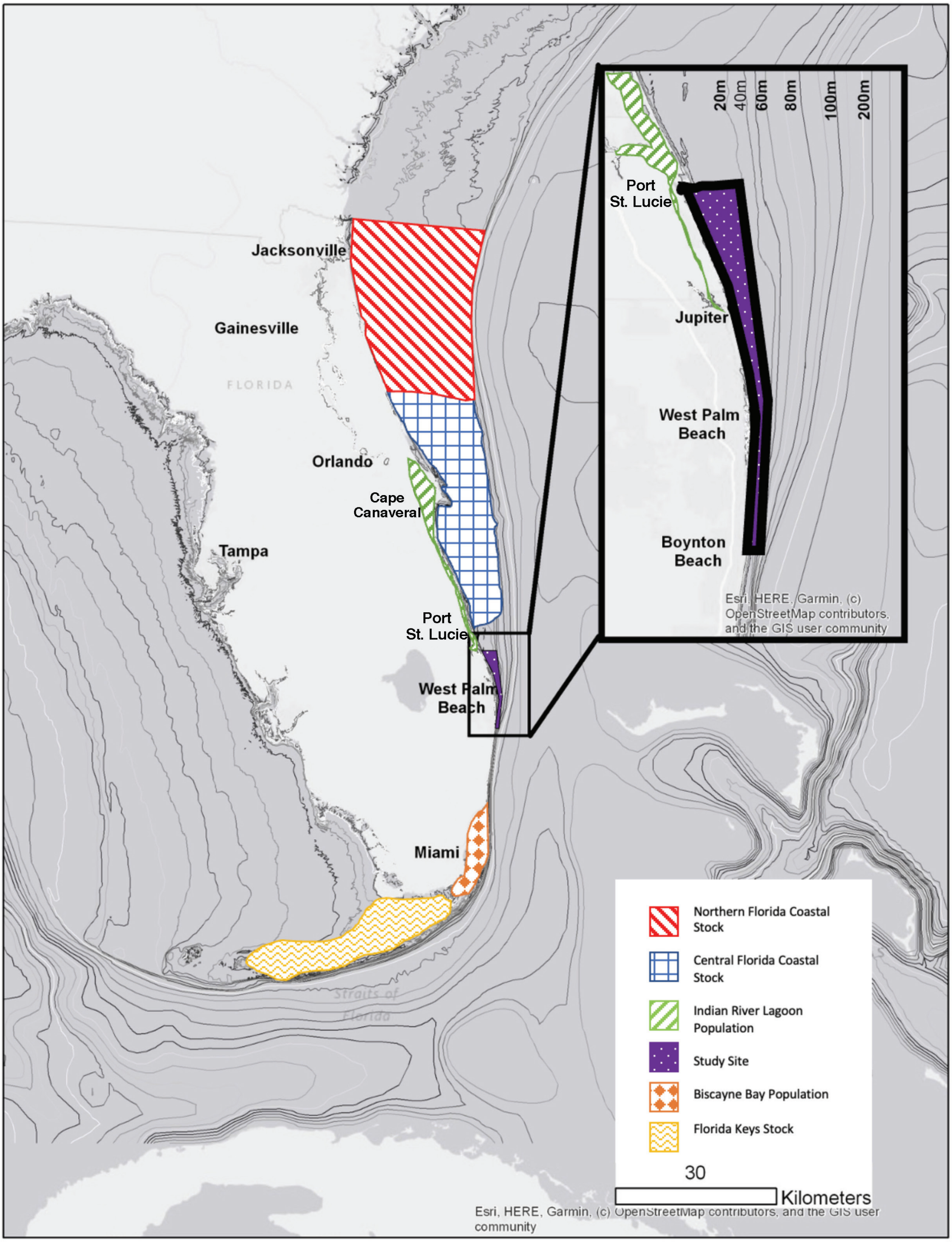

Figure 1. Bathymetric map of Florida, including the recognized residential populations of bottlenose dolphins in eastern Florida: The Northern Florida Coastal Stock (red), Central Florida Coastal Stock (blue), Indian River Lagoon population (green), Biscayne Bay population (orange), and Florida Keys Stock (yellow). No residential population is known between Port St. Lucie and the northern edge of Biscayne Bay. The survey area for this study is shown in purple.

Methods

Data Collection

All research was conducted under federal permits to BJB (LOA #13386, #18152, and #22291). Under this Level B permit, researchers may approach dolphins with the research vessel but may not enter the water, touch the dolphins, or introduce any foreign substance into the water during an encounter.

Weekly and biweekly boat survey transects established roughly 1 km offshore along the coast of southeast Florida from Bathtub Reef (27° 11' N, 80° 09' W) to Boynton Beach Inlet (26° 54' N, 80° 04' W) (Figure 1) were conducted during all seasons between 2016 and 2021. In total, 313 surveys were conducted on a transect in favorable weather conditions (Beaufort sea state ≤ 3, swell < 2 m, no rain, no fog) to reduce detection favorability bias. Between two and five researchers completed all surveys, alternating between binocular observation and visual observation using polarized glasses, as they traveled along the transect at 5 to 8 kts. If bottlenose dolphins were spotted, the research vessel would leave the transect and approach the group. Global Positioning System (GPS) coordinates and oceanographic conditions, including water temperature, tide cycle, and swell/sea state, were recorded at the start of every survey and at any point in which dolphins were encountered. An encounter was defined as an observation of one or more dolphins during a survey. Any dolphins seen by researchers before returning to the transect and resuming survey speed were considered part of the same encounter. Group size (the total number of dolphins within an encounter) was estimated in the field and then confirmed via photo-identification analysis. All dolphins within an encounter were photographed using a Nikon D300 camera regardless of the presence of visible dorsal markings. Dolphins were observed and photographed for up to 1 h or until researchers were confident all individuals had been photographed, at which point the research vessel returned to the transect and continued the survey so as to avoid unnecessarily harassing the animals. Harassment in this study was defined as any action that compromises or alters the natural behavior of the dolphins.

Photo-Identification and Abundance

Surface photographs of unique markings on the dorsal fin of bottlenose dolphins were used to identify individual animals as is standard in dolphin photo-identification studies (Urian & Wells, 1996; Middleton et al., 2011; Díaz López, 2012; Benmessaoud et al., 2013; Pace et al., 2021). Only photographs in which the full dorsal fin is visible and in focus at roughly a 90° angle to the camera lens were used for identification. A digital database of all known individuals was produced and used for determining population abundance and site fidelity.

Site Fidelity

Site fidelity was analyzed using resighting ratios (Díaz López, 2012; Benmessaoud et al., 2013; Baş et al., 2019). Annual and quarterly resighting ratios were determined for each individual. Years were divided into four quarters (January-March, April-June, July-September, and October-December) to account for animals that are only present in certain portions of the year. Resighting ratios were calculated as the number of quarters (or years) where an individual was observed (n_s) divided by the number of quarters (or years) where they could have been present (current quarter [S] minus the quarter first seen [S_f] plus one).

Animals were then divided into three arbitrary but useful categories based on the methods put forward by Díaz López (2012) and Benmessaoud et al. (2013):

1. Full-time residential dolphins have both an annual and quarterly resighting ratio ≥ 0.5.

2. Part-time residential dolphins have a quarterly resighting ratio < 0.5 but ≥ 0.25.

3. Sporadic visitor dolphins have resighting ratios < 0.25.

Results

We encountered 268 dolphin groups over 313 surveys. Five hundred eighty-five individual dolphins were identified within the study area, with discovery of new individuals beginning to plateau after approximately 18 quarters (Figure 2). To determine site fidelity, dolphins who had been in the area for less than 1 y were removed as these individuals could not be statistically analyzed. This left 568 dolphins seen at least 1 y prior to the end of the study. Of these, 478 individuals identified were sporadic visitors, 66 individuals were part-time residents (PTRs), and 24 individuals were full-time residents (FTRs). Of the 268 encounters, 144 encounters included FTRs (53.7%) and 206 included either FTRs or PTRs (76.9%) (Figure 3).

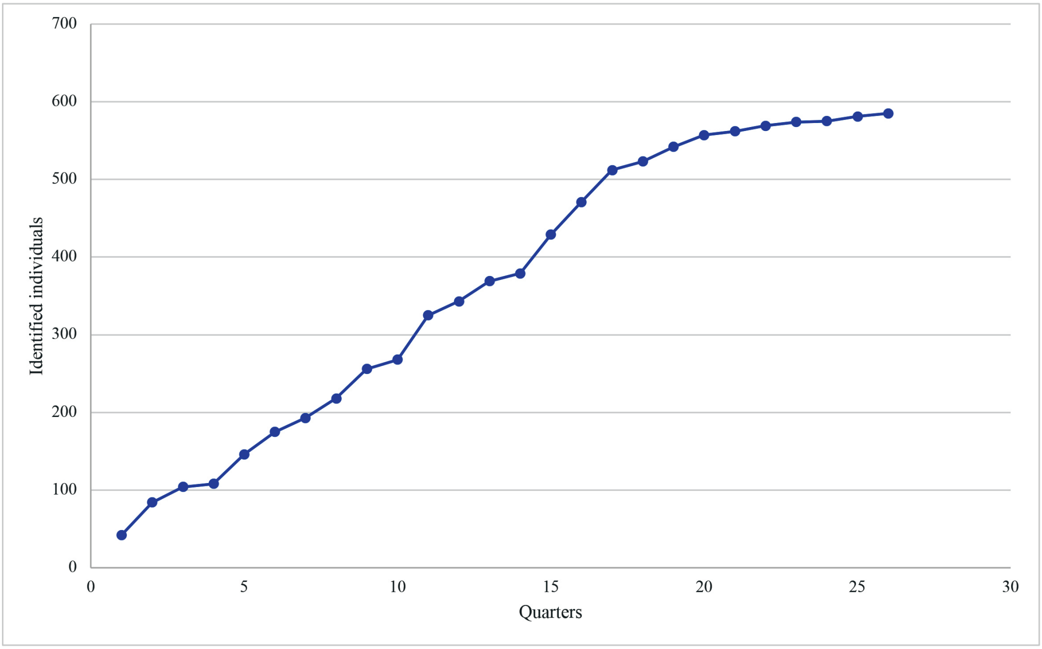

Figure 2. Discovery curve of identifiable individuals over 26 quarters. New animal sightings began to plateau at quarter 18 with around 550 animals.

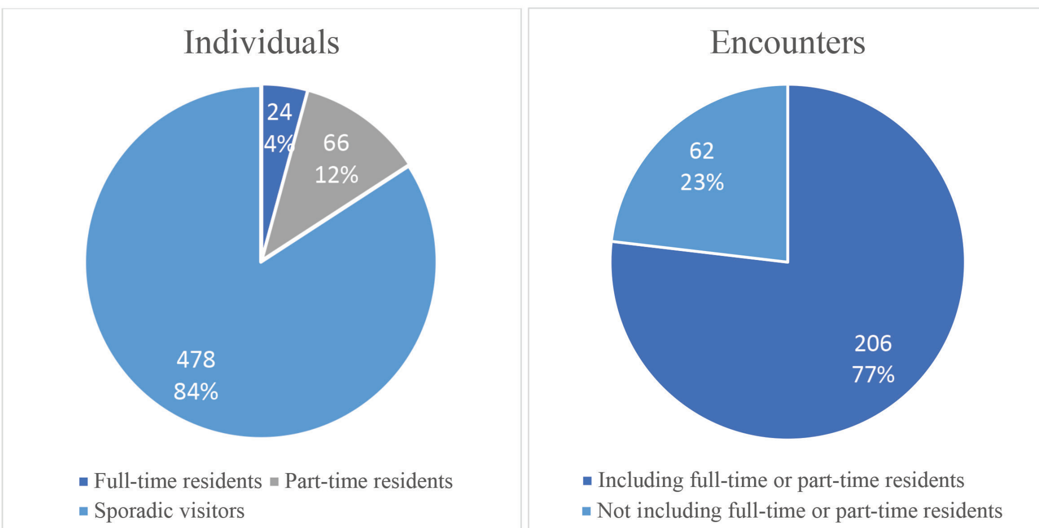

Figure 3. Breakdown of individuals and encounters based on site fidelity. Residential dolphins only made up 16% of identified individuals but were seen in 77% of encounters.

Discussion

The high site fidelity of some animals in this area indicates that this region of southeast Florida most likely serves as a permanent habitat for some coastal bottlenose dolphins. This species shows a tendency toward defined home ranges elsewhere (Benmessaoud et al., 2013; Baş et al., 2019), so it is likely that this study area represents at least a portion of the home range for the FTRs. PTRs may also remain local year-round, with the study area on the outer limit of their home range. However, there is also evidence of a large migratory stock of coastal bottlenose dolphins on the southeastern coast of the U.S. (Gubbins et al., 2003; NOAA, 2010), of which PTRs may be members. Further investigation into the precise timing and location of these PTR sightings is necessary to determine the nature of their behavior outside the study area.

Transient animals may use the region as a corridor between the wide sand banks of central Florida and the waters of Biscayne Bay or the Florida Keys. Large residential populations are known in both areas (Lewis & Schroeder, 2003; Caballero et al., 2012; NOAA, 2018), though fin comparisons would be needed to confirm that transient animals in this region belong to neighboring stocks. If these dolphins do belong to neighboring stocks, this habitat would connect two stocks thought previously to be separated by a geographic barrier (NOAA, 2018). The connection of the CFCS and the Biscayne Bay and Florida Keys Stock would warrant further studies into genetic, pathologic, and cultural crossover between populations.

Bottlenose dolphins are apex predators in the western Atlantic (Connor et al., 2000). Due to this high trophic position, bottlenose dolphins are at an increased risk for bioaccumulation of human-introduced toxins in their environment. Bottlenose dolphins sampled in the Florida Keys show high levels of mercury and persistent organic pollutants (POPs). Further, while females showed lower toxin rates than males, infant mortality increases with overall toxin concentration, indicating that females may transfer toxins to offspring during pregnancy and nursing. Any factor that elevates infant mortality rates could have widespread impacts on population dynamics through time (Damseaux et al., 2017). These threats may also have yet unknown effects on the population structure of dolphins globally (Brightwell et al., 2020).

This study supports the hypothesis that bottlenose dolphins in the coastal waters of Palm Beach County, Florida, have high site fidelity and use the region as a permanent or regular habitat. The presence of residential bottlenose dolphins warrants further study into their behavior, population health, and genetics, as well as adapted conservation efforts to protect this otherwise undocumented group. With dolphins in surrounding regions facing increased threats (Fire et al., 2007; Damseaux et al., 2017; Brightwell et al., 2020; McHugh et al., 2021), the knowledge of a potential genetic or cultural bridge between the northern CFCS and the Biscayne Bay or Florida Keys Stock can greatly aid in efforts to conserve and protect the dolphins along the entire eastern coast of Florida.

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