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**Bottlenose Dolphins (*Tursiops truncatus*) in the Drowned Cayes, Belize: Group Size, Site Fidelity and Abundance**

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**ABSTRACT.**—Group size, site fidelity and abundance of bottlenose dolphins, *Tursiops truncatus*,

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were assessed during 392 photo-identification surveys conducted during 1997-1999 in the Drowned Cayes region, near Belize City, Belize, Central America. During this study 2155 dolphins were sighted across 736 groups. Mean group size was 2.9 (SD = 2.32) which is one of the smallest reported for bottlenose dolphins. One hundred and fifteen individual dolphin were photographically identified, with sighting frequencies ranging from one to fifty ( $\bar{X} = 8.1$ , SD = 9.05). Thirty percent of identified dolphins were judged to be residents, while 23% were photographed only once. Chao's  $M_{th}$  model for closed populations was used to derive an abundance estimate of 122 dolphins (95% CI = 114 -140). This low abundance estimate and a leveling trend in the rate of newly identified individuals, indicates that the Drowned Cayes dolphin population is both small and finite. Group size, abundance, and site fidelity comparisons were made with a 4-yr photo-identification study conducted at nearby Turneffe Atoll. Both the Drowned Cayes and Turneffe Atoll studies had similarly small group sizes, low and variable levels of site fidelity and low abundance estimates, but there was no overlap between individual sightings in the two areas. The observed behavioral patterns and similarities between the two studies raise concerns that increasing pressures on Belize's marine resources may pose a threat to its bottlenose dolphins.

**KEYWORDS.**—Residency patterns, population dynamics, cetaceans, Belize, Caribbean

A recent 4-yr study at Turneffe Atoll in Belize, Central America (Campbell et al. 2002), was one of the first to document the population dynamics of bottlenose dolphins (*Tursiops truncatus*) in a tropical offshore atoll containing coral reefs, sea grass beds and mangroves, and is one of the few published studies on this cetacean species in the Caribbean Sea (see also Grigg and Markowitz 1997; Rossbach and Herzing 1999; Rogers et al. 2004). Turneffe bottlenose dolphins occurred in small groups that were larger when they contained calves, and this population had a high proportion of individuals sighted only once. Further, abundance estimates were low, and only a small proportion of these dolphins showed evidence of site fidelity (Campbell et al. 2002). The habitat characteristics of the Drowned Cayes, where the current study was conducted, are similar to those of Turneffe. Thus, the objectives of

the current study were to examine the generality of the Turneffe findings and interpretations, identify possible overlap between these two dolphin populations, and extend the management and conservation implications of both studies.

The Drowned Cayes are located in the western Caribbean, south of the Yucatan Peninsula, 6 km east of Belize City and 16 km west of Turneffe Atoll (Fig. 1). The study area consisted of a 150 km<sup>2</sup> chain of mangrove islands extending from 17°20'N-17°34'N, and 88°03'W-88°07'W. Like Turneffe Atoll, the Drowned Cayes area is characterized by a predominating substrate of sandy sea grass beds, but also includes a portion of the Belize Barrier Reef. Surface water temperature ranged from 25°-33°C ( $\bar{X} = 29.2$ , SD = 1.62), and water depth, measured during 216 sightings, ranged from 0.9 m to 11.8 m ( $\bar{X} = 4.3$  m). All aspects of the photo-identification methodology used in this study, including: survey methodology, criteria for groups and calves, image processing and analysis of photographic data (i.e., rate of discovery, sighting frequency, abundance), were the same as those described in Campbell et al. (2002). Briefly summarized, boat based surveys lasting approximately 4 h were carried out once or twice daily, and all portions of the study area were covered at least once a month. When dolphins were sighted, the survey vessel stopped while environmental data were recorded and group size was determined. Next, an attempt was made to obtain high quality dorsal fin photographs for each group member. Once photographic data were collected, the survey continued along a predetermined route to search for and photograph additional dolphins.

During 1246 h expended over a 3-yr period (February-December in 1997 and 1998, and April-Dec in 1999), 392 surveys were completed, and 277 h were spent in direct observation of 2155 dolphins sighted across 736 groups. Group size ranged from one to 20 dolphins ( $\bar{X} = 2.9$ , SD = 2.32), but was higher for groups with calves ( $n = 160$ ,  $\bar{X} = 4.6$  [includes calves], SD = 2.68) than without calves ( $n = 576$ ,  $\bar{X} = 2.5$ , SD = 1.99)(Mann-Whitney U = 19540.0, Z = -11.433,  $p = < 0.001$ ). Almost a third (31%)

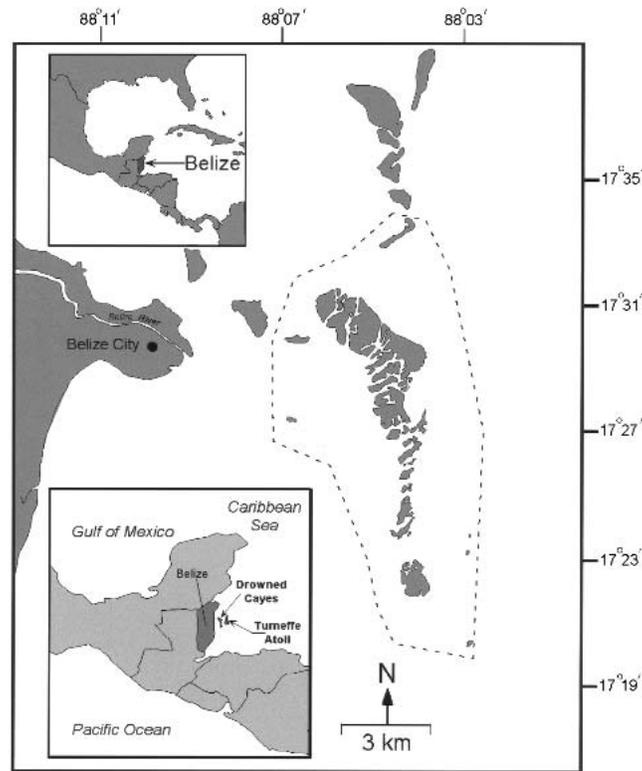


FIG. 1. Drowned Cayes study area (within dashed outline). Insets show the location of the study area from a broad regional (top) and western Caribbean (bottom) perspective.

of all sightings were solitary dolphins and 99% of all groups contained 10 or fewer dolphins. Group sizes for Drowned Cayes ( $\bar{X} = 2.9$ ) and Turneffe dolphins ( $\bar{X} = 3.8$ ,  $SD = 3.55$ , Campbell et al. 2002) are among the smallest reported for any population of bottlenose dolphins (Connor et al. 2000).

Group size in bottlenose dolphins, as in many other species, is a tradeoff between optimizing foraging efficiency and minimizing predation risk (Wells and Scott 1999; Campbell et al. 2002). While there have been no studies of prey characteristics for Drowned Cayes or Turneffe dolphins to date, no observations or images indicated evidence of shark bites, suggesting that predatory threats from sharks are minimal. Low apparent predation at the Drowned Cayes suggests, as it did at Turneffe, that energy intake is a primary selective pressure on group size; and, the small group sizes in these areas are optimized for food resources that are likely low in density.

Similarly, in both the Drowned Cayes and Turneffe, larger calf-groups may be an adaptation that facilitates allomaternal behavior, thereby increasing the foraging efficiency of nursing mothers who are constrained by maternal responsibilities (see review in Campbell et al. 2002).

Across the study period, 115 dolphins were photographically identified. The slope of the Drowned Cayes discovery curve for newly photographed dolphins showed a steep rise until the 90<sup>th</sup> survey when 76 dolphins (66%) had been identified (compare with Fig. 2, Campbell et al. 2002). Few new dolphins were photographed until surveys 190-230 (Aug 1999) when an additional 23 dolphins (18%) were identified. No new dolphins were photographed during the remaining 162 surveys. Sighting frequencies for identified dolphins ranged from 1-50 ( $\bar{X} = 8.1$ ,  $SD = 9.02$ ), with 23% ( $n = 27$ ) of these dolphins identified one time, 50% ( $n = 57$ ) sighted between two

and nine times and 27% ( $n = 31$ ) sighted 10 or more times. Evidence for site fidelity was evaluated by examining sighting frequencies within and between the three study years. Dolphins sighted two or more times in each of the three study years, or four or more times in two successive years, were labeled as residents, and comprised 30% of the identified population. The abundance estimate derived by Chao's closed model  $M_{th}$  was 122 (95% CI = 114-140) (Chao et al. 1992) and was quite similar to the number of identified dolphins ( $n = 115$ ).

Taken together, the discovery rate for new individuals, the high study effort (number of surveys) extending over a 3-yr period, the high proportion of individuals showing low sighting frequencies (vis-à-vis the high number of surveys), the small number of individuals showing evidence for site fidelity ("residents"), and the relatively low abundance estimate, suggests that, as at Turneffe, a small and finite population of dolphins uses this study area. These same data indicate that the Drowned Cayes area can only support a small number of dolphins, probably due to low prey item densities (group size interpretation suggested above). Some dolphins were seen throughout and across years, however, indicating that a degree of fidelity to the area does exist.

Photographs of the 115 Drowned Cayes dolphins were compared to those of 81 individuals photographed during 549 surveys at Turneffe Atoll from 1992-1996 (Campbell et al. 2002). Despite the close geographic proximity of the Drowned Cayes and Turneffe, the high survey effort in both studies, and the presence of a large number of individuals in each population not considered "residents," there was no overlap documented between these populations. While the depth of the channel separating Turneffe Atoll from the Belize Barrier Reef and the Drowned Cayes (range = 274-305 m) may act as a physical barrier to regulate movements of dolphins between the study areas, the distance between Turneffe and the Drowned Cayes could be easily traveled by this species (Stoddart 1962; Tanaka 1987; Wood 1998; Defran et al. 1999). A tentative hypothesis,

consistent with the existing photo-identification data, is that bottlenose dolphins in Belize may have overlapping ranges along the mainland coastline; however, exploitation of the offshore islands, such as the Drowned Cayes and Turneffe Atoll, is selective among subsets of this population. Similar selective partitioning among areas of their range were shown for bottlenose dolphins (Maze and Würsig 1999) as well as humpback (*Megaptera novaeangliae*) and sperm (*Physeter macrocephalus*) whales (Clapham 2000; Whitehead and Weilgart 2000). To date, no mainland coastal photo-identification surveys have been carried out in Belize. Such surveys are needed, however, in order to clarify the home ranges of Drowned Cayes and Turneffe Atoll dolphins, as well as to evaluate the selective partitioning hypothesis we have proposed.

Belize is rich in natural resources that could be vulnerable to ecologically unsustainable growth in tourism, fishing, and development. The accessibility of the Drowned Cayes to the coastal mainland of Belize, including Belize City and the Belize River, places an even higher pressure on levels of resource extraction, pollution, and boat traffic in this region than in other offshore locations such as Turneffe Atoll. Although fishing pressure in the Drowned Cayes, and the rest of Belize, may be considered low compared to highly populated areas in the Caribbean, the demands on fisheries resources are increasing and the effects of overfishing are already evident as changes in fish community structure (Sedberry et al. 1999). Some suggest that reefs in the Caribbean have been overfished for centuries, and the resulting changes in community structure have placed these ecosystems in a precarious state that is now collapsing (Jackson 1997; Jackson et al. 2001). While fishing in the study area is mainly artisanal, even this type of fishing may be unsustainable (Coblentz 1997; Sedberry et al. 1999). Shifts in the ecological dominance from coral to fleshy algae have been found at some reef locations in Belize (Aronson and Precht 1997; McClanahan and Muthiga 1998). Since the first major bleaching event in the history of Belize's coral reefs occurred in 1995, an even more

severe event occurred in 1998 (Aronson et al. 2000). Threats, such as overfishing, pollution, and the results of climatic change, have been shown to detrimentally affect marine mammals in a variety of ways (Harvell et al. 1999; Allen and Read 2000; Fair and Becker 2000; Wilson et al. 2000; Bossart et al. 2003). In the aggregate, these factors indicate that bottlenose dolphins in Belize could play a valuable role as a sentry species in this area. For example, shifts in bottlenose dolphin occurrence and abundance might indicate a further decline in prey (and other fish species) abundance. Similarly, increases in skin lesions (observed on at least two dolphins in the Drowned Cayes population, personal observations), may provide an early signal of compromised immunity to disease (Wilson et al. 2000; Bossart et al. 2003).

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