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Abundance, Residency, and Potential Hazards for Coastal Bottlenose Dolphins (*Tursiops truncatus*) Off a Productive Lagoon in the Gulf of Mexico

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Abstract

Movements of many cetacean species are commonly related to temporal and spatial variations in food resources and human activities. Worldwide evidence shows that anthropogenic pressures faced by coastal dolphin populations are increasing; however, the lack of reliable baseline information generally prevents the assessment of such interactions. We studied the temporal dynamics in abundance, site fidelity, and residency of bottlenose dolphins (*Tursiops truncatus*) off the productive Alvarado lagoon in the Gulf of Mexico, and we assessed the potential hazards posed by human activities and natural predators. This 2-y study (2006 to 2008) was based on the photographic identification of 174 individuals from 871 high-quality dorsal fin photographs obtained during 41 surveys totaling 225.4 h of observation. Overall monthly abundance averaged 125 (SD = 52) dolphins, whereas naturally marked individuals averaged 106 (SD = 25); abundance values were somewhat consistent within and between years, but the community was composed of different dolphins at any given time. Seasonal site fidelity and residency were higher during the dry (March to June) and rainy (July to October) seasons. Previous studies from Alvarado and elsewhere suggest long-term residency (up to 7 y) but also widespread movements (100 to 300 km) for some individuals. Physical evidence of attacks by large predators was exclusively found in nonresident adult dolphins (3.5%), suggesting a seasonal incursion to the area by individuals from deeper waters. Also, dolphins bearing marks of interactions with fisheries were more common in adult residents (11.5%). Despite these threats, dolphins are recurrent in the area, possibly due to high prey abundance and availability, which may constitute the main factors driving their distribution and abundance.

Key Words: population size, migration, fisheries, predation, attacks, bottlenose dolphins

Introduction

Spatial and temporal patterns in aquatic species are related to environmental features such as sea surface temperature, depth, presence of predators, and distribution/abundance of prey (Ballance, 1992). However, in many cetacean species, such movements have been found to relate not only to the natural changes in the conditions of their habitat (Ballance, 1990, 1992), but also to their reproductive status (Wells, 1991; Möller & Beheregaray, 2004) and to levels and types of human activity (Morteo et al., 2004, 2012b; Lusseau, 2005; Pérez-Jorge et al., 2016). Movements and seasonal shifts may lead to significant changes in the number and identity of the individuals present in an area at any given time (Möller et al., 2002; Hubard et al., 2004; Balmer et al., 2008). However, in some cases, some animals may remain in such habitats for extended periods, constituting the *core* of a community (*sensu* Wells et al., 1987). Multiple factors may cause such behavior, but these factors are unknown for most individuals in many coastal species, especially in small odontocetes (Wells et al., 1987; Ballance, 1992). *Core* individuals within a community are often referred to as *residents* and have been extensively studied for their potential to react more effectively to changes in their habitat (Balmer et al., 2008). Therefore, studying resident dolphins helps to better understand the impact of natural or anthropogenic phenomena and their temporal dynamics within particular areas.

Field studies on coastal bottlenose dolphins (*Tursiops truncatus*) in the waters off the Alvarado lagoon began in the early 1990s and revealed a large community (92 individuals) in which some individuals seemed to be annual residents (Del Castillo, 2010); however, intermittent effort and methodological limitations yielded unreliable estimates of the temporal and spatial dynamics for this community (García-Loredo, 1995; Del Castillo, 2010). Artisanal fisheries which represent the most important year-round commercial activity in this area are relevant to bottlenose dolphins in light of the often-antagonistic interactions with local fishers (Morteo et al., 2012b). Suitable information on the abundance, migration, and potential threats is considered essential if management and conservation strategies are to be developed for the Alvarado dolphin community. Consequently, our goal was to use photo-identification surveys and available historical information to determine (1) the temporal dynamics in abundance, (2) the residency parameters of identifiable individuals, and (3) the potential hazards due to predators and human-related activities, especially for the resident dolphins.

Methods

Study Area

The region off Alvarado, Mexico, is an open and shallow (< 20 m) coastal habitat (Figure 1) where river runoffs and ocean currents yield variable sea surface temperatures (20 to 32.5° C; average 27° C) and low underwater visibility (0.1 to 3 m). The prevailing weather is tropical with three seasons: (1) *rainy* (July to October)—when the sea is enriched by organic matter and nutrients running off the lagoon, (2) *windy* (November to February)—when northern cold fronts up to 80 km h^{-1} shift surface circulation for several days, and (3) *dry* (March to June)—when the abundance and availability of food resources are limited by a reduction in average precipitation (Contreras & Castañeda, 2005; Cruz-Escalona, 2005). This study area was selected given the established residency of individual dolphins and their considerable interactions with humans—for example, in gear depredation (Rechimont, 2015), vessel harassment (Morales-Rincon, 2016), fisheries bycatch, intentional mortality (Morteo et al., 2012b), and live captures (Alaniz & Rojas, 2007).

Surveys

Standard photo-identification transect surveys were conducted twice a month from 25 May 2006 to 24 April 2008 at constant speed (15 to

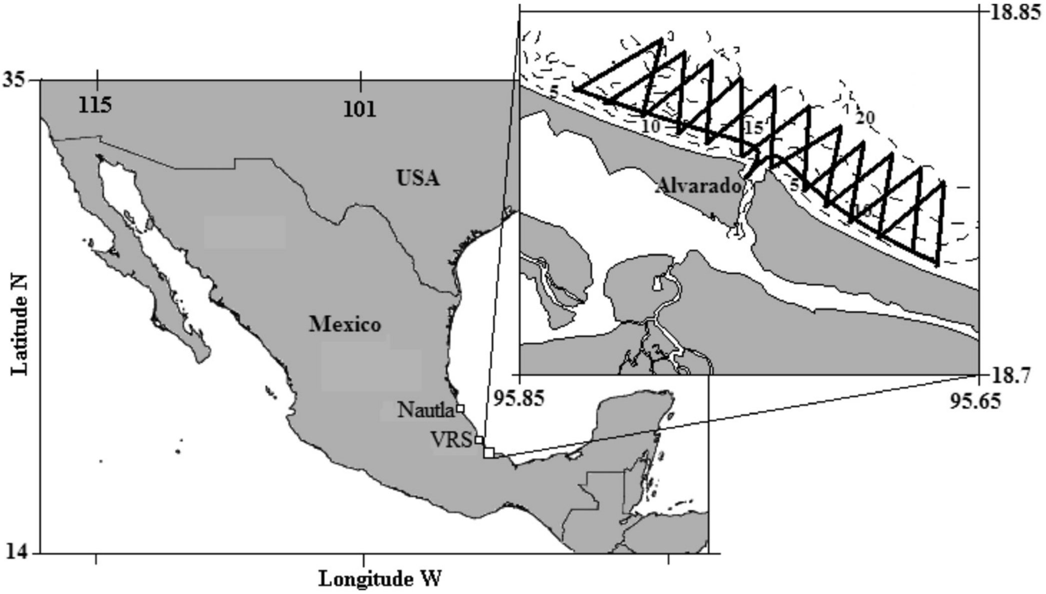

Figure 1. Study area and transect surveys (in bold). Dashed lines show depth contours every 5 m; VRS = Veracruz Reef System.

18 km h^{-1}) on board a 7-m outboard-motor boat (40/60 hp) and always in a Beaufort Sea State of 3 or lower (wind speed < 15 km h^{-1}). Surveys started from the center of the study area at the mouth of the lagoon and navigated along the coast to reach the far end of the 18 km wide, 4 km offshore area; the vessel then zigzagged back to the other side and returned to the mouth along the coast (Morteo et al., 2012b; see Figure 1). Surveys intended to maximize dolphin detectability by taking advantage of their habitat preferences; thus, we navigated the coastal waters (< 20 m depth) within both sides of the lagoon's entrance (Ballance, 1990; Fazioli et al., 2006). Whenever dolphins were sighted, surveys were interrupted to carefully approach the group while minimizing the disturbance to these animals. Group composition was recorded following protocols by Morteo et al. (2004), and groups were defined as including all dolphins observed in apparent association (i.e., within 100 m from each other) (Pérez-Jorge et al., 2016), moving in the same direction and often, but not always, engaged in the same activity (Bräger et al., 1994). Dolphins were followed until all animals were photographed (digital SLR cameras Canon Rebel XT and Nikon D50, with 70 to 300 mm lenses) or until they were lost from sight; after this, the survey was resumed from the position where it was interrupted to maximize spatial coverage.

Data Analyses

Survey Effort—We computed the time spent while looking for dolphins (h) during each survey and performed temporal comparisons (monthly, seasonally, and yearly) via Kruskal-Wallis (K-W) or Mann-Whitney (M-W) tests. The overall encounter rate was computed along with the average group size; the latter was corroborated using photographic data.

Photographic Identification—Individuals were identified by the marking patterns on their dorsal fins, following Würsig & Jefferson (1990) and the manual of the Sarasota Dolphin Research Program (SDRP) (2008). Only dolphins with conspicuous permanent markings were considered identifiable and included in the analyses (Urian et al., 2015). Tooth rakes, superficial scars, wounds, pigmentation marks, and epiphytic organisms were considered temporary features and, thus, unreliable for identification, which is in compliance with the definition of a "verified" and "unverified" sighting from Sheaffer & Jarvis (1995). Additionally, we followed the methods of Würsig (1978) and Ballance (1987) to maximize the probability of photographing marked dolphins during each sighting by using a minimum number of high-quality photographs from each individual (see Morteo et al., 2014). These authors determined that the number of recognizable dolphins in a group of known size reaches an asymptote depending on the number of photographs available per dolphin. They empirically determined that at least 95% of the animals are sighted when at least five random pictures of each individual within a group have been analyzed. We adopted this standard to increase confidence in our estimations as it has been successfully used in other studies (Ballance, 1990; Bejder & Dawson, 2001).

We also recorded individuals with physical evidence of interactions with fisheries (i.e., straight, deep, and/or regularly spaced cuts along the body or the fins were considered to be caused by fishing gear or vessels) (Bloom & Jager, 1994; Wells et al., 1998; Kemper et al., 2005; Kiszka et al., 2008) or predators (i.e., shark bites) (Fertl, 1994; Heithaus, 2001; Kiszka et al., 2008). We only considered animals with damage that was likely caused by one or the other; thus, ambiguous evidence was discarded. Additional 35-mm photographic negatives (Tri-X-Pan ASA 400, shot with a Canon EOS Rebel 2000 and a 70 to 300 mm lens) from 2002 to 2003 by Del Castillo (2010) were also analyzed for comparison; these were obtained from the study area using the same survey procedures. The photo-identification protocols described above were applied accordingly, and the same trained staff analyzed all the negatives; thus, quality and reliability were deemed equivalent between both datasets (Urian et al., 2015).

Abundance—Photo-identification data for all individuals observed in this study were used to construct a discovery curve. Monthly records of new (marked) individuals and their resightings were added to the plot, indicating dolphin immigration (Defran & Weller, 1999; Balmer et al., 2008; Morteo et al., 2012a). Due to the nature of the area, we selected an open mark-resight model (Jolly-Seber or J-S model) as in *SOCPROG*, Version 2.4 (Whitehead, 2009). This is a suitable model when evidence of population closure is weak; it provides robust abundance estimates and migration rates (expressed as the percentage of new marked animals), while allowing entries (i.e., births and immigration represented by positive values) and losses (i.e., deaths and emigration represented by negative values) in the community. To ensure independence among sightings, multiple identifications of an individual during a single survey were counted only once. Also, since one of the key assumptions for mark-resight models is that marked and unmarked individuals have similar sightability (Sheaffer & Jarvis, 1995), we assumed that the latter is not violated by our data since (1) photographs in the field attempt to register all dolphins, regardless of their possessing identifiable marks (Bejder & Dawson, 2001; Ryan et al. 2011); (2) except for the 2002-2003 surveys (not used in abundance estimations), our trained crew used high-resolution photographic equipment; (3) all images were classified and catalogued consistently by at least three experienced analysts (see Morteo et al., 2004), which reduced the chances that individuals were confounded or missed due to different degrees of image quality or dorsal fin mark conspicuousness (Urian et al., 2015); (4) permanent marks in dorsal fins may remain fairly unchanged during short periods (y) (Maze & Würsig, 1999), and individuals still may be recognizable if regularly sighted (Urian et al., 2015); and (5) individuals considered ambiguous or unmarked were discarded from this analysis.

Accordingly, to estimate the total number of individuals (marked and unmarked), we computed a distinctiveness index for each sighting (Williams et al., 1993); this is particularly effective when group sizes are small (Urian et al., 2015). Thus, the number of marked individuals was divided by the total number of animals photographed in each sighting. The index was averaged for all sightings, and the number of marked individuals in each sighting was divided by this average to obtain an approximate number of total individuals (Baird et al., 2008). This index is a variation of the $\check{R}$ from Sheaffer & Jarvis (1995); thus, our customization is based on (1) the J-S model already assuming that all individuals (marked and unmarked) are equally likely to be photographed (i.e., not prone/shy to camera/survey); (2) most unmarked individuals (94.2%) were closely associated to marked individuals (i.e., mother/calf or young pairs) (see Morteo et al., 2014) such that they closely resembled a proportion of the marked nursing females (but these were discarded from analyses to comply with the J-S model); and (3) the number of adult animals considered unmarked in the sample was very low (< 5%) such that their presence (even if repetitive) would have a small effect on abundance estimates overall. The result was standardized by survey effort (h^{-1}) and plotted along with the estimates from the J-S model to represent the total number of animals present in the area at any given time. Finally, temporal differences in abundance estimates were assessed within (months and seasons) and between years (K-W and M-W tests, respectively).

Site Fidelity and Residency—Individual sighting histories of marked animals were used to assess site fidelity, which was computed as the number of resightings divided by the number of surveys in seasons and years (Defran & Weller, 1999; Simões-Lopes & Fabian, 1999). Also, individual residency was determined by computing the parameters from Ballance (1990) following Morteo et al. (2012a) for which (1) occurrence is the number of sighting records, (2) permanence is the number of days between the first and last sightings, and (3) periodicity is the average days between consecutive resightings. This information was used to determine whether the marked individuals were consistently present within and among years and seasons (Williams et al., 1993).

Results

Surveys

Total search effort during the 41 photographic surveys was 225.4 h, with 61.0 h spent following and photographing dolphins. No monthly or seasonal differences were found in survey effort (K-W, $p > 0.05$); thus, temporal differences in data were deemed unrelated to sampling design. Dolphins were encountered in 93% of the surveys, and 1,429 of these animals were counted from 147 sightings. Group size ranged from one to approximately 100 dolphins ($\overline{X} = 9.72$, SD = 13.11); however, most groups (72%) had fewer than 10 members. Dolphin pairs were the most sighted aggregations (18%) followed by triads and tetrads (15% combined). Single individuals represented 14% of the sightings.

Photo-Identification

During the 2006 to 2008 surveys, we photographed 1,353 identifiable dorsal fins from 123 groups (84% of sighted groups), and 40.2% of the 14,011 available photographs were suitable to confidently identify 871 dorsal fins from 174 different individuals, which included 95.6% of adults (only 8 unmarked adults were accounted for). Overall, sightings averaged 5.4 (SD = 2.5) frames per individual, and 77% ($n = 95$) of the sightings had good photographic coverage (i.e., 95% probability of capturing all marked individuals). Due to the somewhat evasive behavior of small groups (e.g., dolphins continuously moving away as the vessel approached, and remaining immersed for larger periods), larger groups were better sampled; thus, unidentifiable dolphins totaled 137, of which 94.2% were calves and young animals. Hence, the vast majority of the adults encountered were considered marked. The distinctiveness ratio (i.e., the proportion of identified animals per sighting) averaged 0.76 (SD = 0.14) for all individuals and 0.98 (SD = 0.03) for only the adults.

Predator and fisheries-related markings were recorded only in adults and accounted for 3.5 and 11.5% of the individuals, respectively (Figure 2). Similarly, the 2002-2003 data showed 4.4% of the adults with scars inflicted by predators (none of these individuals was sighted more than once in the current study) and 17% with evidence of fisheries interactions (80% of which were resighted in the current study).

Abundance—The discovery curve showed that 46% of the identifiable dolphins were recorded within the first 3 mo, and 80% had been accounted for by the end of the first year. The discovery rate for new individuals reduced consistently with time, monotonically decreasing the slope of the curve beyond 4 mo. For the last quarter of the study, the number of dolphins slowly leveled

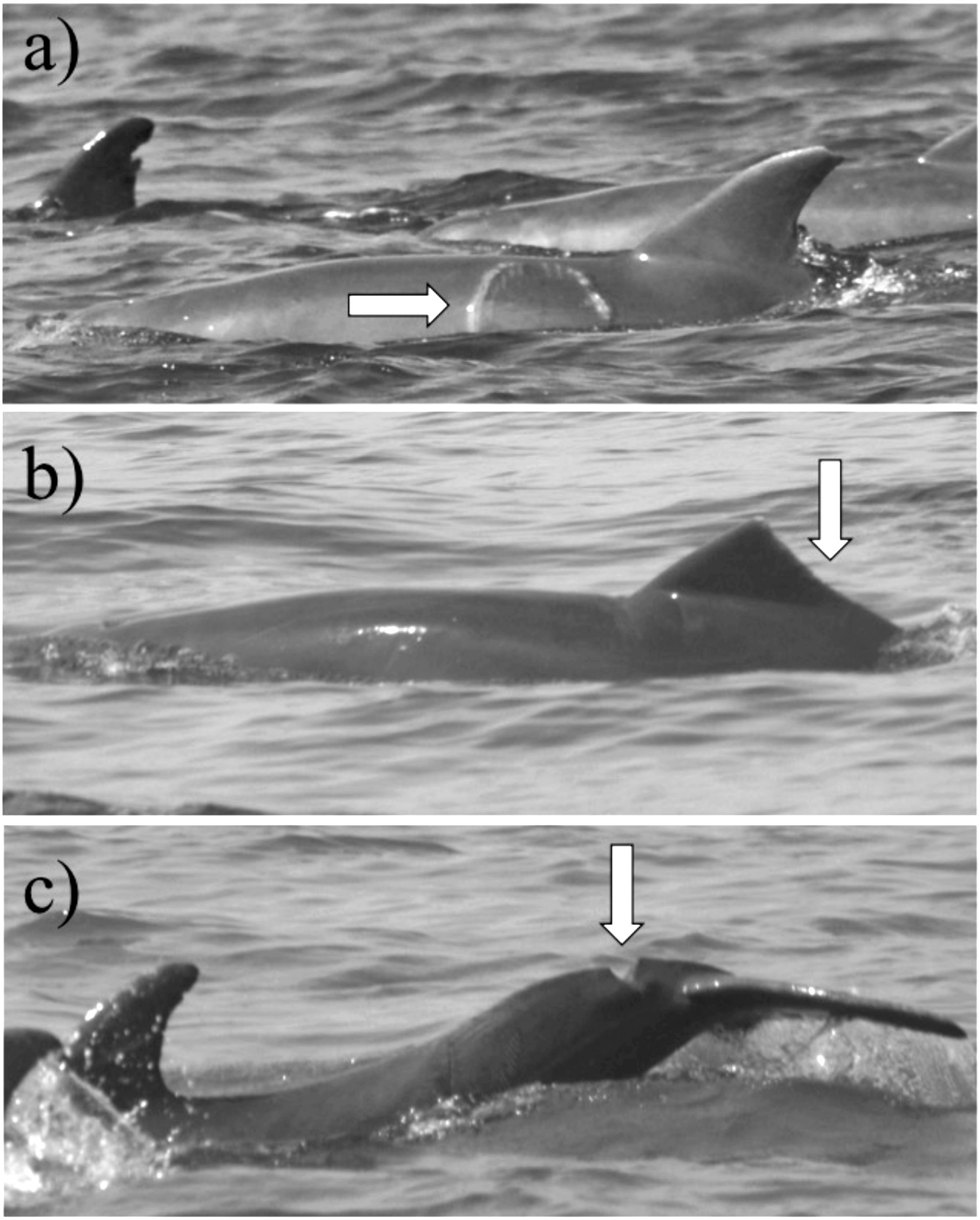

Figure 2. Typical evidence of bottlenose dolphins showing physical signs of interactions with predators (a), and fisheries (b & c) in the study area (Photo credits: Laboratorio Veracruzano de Mamíferos Marinos [LavMMar])

off, suggesting that most animals associated with the study area may have already been identified. Nevertheless, seven additional individuals were discovered during the dry season of the second year (Figure 3). The number of identifications was different only among seasons (K-W, $p < 0.05$), with the dry season being highest (25.7 ± 1.7), followed by the rainy (20.5 ± 2.9) and windy (13.4 ± 3.4) seasons (Figure 3). The majority of new individuals were found during the dry season (K-W, $p < 0.05$) in both years, whereas most of the resightings occurred within the first rainy season (July to October) (K-W, $p < 0.05$) and the following dry (March to June) and rainy (K-W, $p < 0.05$) seasons (Figure 3).

Daily estimates of the marked population using the J-S model ranged from 40 to 163 dolphins, averaging 106 (±25); only monthly differences were significant (K-W, $p < 0.05$), with highest estimates during the second half of 2007 in windy, dry, and rainy seasons (January, May, and August 2007); whereas lower values occurred during the following dry season (November 2007 and February 2008) (Figure 4). Positive values for migratory rates showed overall immigration of new marked animals, which was higher during the dry season ($\bar{X} = 5 \pm 3\%$), followed by the windy ($\bar{X} = 3 \pm 3\%$) and rainy ($\bar{X} = 2 \pm 3\%$) seasons, but showed no significant differences across seasons (χ^2, $p > 0.05$). As stated earlier, unmarked individuals were excluded from these estimates since (1) most were calves and young dolphins having approximately the same temporal patterns as their mothers; (2) new unmarked individuals were rare such that newborns were not recorded (i.e., small dolphins about one third the length of an adult, with fetal folds, higher respiratory rates, or erratic swimming), and unmarked adult immigrants were spotted only eight times and, hence, their influence was deemed negligible; and (3) to the best of our knowledge, no new permanent marks that could have biased our estimates were recorded in unmarked individuals over the study period.

Although the proportion of marked vs unmarked animals was variable (0.68 to 1.00), it showed no temporal significant differences (χ^2, $p > 0.05$); thus, daily estimates for the total number of individuals (marked and unmarked) ranged from 46 to 180 ($\bar{X} = 125$, ±52.4) and were consistent with the trends found for the dry and rainy seasons (Figure 4).

Site Fidelity and Residency—The maximum number of sightings for any marked dolphin was 25 out of the 41 surveys carried out over the 2-y period. Only 31.0% of the 174 individuals were photographed once, and about half of the dolphins (56%) were sighted between two and ten times, supporting the assumption of an open community. Overall site fidelity ranged from 0.05 to 0.61 ($\bar{X} = 0.17 \pm 0.12$) and showed only seasonal differences ($\bar{X}_{dry} = 0.21 \pm 0.14$; $\bar{X}_{rainy} = 0.16 \pm 0.14$; $\bar{X}_{windy} = 0.11 \pm 0.16$, K-W, $p < 0.05$). The 120 individuals that were recorded more than once were last photographed within 6 to 700 d from their first sighting ($\bar{X} = 13.8 \pm 6.7$ mo); however, many individuals disappeared within the first year, suggesting these animals have larger ranges. Also, some temporal trends were evident; for instance,

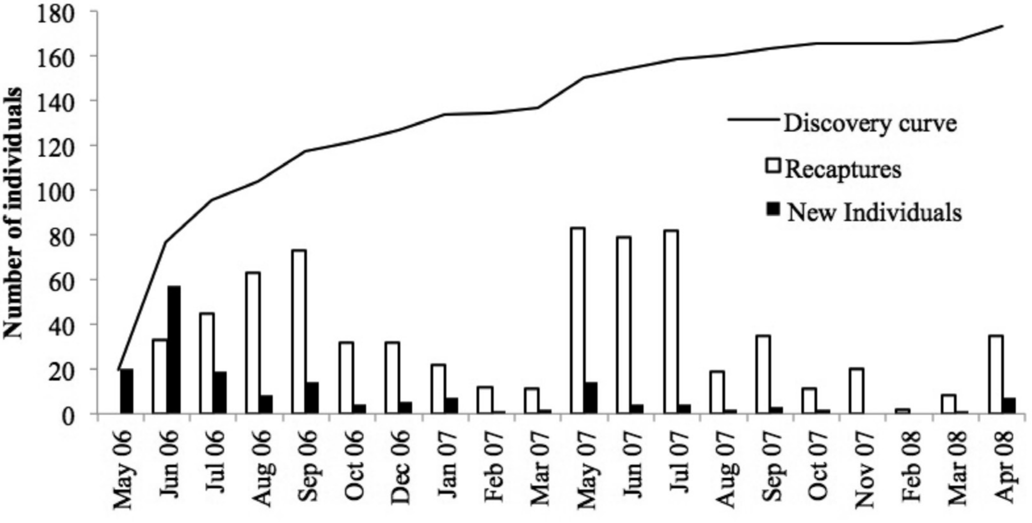

Figure 3. Discovery curve (line) and number of new (black bars) and previously photographed (white bars) individuals in the study area ($N = 41$ surveys)

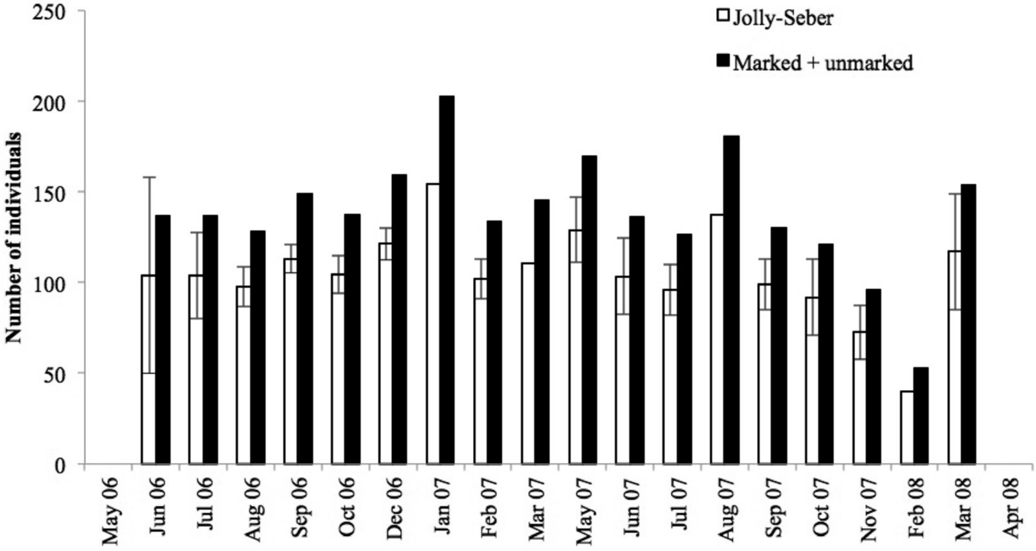

Figure 4. Monthly abundance estimates for bottlenose dolphins. J-S model averages (white bars ± SD) were based on photo-identification data for marked individuals. Animal counts (black bars) were corrected through the distinctiveness index, showing both marked and unmarked individuals.

17% of the 120 resighted dolphins appeared in only one season, and half of these reappeared the following year over the same period (65% and 35% in the dry and rainy months, respectively). From those recorded over two consecutive seasons (39%), 83% repeated the trend the following year (87% in dry and rainy months). Also, 35% of the dolphins were sighted consecutively over a year, and only 9% appeared intermittently within seasons, showing strong site fidelity. The periodicity for these animals ranged from 6 to 483 d; and on average, they were resighted approximately every 3.5 mo (±3.0 SD). Many individuals (69%) were resighted within the next 3.3 mo, however, implying a relative proximity to the area. When comparing with the 2002-2003 dataset from Del Castillo (2010), we found 71 individuals in common, supporting strong site fidelity and long-term residency for at least 30% in a total of 232 distinct individuals identified in this community when both datasets are combined.

Finally, the examination of adult dolphins bearing physical evidence of antagonistic interactions showed that the proportion of individuals with predator marks was small (3.5%) (Figure 2a) and had a low number of resightings (occurrence < 5) and low permanence (< 2.8 mo); whereas the proportion of dolphins with potential anthropogenic-inflicted wounds was larger (11.5%) (Figure 2b & c) and had higher residency (occurrence > 10, permanence > 11.1 mo) and site fidelity (> 0.2). Therefore, potential human-inflicted wounds occurred in 42% of the resident animals, while predator bites were found only in nonresident individuals. The latter was also true for the 2002-2003 data (Del Castillo, 2010) wherein wounds potentially induced by fisheries interactions were found in 17% of the individuals, representing 50% of the resident dolphins in her study; and possible predator markings were found only in nonresident individuals (4.4%).

Discussion

Previous abundance estimates were considerably lower and were based on insufficient survey effort and poor photographic coverage ($\overline{X}$ = 5.2 ± 3.5 by García-Loredo, 1995; $\overline{X}$ = 65 ± 40 by Del Castillo, 2010). Although our study had longer duration and higher photographic coverage, our monthly estimate ($\overline{X}$ = 106 ± 25) is still negatively biased since not all individuals were marked and not all marked individuals may have been accounted for (Defran & Weller, 1999). Thus, the correction introduced with the distinctiveness index is deemed more appropriate in this particular case ($\overline{X}$ = 125, ±52.4). Also, since temporal differences in abundance were not supported by our data, it suggests a fairly "stable" size for this dolphin community.

High site fidelity as well as annual and seasonal residency patterns for many individuals indicate that this is an important area for some cetacean species (e.g., Baird et al., 2008); however, the home range for this dolphin community clearly extends beyond our study location given the low number of resightings (< 10) in many individuals (87%), including a few year-round residents. Comparisons of these data with prior and current photographic surveys in two northwest locations (i.e., the Veracruz Reef System and Nautla) (Figure 1) show individual exchange (two and 11 dolphins, respectively) moving at least 100 to 300 km; such long-range movements have also been reported along the coasts of the western (Martinez-Serrano et al., 2011) and northern (Maze & Würsig, 1999) Gulf of Mexico. Also, the low migration rates found in this study across the year (~5%) may reflect a sparse exchange with neighboring locations, giving no indication of massive movements (i.e., large numbers of dolphins entering the area in pulses or seasonal immigration) (Figure 3) as reported for other regions in the Gulf of Mexico (Scott et al., 1990; Martínez-Serrano et al., 2011) and the Atlantic (Claridge, 1994). Shifts in the distribution of coastal bottlenose dolphins have been linked to the migration of prey (Simões-Lopes & Fabian, 1999), reproductive behavior (such as nursing calves in females), predators (Acevedo-Gutiérrez, 2002), or the search for potential mates in adjacent sites by males (Wells, 1991; Möller & Beheregaray, 2004). Moreover, genetic surveys have revealed significant levels of gene flow within the coastal ecotype in the Caribbean and the Gulf of Mexico (Caballero et al., 2012).

Since individual movement patterns may change the composition of social groups within a given area, these may explain why the structure of many coastal dolphin communities is highly dynamic, being composed of different individuals at different times (Balmer et al., 2008; Defran et al., 2015). However, in some cases, a stable core of individuals may be distinguished by their continuous presence within an area, forming conspicuous association patterns with specific purposes. The latter has been evident in bottlenose dolphins from the Alvarado coastal waters given their sex-specific residency patterns (Morteo et al., 2014) and social affiliations that are correlated to behavioral cues (García-Vital et al., 2015). Moreover, recent data show that at least 47 dolphins have been consistently photographed over the 2006 to 2010 time period (Morteo et al., 2014), and photographic records from 2002-2003 by Del Castillo (2010) increased the number of individuals frequently using this area to 71 individuals. Over half of these dolphins displayed some kind of temporal trend (year-round permanence $\overline{X} = 13.8 \pm 6.7$ mo or seasonal periodicity $\overline{X} = 3.5 \pm 3.0$ mo), which may relate to the advantage gained from remaining close to an area where prey is spatially and temporarily predictable (Baird et al., 2008). In addition, the recurrent presence of individual bottlenose dolphins over the rainy and dry seasons is concurrent with changes in the ecosystem that promotes primary productivity and the availability of potential prey (Contreras & Castañeda, 2005; Cruz-Escalona, 2005), suggesting a direct influence in their feeding habits (Ballance, 1992; Bearzi et al., 2008). Rechimont (2015) already identified 17 species of fish that have been reported as part of the diet of bottlenose dolphins such as the king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), and yellow fin mojarra (*Gerres cinereus*), some of which were depredated directly from gillnet settings in the study area.

Dolphin movements also have been attributed to types and levels of vessel traffic (Morteo et al., 2004, 2012b; Lusseau, 2005; Hernández-Candelario et al., 2015; Pérez-Jorge et al., 2016). In fact, recent studies have already documented the reciprocal evasive response between dolphins and artisanal fisheries within the Alvarado coastal waters, which translates into contrasting spatial distributions (Morteo et al., 2012b) due to the frequent and persistent antagonistic interactions (Del Castillo, 2010; Rechimont, 2015; Morales-Rincon, 2016). Moreover, bottlenose dolphins have been found drowned and entangled in gear, showing stab wounds and severed appendages (Morteo et al. 2012b). However, dolphins seem to exploit the Alvarado area despite these potential threats (Morteo et al., 2012b; García-Vital et al., 2015; Rechimont, 2015; Morales-Rincon, 2016). For instance, the fraction of dolphins with antagonistic markings may be considered a minimum estimate since these only represent the survivors of such encounters; comparisons with prior data (Del Castillo, 2010) show that the proportion of predator-like wounded individuals were similar (3.5 vs 4.4%), but presumed human-inflicted wounds (11.5%) decreased compared to earlier records (17%).

Baird et al. (2008) suggested that localized fisheries interactions might have a greater effect on the resident dolphins than on those moving regularly in and out of the area. Admittedly, it is hard to assess where injuries actually take place for any study based on photographic surveys such as ours. However, the likelihood that bottlenose dolphins are subject to threats from local artisanal fisheries operating in and around the study area is based on unequivocal observations derived from this location—for instance, (1) resident dolphins have up to 2.8 times higher rates of encounters with fisheries compared to transient individuals (Morteo et al., 2012b), which is at least four times more frequent compared to other adjacent coastal locations (Hernández-Candelario et al., 2015; Rechimont, 2015; Morales-Rincon, 2016); (2) dolphins interact exclusively with gillnets, resulting in depredation of 80% of the gear settings despite the variety of the fishing techniques employed (Rechimont, 2015); and (3) the records of retaliation by fishers (García-Loredo, 1995; Del Castillo, 2010; Morteo et al., 2012b; Rechimont, 2015; Morales-Rincon, 2016) led to repeated observations (*n* = 9) of dead and maimed animals clearly resulting from human interactions—hence, the high proportion of resident animals with fisheries-inflicted wounds in the population (42%).

On the other hand, dolphin–predator interactions in the Gulf of Mexico have been commonly attributed to bull sharks (*Carcharhinus leucas*; Shane et al., 1986). However, the most common shark in the area since 1990 is the hammerhead (*Sphyrna lewini*), but large sharks (> 3 m) are rare in the shallow Alvarado coastal waters since these are found well beyond the 25-m isobath (Jiménez-Badillo et al., 2006). In fact, to the best of our knowledge, shark-related wounds are extremely rare in photo-identification catalogues from the Mexican coastal waters of the Gulf of Mexico, and there are only a few reports of such encounters from local news, which suggests that dolphin interactions with larger predators may occur primarily in deeper waters. In the Gulf of Mexico, coastal bottlenose dolphins experience offshore range expansions (Martínez-Serrano et al., 2011; Medellín, 2012), and some individuals may alternate between coastal and offshore waters (Caballero et al., 2012), presumably due to temporal changes in the distribution of prey (Fazioli et al., 2006), especially over the rainy season (Morteo & Hernández-Candelario, 2007). Maze & Würsig (1999) hypothesized that offshore dolphins may use environmental cues (such as extensive water plumes from river runoffs) to take advantage of increased prey populations and that they forage over shallow coastal waters close to rivers and lagoons. Consequently, there is a high number of visiting dolphins during the rainy season. Confirmation of offshore-inshore movements will need additional observations; and photographic, isotopic, and genetic data will help to unveil the details about the interactions of bottlenose dolphins with humans, their predators, and their prey.

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