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Prevalence of Skin Lesions and Injuries in Australian Humpback Dolphins (*Sousa sahulensis*) and Indo-Pacific Bottlenose Dolphins (*Tursiops aduncus*) in Moreton Bay, Queensland

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Abstract

Coastal dolphin populations are highly vulnerable due to their proximity to major urban centres and exposure to cumulative threats from anthropogenic activities. As bioindicators of environmental condition, it is crucial to understand and monitor the health of these coastal dolphin populations. Visual assessments of skin lesions on dolphins can provide useful insights into the health of these populations and exposure to environmental stressors. We examined the prevalence of skin lesions in Australian humpback dolphins (*Sousa sahulensis*) and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) of different age classes inhabiting the near-urban embayment of Moreton Bay, Queensland. The prevalence and extent of nontraumatic and traumatic skin lesions on individual dolphins were assessed using photographs taken during 103 boat-based surveys completed between 2014 and 2016. A total of 15 primary skin lesion categories were identified from 126 humpback and 100 bottlenose dolphins. Differences in the prevalence of skin lesions were evident between age classes and species. Nontraumatic skin lesions were prevalent in 48.4% of the humpback and 61.0% of the bottlenose dolphins. Comparatively, traumatic lesions were evident in almost all humpback (92.3%) and bottlenose (99.0%) dolphins. Anthropogenic-related injuries from entanglement in fishing gear and vessel strikes were substantial and significantly differed between species ($p < 0.05$). Injuries from fishing and vessel activities affected 11.0% of humpback dolphins and 30.0% of bottlenose dolphins, suggesting that these activities pose a major threat to these populations. Findings from this study provide an important baseline to inform ongoing health monitoring and conservation efforts of these vulnerable dolphin populations inhabiting a near-urban embayment.

Key Words: Cetacea, skin diseases, tattoo skin disease, shark predation, human impacts, fisheries interactions, boat strike, entanglement, shark bite

Introduction

Populations of coastal dolphin species that inhabit areas adjacent to major urban centres and ports experience cumulative exposure from many anthropogenic threats (Luksenburg, 2014; Hawkins et al., 2017). As a result, these populations are particularly vulnerable to illness, injuries, and mortality (Chan & Karczmarski, 2019). Monitoring the health of coastal dolphin populations is thus key to understanding the impact of anthropogenic activities, along with detection of emerging disease or outbreaks of infectious diseases (Van Bressem et al., 2008; Chan & Karczmarski, 2019). Assessing the health of free-ranging dolphin populations is inherently difficult due to the challenges of observing these animals in the coastal and oceanic environment (Wilson et al., 1997). One inexpensive and non-invasive method commonly used to infer the health of dolphin populations is the visual examination of skin lesions from photographs (Wells & Scott, 1997; Nery et al., 2008; Van Bressem et al., 2008, 2015; Hart et al., 2012; Mouton & Botha, 2012; Yang et al., 2013; Hupman et al., 2017; Félix et al., 2018; Chan & Karczmarski, 2019; Leone et al., 2019).

Skin lesions can be broadly categorised as originating from nontraumatic or traumatic sources based on the visual appearances (e.g., colour, shape, texture, pattern; Leone et al., 2019). Though the specific aetiology of many nontraumatic types of lesions is unknown, some have been linked to potentially infectious pathogens, including bacteria (e.g., *Vibrio* spp.), fungi (e.g., *Paracoccidioides* sp.), epibionts (e.g., diatoms), and viruses (e.g., Caliciviridae, Herpesviridae, Papillomaviridae, Chorodopoxvirdae; Geraci et al., 1979; Van Bressem et al., 2008; Hart et al., 2012; Mouton & Botha, 2012; Vilela et al., 2016; Duignan et al., 2020). Infestation of the epidermis from such pathogens not only signals emerging diseases and viruses in a population, but also immune dysfunction and chronic exposure to environmental stressors (Reif et al., 2009; Van Bressem et al., 2009b, 2009c; Hart et al., 2012). Environmental factors, including salinity and temperature, in addition to contaminant exposure, have been linked to increased levels of several types of nontraumatic skin lesions, including tattoo-like skin disease, lobomycosis (and lobomycosis-like disease), and freshwater skin disease (Wilson et al., 1997; Van Bressem et al., 2009a; Fury & Reif, 2012; Hart et al., 2012; Bossart et al., 2017; Duignan et al., 2020). However, relationships between environmental stressors and nontraumatic lesion prevalence are made more complex by demographic (e.g., sex, age), social, and behavioural factors (Bechdel et al., 2009; Félix et al., 2019; Leone et al., 2019; Powell et al., 2019; Leu et al., 2020).

Traumatic lesions can also be caused by numerous natural and anthropogenic sources (Heithaus, 2001b; Kiszka et al., 2008; Félix et al., 2018; Leone et al., 2019). Many sources of tramata leave distinct patterns of scarring and injuries on dolphins, including bite wounds obtained during social interactions with conspecifics and sharks during predation attempts, fishing gear entanglements, and boat strikes. Therefore, measuring the prevalence of these lesions can provide useful insights into, for example, levels of agonistic or aggressive social interactions (Scott et al., 2005; Marley et al., 2013), predation pressure (Corkeron et al., 1987; Heithaus, 2001a, 2001b; Heithaus et al., 2017; Smith et al., 2018), and detrimental interactions with fishing and boating activities (Wells & Scott, 1997; Kiszka et al., 2008; Nery et al., 2008; Bechdel et al., 2009; Luksenburg, 2014; Félix et al., 2018; Wang et al., 2018).

Skin lesions have been described in detail for numerous dolphin species (Family Delphinidae) globally (Van Bressem et al., 2006, 2009a, 2009c, 2015; Nery et al., 2008; Yang et al., 2013; Hupman et al., 2017; Wang et al., 2018; Chan & Karczmarski, 2019), and most extensively in common bottlenose dolphins (*Tursiops truncatus*; e.g., Wilson et al., 1997; Maldini et al., 2010; Bossart et al., 2017; Toms et al., 2020). However, few studies have described both nontraumatic and traumatic lesions in Indo-Pacific bottlenose dolphins (*Tursiops aduncus*; e.g., Kiszka et al., 2008; Chabanne et al., 2012; Fury & Reif, 2012; Powell et al., 2018), and none are available for Australian humpback dolphins (*Sousa sahulensis*)—two coastal species that have tendencies to inhabit near-urban areas throughout their range.

Moreton Bay, Queensland, is located adjacent to one of Australia's major cities (Brisbane) and is inhabited by resident populations of Australian humpback and Indo-Pacific bottlenose dolphins. The health of these sympatric dolphin populations is of concern due to their exposure to multiple threats, including boating and fishing activities, dredging, habitat degradation from coastal development, and pollution (Meager et al., 2018). Assessing the health of the endemic Australian humpback dolphin (hereafter "humpback dolphin") population is especially pertinent due to their "Vulnerable" status (Parra et al., 2017). Moreton Bay's relatively small population of 128 humpback dolphins (95% CI: 67 to 247) is at the southernmost extent of the species' range (Meager & Hawkins, 2017). The sympatric Indo-Pacific bottlenose dolphin (hereafter "bottlenose dolphin") population is comparably larger, containing around 554 individuals (95% CI = 510 to 598) (Ansmann et al., 2012b). Both populations are socially differentiated, highly site specific, and occupy areas of habitat that coincide with areas of high human use (Ansmann et al., 2012b, 2015; Meager et al., 2018; Hawkins et al., 2020). Both species are known to engage in "risky'" feeding behaviours, including feeding from trawler bycatch and human provisioning (i.e., being hand-fed by people; Corkeron et al., 1990; Orams, 1995; Chilvers & Corkeron, 2001). Such risky feeding behaviours can increase the vulnerability of individuals involved to lesions, injuries, diseases, and mortality (Christiansen et al., 2016; Félix et al., 2018; Leone et al., 2019). Additionally, preliminary studies indicate that this population of humpback dolphins has high concentrations of organochlorine pollutants (PCBs and DDXs) that are above levels associated with reproductive toxicity (Weijs et al., 2016).

This study aimed to establish a baseline of nontraumatic and traumatic skin lesion prevalence and extent in humpback and bottlenose dolphin populations in Moreton Bay using visual assessments from photographs. This study provides the first description of skin lesions in the humpback dolphin and draws comparisons between the two species. Age-related differences in the prevalence of lesions between adults and calves is also investigated. This study presents an important point of reference into the health and exposure to anthropogenic threats of these dolphin populations and provides for more informed conservation measures.

Methods

Data Collection

Boat-based surveys in Moreton Bay, Queensland, were completed between 2014 and 2016 and encompassed an area of 1,523 km^2 (Figure 1). To ensure equal search coverage, six pre-defined routes delineated the survey area (see Meager et al., 2018, for detailed survey methods). Surveys were carried out in calm sea conditions (Beaufort Sea state of ≤ 3), with vessel speeds ≤ 12 kts. While on survey, at least three observers scanned for dolphins around the vessel at all times.

When dolphins were encountered, the survey vessel steered away from the survey route and commenced a group follow for up to 60 min. During the follow, the species, composition, and GPS location were noted along with the group behaviours (Meager et al., 2018; Hawkins et al., 2020). Group composition was defined as the number of adults (fully grown individuals), juveniles (individuals approximately 3/4 the size of an adult), and calves (individuals < 2/3 the size of an adult frequently swimming in infant or baby position) (Karczmarski et al., 1999; Fury & Reif, 2012). Calves < 2/3 of an adult are likely to be less than 1 year of age (Read et al., 1993; Chang et al., 2016).

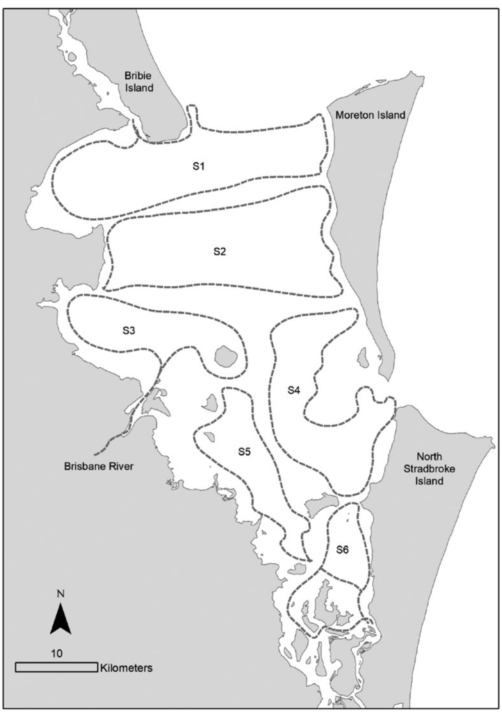

Figure 1. Map of the Moreton Bay, Queensland, study site showing the six survey sections (S1, S2, S3, S4, S5, and S6) and repeated survey routes (dashed lines) made between 2014 and 2016

Photographs were taken of the left and right sides of the dorsal fin and other body segments of each individual in a group where possible. Digital photographs were taken using either a Nikon D7100 (Nikon, Minato City, Tokyo, Japan) or Canon 60D or 5D (Canon, Ota City, Tokyo, Japan) with 300- or 400-mm lens. Following standard photo-identification (photo-ID) methodologies, individual dolphins were identified using the distinct combinations of permanent nicks and notches on the trailing edge of the dorsal fin (Mazzoil et al., 2004; Urian et al., 2015). Individuals that were sufficiently "marked" and could be identified were catalogued in an *Access* database (Microsoft Corp., Redmond, WA, USA) along with sighting and behavioural information of that individual.

Skin Lesion Assessment

Photographs of individual dolphins' dorsal fins and other body segments (e.g., rostrum, melon, flank, caudal peduncle, tail fluke) were considered for skin lesion analysis (Figure 2; Toms et al., 2020). Marked individuals in the photo-ID catalogue were included in the analysis to ensure confident identification across multiple photos and to limit over-representation of individuals with less distinct markings. All photographs available of each individual were assessed for quality and scored on a scale of 1 (poor quality) to 10 (excellent quality) based on the clarity, lighting, angle, and resolution (Wilson et al., 1997; Bearzi et al., 2009; Yang et al., 2013). Only images of sufficient quality (score ≥ 5) were considered for each individual. There was an insufficient number of suitable images of individuals available to enable assessments in temporal changes of skin lesions. Therefore, all images of each individual were pooled; and lesions of a particular type, if detected, were only recorded once as present.

All humpback dolphins with images of sufficient quality were analysed. For the larger bottlenose dolphin population, a subsample of individuals was selected. A random number generator was used to select an individual dolphin's identification number from the catalogue. If the images of the individual were of sufficient quality, it was then included in the analysis. This process continued until a minimum of 15% of the estimated adult population size (Ansmann et al., 2012b) was obtained, which is considered a sufficient representative sample (Bartlett et al., 2001). This approach was applied to obtain a sufficient representation of the population while limiting over-representation of individuals from the same areas within the study site and individuals that had been encountered many times.

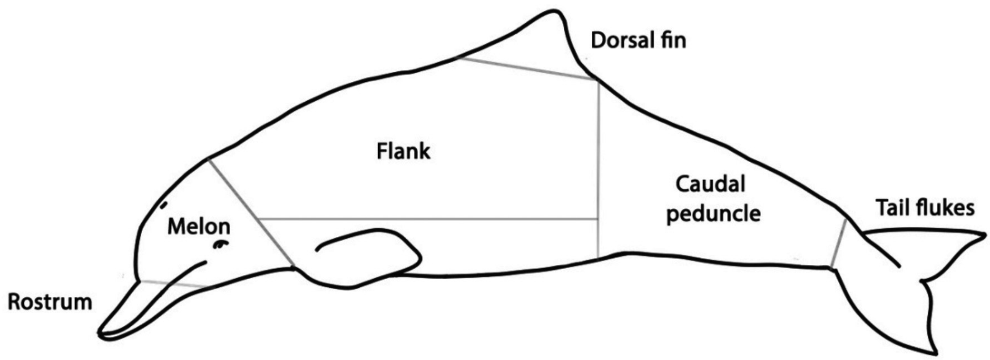

Figure 2. Diagram of an Australian humpback dolphin (*Sousa sahulensis*) illustrating guidelines for each body segment used to allocate position and extent of lesion categories

Calves were then selected and assessed only if their mothers were also included in the analysis. As calves generally lack permanent markings, the selection of the subsample was based on known marked females that were in the company of dependent offspring during at least one group follow. Maternity of calves was inferred if they spent most of their time next to the same adult female in infant position during at least one group follow (Mann et al., 2000; Chang et al., 2016). As juveniles were generally unmarked and tend to spend more time away from their mothers, it was not possible to obtain a sufficient sample size for this age class. Therefore, this age class was excluded from the analysis.

As individuals were distinguished using dorsal fin markings, at least one side of the dorsal fin for all individuals was assessed for lesions in the analysis. Individuals were not included if no photos of the dorsal fin surface were of sufficient quality. As the dorsal fin is not a sufficient proxy alone to determine whether lesions are present, other body segments were also included in the assessment (Toms et al., 2020). Other body segments were assessed where > 10% was visible (Bearzi et al., 2009) in images of sufficient quality. For each body segment, the orientation (left or right side) was noted along with the percentage visible in the image. The amount visible in images of body segments was classified as low (< 20% of body segment visible), medium (20 to 50% visible), and high (> 50% visible) (Bearzi et al., 2009).

Skin lesions were divided into two broad classifications: (1) nontraumatic (including those of potential infectious aetiology) and (2) traumatic (e.g., rake marks, shark bites) (Leone et al., 2019). As suggested by Toms et al. (2020), a subsample of images of both species was first used to define lesion categories which were based on descriptions from previous studies (Supplementary Table S1; supplemental tables for this article are available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147). Lesion categories were grouped according to features and then used as a reference to improve inter-observer reliability. Nontraumatic and traumatic classifications were further divided into primary and secondary categories based on similarity of features and/or source. Notches on the trailing edge of the dorsal fin were excluded from the analysis except where these notches were from injuries caused by anthropogenic sources (e.g., entanglement, boat strike) as opposed to occurring from social interactions with conspecifics.

In addition, to address potential biases that can arise from using visual-based methods to detect and categorise lesions, the following steps were also applied. Four team members (HP, MG, LPM, and EH) each assessed the images independently, and data were reconciled by the most experienced observer for final analysis (EH) (Toms et al., 2020). Observer confidence was used as a measure of certainty for each lesion recorded. Certainty was defined as either "positive" (the observer was confident of lesion classification), "probable" (the observer was somewhat confident of the lesion classification), or "unsure" (the observer was not confident in the lesion classification) (Toms et al., 2020).

The level of certainty for lesion classification was then pooled and expressed as a percentage. The level of agreement between observers in the classification of lesion categories was also calculated as a percentage. This process was used to both inform the reconciliation processes and to provide a measure of reliability of observer classification for lesion categories (Toms et al., 2020).

The presence or absence of different types of skin lesions were scored for the dorsal fin and other body segments, where available, along with the orientation of the segment in the image (left or right side). The proportion of individuals that exhibited a particular type of skin lesion was defined as the prevalence (Wilson et al., 1997; Bearzi et al., 2009). Comparatively, extent or severity of lesion coverage was expressed as a percentage of each individual's epidermis covered by the lesion for that body category (Wilson et al., 1997, 1999). Extent of lesion coverage was then divided into low (< 20% of visible epidermis), medium (20 to 50% of visible epidermis), and high (> 50% of visible epidermis) (Bearzi et al., 2009). A visual reference (Figure 2) was developed to assist observers in estimating the percentage of body segments visible and the extent of lesions (Toms et al., 2020). The mean number of lesion categories, mean lesion prevalence, and mean extent were calculated for each species, age class, and body segment. To test the null hypothesis that there was no difference in the occurrence of lesion categories between species, age class, and body segment, Pearson's Chi-square goodness of fit tests with a p value of 0.05 were applied. Bonferroni correction was then used to adjust p values for repeated testing of the dataset. Due to low sample sizes, it was only possible to apply Chi-square tests to nine skin lesion categories—(1) abrasions, (2) anthropogenic, (3) bite wounds, (4) dark lesions, (5) pale lesions, (6) scarring, (7) targetoid, (8) indentations, and (9) missing tips—for all individuals with age class combined. Similarly, due to low sample sizes, the occurrence of lesions for the rostrum, melon, and tail flukes were combined for this analysis.

Results

Sampling Effort

Between 2014 and 2016, 102 surveys were completed with 783 hours and 8,232 km of effort. Throughout the study, 226 groups of dolphins consisting of 690 animals (including repeated sightings of individuals) were observed. Photographs that matched the criteria for skin lesion assessment were suitable for 91 of the 126 humpback dolphins identified (76 adults and 15 calves). Of the 374 individual bottlenose dolphins identified, 100 were examined for skin lesions (87 adults and 13 calves).

Dorsal fins for all individuals were assessed as per the minimum criteria for photographic analysis. Assessment of non-dorsal body segments—flank, caudal peduncle, melon, and tail fluke—were available for 82 humpback and 82 bottlenose dolphins. As photos were taken at the surface while dolphins were often partially submerged, some body segments were better represented than others. For example, images of the flank were available for 75 humpback and 77 bottlenose dolphins, while images of the melon and tail fluke combined were available for only 33 humpback and 46 bottlenose dolphins. For non-dorsal body segments, the percentage of the epidermis that could be visibly assessed for humpback and bottlenose dolphins was high (> 50%) for 45.1% (n = 37) and 71.9% (n = 59), respectively; medium (20 to 50%) for 84.1% (n = 69) and 90.2% (n = 74), respectively; and low (< 20%) for 8.5% (n = 7) and 10.9% (n = 9), respectively.

Lesion Categorization

Fifteen primary lesion categories were identified, with seven classified as nontraumatic and eight as traumatic. Fourteen primary lesion categories were identified in humpback dolphins and 13 in bottlenose dolphins. Two primary lesion categories were only observed in one species; these were a possible annular lesion on one humpback dolphin and a pale dermatitis on one bottlenose dolphin. The number of different lesion categories detected on individual dolphins ranged between one and eight ($\bar{x}$ = 3.5, SD = 2.0). Humpback dolphins had slightly fewer lesion categories compared to bottlenose dolphins ($\bar{x}$ = 2.7, SD = 1.7 and $\bar{x}$ = 3.7, SD = 2.2, respectively). For nontraumatic categories, 18.6% of humpback (n = 17) and 33% of bottlenose (n = 33) dolphins had more than two types of lesions. Comparably, 67.0% (n = 61) of humpback and 76.0% (n = 76) of bottlenose dolphins had more than two types of traumatic lesions. (Several examples of primary and secondary lesions detected in both species are shown in Figure 3, with full descriptions of all categories outlined in Supplementary Table S1, all of which have been described in the literature.)

Observer agreement was generally high for lesion presence (humpback: 100.0%; bottlenose: 94.0%). In relation to the allocation of lesion types, observer agreement was ≥ 60% for 12 lesion categories in humpback dolphins and for 12 lesion categories (of the 13 identified) in bottlenose dolphins (Supplementary Table S2). Observers were highly confident in their allocation of lesion types for 77.3% of assessments, probable for 19.7%, and unsure for 3.0%.

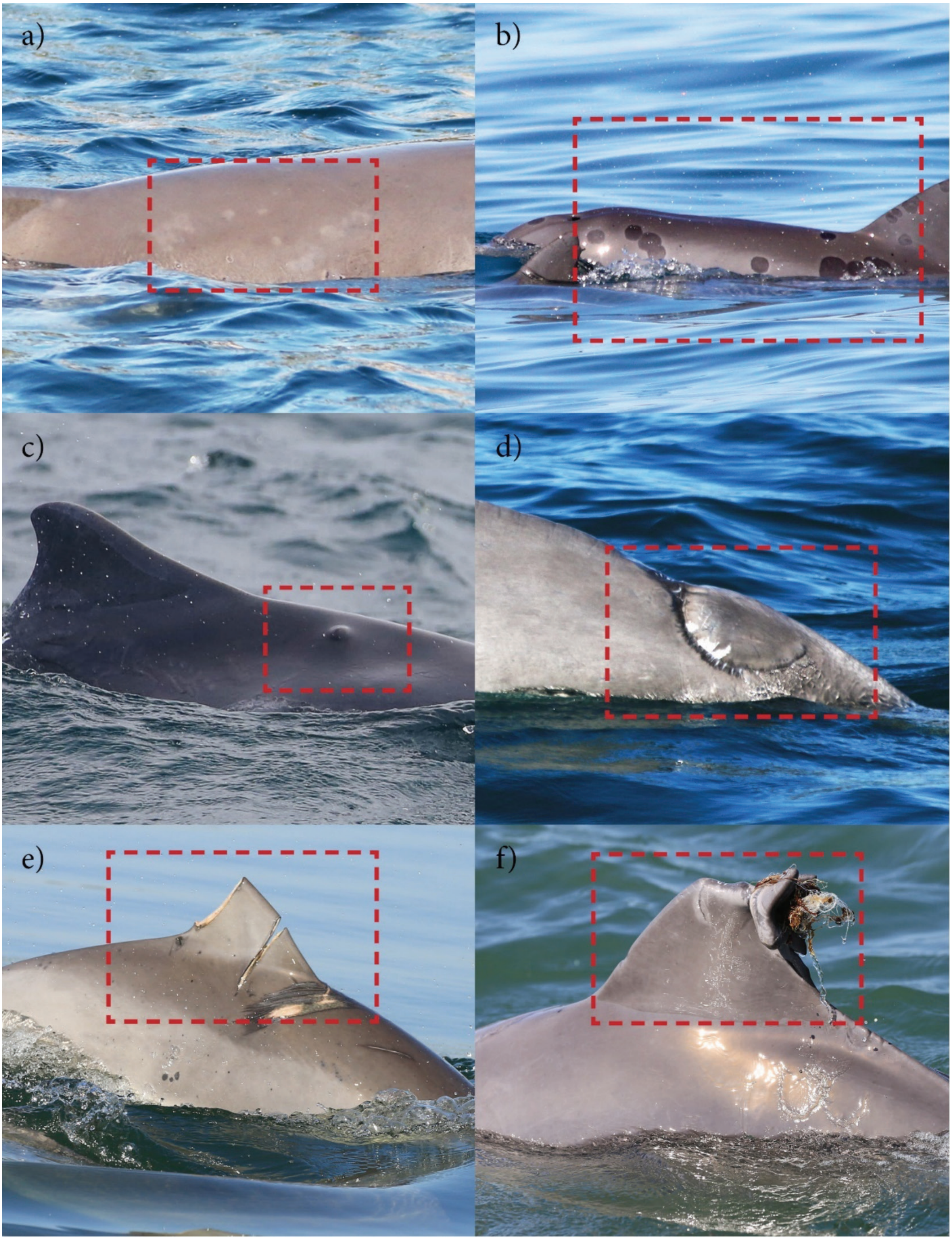

Figure 3. Examples of primary skin lesion categories found in Australian humpback dolphins (images a, c, and d) and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) (images b, e, and f) in Moreton Bay, Queensland: (a) pale lesions, (b) dark lesions (secondary category – tattoo-like skin disease), (c) nodular, (d) bite wound, (e) anthropogenic (secondary category – boat strike), and (f) anthropogenic (secondary category – entanglement).

Overall, most nontraumatic and traumatic lesions for both species had low extent of coverage (Supplementary Table S3). However, among all lesion types, more individuals displayed a medium to high extent of abrasions, bite wounds, unknown scarring, and indentations for both species. Differences in the extent of coverage of either nontraumatic or traumatic lesions did not significantly differ between species or body segment ($\chi^2 = 3.797$ to 13.766, df = 6, $p > 0.01$).

Prevalence of Lesions

At least one lesion was present on 92.3% (n = 84) of humpback dolphins, including 97.4% of adults (n = 74) and 66.0% of calves (n = 10). Comparably, 99.0% (n = 99) of all bottlenose dolphins had at least one lesion, including 98.9% (n = 86) of adults and 100.0% (n = 13) of calves. The occurrence of primary lesion categories significantly differed between species ($\chi^2 = 351.560$, df = 8, $p < 0.05$). Table 1 outlines the prevalence of each primary and secondary lesion category for each species and age class.

Nontraumatic Lesions

The overall prevalence of nontraumatic lesions was lower in humpback (48.4%, n = 44) compared to bottlenose (61.0%, n = 61) dolphins. For both species, the occurrence of nontraumatic lesions was significantly more likely to occur on the flank compared to all other body segments ($\chi^2 = 18.981$ to 101.190, df = 3, $p < 0.01$; Table 2).

The prevalence of nontraumatic lesions was significantly higher ($\chi^2 = 10.075$, df = 1, $p < 0.01$) for adult humpback dolphins (55.3%, n = 42) compared to calves (13.3%, n = 2). Conversely, for bottlenose dolphins, the prevalence of nontraumatic lesions was higher for calves (76.9%, n = 10) compared to adults (58.6%, n = 51), although this difference was not significant ($\chi^2 = 0.916$, df = 1, $p > 0.01$). Between species, nontraumatic lesions were significantly higher in the calves of humpback compared to bottlenose ($\chi^2 = 9.049$, df = 1, $p < 0.01$) dolphins but were not significantly different for adults ($\chi^2 = 0.075$, df = 1, $p > 0.01$).

Of the nontraumatic lesions, nodular lesions were the least prevalent for both species (Table 1). Dark, pale, and targetoid lesions were overall the most prevalent primary lesions for adults and calves of both humpback and bottlenose dolphins. The prevalence of these lesion categories were similar between species and did not significantly differ ($p > 0.01$; Table 3).

Traumatic Lesions

The prevalence of traumatic lesions was similar for both species (humpback: 92.3%, n = 84; bottlenose: 99.0%, n = 99) and were significantly more likely to occur on the caudal peduncle ($\chi^2 = 18.981$ to 101.190, df = 3, $p < 0.01$; Table 2).

For humpback dolphins, adults (97.3%, n = 74) had a higher prevalence of traumatic lesions compared to calves (66.7%, n = 10). However, the opposite was evident for bottlenose dolphins, with calves having a higher prevalence (100.0%, n = 13) of traumatic lesions compared to adults (98.9%, n = 86). However, the occurrence of traumatic lesions between age classes both within ($\chi^2 = 3.165$ to 10.075, df = 1, $p > 0.01$) and between ($\chi^2 = 0.415$ to 1.409, df = 1, $p > 0.01$) species were not significant.

Abrasions, specifically rake marks, were the most prevalent traumatic lesion for both species (Table 1). Bite wounds and unknown scarring were also common, occurring more in humpback dolphins; however, differences in these lesion types were also not significant between species ($p > 0.01$; Table 3). The occurrence of anthropogenic lesions, indentations, and missing tips were significantly higher in bottlenose dolphins compared to humpback dolphins ($p < 0.01$; Table 3). For humpback dolphins with anthropogenic lesions, 60.0% (n = 6) were attributed to boat strikes and 40.0% (n = 4) were from fishing gear entanglements. For bottlenose dolphins, 12.9% (n = 6) were consistent with boat strike injuries and 80.6% (n = 25) with fishing gear entanglements. One individual ("Q15") had an anthropogenic scar from a freeze brand on the face of the dorsal fin from a previous research study in Moreton Bay (Chilvers et al., 2001). Indentations were prevalent on the dorsal fin (humpback: n =8; bottlenose: n =24) and caudal peduncle (humpback: n = 6; bottlenose: n = 21) in both species. Of all indentation cases, 21 were attributed to anthropogenic causes. Individuals with missing tips included 20 individuals with amputated dorsal fins and three with missing tips of the tail fluke. Additionally, one humpback dolphin was missing the tip of the upper rostrum. In total, 12 cases of missing tips of both species were also related to anthropogenic causes.

Table 1. The number of individuals (*n*) and prevalence (expressed as a percentage [%]) of primary and secondary lesion categories for different age classes for Australian humpback dolphins (*Sousa sahulensis*) and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in Moreton Bay, Queensland. **Note:** Individuals can exhibit multiple types of primary and secondary lesion categories.

			Humpback						Bottlenose					
Trauma classification	Primary lesion category	Secondary lesion category	Calves		Adults		Species total		Calves		Adults		Species total	
			n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Nontraumatic	Annular lesion		0	0.0	1	1.3	1	1.1	0	0.0	0	0.0	0	0.0
	Dark lesion		0	0.0	22	28.9	22	24.2	2	15.4	40	46.0	42	42.0
		Black spots	0	0.0	8	10.5	8	8.8	2	15.4	33	37.9	35	35.0
		Dark centre	0	0.0	1	1.3	1	1.1	0	0.0	0	0.0	0	0.0
		Other	0	0.0	4	5.3	4	4.4	0	0.0	6	6.9	6	6.0
		Tattoo-like skin disease	0	0.0	9	11.8	9	9.9	2	15.4	5	5.7	7	7.0
	Orange spots/film		0	0.0	6	7.9	6	6.6	0	0.0	6	6.9	6	6.0
	Pale dermatitis		0	0.0	0	0.0	0	0.0	0	0.0	2	2.3	2	2.0
	Pale lesion		1	6.7	18	23.7	19	20.1	6	46.2	19	21.8	25	25.0
	Nodular		1	6.7	0	0.0	1	1.1	0	0.0	4	4.6	4	4.0
	Targetoid		1	6.7	16	21.1	17	18.7	3	23.1	22	25.3	25	25.0
		Dark fringed	1	6.7	9	11.8	10	11.0	1	7.7	22	25.3	23	23.0
		Light fringed	0	0.0	8	10.5	8	8.8	2	15.4	11	12.6	13	13.0
	Total # individuals with nontraumatic lesions		2	13.3	42	55.3	44	48.4	10	76.9	51	58.6	61	61.0
Traumatic	Abrasions		9	6.0	64	84.2	73	80.2	12	92.3	82	94.3	94	94.0
		Rake marks	9	6.0	64	84.2	73	80.2	10	76.9	82	94.3	92	92.0
		Other	0	0.0	0	0.0	0	0.0	12	92.3	11	12.6	23	23.0
	Anthropogenic		0	0.0	10	13.2	10	11.0	0	0.0	30	34.5	30	30.0
		Entanglement	0	0.0	4	5.3	4	4.4	0	0.0	25	28.7	25	25.0
		Boat/propeller strike	0	0.0	6	7.9	6	6.6	0	0.0	6	6.9	6	6.0
	Bite wounds		1	6.7	40	52.6	41	45.1	2	15.4	27	31.0	29	29.0
		Fresh	0	0.0	1	1.3	1	1.1	2	15.4	0	0.0	2	2.0
		Healed	0	0.0	40	52.6	40	44.0	0	0.0	27	31.0	27	27.0
	Indentation		0	0.0	13	17.1	13	14.3	0	0.0	34	39.1	34	34.0
	Laceration		0	0.0	2	2.6	2	2.2	0	0.0	0	0.0	0	0.0
	Missing tip		0	0.0	3	3.9	3	3.3	0	0.0	18	20.7	18	18.0
	Open wound		1	6.7	3	3.9	4	4.4	0	0.0	2	2.3	2	2.0
	Unknown scarring		2	13.3	35	46.1	37	40.7	3	23.1	54	62.1	57	57.0
		Depressed	0	0.0	14	18.4	14	15.4	1	7.7	23	26.4	24	24.0
		Raised	0	0.0	5	6.6	5	5.5	0	0.0	0	0.0	0	0.0
		Other	2	13.3	24	31.6	26	28.6	3	23.1	47	54.0	50	50.0
	Total # individuals with traumatic lesions		10	66.7	74	97.4	84	92.3	13	100.0	86	98.9	99	99.0

Table 2. Prevalence of primary lesion categories on body segments of Australian humpback and Indo-Pacific bottlenose dolphins in Moreton Bay, Queensland. **Note:** Number (*n*) of individuals indicates the number of individuals that were observed with a lesion on the corresponding body segment. The total number of individuals represents the number of dolphins that were assessed for each body segment category.

		Humpback								Bottlenose							
Body segment:		Caudal peduncle		Dorsal fin		Flank		Other		Caudal peduncle		Dorsal fin		Flank		Other	
Trauma classification	Primary lesion category	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Nontraumatic	Annular lesion	1	1.6	0	0.0	1	1.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Dark lesion	7	11.5	7	7.7	12	16.0	1	3.0	21	30.0	29	29.0	21	27.3	7	15.2
	Orange spots/film	2	3.3	2	2.2	0	0.0	2	6.1	3	4.3	1	1.0	2	2.6	0	0.0
	Pale dermatitis	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	2.0	0	0.0	0	0.0
	Pale lesion	5	8.2	3	3.3	16	21.3	1	3.0	13	18.6	4	4.0	12	15.6	1	2.2
	Nodular	0	0.0	1	1.1	0	0.0	0	0.0	2	2.9	2	2.0	2	2.6	0	0.0
	Targetoid	8	13.1	1	1.1	11	14.7	1	3.0	13	18.6	9	9.0	20	26.0	7	15.2
	Total # individuals with nontraumatic lesions	20	32.8	14	15.4	29	38.7	5	15.2	33	47.1	39	39.0	38	49.4	14	30.4
Traumatic	Abrasions	43	70.5	59	64.8	43	57.3	13	39.4	62	88.6	88	88.0	68	88.3	24	52.2
	Anthropogenic	3	4.9	4	4.4	1	1.3	3	9.1	4	5.7	27	27.0	1	1.3	1	2.2
	Bite wounds	22	36.1	4	4.4	32	42.7	0	0.0	20	28.6	1	1.0	17	22.1	0	0.0
	Indentation	6	9.8	8	8.8	1	1.3	0	0.0	21	30.0	24	24.0	0	0.0	0	0.0
	Laceration	0	0.0	2	2.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Missing tip	0	0.0	1	1.1	0	0.0	3	9.1	0	0.0	17	17.0	0	0.0	1	2.2
	Open wound	1	1.6	0	0.0	2	2.7	1	3.0	0	0.0	1	1.0	1	1.3	0	0.0
	Unknown scarring	12	19.7	15	16.5	20	26.7	4	12.1	20	28.6	33	33.0	38	49.4	2	4.3
	Total # individuals with traumatic lesions	56	91.8	70	76.9	60	80.0	18	54.5	67	95.7	92	92.0	73	94.8	26	56.5
Total # individuals		61		91		75		33		70		100		77		46	

Table 3. Results comparing the prevalence of primary lesion categories between Australian humpback and Indo-Pacific bottlenose dolphins in Moreton Bay, Queensland, from Chi-square tests with Bonferroni correction. **Note:** Due to low sample sizes, only nine of the 15 primary lesion categories were included in the analysis. * denotes significant outputs.

Trauma classification	Primary lesion category	χ^2	df	*p* value
Nontraumatic	Dark lesion	6.017	1	> 0.0045
	Pale lesion	0.254	1	> 0.0045
	Targetoid	0.771	1	> 0.0045
Traumatic	Abrasions	7.028	1	> 0.0045
	Anthropogenic	9.284	1	< 0.0045*
	Indentation	8.947	1	< 0.0045*
	Missing tip	9.077	1	< 0.0045*
	Scarring	4.457	1	> 0.0045
	Shark bites	4.621	1	> 0.0045

Discussion

This study is the first to describe the prevalence of nontraumatic and traumatic skin lesions in Australian humpback dolphins and adds to the limited work on Indo-Pacific bottlenose dolphins. Similar primary lesion types were evident in both sympatric species. Almost all types of skin lesions detected in this study have been described in other delphinid species elsewhere.

Nontraumatic Skin Lesions

At least one of the seven primary nontraumatic skin lesions affected 48.4% of humpback and 61.0% of bottlenose dolphins in Moreton Bay. The prevalence of nontraumatic lesions observed in the present study was similar to a number of comparable studies. In *Sousa chinensis*, from all age classes in Western Taiwan, Yang et al. (2013) reported five types of nontraumatic skin lesions with a total combined prevalence of 37.1% (*n* = 97). Similarly, 38.0% (*n* = 266) of identifiable *Tursiops truncatus* of all age classes in Sarasota Bay, Florida, had at least one of the 12 nontraumatic lesion types described (Hart et al., 2012). Comparatively, 49.0% (*n* = 169) of identifiable *T. truncatus* (including all age classes) in North Carolina had one of the six nontraumatic lesion types described (Taylor et al., 2021). The extent of lesion coverage observed in Moreton Bay dolphins was also generally low; however, there were some exceptions to this, with medium and high extent observed in some individuals for dark, pale annular, and targetoid lesions. Furthermore, 18.0% of humpback and 33.0% of bottlenose dolphins had more than one type of nontraumatic lesion in Moreton Bay. While the aetiology of most nontraumatic skin lesions identified in this study are not yet known, a number have been linked to infectious pathogens such as viruses and fungi, and at least one (lobomycosis/lacaziosis) is indicative of immune suppression or dysfunction (Reif et al., 2009; Van Bressem et al., 2009b, 2009c; Hart et al., 2012). Nevertheless, the high prevalence of miscellaneous skin lesions observed in the present study is of concern.

There were some differences observed in the prevalence of nontraumatic lesions and lesion types between adults and calves of both species. Adult humpback dolphins had a significantly higher prevalence of nontraumatic lesions compared to calves, while the opposite was evident in bottlenose dolphins. Bottlenose dolphins of both age classes in general appear to be more susceptible to nontraumatic lesions compared to humpback dolphins. These differences may result from physiological and biological factors combined with social, behavioural, and environmental conditions which are discussed below.

Dark lesions were the most prevalent nontraumatic lesions observed in both humpback (24.2%) and bottlenose (42.0%) dolphins in Moreton Bay. Dark lesions categorised as tattoo-like skin disease (TSD) have been the most extensively studied types of lesions in coastal dolphins and provide a useful comparison between global populations (Van Bressem et al., 2009c). This type of lesion has also been noted as being a potentially useful indicator of individual and population health (Van Bressem et al., 2009c). The overall prevalence of TSD was relatively lower in the present study (7.0 to 9.9%) compared to several other populations. For example, the TSD prevalence ranged between 19.0 and 42.6% in *T. truncatus* populations from Charleston, Brunswick, and Sapelo Islands and Sarasota Bay (Hart et al., 2012); 19.4% in *T. aduncus* from Shark Bay, Western Australia (Powell et al., 2018); and 34.7% in *S. chinensis* in Hong Kong (Chan & Karczmarski, 2019). However, prevalence was similar to the overall prevalence observed in *T. aduncus* that use the nearby Clarence and Richmond river estuaries in New South Wales (13.0 to 17.4%, respectively; Fury & Reif, 2012), and higher than *S. chinensis* from Western Taiwan (Yang et al., 2013). Such differences can be due to environmental parameters (Fury & Reif, 2012) in addition to age class and species susceptibility. Differences between species and age class were evident with the Moreton Bay dolphin populations. Specifically, TSD lesions were detected in only adult humpback dolphins (11.8%); while in bottlenose dolphins, they occurred in both adults (5.7%) and calves (15.4%). Similar to the present study, the prevalence of TSD was higher in identifiable adult humpback dolphins from Hong Kong waters (40.8%, *n* =334) compared to juveniles (19.0%, *n* = 79) and calves (0.0%, *n* = 23) in the same population (Chan & Karczmarski 2019). Bottlenose dolphin calves from Shark Bay, Western Australia (19.4%, *n* = 199), and the Clarence and Richmond Rivers in New South Wales (13.0%, *n* = 518 and 17.4%, *n* = 202, respectively) also had a higher TSD prevalence compared to identifiable adults (Fury & Reif, 2012; Powell et al., 2018).

It has been theorised that weaned juvenile dolphins are more prone to infectious pathogens like TSD as they lose maternal immunity, while calves and adults are less prone due to respective maternal and active immunity (Van Bressem et al., 2009c). If this pattern shifts, a more systematic problem affecting the immunity and health of the population may be present (Van Bressem et al., 2009c). Powell et al. (2018) found that bottlenose dolphin calves aged between 1 to 2 years were more susceptible to TSD in Shark Bay. As all calves were presumably less than 1 year of age in the present study, it was predicted that adults would exhibit more of the nontraumatic lesions, including TSD lesions. While this was evident for humpback dolphins, it was not the case for bottlenose dolphins. This may, in part, be due to the low sample size and age of calves selected. Nonetheless, the relatively high proportion of bottlenose dolphin calves (76.9%) that had nontraumatic lesions is cause for concern. Further assessments are required to examine the recurrence and recrudesce of these lesions between age classes (including juveniles) over time. Ongoing monitoring of these lesions could provide a useful health indicator for these dolphin populations.

Pale (20.1 to 25.0%) and targetoid (20.1 to 25.0%) lesions were also commonly observed in both humpback and bottlenose dolphins in Moreton Bay. Using histological analyses of pale lesions, Hart et al. (2012) found these lesions could be related to several different causes: healing trauma, previous viral infections, inflammation, ecoparasite attachment, and herpesvirus. These authors, using PCR analysis, also found sequences from pale and targetoid lesions (labelled as "white-fringed" lesions) that were consistent with delphinid herpesvirus and demonstrated the variety of potential aetiological causes of these lesions.

The prevalence of orange film (6.0 to 6.6%), and nodular lesions (1.1 to 4.0%) were relatively low for both humpback and bottlenose dolphins of Moreton Bay. Interestingly, orange film (11.3%) and nodular lesions (15.5%) had the highest prevalence of nontraumatic lesions in *S. chinensis* from Western Taiwan. Similar observations were reported for *S. chinensis* in Hong Kong with nodular lesions having a prevalence of 30.8% ($n = 435$; Chan & Karczmarski, 2019). In western Kyushu, Japan, 16.7% ($n = 216$) of marked and unmarked bottlenose dolphins of all age classes combined were affected by nodular lesions (Van Bressem et al., 2012). Nodular skin lesions observed in the present study were similar to those observed in *S. chinensis* by Yang et al. (2013) and characterised by a raised lump the same uniform colour as the skin. Whether nodules are an early form of lobomycosis-like disease (LLD) or are a separate disorder has not been confirmed (Van Bressem et al., 2009a, 2012); however, no observations were made of nodular skin lesions occurring in granulomas, ulcerated, or in plaques (Van Bressem et al., 2009a) as is consistent with LLD. However, LLD has been detected in Australian snubfin dolphins (*Orcaella heinsohni*) in the Northern Territory (Palmer & Peterson, 2014); and more recently in 2021, in a deceased bottlenose dolphin near Byron Bay, New South Wales (E. R. Hawkins, unpub. data, 2021). Monitoring changes in the prevalence of nodular lesions, and particularly cases of LLD, could provide an early indication of the emergence of infectious viruses in Moreton Bay populations.

Shifts in the prevalence in some nontraumatic lesion types have been linked to a number of environmental factors (Van Bressem et al., 2009a; Maldini et al., 2010; Hart et al., 2012; Félix et al., 2019; Powell et al., 2019). For example, higher prevalence of nontraumatic skin lesions, including TSD, have been linked to lower salinity and water temperatures (Wilson et al., 1999; Fury & Reif, 2012; Hart et al., 2012). Environmental parameters, such as salinity and turbidity, can shift over rapid or temporal scales in Moreton Bay, especially during periods of flood and drought (Yu et al., 2013; Gibbes et al., 2014). Water temperatures can also vary seasonally between 17.8ºC in cooler months to 28.4ºC in the warmer months. Surveys for this study took place during periods of both low and high rainfall, including minor flooding events, and months of lower water temperatures (April to September). In addition to natural shifts in environmental parameters, habitat degradation and exposure to contaminants have also been linked to increased susceptibility of dolphins to nontraumatic lesions (Van Bressem et al., 2009b; Mouton & Botha, 2012). In Moreton Bay, contaminants linked to immune suppression, including PCBs and some heavy metals, have been detected in humpback and bottlenose dolphins, respectively (Ansmann et al., 2015; Weijs et al., 2016). These factors may have contributed to the susceptibility of humpback and bottlenose dolphins to nontraumatic skin lesions during the study period. Due to their sympatric habitation, both species are exposed to similar environmental conditions, and differences observed between species may be linked to variability in biological or physiological responses.

Furthermore, disparities in the prevalence of nontraumatic lesions both within and between species are also likely to be influenced by social and behavioural factors (Félix et al., 2019; Powell et al., 2019). Both populations of humpback and bottlenose dolphins in Moreton Bay are socially divided. Strong social bonds form the foundation of different communities which have high site fidelity and preferences for different habitats (Ansmann et al., 2012a, 2015; Meager et al., 2018; Hawkins et al., 2020). This social differentiation can lead some social groups to be more vulnerable to acquiring pathogens and immune dysfunction due to more acute exposure risks. For example, humpback dolphin social communities that have core habitats adjacent to the Port of Brisbane and Brisbane River estuary are particularly vulnerable due to their higher exposure to contaminants and habitat degradation (Meager et al., 2018; Hawkins et al., 2020). Examining differences between social communities within these populations was beyond the scope of this study. Further investigation is warranted to examine the interplay of environmental conditions, anthropogenic activities, and social interactions on the susceptibility of different communities of both species to nontraumatic skin lesions.

Traumatic Skin Lesions

In the present study, traumatic lesions affected almost all individuals of both species (92.3% of humpback and 99.0% of bottlenose dolphins), with the most prevalent being rake mark abrasions. The prevalence of abrasions was comparable between humpback (80.2%) and bottlenose (92.0%) dolphins, suggesting similar levels of aggressive interactions with conspecifics and socio-sexual behaviours in adults of both species (Scott et al., 2005; Marley et al., 2013). Differences observed in abrasion prevalence between young calves of less than 1 year old suggests that bottlenose dolphin calves are involved in more aggressive social interactions than humpback dolphin calves (92.0 and 60.0%, respectively). However, the ages of calves included in the sample may have played a role as calves tend to become more social with age (Powell et al., 2019).

Shark predation was evident in both humpback and bottlenose dolphins and more prevalent in adults. Historically, 36.6% (n = 334) of identified bottlenose dolphins (of all age classes) have exhibited shark bites in Moreton Bay (Corkeron et al., 1987). While 29.0% of bottlenose dolphins had bite wounds, humpback dolphins appear to be more susceptible with almost half of the individuals (48.8%) exhibiting shark bite wounds. Similar patterns have been observed in adult humpback (46.2%, n = 26) and bottlenose (17.9%, n = 84) dolphins in tropical northwestern Australia (Smith et al., 2018). These similarities suggest that humpback dolphins are generally more vulnerable to predation attempts from sharks. Habitat use and behavioural factors, including foraging strategies, may contribute to this increased vulnerability to predation. Some humpback and bottlenose dolphins in these populations, along with predatory shark species, follow trawlers to feed on discarded bycatch (Corkeron et al., 1990). Dolphins engaging in trawling feeding behaviours are in theory more likely to be susceptible to attacks from sharks which could explain the overall higher prevalence observed in Moreton Bay. Shark bites were also more prevalent in adults than calves for both species. This lack of fresh or healed shark bites on calves in Moreton Bay suggests that either (1) mothers and group members successfully protect calves from predation attempts but expose themselves to attack or (2) calves are less likely to survive an attack. The risk of predation is likely to increase during the warmer months which coincides with the increased presence of tiger sharks (Taylor, 2007) and peak calving periods for dolphins in Moreton Bay (E. R. Hawkins, unpub. data).

Scarring and injuries caused by anthropogenic activities, specifically vessel strikes and fishing interactions, were observed in both species, with prevalence being significantly greater in bottlenose (30.0%) than humpback (11.9%) dolphins. This prevalence was higher than those reported from comparable studies for identifiable bottlenose dolphins of all age classes in Ecuador (13.2%, n = 189; Félix et al., 2018) and Indo-Pacific humpback dolphins in Hong Kong (10.3%, n = 435; Chan & Karczmarski, 2019), but less than those in Western Taiwan (57.7%, n = 97; Wang et al., 2017).

Of the anthropogenic lesions observed, fishery-related injuries were evident in 4.4% of humpback and 25.0% of bottlenose dolphins. Major injuries (Andersen et al., 2008) and deformities from entanglements in fishing gear included amputation of the dorsal fin as well as sections of the tail fluke and rostrum. Notably, distinctive patterns of scarring in 67.0% (n = 12) of bottlenose dolphins with missing dorsal fin tips and one individual humpback dolphin with a missing tip of the upper jaw were consistent with fishing line entanglement. All other missing tip injuries were more likely to be related to social interactions and other natural causes (Luksenberg, 2014) but were not explored further here.

Compared to other populations, the proportion of fishing-related injuries in bottlenose dolphins observed herein is higher than those reported for all age classes of this species encountered in Mayotte (16.7%, n = 42; Kiszka et al., 2008) and adult *T. truncatus* encountered in Maui Nui, Hawai'i (27.0%, n = 255; Machernis et al., 2021). However, for humpback dolphins, it was lower than identifiable individuals of all age classes from Xiamen, China (11.7%, n = 60; Wang et al., 2018). The patterns of fishing-related injuries suggest that the majority are likely to be caused by fishing line and ropes (Read & Murray, 2000) which is also supported by observations of live entanglements in the field (Authors' pers. obs.). Furthermore, recreational fishing activities are widespread throughout the study area, with 60% of Queensland's recreational fishers living in the surrounding area of Moreton Bay (Environmental Protection Agency [EPA], 2008). Although it is possible that some dolphins gain injuries from feeding around beam and otter-board trawlers, these practices are highly restricted throughout the study area, and entanglement in trawl gear resulting in dolphins becoming bycaught appears rare (Robins & Courtney, 1998). Other fishing practices, including gillnetting, that present a critical threat to dolphins globally (Reeves et al., 2013) are also highly restricted or not permitted in Moreton Bay. Furthermore, baited drum lines used by the Queensland Shark Control Program are widespread throughout the study area. Dolphins of both species are known to depredate from these lines (Authors' pers. obs.), occasionally becoming caught, and it is possible that some traumatic lesions could occur as a result of interacting with the equipment as the dolphin dislodges the bait.

Popular areas for recreational fishing also overlap with areas frequently used by dolphins and coincide with areas where risky feeding behaviours have been observed (Authors' pers. obs.). Both humpback and bottlenose dolphins in Moreton Bay engage in risky feeding behaviours associated with human-related conditioning, including feeding from trawler bycatch (Corkeron et al., 1990), illegal and permitted provisioning (hand-feeding), and depredation of fishing gear (Authors' pers. obs.). Such conditioned behaviours, particularly those related to human provisioning, can directly increase the risk of pathogenic infections, injury, declines in reproductive success, and mortality from fishing gear ingestion and entanglement, in addition to vessel strikes (Donaldson et al., 2010; Powell & Wells, 2011; Christiansen et al., 2016; Senigaglia et al., 2019). It is therefore possible that these risky behaviours contribute to the relatively high level of anthropogenic-related injuries detected in Moreton Bay's dolphins. While most cases may be nonfatal, mortalities of dolphins in Moreton Bay and surrounding regions have been attributed to entanglement in fishing gear (Meager, 2016). Acquired injuries from anthropogenic causes can also increase the susceptibility of pathogens and compromise an animal's health, contributing to mortality and reproductive declines (Mouton & Botha, 2012; Félix et al., 2018, 2019).

The prevalence of vessel strike injuries found in Moreton Bay dolphins were similar in humpback (6.6%) and bottlenose (6.0%) dolphins. This is comparable to those reported for identifiable bottlenose dolphins of all age classes in the Indian River Lagoon, Florida, where injuries consistent with vessel strikes were found in 6.0% ($n = 43$) of individuals (Bechdel et al., 2009). While it was not possible to determine the types of vessels that likely caused the injuries, most cases were presumed from scarring patterns to be a result of faster moving vessels as opposed to slower and more predictable large ships that move in and out of the port facilities. Small, fast-moving vessels were also observed to collide with dolphins on more than one occasion during field observations of this study. Like other lesion categories, the detection of vessel-strike injuries is likely to be conservative as some marks and injuries can be small or difficult to detect once healed, and those resulting in mortality are unlikely to be recorded. In addition, taking photographs at the surface means that the majority of the dolphin's body remains underwater, limiting the body areas available for assessment (Chan & Karczmarski, 2019; Toms et al., 2020). While our data also represent only a portion of the two populations, the results presented herein provide a reliable baseline and can be considered minimum estimates of the prevalence of skin lesions in these coastal dolphin populations.

Conclusions

This study has presented a snapshot of the prevalence of skin lesions in Australian humpback and Indo-Pacific bottlenose dolphins living in the near-urban embayment of Moreton Bay. This snapshot can be used as a baseline for monitoring the health of these populations. Both nontraumatic and traumatic lesions affected most dolphins examined, with varying prevalence evident between species and age classes. The prevalence of anthropogenic lesions, including some potentially major injuries (Andersen et al., 2008) in Moreton Bay, raises concern for the effect on population fitness. As the human population in southeast Queensland continues to rise, anthropogenic activities and associated threats, including boating and fishing; expansion of urban areas; coastal development; and pollution will intensify and place greater pressure on these dolphin populations. It is imperative that temporal and spatial shifts in the lesion prevalence for these two threatened species continue to be monitored. Changes in lesion prevalence over time can provide an indication of chronic pathogenic outbreaks and anthropogenic injuries, both of which could have implications for the health, reproductive success, and status of these populations. Findings presented herein can be used to directly inform and monitor the impacts of management and conservation efforts to facilitate the coexistence of both humans and dolphins in Moreton Bay.

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