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CHAPTER EIGHT

A Review of the Status of the Indian Ocean Humpback Dolphin (*Sousa plumbea*) in Pakistan

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Abstract

Limited historical and new information on Indian Ocean humpback dolphins, *Sousa plumbea*, in Pakistan are reviewed. Although present along most of the coast, *S. plumbea* concentrates in the mangrove-lined creek system of the Indus Delta.

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(Sindh), Miani Hor (Sonmiani Bay), Kalmat Lagoon, Gwadar and the Dasht River estuary (Gwater Bay, Jiwani). Other areas of distribution comprise the Karachi coast, Kund Malir, Ormara and Pasni. In the Indus Delta, 46 small-boat surveys conducted monthly (minus July and October) in 2005–2009, documented 112 sightings (439 individuals) in major creeks, smaller channels and nearshore waters. Group sizes ranged from 1–35 animals (mean = 3.92 ± 4.60). Groups of 1–10 animals composed 91% of total (27.9% single animals). An encounter rate of 0.07–0.17 dolphins km⁻¹ lacked a significant trend across survey years. A discovery curve remained steep after 87 dolphins were photo-identified, suggesting the population is vastly larger. In Sonmiani Bay, Balochistan, during 9 survey days in 2011–2012, group sizes ranged from 1–68 animals (mean = 11.9 ± 13.59; n = 36), totalling 428 dolphins. Incidental entanglements, primarily in gillnets, pollution (especially around Karachi), overfishing and the ship breaking industry in Gaddani, pose major threats. Incidental catches occur along the entire Pakistani coast. Of 106 stranded cetaceans, 24.5% were S. plumbea. Directed takes in Balochistan, driven by demand for bait in shark fisheries, have reportedly declined following dwindling shark stocks. Habitat degradation threats include depletion of prey and increased maritime traffic. Domestic sewage and solid waste pollution are predominant on the Balochistan coast, especially at Miani Hor, Kund Malir, Ormara, Kalmat Lagoon, Pasni, Gwadar and Jiwani. An exhaustive habitat assessment combined with appropriate fishery management is the only way to safeguard the future of S. plumbea in Pakistan.

1. INTRODUCTION

Despite its widespread occurrence in a variety of coastal habitats in the Indian Ocean, studies on the biology and ecology of the Indian Ocean humpback dolphin, or plumbeous dolphin, Sousa plumbea (Cuvier, 1829), are relatively limited. Research has targeted mainly South Africa (Best, 2007; Karczmarski, 1996, 1999, 2000; Ross, 1984, 2002; Ross et al., 1994), Zanzibar (Stensland et al., 2006), Mozambique (Guissamulo and Cockcroft, 2004), Pakistan in the 1970s (Pilleri, 1972, 1973, 1975; Pilleri and Gihr, 1972, 1974; Pilleri and Pilleri, 1979), India (Parsons, 1998; Sutaria and Jefferson, 2004), and the Arabian region (Baldwin et al., 2004).

The taxonomy of the genus Sousa experienced great flux over the decades, with recent insights supportive of multiple species, largely in accordance with historical morphology-based conclusions. A view (e.g. Jefferson and Karczmarski, 2001), that lumped all Indo-Pacific humpback dolphins into one widely distributed, highly variable species Sousa chinensis, is now considered obsolete (Jefferson and Rosenbaum, 2014; Jefferson and Van Waerebeek, 2004; Parra and Ross, 2009). The western Indian Ocean S. plumbea is distributed from South Africa’s Cape Province to India and possibly through the Bay of Bengal where it is thought to overlap with
Indian Ocean Humpback Dolphins of Pakistan

2. DISTRIBUTION IN PAKISTAN

2.1 General

*Sousa plumbea* is known to be present in varying densities along most of Pakistan’s 990 km long coastline (Figure 1); however, specific sightings data resulting from dedicated boat surveys and studies of beach cast specimens are scant, except for in the Indus River Delta, Sonmiani Lagoon and Makran coast (Ahmad, 1998; GoP, 2007; Gore et al., 2012; Hasan and Ahmad, 2006; Kiani, 2014; Niazi, 1990; Pilleri and Gihr, 1972, 1974; Roberts, 1977, 1997; Roberts et al., 1983; SDO, 2012; WWF, 2008; Zbinden et al., 1977). Sightings and stranding records in 2005–2009 from the entire coastline demonstrate presence at Karachi coast (24°47'N, 66°59'E), Miani Hor, Sonmiani Bay (25°10’N, 66°30’E), Ormara (25°12’N, 64°38’E), Kalmat Hor (25°23’N, 64°02’E), Pasni (25°15’E, 63°28’E), Gwadar (25°06’N, 62°19’E) and Jiwani (25°02’N, 61°43’E).
It is premature to evaluate whether humpback dolphins present in these different areas all represent locally resident populations or whether they are linked by migration, especially for areas in relatively close proximity to each other, such as the Indus Delta and the Karachi coast and several locations along the 670 km long Balochistan coast in western Pakistan.

Figure 1 (A) Map showing the Sindh and the Balochistan coastline of Pakistan with all the major coastal areas marked. The Sindh coast in the east extends from the border with India to Churna Island, while the Balochistan coast in the west extends from west of Churna Island and Hub River estuary to Jiwani at Pakistan–Iran border; (B) Hydrography of the Sindh and the Balochistan coastlines of Pakistan.
2.2 Indus River Delta

The Indus River Delta covers an area of about 41,440 km$^2$ and is among one of the most globally important coastal environments in Pakistan (Ahmad, 1998). It was declared a Ramsar site on 5 November 2002, due to its biological diversity and for being the largest strand of mangrove forest along the Pakistan coast (Ahmad, 1998; Siddiqui et al., 2008). The estuarine creeks and mangrove forests form major nursery grounds for many species of fish and shrimps (Shah et al., 2007). The delta is rich in micro-invertebrates, shrimps, fin-fishes, reptiles, birds and mammals. Recent surveys indicate that humpback dolphins are still common in the Indus Delta (Gore et al., 2012; Kiani, 2014). Between November 2005 and May 2009, a total of 46 small-boat survey day trips were carried out in various major creeks and smaller interconnecting channels of the Indus Delta (Figure 2), during every month of the year except July and October. However, most of the effort (Table 1) was concentrated during the northeast monsoon (November–February) and the spring inter-monsoonal period (March–May), due to favourable sea conditions. Total

![Figure 2](image.png)

Figure 2: The Indus Delta creek system with names of surveyed creeks where Kiani (2014) confirmed Indian Ocean humpback dolphins, *Sousa plumbea*. The frequent presence of humpback dolphins in “other creeks” near the border with India is supported by anecdotal records from fishermen and other locals.
search effort was 209 h, in addition ca. 47 h were spent following and photographing an estimated 439 individuals (sum of estimated group sizes) during 112 encounters (Table 2).

Humpback dolphins were found in the upper, middle and lower sections of creeks, as well as in nearshore waters contiguous to the creek mouths (Figure 3). Dolphins were always encountered in Turshian Creek whenever it was surveyed \((n = 10)\). This creek is very close and to the west of Khobar Creek, which is the creek through which the Indus River discharges into the sea (see Figure 2; Gore et al., 2012; Kiani, 2014).

Besides \(S. \) plumbea, Indo-Pacific bottlenose dolphins \(T. \) aduncus, and Indo-Pacific finless porpoises \(N. \) phocaenoides, are also found in inshore waters, but are never observed inside the Indus Delta creeks (Ahmad, 1998; Shah et al., 2007; Siddiqui et al., 2008). Presently, biodiversity of the Indus Delta, including humpback dolphins, is under a multitude

### Table 1 Distribution of Small-Boat Survey Effort for Indian Ocean Humpback Dolphins, \(S. \) plumbea, Across Months and (Monsoon) Seasons, 2005–2009

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season</td>
<td>NE</td>
<td>NE</td>
<td>IMS</td>
<td>IMS</td>
<td>IMS</td>
<td>SW</td>
<td>SW</td>
<td>SW</td>
<td>SW</td>
<td>IMA</td>
<td>NE</td>
<td>NE</td>
<td></td>
</tr>
<tr>
<td>Number of surveys</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>13</td>
<td>46</td>
</tr>
</tbody>
</table>

NE, northeast monsoon; IMS, spring intermonsoonal period; SW, southwest monsoonal period; IMA, autumn intermonsoonal period. See also Gore et al. (2012) and Kiani (2014).

### Table 2 Survey Parameters Including Encounter Rates for Indian Ocean Humpback Dolphins, \(S. \) plumbea, During Small-Boat Surveying in the Indus Delta Creek System, 2005–2009

<table>
<thead>
<tr>
<th>Survey Series</th>
<th>Year</th>
<th>Number of Surveys</th>
<th>Number of Sightings</th>
<th>Effort Distance (km)</th>
<th>Number of Dolphins Seen</th>
<th>Cumulative Number of Sightings (km(^{-1}))</th>
<th>Number of Dolphins (km(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2005</td>
<td>06</td>
<td>22</td>
<td>543.4</td>
<td>38</td>
<td>0.04</td>
<td>0.07</td>
</tr>
<tr>
<td>2</td>
<td>2006</td>
<td>08</td>
<td>08</td>
<td>342.0</td>
<td>51</td>
<td>0.02</td>
<td>0.15</td>
</tr>
<tr>
<td>3</td>
<td>2007</td>
<td>12</td>
<td>43</td>
<td>956.6</td>
<td>172</td>
<td>0.04</td>
<td>0.17</td>
</tr>
<tr>
<td>4</td>
<td>2008</td>
<td>09</td>
<td>22</td>
<td>523.9</td>
<td>69</td>
<td>0.04</td>
<td>0.13</td>
</tr>
<tr>
<td>5</td>
<td>2009</td>
<td>11</td>
<td>17</td>
<td>656.4</td>
<td>109</td>
<td>0.03</td>
<td>0.17</td>
</tr>
<tr>
<td>Total/mean</td>
<td>–</td>
<td>46</td>
<td>112</td>
<td>3022.1</td>
<td>439</td>
<td>0.03</td>
<td>0.14</td>
</tr>
</tbody>
</table>

See Gore et al. (2012) and Kiani (2014).
of stresses due to the reduced influx of freshwater from the Indus River, pollution (domestic, agricultural and industrial sewage), land clearance, over-exploitation of fish resources, sea water intrusion leading to increased salinity, and unsustainable exploitation of mangroves by coastal communities (Ahmad, 1998; Shah et al., 2007).

2.3 Balochistan Coast

A total of 36 humpback dolphin sightings were recorded in waters 3–13 m deep (mean = 7.0 ± 2.79 m) at Miani Hor, Sonmiani Bay (25°10′N, 66°30′E), Balochistan coast, during nine survey days from July 2011 to June 2012 (Figure 4) as conducted by the SDO (2012). The mean group size was 11.89 ± 13.59 animals (median = 7; n = 36) with the largest group, some 68 animals, encountered in 6 m deep water on 12 November 2010. Dominant behaviour included feeding (77.8%), followed by travelling (25%), surface active behaviour (2.8%), and resting/socializing (8.1%). Threats included by-catch in fisheries (particularly gillnets), degradation of habitat from infrastructure development (e.g. jetty construction),

Figure 3 Distribution of all on-effort sightings of Indian Ocean humpback dolphins, *Sousa plumbea*, in the Indus Delta creek system, southeast Pakistan, from November 2005 to May 2009. The Indus River is outlined (long blue line; light grey in the print version). See also Gore et al. (2012) and Kiani (2014).
mangrove deforesting, unsustainable fisheries harvest, increasing marine traffic (fishing boats) and contamination (solid waste, domestic sewage). This humpback dolphin population is also targeted by a limited number of dolphin-watching excursions annually by tourists from Karachi, under the SDO umbrella.

3. STOCK STRUCTURE

Zhou et al. (1980) argued early on that morphological differences between populations in the Indian and western Pacific Oceans warranted treating them as different species, *S. plumbea* and *S. chinensis*, respectively (see Jefferson and Rosenbaum, 2014). A multivariate analysis of cranial morphometrics clearly separated *S. plumbea* from both, the Atlantic humpback dolphin, *S. teuszii* and *S. chinensis* (Jefferson and Van Waerebeek, 2004), supported by recent genetics studies (Jefferson and Rosenbaum, 2014; Mendez et al., 2013), which furthermore recognized an Australian species, the Australian humpback dolphin, *S. sahulensis*. Humpback dolphins in Pakistan are manifestly *S. plumbea* with their large distinctive hump and predominantly grey, “plumbeous” colouration. Intraspecific variation of *S. plumbea* remains largely unstudied, but considerable stock structure may exist, including at subspecific level. Based on observations that humpback
dolphins in Pakistan, similar to Iran and western India, show mixed phenotypic features, i.e., distinct dorsal humps found in *S. plumbea*, but heavy spotting on different body parts as in *S. chinensis*; Gore et al. (2012) suggested that Pakistan population(s) may represent an intermediate form.

Pilleri and Gihr (1972) first photographically documented the cranial and postcranial skeleton of humpback dolphins from Pakistan and suggested interspecific differences in the thoracic region (12 Th.v., 26% of vertebral column length in *S. chinensis* vs. 11 Th.v., 22–24% in *S. plumbea*); however, this was based on a small sample size. Statistically, adequate sample sizes of osteological specimens and genetic samples from the entire range will be required to allow for geographic variation analysis.

Observations indicate that neonates and calves are light grey with even paler, often whitish, rostra and with a slightly bigger head in proportion to body size (Figure 5A). Juveniles appear a darker hue of grey than calves, with, compared to adults, few markings on their body and usually no pink spotting on fins, beak or flukes, and no mottling ventrally. Adult animals are dark grey, sometimes brownish grey, often with pink spotting on rostrum, dorsal fin (especially the tip), underside and flukes. Larger, apparently older, animals show markedly increased spotting as compared to juveniles. Adults are usually well marked, apt for photo-ID studies, i.e. with frequent cuts, nicks and serrations on the dorsal fin, and scars of former injuries over much of the body. The dorsal hump is well developed and is most pronounced in the largest, presumably older, individuals, i.e. those dark grey in colour, with robust bodies and strong musculature, specifically in the peduncle area (Figure 5B and C; and see Kiani, 2014).

![Figure 5](https://example.com/image.jpg) 

**Figure 5** Examples of individual and ontogenetic variation in external features of Indian Ocean humpback dolphins, *Sousa plumbea*, in Indus Delta, Pakistan. (A) Three animals, one of which is a light grey-coloured calf, in Dabbo Creek, 18 December 2007. (Continued)
Figure 5—cont’d  Note the calf has a proportionally developed hump; (B) Adult with strongly developed dorsal hump, moderate speckling and pinkish (grey in the print version) fin tip, near Phitti Creek, 15 May 2009; (C) Leading individual shows an unusually pronounced dorsal hump and some speckling, near coast of Keti Bunder, 29 May 2008; (D) Mating group in trio formation, Khuddi Creek, 28 January 2009.
4. ABUNDANCE

Encounter rate varied from 0.07 to 0.17 humpback dolphins km$^{-1}$ of small-boat surveying in the Indus River Delta across five study years, 2005–2009 (see Table 1; Gore et al., 2012; Kiani, 2014), without showing any significant trend (Pearson R = 0.2365; p = 0.701). Mean encounter rate per distance surveyed was 0.14 humpback dolphins km$^{-1}$ (439 animals over 3022 km survey effort).

No reliable abundance estimates exist for Pakistan’s *S. plumbea* populations. Pilleri and Pilleri (1979) explored 30 km of the northern delta and encountered about 100 animals. They estimated that if the delta is 130 km from north to south, the total population from Gizri Creek to the Indian border should be “some 430 or perhaps 500 animals”. The guess-estimate of 500 individuals was later adapted by Ross et al. (1994) and others. In 2005–2009, a preliminary minimum population estimate obtained by cataloguing uniquely marked (photo-identified) animals of the Indus River Delta population was 87 (see Gore et al., 2012; Kiani, 2014). The number of resightings was extremely low (n = 5), while the steep discovery curve (Figure 6) indicated that new animals were still being added to the catalogue at a high rate at the end of the study period. Combined, this is strongly

![Discovery curve](image)

**Figure 6** Discovery curve showing cumulative number of uniquely identified humpback dolphins, *Sousa plumbea*, during surveys conducted from 2005–2009 in the Indus Delta (see Gore et al., 2012; Kiani, 2014). No sufficiently high-quality photos were available for reliable individual identification in 2005–2006.
suggestive of a large population in the Indus Delta. In view of incomplete recent spatial and temporal coverage, the guesstimate by Pilleri and Pilleri (1979) of ca. 500 animals, conceivably may still be useful as general reference. If confirmed, the Indus Delta could contain the largest known population of *S. plumbea* in the world, besides Algoa Bay, South Africa, which was estimated as ca. 466 dolphins (Karczmarski, 2000; Karczmarski et al., 1999).

5. HABITAT

The Sindh coast provides shallow water habitat, as preferred by *S. plumbea*, up to a long distance from shore (see Figure 1B). The wide continental shelf ranges from about 77 km at Karachi, up to 160 km near Kori Creek mouth (Gore et al., 2012; see Figure 1B). In the Indus Delta, humpback dolphins were frequently sighted in all the major mangrove creeks, in some smaller interconnecting channels and in nearshore waters (see Gore et al., 2012; Kiani, 2014). Sea surface temperatures at sightings ranged from 12–31 °C with a mean of 23.1 °C ± 1.2, while salinities ranged from 10–38 ppt. Lowest salinity was recorded in Khobar Creek during SW monsoon after great inflow of rainwater. The dolphins were recorded both in clear and turbid water. Pilleri and Pilleri (1979) noted that *S. plumbea* preferentially remained in muddy, yellow water and “very seldom” was seen in the green water of the Arabian Sea, an environment where the Indo-Pacific bottlenose dolphin, *T. aduncus*, was common. *Sousa plumbea* were observed using smaller interconnecting waterways to move between major creeks in the Indus Delta, but also to take open sea routes between creeks. Prey movement during changing tidal levels could be a driving force behind such activities. In 2005–2009, one humpback dolphin group was seen 20 km from shore, and another distant sighting occurred ca. 9 km from the nearest land, but all other sightings were recorded within a few 100 m from shore, or inside the creeks (see Figure 3; Kiani, 2014).

Mean depth at sightings was 11.24 m (SD = 6.47 m; *n* = 105; range 1.5–30 m). Most dolphins were observed in depths ranging from 1 to 20 m with fewer dolphins encountered in deeper water (Figure 7). A strong negative correlation (Pearson *R* = 0.822; *n* = 6; *p* = 0.045) was found between water depth and cumulative number of dolphins (Kiani, 2014).

Khobar Creek, which receives fresh water from the Indus River, apparently was heavily used, as three sightings with some of the larger group sizes in Pakistan (*n* = 16, 22, 35) were recorded there (Kiani, 2014). Comparable observations were made in the Sunderbans area, Bangladesh, a delta that also receives fresh water from upstream (Smith et al., 2008).
Dolphins were sighted in inshore waters contiguous to the Indus Delta, particularly during winter months, suggesting that they possibly use coastal routes to move between creeks and interconnecting channels (Kiani, 2014). The negative correlation between numbers of dolphins and water depth (see Figure 7) is in line with reports from other areas (Ross et al., 1994). However, Afsal et al. (2008) reported humpback dolphins in 50 m deep waters off the Arabian Sea coast of India. All *S. plumbea* observed by Parsons (1998) in Goa, India, were coastal or associated with an estuary. Coastal animals occurred within 3–4 km from shore or within 8 km of the mouth of a river, and all animals were sighted in waters less than 10 m deep (Parsons, 1998).

6. **BIOLOGY AND BEHAVIOUR**

6.1 **General Behaviour**

Kiani (2014) observed multiple behaviour patterns, with the most common (% frequency of occurrence): travelling (52%), feeding/foraging (47%) and social or surface active behaviours (33%) (Figure 8). Actions such as breaching, tail slapping and surfacing with full head showing were also commonly observed. On 24 occasions (21.4%), humpback dolphins were sighted, when sea birds (terns, gulls, cormorants) were present near-by. Mean dive time lasted 55.4 s (SD = 55.6 s; median = 29 s; range 5–255 s; n = 51).

Dolphins were sighted at all hours throughout the day but were seen moving between creeks primarily during evening hours. Larger group sizes
recorded during mornings and midday hours, as compared to evening ses-
sions, may be formed for foraging purposes (co-operative feeding) and for
resting and socializing (Kiani, 2014).

Karczmarski (1999) reported seasonal variations in occurrence, abun-
dance and group size in humpback dolphins from South Africa. In Pakistan,
most survey effort in 2005–2009 was concentrated during the NE monsoon
(November–February) and spring intermonsoonal period (March–May) in
view of favourable sea conditions (see Gore et al., 2012; Kiani, 2014; SDO,
2012); therefore, seasonality cannot yet be evaluated.

6.2 Feeding

Feeding behaviour showed very little diversity (Kiani, 2014). In smaller
groups, dolphins kept varying distances from each other while chasing prey
in different directions. The larger groups were spread over a wide area, and
were divided into several subgroups while chasing prey without any spe-
cific pattern. No information is available on prey species of *S. plumbea*
in Pakistan. Off Natal, South Africa, all prey items were fish, 61% littoral or
estuarine species and 25% demersal species primarily associated with reefs
(Ross et al., 1994).

6.3 Sexual Behaviour

Courtship and sexual/mating behaviour were recorded during four sightings
(3.6%) in the Indus Delta, only during the northeast monsoon period (January
and February) (see Kiani, 2014). Median group size for these pods was 9.5
(range, 4–19) and all had a mixed age composition. The individuals that engaged in sexual behaviour tended to remain well separated from the core group (see Figure 5D). During courtship, the pair moved quickly one after another while changing the positions in a helical pattern and was involved in relatively increased aerial and social activity. Animals aligned with each other and made frequent body contacts while spending 10–20 s at the surface. During this, the presumed female at times was seen swimming slowly upside down, exposing flippers and occasionally opening its beak pointed towards the sky. Next, the animals moved some 50–100 m from their previous location and the described sequence was repeated, as evident from multiple observations. The actual mating behaviour following courtship involved slow, sub-surface movements in an upside-down posture (possibly by females when approached by males). After body alignment, the presumed male stayed on top of the female, interlocked for about 20–30 s and the pair moved slowly in this position in apparent copulation. The animals separated after this for several minutes. Such copulatory aligning was repeated several times (see Kiani, 2014). Sexual behaviour was estimated to last for more than 2 h. Similar behaviour has been reported from Algoa Bay (Best, 2007).

On three occasions, only two animals were seen engaged in sexual activity, but on one occasion, competition for mating was observed when two presumed males chased one female (see Kiani, 2014). The pursuing individuals, swimming at high speed in a circular pattern, displayed a lot of high-energy activity including splashes, leaps and body contact. It could not be ascertained whether both males managed to mate with the female or whether only one dominant male repeated mating. At least one pair was involved in courting behaviour, as described above and only one pair was generally engaged in mating at a given point in time. Other animals were not observed to interrupt such mating sessions. Sexual behaviour was very similar on all four occasions. Occasionally, an atypical posture was observed, when an animal was lying motionless at the surface on its back exposing throat, belly and flippers and at times briefly opening its beak. When interrupted for respiration the dolphin often resumed that same posture. Sometimes a vertical position was displayed with the tail and peduncle held above the surface for some moments before gently diving.

### 6.4 Group Size and Composition

In the Indus River Delta, group sizes varied considerably from 1 to 35 animals (mean = 3.92 ± 4.60; median = 2; n = 111) (see Kiani, 2014). Singletons were the most frequent group size class (27.6%) with gradually declining frequency
for larger groups (Figure 9) and typically consisted of large solitary animals, probably mostly adult males, with well-developed humps and musculature, particularly in the peduncle. Overall, groups of 1–10 animals made up 91% of total sightings. Generally in the bigger groups, some subgroups stayed close to each other and merged occasionally while chasing prey and feeding. Group composition was highly variable, i.e., only adults, only juveniles, mixed adults and juveniles, mother and calf pairs and undetermined (Figure 10). The

![Observations on group size](image1.png)

**Figure 9** Distribution of group sizes (as percentage of total observations), with standard error bars, in Indian Ocean humpback dolphins, *Sousa plumbea*, observed in the Indus Delta (see Kiani, 2014).

![Group composition](image2.png)

**Figure 10** Group composition (age classes) in Indian Ocean humpback dolphins, *Sousa plumbea*, observed in the Indus Delta, 2005–2009. See also Kiani (2014).
presence of neonates/calves in a large proportion of sightings (21.9%) is a likely indication of the relevance of the Indus Delta as calving and nursing area for the species.

Mean group size (3.92) was comparable to those observed along the west coast of India, i.e., 3.9 and 9.5 dolphins, respectively in shallow and deeper waters (Sutaria and Jefferson, 2004) and 2.6 individuals in Goa, western India (Parsons, 1998). In larger groups, animals of all age classes were present, with adults being the predominant class, in accordance with findings from elsewhere (Goodwin, 1997; Jefferson and Karczmarski, 2001).

### 6.5 Residency

Residency has been documented in most places where *S. plumbea* has been studied, including Algoa Bay and KwaZulu-Natal, South Africa (Karczmarski et al., 1999b), Zanzibar in Tanzania (Stensland et al., 2006) as well as in India (Parsons, 1998). As only five animals were resighted, each only once, no quantification of residence pattern or site fidelity in the Indus Delta was possible.

Humpback dolphins are seen throughout the year in the Indus Delta. Individual dolphins may be resident and use the area opportunistically. Furthermore, humpback dolphins of the Indus Delta may be using some areas of the Indian coastline adjacent to the Pakistan border and vice versa, such as Gulf of Kachchh in Gujarat State, and even beyond. There is also cross-border movement potential for animals observed in Dasht River estuary around the coastal town of Jiwani (Gwater Bay) at the Pakistan–Iran border (see Kiani, 2014). Comparison with photo-ID databases between both neighbouring countries could help improve the understanding of any long-range, cross-border movements.

### 6.6 Interaction with Boats

Humpback dolphins do not approach small local wooden fishing vessels while moving, but do sometimes approach when they are stationary with the engine switched off. Bow riding was never observed, although occasionally animals may ride the stern wave of a boat.

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### 7. PARASITES AND PATHOLOGY

No information is available on the pathology and helminth or other parasites of *S. plumbea* in Pakistan or the Arabian Sea. During photo-identification work, no striking macroscopical skin conditions were noted.
However, a detailed examination of photographs, especially for dolphins from the heavily contaminated waters near Karachi, might provide insight regarding skin condition and overall health in these dolphins. Several dolphin communities inhabiting polluted coastal waters world-wide have developed multiple cutaneous diseases, some life-threatening (e.g. Van Bressem et al., 2009, 2015). Lane et al. (2014) reported lobomycosis-like disease in a S. plumbea from KwaZulu-Natal Coast.

8. ANTHROPOGENIC THREATS AND CONSERVATION

8.1 General

There are likely limits to the adaptability of dolphins to habitat deterioration (Wells, 1993); therefore, long-term monitoring and quantification are essential. As a cetacean with an obligate nearshore habitat, ecologically constrained to a narrow coastal strip, S. plumbea is facing severe threats to its conservation in Pakistan, as elsewhere, due to negative impacts from accelerated coastal development and associated human pressure. Known and suspected threats include accidental entanglements in fishing gear, habitat degradation, pollution, probable competition for food due to widespread use of non-selective fishing gears and increasing vessel traffic with associated noise pollution and risk of boat strikes (Iqbal, 2014; Kiani, 2014). Coastal areas in close proximity to industries, port installations (e.g. Port Qasim) and major human settlements (e.g. Rehri and Ibrahim Hyderi villages) are of highest concern.

8.2 Fisheries Interactions

Along the entire coastline of Pakistan, accidental entanglement in fishing nets, mostly gillnets, appears to be the principal threat to humpback dolphins (Figure 11A). The impact is most severe during peak fishing season, i.e., the northeast monsoon from November to February. From 2005 to 2009, humpback dolphins were one of the most commonly stranded cetacean species in Pakistan (24.5%, n = 106) (Kiani, 2014).

A one year study (2010–2011) carried out along the Gwadar west Bay, located at 25°02’N, 62°19’E on the Balochistan coast, showed that out of 73 dead dolphins recorded stranded on a 20 km stretch of coastline, 22 (30.1%) were Indian Ocean humpback dolphins (A. Shah, IUCN-Pakistan, personal communication, June 2011).
Fisheries in Pakistan are generally open access, which has resulted in overcapacity of the fishing fleet. A 2011, boat census in the Indus Delta carried out by Pakistan’s Marine Fisheries Department (MFD) and WWF-Pakistan has shown ca. 167% increase in number of boats since the previous census of 1986, from 6488 to 17,325 fishing boats (M. Khan, former Director General MFD, personal communication, 2011). Unsustainable exploitation of coastal fishing resources occurs by legal and illegal fishing, specifically in the Indus Delta (Ahmad, 1998; Hasan and Ahmad, 2006; Siddiqui et al., 2008). Artisanal fisheries in Pakistan mainly

Figure 11  Examples of fisheries interactions with *Sousa plumbea* in Pakistan. (A) Live humpback dolphin entangled in local fishers net, rescued and released in Hajamro Creek near coastal town of Keti Bunder, Indus Delta, 6 June 2008; (B) Illegal fisheries may deplete prey species of creek-dwelling humpback dolphins, such as this bottom trawling inter Phitti and Khuddi Creeks, Indus Delta, 15 April 2009.
operate in coastal and nearshore areas also occupied by and target small pelagic, benthic-pelagic and demersal fish species (Ahmad and Hasan, 1997; FAO, 2005; Hasan, 1993; Van Zalingae et al., 1987; WWF, 2005). Only about 25% of the Pakistan fishing fleet operates in deeper offshore waters (WWF, 2005). Use of gillnets of different types is very common in nearshore as well as offshore fisheries, with high risk for cetacean entanglements.

With low catch per unit effort (CPUE) and establishment of a big market for “trash fish”, there is a tendency to use those fishing gears that require less input in terms of manpower, time and costs. As a result, the use of banned fishing gears such as Bullo (estuarine set bag net), Guijo (small-mesh size gillnet in various forms) and Katra nets (purse seine) targeting small pelagic species is widespread, particularly along the Sindh coast (Abildgaard and Khan, 1986; Gestsson, 1994). In all these nets, indiscriminate bulk catches of juveniles of commercial fish species are reported. In 1998 and 2003, the Government of Pakistan banned Bullo, Guijo and Katra nets of less than 1.5 cm mesh size and nets over 250 cm in length and 12.2 m in width in the creeks and coastal waters of Sindh, a known habitat for humpback dolphins. Katra nets less than 5 cm mesh are prohibited in all creeks and inshore territorial waters. Despite this, their use is extensive and is causing serious damage to coastal habitats. Fishing at the time of spawning is also common along the Sindh coast. Trawlers use bottom dragging, which disturbs the seabed and causes long-term damage (Figure 11B; M.S. Kiani, personal observations). Fish stocks are depleted or are moving away from the coast to deeper waters, while shrimp stocks are shrinking. Overfishing, well documented in the mangrove areas and the Indus Delta along the Sindh coast (Hasan, 1993; Van Zalingae et al., 1987), resulted in a CPUE decrease, mainly because of massive takes of juvenile fishes and shrimps.

At fisher community interviews, 28% of the fishers identified by-catch as a major threat to cetaceans, particularly coastal species such as humpback dolphin and Indo-Pacific finless porpoise, as their habitats directly overlap with fishing grounds (Kiani, 2014).

Entangled animals are used opportunistically for various purposes. Fishers in the Indus Delta and Balochistan coast use humpback dolphin oil for treatment of rheumatism and also apply it on boats for waterproofing. Some limited evidence of the use of dolphins as shark bait was recorded in Balochistan. However, according to fishers, this practice has reduced considerably due to fast dwindling stocks of sharks, a consequence of over-fishing. Indo-Pacific finless porpoise was primarily used as shark bait but
also humpback and bottlenose dolphins. Species that closely interact with boats, such as spinner dolphins (*Stenella longirostris*), were killed using hand-held harpoons called *Kaaba* (Kiani, 2014; A. Rahim, Coastal Scientific Society Gwadar Balochistan, personal communication to M.S. Kiani, December 2012; A. Shah, IUCN, personal communication to M.S. Kiani, June 2012). Systematic monitoring will be desirable as these examples suggest that Pakistan’s *S. plumbea* population(s) may be severely affected by interactions with coastal artisanal fisheries. Evidence is lacking, at least presently, of human consumption of cetacean meat (marine bushmeat), which was, and may still be, a major concern in Calicut on the SW coast of India (Lal Mohan, 1994) and continues to be a primary threat to *S. teuszii* conservation in western Africa (Ayissi et al., 2014; Van Waerebeek et al., 2004; see Collins, 2015).

## 8.3 Water Pollution

Industrial and domestic sewage pollution in coastal waters and tidal creeks is a major concern specifically around the populous and rapidly expanding industrial city of Karachi, on the northwestern most part of the delta. In the southeastern part, major pollution sources include pesticides like organochlorines (e.g. DDT), various hexachlorocyclohexanes and domestic water flushed into the Indus River from inland areas (Ahmed, 1977; Akhtar et al., 1997; Beg, 1997; Beg et al., 1984; Haq, 1976; Mashiatullah et al., 2010; Rizvi et al., 1988; Saifullah et al., 2002; Saleem and Kazi, 1995; Sultana et al., 2012, 2014; Tariq et al., 1993; Zaigham, 2004). Domestic sewage from human population centers in the southeastern Indus Delta bordering the Indian coast, such as Keti Bunder and Shah Bunder, is thought to be another major source of water pollution, in humpback dolphin habitat (Kiani, 2014).

Untreated industrial effluents and agricultural run-off are the main sources of coastal and marine pollution in Sindh. Effluents containing lead, mercury and other heavy metals, mainly from tanneries, are extremely harmful to marine life. It is estimated that annually about 37,000 tonnes of industrial waste are being dumped in the coastal environment of Karachi, whereas 20,000 tonnes of oil finds its way to beaches and harbours and the fishing grounds of Karachi annually (Indus Ecoregion Programme).

Thermal pollution is another cause of concern from at least four power plants and a big steel mill on the Karachi coast, which discharge more than 1500 million m$^3$ of warm water annually, affecting life cycles of many marine

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species (HDIP, 2008; Khalil, 1999). This may indirectly result in loss of habitat and food resources for coastal cetaceans including humpback dolphins.

The Balochistan coast, relatively speaking, has been less polluted with its small rural towns and villages along the coast and being devoid of major rivers (Ali and Jilani, 1995). However, currently the Balochistan environment is degrading due to poor law enforcement and a general lack of stewardship for marine environment protection (M.S. Kiani, pers. observations, 2005–2014). Ship breaking industry in Gaddani near Miani Hor (Sonmiani Bay) and inauguration of a new port in Gwadar pose potential threats to local humpback dolphins. Domestic sewage and discarded solid waste are predominant in all known humpback dolphin areas along the Balochistan coast, which include Miani Hor, Kund Malir, Ormara, Kalmat, Pasni, Gwadar and Jiwani.

8.4 Other Threats and Legislation
Other threats to humpback dolphins in Pakistan include loss of habitat (mangrove forest) due to land reclamation for development projects, deforestation and camel grazing, which causes damage to new mangrove plants due to trampling. For almost half of the year, no freshwater flows through the delta from the Indus, because its entire flow is diverted for irrigation purposes. This has devastated the ecology of the delta and has almost certainly negatively impacted humpback dolphin feeding ecology. Mangrove deforestation results in the destruction of vital nursery grounds of small fish and perhaps other neritic species that are prey to *S. plumbea* (see Kiani, 2014).

Pakistan National Action Plan for Conservation of Marine Cetaceans (Gore, 2008) states that specific laws for the protection of marine cetaceans in Pakistan are lacking, though Indus river dolphin, *Platanista gangetica minor*, is protected under Sindh Wildlife Act of 1972. It is unclear whether cetaceans are covered by The Balochistan Wild Life Protection Act (No. XIX of 1974) or are covered under the term “game” (The Balochistan Gazette No. 64, 1974), as they are not explicitly listed. Marine cetaceans are not listed in The Sindh Wildlife Protection Ordinance 1972 (with Amendments up to 1 June 2001, printed 2003) (The Gazette of Pakistan, Extra., Dec 6, 1997). The Gazette of Pakistan (Extra., June 30, 1998) is also unclear about protection for marine cetaceans, e.g., whether they are legal “fish” for the purposes of the act, which states under Act No. 35 of 1997, 2nd Paragraph, that “fish means all aquatic animals of inland, marine and brackish water origin ...”. This Act regulates quality and promotes export of fish and fishery products from Pakistan (The Gazette of Pakistan, Extra.,
June 30, 1998, Part II Statutory Notifications S.R.O. 739 (I)/98 under section 18 (I) of the Pakistan Fish Inspection and Quality Control Act, 1997). However, Paragraph 5 (Export Restriction Point c) states that dolphins, porpoises and whales are totally forbidden for export and domestic consumption (Environmental Law in Pakistan Part 1 Federal: governing natural resources, processes and institutions affecting them, 2005). Arguably relevant to whale- and dolphin watching, the 15. 6.1.9.4 Pakistan Tourist Guides Act, 1976, requires tourist guides to have a licence and a professional code of conduct. Further, 6.1.9.5 Travel Agencies Act, 1976 covers transport, lodging and conducting guided tours, but does not provide for ecotourism or protection of natural resources from industry. Preparation of a specific national policy and legislation for the conservation of cetaceans after consultation with all relevant stakeholders (both government and non-government) can play a vital role for long-term protection of these animals against various threats.

9. CONCLUSIONS AND RECOMMENDATIONS

In Pakistan, dedicated research effort in all cetacean biology disciplines needs to be either initiated or vastly expanded. Specimens should be collected from by-catches and strandings for natural history studies and biological research. In order to reliably detect population trends abundance or density will need to be determined using distance sampling or capture-recapture techniques based on photo-identification of naturally marked individuals (e.g. Buckland and Turnock, 1992; Gope et al., 2005; Würsig and Jefferson, 1990).

Marine sanctuaries and marine protected areas (MPAs) can play a vital role in promoting conservation by directly protecting the dolphins by implementable legislation and enforcement (Karczmarski et al., 1998; Simmonds and Hutchinson, 1996). However, strengthening of awareness will prove equally essential, as without community support any protection measures will remain inconsequential. The Indus Delta is among one of the proposed sites for the declaration of a first marine protected area in Pakistan, but additional studies should be conducted before this will happen (Siddiqui et al., 2008). Slowly developing, but poorly managed, dolphin-watching tourism in the vicinity of the industrial city of Karachi and in Miani Hor (Sonmiani Bay) along the Balochistan coast needs to be properly monitored and regulated if the purpose of alternate livelihood for coastal communities is to be achieved. Given adequate legislation and properly regulated
management, Indian Ocean humpback dolphins may become seen as a valuable aquatic resource exploitable for ecotourism (Karczmarski et al., 1998).

Absolute abundance estimates and trends and stock identification are currently lacking, but circumstantial evidence suggests that direct and indirect interactions from fisheries, pollution, habitat degradation and possibly decreasing food resources due to overfishing (including illegal fishing practices) may be causing species decline. An exhaustive habitat assessment coupled with appropriate fishery management is the only way to safeguard the future of S. plumbea and many other neritic species in the coastal waters of Pakistan.

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