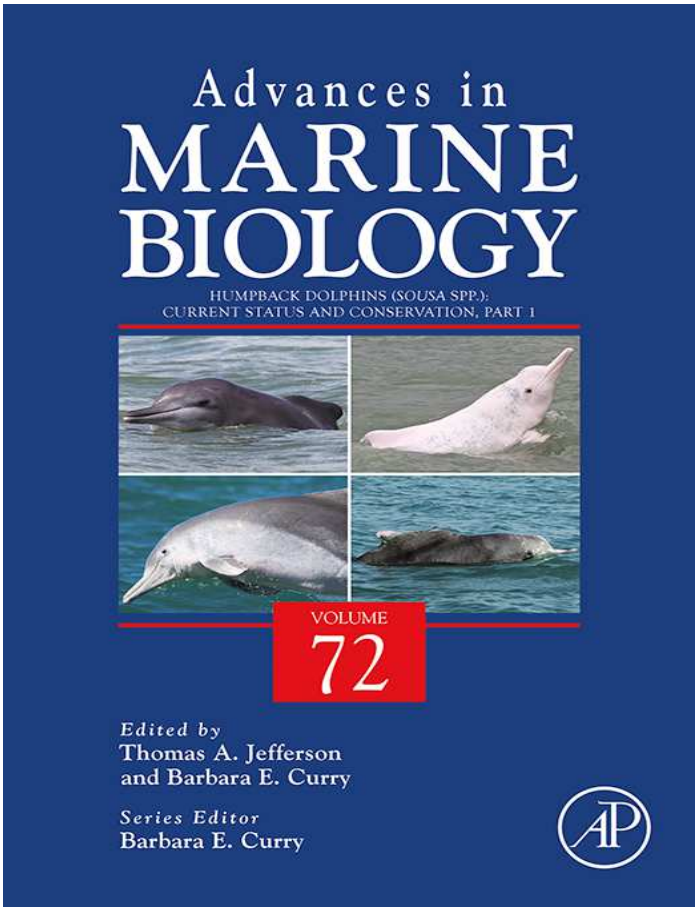

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CHAPTER NINE

Humpback Dolphins (Genus *Sousa*) in India: An Overview of Status and Conservation Issues

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Contents

Abstract

This chapter aims to collate recent work done by different research teams along the Indian coast and presents research plans for the conservation and management of the genus *Sousa* in Indian waters. Humpback dolphins are the most common nearshore cetaceans found along the Indian coast. The taxonomy is confused, but two or more species of humpback dolphins may be present in India. Dedicated research on

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humpback dolphins and other cetaceans has been initiated only in the past few years and vast gaps in the ecology and conservation of the genus from the region remain. Dedicated and opportunistic research indicates that humpback dolphin presence is continuous along the west coast of India, owing to the contiguous favourable habitat of shallow nearshore waters, while along the east coast humpback dolphins are apparently found in pockets. Humpback dolphins are also the most numerous in incidental catch records from the coast, owing to the large overlap in space use with nearshore fisheries like small gillnets, trawls, shore seines and purse seines. Along many coastal sites, humpback dolphins are known to cause damage and depredation of fish catch of certain fishing gears, making them unpopular. At the same time, many fishers along the west coast have developed local dolphin-watching programmes as an alternate source of livelihood, providing positive impetus for conservation. However, research on the long-term effects of dolphin watching and its management is required. Some recommendations for more effective management of this species are made.

1. INTRODUCTION

1.1 General Background

Humpback dolphins (*Sousa* spp.) are the most common cetaceans found in Indian waters and are highly vulnerable to a number of anthropogenic pressures. Interactions between humans and marine life have greatly increased due to large infrastructural developments and intensive fisheries (De Boer et al., 2003). As coastal infrastructure rapidly develops it is crucial to study the impacts anthropogenic pressures pose on population dynamics, socialising and foraging behaviour of these animals. Research projects that have been initiated in India to study the basic biology and ecology of humpback dolphins are listed in Table 1. West Bengal and Andhra Pradesh are the only two coastal states of east India where no research has been conducted for this species. This focused research has helped address gaps in knowledge of humpback dolphins in the waters of India and has set the stage for continuous monitoring and further detailed studies.

Because there is a paucity of systematic and long-term ecological studies for humpback dolphins in Indian waters, we have found that anecdotal evidence or traditional ecological knowledge (TEK) is useful to bridge an understanding of past conditions with those of the present (e.g. Burbano et al., 2014; Coll et al., 2014). Information collected by surveys of fishing communities can provide insight, including that regarding dolphin behaviour and occurrence, human attitudes toward the animals, and the impacts of habitat degradation. For example, results of fisher surveys have indicated the need to focus attention on destructive fishing gear (trawling, small mesh

Table 1 Dedicated Research on Humpback Dolphins (*Sousa* spp.) in India Since the Year 2000

Study	Region	Methods	References
Cetacean populations in the Gulf of Kachchh and along the coast of Goa	Goa, west India, Gulf of Kachchh, Gujarat 2001–2002	Boat-based visual survey	Sutaria and Jefferson (2004)
Humpback dolphins in Ashtamudi estuary, Kerala	Kerala—Ashtamudi Estuary, southwest India 2011–2012	Interview survey, land-based observation	Bijukumar and Smrithy (2012)
Ecological and anthropogenic factors affecting habitat use and behaviour of humpback dolphins along the southwest coast of India	Kerala—Cochin, Munambam and Ashtamudi Port, southwest India 2012–2013	Interview survey, land-based observation, boat-based visual survey	Panicker and Sutaria (2013)
Distribution and habitat use of humpback dolphins on the south-east coast of India	Tamil Nadu, Andhra Pradesh 2012–ongoing	Boat-based survey, interview survey	Muralidharan (2013)
Population of cetaceans along the coast of Sindhudurg Small cetaceans of Maharashtra: Study to identify threats, habitat and local perception to facilitate conservation efforts	Maharashtra—Vijaydurg to Redi (Sindhudurg district), west India 2012–ongoing	Interview survey, mortality studies, boat-based visual survey opportunistic acoustic sampling	Sule et al. (2015)

purse seine), coastal aquaculture and industries to understand their role in depletion of nearshore fisheries in India (R. Muralidharan, unpublished data). Fisheries surveys combined with shore- and boat-based observation are a powerful tool to reconcile humpback dolphin conservation efforts across the Indian coast.

This chapter reviews past information and also includes preliminary information from current research related to status and conservation of

humpback dolphins from India. We review records to provide distribution information for humpback dolphins. For sites where dedicated research has been initiated and long-term data are being collated, we provide details regarding group size, encounter rate and space use. Threats are reviewed, adding preliminary information from our TEK surveys of fishers. We also give a brief overview and recommendations for conservation and policy measures relating to humpback dolphins in the region.

1.2 Characteristics of the Indian Coast

The Indian coastline is approximately 7517 km in length and is made up of nine coastal states with two groups of offshore island archipelagos (Figure 1; Sanilkumar et al., 2006). The peninsular Indian coastline is about 5422 km long (west coast 2877 km, east coast 2545 km; Sanilkumar et al., 2006). The continental shelf on the west coast is very wide, with its widest in southern Gujarat at 374 km to the 100 m isobath, it narrows to about 97 km near southern Maharashtra and is narrowest near central Kerala at about 51 km

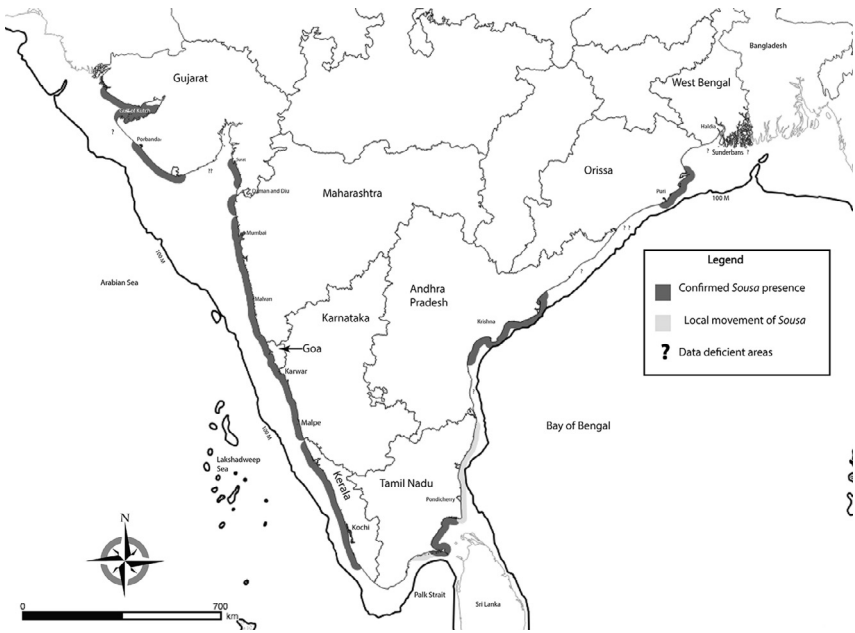

Figure 1 Map showing the probable distribution of humpback dolphins (genus *Sousa*) along the coast of India based upon published records and those recorded in the Marine Mammal Conservation Network of India Database (http://www.marinemammals.in/database/sightings-a-strandings).

(Kumar et al., 2006). Around central Ratnagiri, Maharashtra, the continental shelf (100 m isobath) narrows from about 300 to 150 km. Bottom profile in this area changes as well, from muddy to sandy/rocky (Sanilkumar et al., 2006). The continental shelf on the east coast is narrow, compared to the west coast (Sanilkumar et al., 2006), ranging from 28 to 41 km to the 100 m isobaths, with a few wider continental shelf sections near Point Calimere, Palk Bay, central and north Orissa and West Bengal (Kumar et al., 2006). The west coast of India thus has a much larger nearshore shallow stretch—the preferred humpback dolphin habitat, than the east coast of India.

2. TAXONOMY

2.1 Taxonomic Notes

Until recently, within the genus *Sousa*, the International Union for Conservation of Nature and the International Whaling Commission only recognised two species, *S. chinensis* and *S. teuszii,* with two distinct morphological types in *S. chinensis*; the *chinensis* and *plumbea* types. The scientific community though has historically considered a range of species, from a single, highly variable species (*S. chinensis*) to nine species in total (Jefferson and Rosenbaum, 2014). Frère et al. (2008, 2011), using mtDNA, showed that South African, Chinese and Australian populations of *S. chinensis* were paraphyletic, with *S. chinensis* from China and *S. plumbea* from South Africa more closely related to the Atlantic humpback dolphin *S. teuszii* than to Australian animals (Frère et al., 2008, 2011). Most experts have agreed that the taxonomy needed to be revised (Frère et al., 2008, 2011; Jefferson and Karczmarski, 2001; Jefferson and Van Waerebeek, 2004; Mendez et al., 2013).

Based on a thorough review of genetic, morphological, coloration and biogeographic information, Jefferson and Rosenbaum (2014) split the genus into four species, and the Society for Marine Mammalogy (2014) has recognised this split. The four species are *S. teuszii* (Atlantic humpback dolphin), *S. chinensis* (Indo-Pacific humpback dolphin), *S. plumbea* (Indian Ocean humpback dolphin) and *S. sahulensis* (Australian Humpback dolphin) (Jefferson and Rosenbaum, 2014).

In India, Sutaria and Jefferson (2004) first showed the morphological difference between east and west coast *Sousa*, stating that two distinct types might exist along the Indian coast, *chinensis* type extending from West Bengal to the Tamil Nadu on the East coast and *plumbea* type along the entire west coast, extending to Rameshwaram, Tamil Nadu, along the East coast.

Morphologically, the individuals observed off the coast of Pondicherry, Chennai and Mandapam (Strait between Palk Bay and Gulf of Mannar) and Orissa (Bay of Bengal) along the east coast do not have a prominent hump. However, the animals from Orissa differ from Tamil Nadu in colouration and are far more pink/white (Sutaria and Jefferson, 2004). Animals observed along the west coast of India (Arabian Sea) show a large hump and appear dark grey, thus resembling *S. plumbea* (see Sutaria and Jefferson, 2004). Dolphins that appear to be *S. plumbea* have also been recorded from the northwest coast of Sri Lanka in the Puttalam Lagoon, Bar Reef area, Palk Bay and Talaimannar, adjacent to Adam's Bridge (Bröker and Ilangakoon, 2008; Ilangakoon, 2005, 2006; Nanayakkara et al., 2014).

Mendez et al. (2013) speculated that the Indian population, along with Arabian-Oman and Thailand populations, formed a single cluster, although with distinct haplotypes. However, sample size for specimens from the Indian subcontinent from this study was insufficient ($n = 3$) to obtain greater clarity on this matter. Based on genetic analysis of the mtDNA control region, the population of humpback dolphins found off the coast of Bangladesh in the northern Bay of Bengal, constitutes a separate phylogenetic (and management) unit within the genus *Sousa* (Amaral et al., 2015; Mendez et al., 2013). Currently, it is unknown whether this distinct taxon (species or subspecies) is found elsewhere in the Bay of Bengal, including Indian waters (see Amaral et al., 2015; Jefferson and Curry, 2015; Mendez et al., 2013).

Based on their study of a resident group of six individuals of *S. plumbea* in Puttalam Lagoon, northwest Sri Lanka, Nanayakkara et al. (2014) speculated that those dolphins may be of the *lentiginosa*-type (possibly a subspecies) as defined by Jefferson and Rosenbaum (2014). While recent speculation that the east coast of India may have a distinct species/subspecies, possibly *S. lentiginosa* (see Jefferson and Smith, 2016) is intriguing, to date there has been no large-scale study examining the genetic makeup of the *Sousa* population complex across the Indian subcontinent. Clearly, such an examination of this area is wanting.

2.2 Common Names

Other common names used in the area include: *fukariyo* (Gujarat), *gada reda* (Maharashtra), *gad reda* or *gaadha reda* (Karnataka, northern areas), *kadal panni/kadal ongi* (Kerala), *sori vedan/paru vedan/vella ongi* (Tamil Nadu) and the *Thella thoralu/goonu* (Andhra Pradesh).

3. DISTRIBUTION RECORDS

The Marine Mammals of India database provides details on past published and anecdotal evidence of humpback dolphins along coastal stretches of mainland India (http://www.marinemammals.in/database/sightings-a-strandings). There are records of humpback dolphins from all of the coastal states, with the exception of West Bengal. In Figure 1, we display all these records along with records from ongoing studies.

3.1 West Coast

3.1.1 Gujarat

Humpback dolphin presence has been reported from the Gulf of Kachchh, coast of Bhuj district, the coast of Saurashtra and the coast of Surat in Gujarat. Based on reports, sightings are more common near Tapi River mouth in south Gujarat (D. Desai, Prayas Nature Club, Surat, Gujarat personal communication, 2013, 2014, 2015), near Chusna and Pirotan islands in the Gulf of Kachchh (Sutaria and Jefferson, 2004), and near Madhavpur Beach, Porbandar (D. Sutaria, unpublished data). There are no reports of humpback dolphins in the Gulf of Khambhat.

3.1.2 Maharashtra

Humpback dolphin mortality and sighting records are available from the entire Maharashtra coastline. Fisher observations and anecdotal evidence suggest that the frequency of humpback dolphin sightings is low along the northern region (Thane and Mumbai districts), whereas the sighting frequencies seem to get higher as one moves southwards, in Raigad, Ratnagiri and Sindhudurg districts. Even within the southern district of Sindhudurg, ongoing studies show that humpback dolphin densities are much higher in the southern region (from Malvan to Redi) and the northernmost edge (Vijaydurg bay) of Sindhudurg district. In northern Maharashtra (i.e. in Thane and Mumbai districts), very few anecdotal and opportunistic sightings have been recorded.

3.1.3 Goa

Sightings and strandings have been recorded from all along the coast of Goa (see Parsons, 1998). Surveys conducted in 2000–2001 (Sutaria and Jefferson, 2004), showed that densities were higher in northern Goa than in the

adjoining region of south Maharashtra. However, there has been a lack of recent research on humpback dolphins in Goa. Opportunistic surveys suggest that distribution and density of humpback dolphins along the coast of Goa have declined since 2004 (D. Sutaria, unpublished data).

3.1.4 Karnataka

No dedicated research has been carried out in Karnataka. Humpback dolphins have been observed along the Karnataka coast, with groups seen at Karwar, Gokarna, Honavar, Kundarpura, Malpe and Mangalore (D. Sutaria, unpublished data).

3.1.5 Kerala

Humpback dolphin presence has been reported from all across the state of Kerala. This includes from Kasargod and Kozhikode in the northern region, from Chavakkad, Cochin, Munambam and Marari in the central region, and from Azheekal, Ashtamudi, Kovalam, Paravur and Varkala in southern part of the Kerala. Thus, the entire coastline appears to be used to some degree. High densities of humpback dolphins are seen around the Kochi, Ashtamudi and Munambam estuaries. However, this may be a result of concentrated research effort in these areas (Afsal et al., 2008; Bijukumar and Smrithy, 2012; Panicker and Sutaria, submitted).

3.2 East Coast

3.2.1 Pondicherry

Opportunistic records since 2012 show that humpback dolphins are often observed within 100 m from shore mostly travelling north in direction along the Pondicherry coast (D. Sutaria, unpublished data). We speculate that humpback dolphins carry out seasonal movements along the Pondicherry–Tamil Nadu coast, as favourable shallow habitat is sparse and prey movement is seasonal in these waters.

3.2.2 Tamil Nadu

Our interview surveys (R. Muralidharan, unpublished data; D. Sutaria, unpublished data) show that humpback dolphins are present along the coast, but space use varies seasonally along the coast. In the southern part of Tamil Nadu (along Gulf of Mannar), humpback dolphins are sighted in areas with muddy bottom and around coral reef islands and occur year-round only in the shallow waters off Kodikkarai and Nagapattinam and the islands adjacent to Rameshwaram, in Gulf of Mannar and Palk Bay. In central Tamil Nadu,

they are observed in shallow areas (around Point Calimere in Nagapattinam) characterised by turbid waters and mud flats.

3.2.3 Andhra Pradesh

Interviews being carried out by us in Andhra Pradesh from 2014–2015 (R. Muralidharan, unpublished data), suggest that humpback dolphins are found in the shallow estuaries with thick mangrove patches, adjoining the Krishna–Godavari basin.

3.2.4 Orissa

Dedicated boat surveys of the coast of Orissa and four rivers (Rushikulya, Devi, Budhabalanga and Subernekha rivers) of Orissa were carried out in 2004–2005 (Sutaria, 2009). Humpback dolphins were sighted only in the central coast of Orissa, between Devi River mouth and Dhamra, including Bhitarkanika Wildlife Sanctuary and Gahirmatha Marine Protected Area.

3.2.5 West Bengal

Considering their presence in the Bangladesh portion (see Smith et al., 2015), we presume that coastal West Bengal and the Sunderbans of West Bengal might have humpback dolphins, but no research has been carried out in this region.

4. POPULATION STATUS

There are no robust estimates of total abundance for humpback dolphins in Indian waters yet. Photo-identification based mark-recapture analysis is currently being conducted to estimate population size for humpback dolphins in Sindhudurg in Maharashtra and Kerala (Jog et al., submitted; Muralidharan, 2013; Panicker and Sutaria, 2013, submitted; Sutaria and Jefferson, 2004). There are preliminary density estimates and encounter rates for humpback dolphins off Gujarat, Maharashtra, Goa, Kerala, Tamil Nadu, Pondicherry and Orissa (Table 2).

4.1 West Coast

4.1.1 Gujarat

Sutaria and Jefferson (2004) observed a total of 21 groups of humpback dolphins during a search effort of 570 km. A total of 15 groups were sighted along the coast and six groups were sighted around the islands. Fifty-seven percent of the sightings were in water depths of 0–10 m. It was found that

Table 2 Encounter and Group Size Data for Dedicated Humpback Dolphin (*Sousa* spp.) Studies in India Since the Year 2000

State	Location	Number of Encounters	Group Size	Effort	Method of Survey	Month/Year	Source
Gujarat	Gulf of Kachchh	21	Avg: 3.9 Min: 1 Max: 11	570 km	Boat-based visual survey	January 2001	Sutaria and Jefferson (2004)
Maharashtra	Sindhudurg coast	99	Avg: 11.46 Min: 1 Max: 120	781 km	Boat-based visual survey	May 2014 to May 2015	Sule et al. (2015)
Goa	Entire coast	135	Avg: 6.3 Min: 1 Max: 35	573 km	Boat-based visual survey	February 2001	Sutaria and Jefferson (2004)
Karnataka	Encounter and group size data are unavailable for this region						
Kerala	Ashtamudi, Kochi and Munambam estuaries	934	Avg: 2 Min: 1 Max: 8	432 h (2592 10-min scans)	Shore-based scan sampling	April 2012 to January 2013	Panicker and Sutaria (2013, 2015, in review)
	Coastal waters off Kochi and Munambam	34	Avg: 2.78 Min: 1 Max: 15	76.5 km	Boat-based visual survey	March, April 2013	Panicker and Sutaria (2013)
Tamil Nadu	Chennai coast	4	Avg: 20	120 km	Boat-based visual survey	February 2013	Muralidharan (2013)

Pondicherry	Entire coastline	31	Avg: 15 Min: 2 Max: 100 Density: 0.27/km^2	Opportunistic observations	Shore-based surveys	August 2012 to May 2015	D. Sutaria (unpublished data)
Andhra Pradesh	Encounter and group size data are unavailable for this region						
Orissa	Entire coastline	4	Avg size: 7.28 Min: 3 Max: 70 Density: 0.27/km^2	810 km	Boat-based visual survey	December 2004 to January 2005	Sutaria (2009)
West Bengal	Encounter and group size data are unavailable for West Bengal. Past records of presence are also unavailable. However, the neighbouring country of Bangladesh, which shares the Ganges–Brahmaputra delta with India, has a sizeable population of *Sousa* (see Jefferson and Smith, 2016).						

in waters ranging from 1 to 20 m, the average group size remained between 1.5 and 3.0 individuals, while in waters 21–30 m deep, average group size was 9.5.

4.1.2 Maharashtra

Along the Sindhudurg coast, humpback dolphin densities seem to be higher around river mouths (Redi, Devbag sangam and Vijaydurg estuary), and densities were relatively lower in the north Sindhudurg region as compared to the southern region (Jog et al., submitted). Group sizes were larger in southern Sindhudurg, with subgroups showing tighter associations. Sightings in north Sindhudurg were closer to shore as compared to the south. Based on current photo-identification surveys, 153 individuals have been identified as of December 2014 in Sindhudurg region (Jog et al., submitted). Humpback dolphins were sighted at a maximum depth of 15.6 m, with 47.05% of sightings within 10 m depth and 52.94% of sightings between 10 and 20 m ($n = 85$ sightings). Fourteen humpback dolphin carcasses were reported between February 2012 and April 2015 (11 from Sindhudurg district and 3 from Mumbai).

4.1.3 Goa

In Goa, a total of 135 humpback dolphin groups were sighted by Sutaria and Jefferson (2004). Out of the 135 groups sighted, 100 groups were sighted in the north, closer to the river mouths, and 60% of sightings were in water depths of 6–10 m. One dead humpback dolphin was found during this study in 2001–2002.

4.1.4 Kerala

Recent work indicates that there is seasonal variation in the occurrence of humpback dolphins in estuarine regions of Kerala, namely, Ashtamudi, Munambam and Kochi. Individuals used estuaries to a higher extent in summer and the pre-monsoon season, and a much lower extent in the monsoon season (Panicker and Sutaria, 2013, submitted). The high influx of freshwater leading to a decreased salinity was found to be the determining factor that explains this change of use (Panicker and Sutaria, submitted). Salinity levels are not considered to be a physiological barrier affecting dolphin distribution, but are likely to influence prey distribution and abundance. Although dolphins were observed travelling, milling and socialising in the estuaries, the majority of time was spent foraging in all seasons (Panicker and Sutaria, 2013, submitted). Dolphins feed mainly on fish of the mullet family

(*Liza macrolepis, L. parsia, Mugil cephalus, Valamugil* spp.) in the estuaries (Bijukumar and Smrithy, 2012; Panicker and Sutaria, submitted). This suggests that estuaries are important feeding grounds for the species (Panicker and Sutaria, 2013, submitted). In Ashtamudi, apart from foraging, milling (including resting) activity was seen to a higher degree (than Munambam and Kochi) showing that dolphins use this estuary not just for feeding (Panicker and Sutaria, 2013). A high number of calves/juveniles were observed in Ashtamudi estuary and adjacent Sakthikulangara Bay through the study period, suggesting this site may serve as a nursing ground. One dead humpback dolphin was found during this study off Kochi. Possible cause of death was net entanglement, as fishing line was found around the body.

4.2 East Coast

The distribution pattern of humpback dolphins on the east coast of India is more discontinuous that on the west coast. Dolphins on the east coast appear to form discrete populations. The distinct bathymetric variation patterns make the coast less suitable as humpback dolphin habitat, and this likely affects the distribution. Recent studies (Sutaria, 2009) seem to suggest that the distribution of humpback dolphins along the east coast of India (Orissa to Tamil Nadu) is concentrated in a few small pockets: Gahirmatha to Puri, Orissa; Point Calimere, Chennai, Pondicherry, Rameshwaram, Palk Bay in Tamil Nadu; a few locations in Andhra Pradesh.

4.2.1 Tamil Nadu and Andhra Pradesh

Information regarding sightings and group size from Tamil Nadu coast has been meagre. Occasionally, humpback dolphins have been observed from shore (mostly during morning and evening hours) in larger groups. Humpback dolphins are more frequently observed in Tamil Nadu and Andhra Pradesh between the months of December and April, coinciding with the occurrence of nearshore fish species along the coast (R. Muralidharan, unpublished data).

4.2.2 Pondicherry

Of the 31 groups of humpback dolphins reported from Pondicherry, 76% were milling off the esplanade (D. Sutaria, unpublished data). Most groups were observed travelling or milling, and groups were travelling south to north (see Section 3.2). There seems to be seasonal variation in dolphin occurrence, with maximum sightings between May and September annually (fewer sightings were from December to April).

4.2.3 Orissa

Four groups of humpback dolphins were encountered in the nearshore waters of Orissa in 2004–2005 (Sutaria, 2009). Six dead humpback dolphins were also found between 2004 and 2006 along the Orissa coast. In 2015, the Orissa State Forest Department survey produced a total count of 173 humpback dolphins from Gahirmatha in the coastal waters of central Orissa.

5. HUMAN INTERACTIONS AND THREATS

5.1 Fisheries Interactions

Humpback dolphins are often seen foraging in and around estuarine regions and are particularly impacted by human activities in the coastal zone, which is exploited extensively by artisanal and commercial fisheries (Panicker and Sutaria, 2013; Parra and Jedensjö, 2014; Sutaria and Jefferson 2004). They are generalists, preying on a wide variety of nearshore, estuarine and reef fishes. In Indian waters, they have been observed to primarily feed on mullets, pomfrets, mackerel and sardines (Panicker and Sutaria, submitted; Sule et al., 2015).

5.1.1 Tamil Nadu and Andhra Pradesh Coast

Our observations beginning in 2009 have indicated that humpback dolphins are identifiable by coastal fishers based on colouration patterns, presence around shallow waters and sometimes around fishing nets. The species is referred to as *Kuttiyandi* following a traditional myth. In the story, *Kuttiyandi* (a god or demigod) made a ring out of clay and threw it into the water, asking the dolphins to search for it. It is believed to this day, that the dolphins have been searching for the ring. Interestingly, the ring searching behaviour explained by fishers in their stories coincides with crab-feeding behaviour of humpback dolphins. Humpback dolphins, according to fishers, are known to nudge muddy bottom to forage on crabs forming circular mud plumes on the water surface. In both north Tamil Nadu and Andhra Pradesh, humpback dolphins are known for depredation of small forage fish from fishing gear, thus damaging gear, but there is no animosity in the region toward the species despite the heavy losses incurred by fishers. However, a marked conflict is evident in the southern regions of Tamil Nadu, where a similar behaviour is present.

The greatest number of records of live/dead strandings due to fishing gear entanglement and bycatch is reported for the state of Tamil Nadu.

Older fishers from the region have reported frequent depredation of their fish catch by humpback dolphins, but these encounters seem to be on the decline, probably related to decline in dolphin presence itself (R. Muralidharan, unpublished data). Fishers seem to attribute this decline over time to the collapse of nearshore fisheries, usage of destructive fishing gear and lack of river flow into estuaries (R. Muralidharan, unpublished data).

Artisanal fishers in Tamil Nadu indicate that entanglement of humpback dolphins occurs only in large mesh, multifilament gillnets (R. Muralidharan, unpublished data) but they prefer to forage around small mesh size monofilament gillnets, as this gear type catches a preferred size of fish. We assume that if entangled, humpback dolphins can break free from small mesh monofilament gillnets as also reported by fishers in Kerala (Panicker and Sutaria, 2013, submitted).

5.1.2 Kerala

Humpback dolphins are commonly seen in Kerala waters. Locally they are known as "*kadal panni*" (sea pig). The name seems to have stemmed from two sources, one from the behaviour by which the dolphins dig up the sea floor with their snouts (much like pigs do) and the second one being the similarity of taste between pork and dolphin meat.

Observations of fishers in the region were collected by interview survey during 2012–2013 (Panicker and Sutaria, 2013, submitted; see Table 1). Average number of years of fishing experience was 32.43 years $\pm$ 1.47 (SE) for fishers in this region. Fishers observed that dolphins were found in groups within the estuary throughout the year, with higher usage seen in summer and pre-monsoon months. Fishers told us that dolphins often came close to the nets in the estuary, but mostly did not directly interact with their nets. Those using cast and Chinese dip nets said that the dolphins were a useful ally because they chased fish toward the shore and into their net resulting in higher catch (see also Bijukumar and Smrithy, 2012). It was reported that, very rarely, dolphins removed fish from the nets (bit fish off of the nets) in the estuary. However, fishers said that in coastal waters, stealing behaviour by dolphins was more frequently observed especially by older individuals (ones which were heavily pigmented), often resulted in huge losses. Fishers seemed to think that higher abundance of preferred fish species in the estuary might be one reason for decreased conflict in the estuarine waters. Deterrence of "stealing" behaviour was attempted by introducing dolphin excluder nets, fishers entering the water or by using

fireworks illegally to scare the animal away (D. Panicker, D. Sutaria, personal observations). Excluder nets have also been used in Calicut, where it has been popular among ring net fishers (Sivadas and Pradeep Kumar, 2009). The effectiveness of the excluder nets over time is yet to be assessed. Fisher associations have demanded insurance cover for damage done to nets by dolphins and have also suggested that the government should develop fisheries management systems that are informed by scientific research to prevent such human–dolphin conflict (Martin, 2013).

Fishers said that bycatch of dolphins rarely occurs in estuaries, and that dolphins swiftly avoid nets (Panicker and Sutaria, 2013). Fishers also said that in the rare cases that entanglement occurs, dolphins can easily break free from the monofilament gillnets. Bycatch in coastal waters was considered more frequent. Fishers were aware of existing laws that ban consumption or landing of dolphins, and a direct fishery targeting dolphins does not exist in the region. As a result bycatch is usually discarded at sea itself. Although, one-third of fisher respondents told us that dolphins are still consumed at a local scale when accidentally caught in nets.

Although fishers were aware of the law to protect humpback dolphins, their understanding of the law varied. Some fishers perceived an increase in dolphin abundance due to the absence of hunting (and lack of other predators or threats) thereby seeing the law as obsolete. Other fishers attributed decreasing fish stocks, detrimental fishing practices and pollution to a decrease in dolphin abundance.

5.1.3 Maharashtra

In Maharashtra, humpback dolphins are known to forage around small gillnets and shore seines (Jog et al., submitted). Fishers suffer monetary losses because of net damage and loss of catch (Jog et al., submitted). This is a conservation concern and has resulted in conflict between fishers and dolphins, increasing the probability of accidental entanglement and mortalities.

Along the Sindhudurg coast, fishing operations range from shore seines, nearshore gillnets, bottom set gill and cast nets to industrial trawl nets and purse seiners. Trawls and purse seiners mainly operate offshore. Small gillnets and shore seines operate almost exclusively in the narrow coastal zone. Recently, small purse nets have been introduced to the fishery in southern Sindhudurg. Seasonal longline fisheries also operate from gillnet vessels in some villages; small handheld gear, such as hook and line and cast nets are used in the shallows and in estuaries.

Fisher perceptions in Maharashtra towards humpback dolphins are negative, varying significantly across age class and gear type, and appear to be strongly influenced by type of gear used (Jog et al., submitted). Small gillnet users particularly think of humpback dolphins as a nuisance. These nets operate mainly in the shallow coastal waters (less than 20 m in depth), where the humpback dolphins are found. Dolphins often forage near, or from, the nets, damaging them in the process, earning them their local moniker "*Gada Reda*" (*Marathi*), "clumsy bull." This is a serious issue, as small gillnet fishers are generally the poorest class of fishers. Many fishers also say they believe that humpback dolphins are highly intelligent and can tell the difference between various gear and craft and also target specific fish species like pomfret and mullet (Jog et al., submitted). Many fishers have also recounted incidents where dolphins have depressed the top ropes of shore seine nets and vaulted over to escape after foraging from these nets (Jog et al., submitted).

The younger generations of fishers who are actively involved in dolphin-based tourism are more tolerant of these dolphins, while older fishers generally have a negative attitude toward the dolphins. Older fishers have spent more time using non-mechanised boats, which may lead to a greater area overlap with humpback dolphins. The advent of engines allowed the younger fishers to move beyond the range of this species. In addition, the older generation of fishers used hand-woven nets, which were easily torn and were labour intensive and expensive to repair. These negative interactions led to deliberate killing of these dolphins. The carcasses were used for bait, oil (tallow) and fertiliser. Flukes were used to claim a bounty from the government until 1966 (Jog et al., submitted).

Perceptions toward these dolphins were affected by the frequency of interactions and area overlap with fishing (Jog et al., submitted). Fishers in the northern part of Sindhudurg district (Sarjekot to Vijaydurg) are mainly engaged in large gillnet, purse seine and trawl fisheries. This gear is generally used outside the dolphins' range (<20 m depth) and the fishers mostly encounter humpback dolphins only while exiting or entering harbours. Fisher perceptions in this area are therefore influenced largely by depth-based resource partitioning, thereby minimising negative interaction (Jog et al., submitted).

5.2 Coastal Development

People use coastal ecosystems for various purposes such as food production, economic benefits, tourism and defence. Nearly 50% of the world's

population lives in coastal areas, this number is steadily increasing, especially in developing countries such as India (Creel, 2003). India has 0.25% of the world's coastline and supports 11% of the global population, housing some of its largest cities such as Kolkata, Mumbai, Chennai, Kochi and Vishakhapatnam (around 250 million people live within 50 km of the coastline; http://www.moef.nic.in/downloads/public-information/Notice_ICZM.pdf). The unplanned and unprecedented rise in large-scale development activities along the Indian coastline has prompted an increase in industry, especially near major ports (Rodriguez and Sridhar, 2010). Physical barriers such as seawalls and breakwaters have increased coastal erosion, especially in states like Kerala. Ports, along with associated manufacturing and processing, affect about 45% of the Indian coastline (Lakshmi et al., 2012). Twelve major ports and 200 non-major ports dot the coastline of India with more proposals being made on developing new or expanding existing ports (www.shipping.nic.in). Often the areas selected for port building and other large-scale developmental activities are medium- or large-sized estuaries due to their sheltered nature and better accessibility (Rodriguez and Sridhar, 2010). The increase in habitat modification accompanying development, and the preference of humpback dolphins for sheltered bays and estuaries, makes it critical to understand the impact of development in the region. Jefferson et al. (2009) have studied the impacts of similar large-scale development on *S. chinensis* in Hong Kong. In India, such studies are wanting and the impacts of coastal development on humpback dolphins are poorly understood.

Panicker and Sutaria (2013, submitted) compared ports of differing sizes, Neendakara port (Ashtamudi estuary), Munambam port and Kochi port, and explored habitat use and behaviour at a macro-scale. Time activity budgets of humpback dolphins in the estuarine ports showed that dolphins spent the majority of their time in foraging and related activities in all three estuaries, highlighting the importance of the estuaries as feeding grounds. No time was spent milling (or resting) in the major port of Kochi (greater human activity), whereas milling was observed in both of the other ports included in the study (Figure 2; Panicker and Sutaria, 2013, submitted). A higher proportion of travelling was also seen in the major port, suggesting increased movement within the estuary. Although immediate behavioural responses were not quantified for this study, temporary displacement due to heavy boat traffic was observed several times (Panicker and Sutaria, 2013, submitted).

Further examination on the effect of boat traffic on humpback dolphins within the major port indicated that there was no spatial avoidance due to the presence of boats (Figure 3; and see Panicker and Sutaria, submitted).

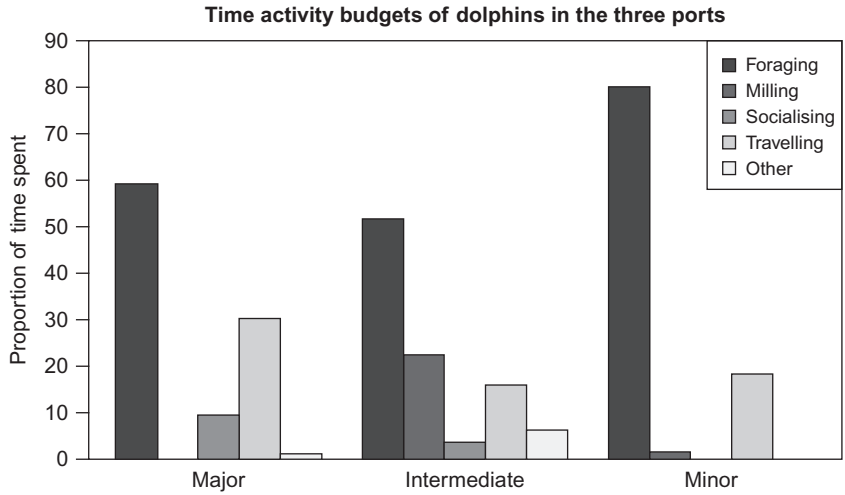

Figure 2 Time activity budget of humpback dolphins (genus *Sousa*) across the three ports (Munambam, Ashtamudi and Kochi estuaries) in Kerala. *From D. Panicker (unpublished data).*

Figure 3 Map of vessels and humpback dolphins (genus *Sousa*) in the Cochin estuary in 2012–2013. *From D. Panicker (unpublished data).*

However, immediate behavioural responses that were not quantified here, would better explain some of the habitat use patterns exhibited by humpback dolphins. Dolphins may be adapting behaviourally to increased vessel traffic through strategies such as increased dive intervals and temporary displacement, which may in turn reduce foraging effectiveness and have long-term impacts on fitness and survival.

With the lack of detailed studies on the impact of habitat degradation on humpback dolphins, it is important to adopt a precautionary approach for conservation efforts. The known habitat requirements and conservation of the species must be included in the policy-making process and relevant legal frameworks. For example, environmental impact assessments (EIAs) of coastal projects must account for humpback dolphin presence/absence. From existing studies and anecdotal reports, it is clear that this species is found throughout the east and west coasts. In areas where local distribution data are lacking, studies should be commissioned to ascertain the same. For example, the EIA of the proposed Vizhinjam port in southern Kerala does not mention humpback dolphins (http://www.vizhinjamport.in/eia-30-5-13.php), despite the fact that the port will be situated close to estuaries and that humpback dolphins have been recorded in the region (Sutaria and Jefferson, 2004).

The Tamil Nadu coast has experienced coastal erosion at several locations, mainly from coastal development activities, like the building of sea walls and harbours (Lakshmi et al., 2012). A number of thermal power plants and shipping harbours have been proposed for the coast (Rodriguez and Sridhar, 2010). Reduction in river flow in the numerous estuaries along the coast, along with constant dredging activities, has led to siltation and to the degradation of mangrove areas (Blasco and Aizpuru, 2002) and suitable humpback dolphins habitat along the coast.

Interviews with small scale, artisanal fishing communities along Tamil Nadu coast have shown that people have observed a massive decline in fish catch, which fishers attribute to nearshore trawling and small mesh size purse seining operations in the region. Interviews along the Andhra Pradesh coast in Godavari and Krishna river estuaries show stark differences in coastal development activities between these two areas. For instance, the depth of Gaderu river estuary in Kakinada, East Godavari district, was about 25 m deep before an industrial complex was set up there almost 15 years ago; however, the present depth is around 3 m and fishers say that one can walk across Gaderu river estuary during low tide. Fishers say that in the past humpback dolphins were common in the area, but have not been observed entering into the Gaderu estuary for the past 10 years. In contrast,

fishers in Krishna estuary have observed an increase in humpback dolphin numbers over recent years. There are no major industries, other than vast aquaculture farms around the Krishna estuary.

5.3 Dolphin-Watching Tourism

Nature-based tourism is an increasing global phenomenon, growing rapidly in developing countries as a form of alternate livelihood. Forty-four communities from 19 countries benefit from whale watching in south and south-east Asia. Worldwide, 106 countries and 495 communities are known to earn income from the whale-watching industry (Hoyt, 2001, 2005).

In India, only two species of marine cetaceans are currently the focus of the dolphin-watching industry. These are humpback dolphins and Irrawaddy dolphins, *Orcaella brevirostris*, the latter limited to Chilika Lake, Orissa. The dolphin-watching industry is a locally developed cottage industry creating an opportunistic source of income. Dolphin watching on the west coast is common along Goa and Karnataka, Sindhudurg in Maharashtra and in Cochin and Varkala, Kerala. The proximity to shore, accessibility and prior knowledge of fishers regarding locations where dolphins are commonly sighted, offers an advantage to the growth of humpback dolphin watching in India. However, there is very little information assessing the sustainability of the industry. Research must be conducted to better inform policy in India and to show that alternate livelihoods with a community-driven conservation strategy in place can be sustainable.

To assess the importance of dolphins and tourism, data were collected from two groups of stakeholders: tourist operators who are also fishers and tourists (Sule et al., 2015). Managers and members of locally run dolphin associations were interviewed to understand how they operate and how the industry has grown over recent years. A content analysis of logbook data and interviews with tourists was done to better understand the value of the industry. Questionnaire surveys with fishers involved in tourism were completed to document fisher perceptions towards tourism and dolphin conservation (Sule et al., 2015). Boat surveys are also underway to assess the effect of dolphin watching on the behaviour and health of the dolphin populations being targeted (Sule et al., 2015).

5.3.1 Kerala

Kerala is an important tourist destination. Dolphin watching has been advertised in various tourist areas such as Varkala, Kochi and Ashtamudi. Medium- and small-sized motorboats and speedboats are used for dolphin

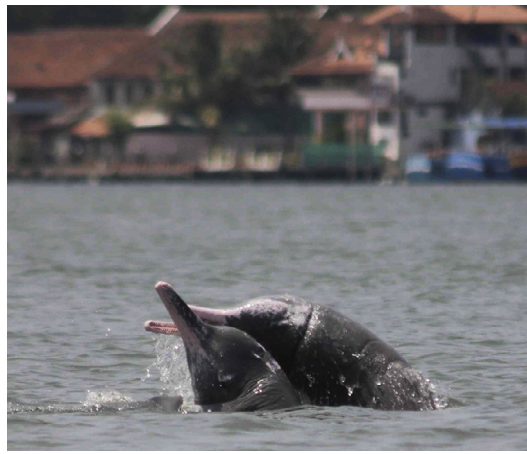

Figure 4 Two adult humpback dolphins (genus *Sousa*) and a calf socialising in Kochi Harbour. *Photograph by Divya Panicker.*

watching (Figure 4). Tour operators promise a high likelihood of dolphin sightings with some operators currently giving cash-back (50%) or repeat trips in case of no sightings. The tourism industry in Kerala has not been studied. It is critical to do so before an exclusive dolphin-watching industry is formed to ensure necessary regulations are in place.

5.3.2 Sindhudurg

Tourism as an industry alternate to fisheries has flourished in Sindhudurg, Maharashtra since 2005 (Chakravarty, 2003; Chakravarty et al., 2008). Many home stays and restaurants have turned into a full-fledged industry based on dolphin watching. Tourism activities here are still localised with a few major fishing villages such as Devbag and Tarkarli dominating the dolphin-watching industry. A few tours operate from Medha Nivati, Sagareshwar, Sagatirth, Shiroda Velagar and Aravli Velagar. Talashil has a budding dolphin-watching industry, but the frequency of tourists coming here or of dolphins being seen seems to be very low (Jog et al., submitted). There are a total of 26 tourism units, from Talashil in the north to Shiroda in southern Sindhudurg, where dolphin tours operate. Tarkarli and Devbag see maximum tourist traffic out of all other areas. There are about 15 tourism units in this region with about 300–350 boats operating (for tours) (Jog et al., submitted). November to January and March to May are peak seasons. Based on projections from one tourism unit in Devbag (an association with 52 boats registered under it), each boat makes about

US$2000 per year (Jog et al., submitted). Other places south and north of Malvan have seven small-scale tourist outlets, most of them developed in the past 3–5 years (Jog et al., submitted).

The advent of dolphin-based tourism has led to increased awareness about the presence of cetaceans in this area among the locals as well as tourists, but most of the tourism operators are misinformed about these animals (Jog et al., submitted). In light of the diminishing fishing industry, humpback dolphins have emerged as the new cash source of income for the fishers. This change in attitude of the younger generation and dolphin tourism operators seem to be a good omen for cetaceans in this area. This potential amity of the younger generation towards cetaceans can be tapped for engaging them in community led conservation endeavours. However, this new industry may also introduce unforeseen threats into dolphins' habitat.

Recently, water sports have gained widespread popularity in this region. Most tourist sites offer sports activities like jet ski rides, "banana boat" rides and parasailing in addition to dolphin-watching tours. These high-speed vessels operating in the shallows pose a great risk of boat strikes for humpback dolphins, and the engine noise generated may pose a new set of threats for the dolphins.

5.4 Noise

Vocal repertoire and communication behaviour of humpback dolphins in Indian waters has not been well studied. Because these dolphins are the focus of developing dolphin-watching industries in a few areas and are impacted by habitat degradation, it is essential to gauge how increased ambient noise in the marine environment will affect these animals. Studies on humpback dolphins in Australia and Hong Kong have shown that communication is affected by vessel traffic and boat noise (Sims et al., 2012b; Van Parijs and Corkeron, 2001a,b; Wang et al., 2013).

Recent observations of humpback dolphins along the Sindhudurg coast as well as Cochin harbour have indicated that dolphins forage and socialise within areas of high disturbance and stress, instead of abandoning these areas (Panicker and Sutaria, submitted) If vessel noise leads to auditory masking, individuals may alter vocal behaviour to compensate (e.g. Sims et al., 2012a).

Developing coastal infrastructure and increasing vessel traffic have a heavy overlap with the habitats of these dolphins. Hence there is a need to study the effect of noise as a source of habitat degradation and its effect on the acoustic behaviour of these animals. In May and October of 2014, opportunistic

passive acoustic monitoring (PAM) data were collected using an SQ26-MT hydrophone (Cetacean Research Technology), during two sets of visual surveys along the Sindhudurg coast (Sule et al., 2015). Both clicks and whistles were recorded. Whistles were recorded during socialising, as well as foraging states, as observed in other humpback dolphin populations (Van Parijs and Corkeron, 2001b). Further analysis of these and other data are required to better understand the impacts of various sources of anthropogenic noise on humpback dolphins.

6. CONSERVATION AND MANAGEMENT

Humpback dolphins are common residents of the Indian coastline. The paucity of research in the past has also been reflected in a lack of specific conservation or policy measures designed towards protecting humpback dolphins or their habitats in Indian waters. Although the Wildlife Protection Act (WPA 1972) gives at least nominal protection to all cetaceans in Indian waters, there is no provision for detailed protection on any particular species.

Furthermore, the enforcement of laws is poorly developed. The forest department, marine police and coast guard are in charge of monitoring the bycatch or disturbance to cetacean species. The training, if any is given, to these departments to carry out such tasks are unclear. A complete ban on hunting cetaceans is in effect across all the major harbours in India (as per WPA 1972). Fishers all along the coast are well aware of the law and mostly refrain from bringing any dead cetaceans to the harbours, fearing conviction. However, landings in remote areas along the coast (especially by artisanal fishers) are unmonitored and regulation without community support would be difficult. At present there are no targeted conservation efforts for this species by the government or the local community.

Dedicated conservation-oriented studies on humpback dolphins have only just begun in India. Effectively monitoring habitat used for foraging and other important life functions can help facilitate appropriate conservation efforts (Bailey and Thompson, 2009; Markowitz et al., 2004; Pirotta et al., 2015). Recently initiated work includes programmes to estimate population size and calculate trends using mark-recapture analysis in Maharashtra (by the State Forest Department in conjunction with the United Nations Development Program), to monitor the intensity of operational interactions with fisheries and the influence of fisheries on foraging strategies and group dynamics in Maharashtra and Kerala, a PAM study in Maharashtra, a study on interactions between fishing gears and dolphins in Kerala, and a study of

fisher perceptions and boat surveys to study movements and habitat use in relation to coastal development in Tamil Nadu. Novel methods, such as those involving PAM, can provide important data on ambient noise, spatial and temporal data on foraging and other activities and on communication without causing disturbance (Richardson et al., 1995).

Finally, given the overlap of humpback dolphin habitat with intense human activities in the coastal waters of India, it is vital to have a specific legal framework pertaining to humpback dolphins, particularly with regulations regarding the major threats as we currently understand them: dolphin-watching tourism, large coastal development projects and fisheries interactions.

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