Occurrence of whales and dolphins in Pakistan with reference to fishers' knowledge and impacts

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ABSTRACT

This paper reports the findings of a project (Cetacean Conservation Pakistan) launched in 2004 with a view to: (a) undertaking quantitative surveys to determine the variety and abundance of species present; (b) working with local fisher communities to collate local knowledge and promote public awareness; and (c) promoting a marine cetacean conservation strategy and measures. Boat-based surveys for live animals and shore surveys for beachcast specimens have confirmed the presence of twelve species of whale and dolphin. Among these bottlenose dolphins (*Tursiops* sp.) occur both inshore along the coasts of Sindh and Balochistan, and offshore in parts of Balochistan; these two populations possibly representing different sub-species. Indo-Pacific humpback dolphins (*Sousa chinensis*) are common inshore around the mouth of the Indus Delta and in large sheltered bays in Balochistan, where finless porpoise (*Neophocaena phocaenoides*) also occur. Spinner dolphins (*Stenella longirostris*) were observed in very large schools (up to 2,000) around the shelf edge in eastern Balochistan, as were Risso's dolphins (*Grampus griseus*) in smaller numbers. Common dolphins (*Delphinus capensis*) were recorded even further offshore. There were two sightings of humpback whales (*Megaptera novaeangliae*), and one of a killer whale (*Orcinus orca*). Bryde's whales (*Balaenoptera edeni*), sperm whales (*Physeter macrocephalus*) and Cuvier's beaked whales (*Ziphius cavirostris*) were recorded only during beach surveys, while skeletal remains in institutions also supported the occurrence of blue whales (*Balaenoptera musculus*). Work with local fisher communities supported this picture of species distribution and provided information on threats to local cetaceans. These are principally occasional entanglement in fishing gear and opportunistic exploitation for use as food, as bait, as medicine or for other purposes. The project incorporated policy development and the preparation of a marine cetacean biodiversity action plan that included the listing of species in provincial conservation legislation, the designation of a marine protected area in Balochistan, the establishment of a national whale and dolphin conservation society, and trials of whale and dolphin watching as a means of raising public awareness and providing alternative economic value.

KEYWORDS: ABUNDANCE ESTIMATE; ARABIAN SEA; KILLER WHALE; BRYDE'S WHALE; SPERM WHALE; CUVIER'S BEAKED WHALE; BLUE WHALE; BOTTLENOSE DOLPHIN; CETACEANS; CONSERVATION; FINLESS PORPOISE; FISHERIES INTERACTION; HABITAT; RISSO'S DOLPHIN; COMMON DOLPHIN; INDO-PACIFIC HUMPBACK DOLPHIN; HUMPBACK WHALE; INCIDENTAL CATCHES; INDIAN OCEAN; SPINNER DOLPHIN; SURVEY-SHORE-BASED; SURVEY-VESSEL

INTRODUCTION

Scientific background

Until now there has been little information available on the identification, distribution and relative abundance of cetaceans occurring in the Pakistani portion of the Arabian Sea (NW Indian Ocean). Some reviews have indicated the species most likely to be present (e.g. De Boer *et al.*, 2002; de Silva, 1987; Roberts, 1997), while reports arising from illegal Soviet whaling off Pakistan during the 1960s (when 164 humpback whales were killed off Pakistan between late-October and mid-December over a three year period) indicate that significant, previously unstudied populations of humpback whales (*Megaptera novaeangliae*), blue whales (*Balaenoptera musculus*) and sperm whale (*Physeter catadon*) might be present (Mikhalev, 1997; 2000).

In addition, there have been various reports of incidental sightings or strandings. Ahmed and Rizvi (1985) reported a humpback whale caught off Port Qasim on the Sindh coast, as well as records of humpback dolphins (*Sousa plumbea*), long-beaked common dolphins (*Delphinus capensis*) and melon-headed whales (*Peponocephala electra*) off Sonmiani, Balochistan. Ahmad and Ghalib (1975) collated reports of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*), Indo-Pacific humpback dolphins, finless porpoises (*Neophocaena phocaenoides*), blue whales, fin whales (*B. physalus*) and sperm whales from along both the Sindh and Balochistan coasts. Roberts (1997) reported a Bryde's whale (*B. edeni*) sighted off Las Belas, Balochistan, and a dwarf sperm whale (*Kogia sima*) sighted off the Indus Delta, Sindh province. A pygmy sperm whale (*K. breviceps*) was reported off Sonmiani (M. Khan and S.H.N. Rizvi, pers. comm). In addition Pilleri and Gihr (1972a; 1972b), on visiting coastal areas to search for cetacean remains, found four finless porpoises, seven humpback dolphins, five common dolphins and a bottlenose dolphin; they also found a vertebra that they suggested belonged to a Cuvier's beaked whale *Ziphius cavirostris* (see Gore *et al.*, 2007b for discussion). Similarly, until recently no systematic surveys of cetaceans had been conducted off the coasts of Pakistan's neighbours – India (Afsal *et al.*, 2008) and Iran (Braulik *et al.*, 2010a).

As noted by Kumarran (2002; 2009) a lack of data regarding threatened species invariably weakens national biodiversity policies. Thus in Pakistan, Rizvi *et al.* (1995) concluded there was inadequate information available on small cetaceans in Pakistan's Indus Delta region and called for detailed assessments to facilitate the preparation of species action plans. More recently such information has again been required in support of Pakistan's National Conservation

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Strategy and Biodiversity Action Plan. Accordingly the research reported here was undertaken between 2004 and 2009 in order to determine the identity, relative abundance, habitats, seasonality and association patterns of cetaceans occurring in the coastal waters of Pakistan.

Fishers and cetaceans

The territorial waters of Pakistan are included in the Indian Ocean Sanctuary, which was established in 1979 to protect whales from hunting. It should however be noted that this protection does not extend to dolphin species and that all cetaceans in the region remain susceptible to mortality or injury from non-targeted fishing activities. In this context, an early concern for this project was that Pakistan had greatly increased its export of fish in recent years (Marine Fisheries Department, 2006), an indicator of considerable intensification of fishing activities. As well as potentially diminishing the availability of food for cetaceans, increased fishing readily leads to increased cetacean bycatch, and perhaps also increased numbers of boat strikes (Niazi, 1990). On a global level Northridge (2002) concluded that porpoises (Phocaenidae) often entangle in gillnets, while dolphins are widely caught in pelagic trawls and purse seine nets, as well as on hooks. Reeves *et al.* (2003) suggested that local declines in small cetaceans are most usually due to increased vessel activity and intensification of fisheries. In Pakistan a variety of fishing vessels from 6–8m long *tony*, *katti* or *hori* to 15–25m trawlers are used nearer the coast, while offshore larger gill-netters and trawlers operate (Marine Fisheries Department, 2006). These different vessels deploy a very wide range of gear, including drift nets (2 types), bottom set gillnets (3 types), surround gillnets (4 types), encircling nets (like seine nets, 4 types) and trawl nets (3 types), as well as trap nets (5 types), pots (2 types), hand lines, long lines (3 types), and jig lines (2 types) (Hussain and Amir, 2006). Hence there is considerable scope for unintentional injury or bycatch of cetaceans, as well as a potential for deliberate targeting, which has already been reported as occurring to some degree in Pakistan (Niazi, 1990).

Thus in 2004 a project (Cetacean Conservation Pakistan) was launched with a view to: (a) undertaking quantitative surveys to determine the variety and abundance of cetaceans present in Pakistani waters; (b) working with local fisher communities to collate local knowledge of both cetacean occurrence and fishers' interactions with them; and (c) promoting public awareness of cetacean issues and developing a strategy and measures for securing cetacean conservation. As with other taxa, the extent to which effective conservation can be achieved depends on the attitude of key stakeholders, including most critically in this case local fishers; thus this work was also undertaken with a view to encouraging fishers' and wider community support for conservation measures. This paper reports the results of that project.

METHODS AND STUDY AREA

Study area

Pakistan has two coastal provinces with contrasting coastlines (Majid, 1988). The Balochistan or Makran coast bordering Iran in the west extends for about 800km, and is dominated by large rocky cliffs interspersed with long sandy shores. The continental shelf varies in width from about 3km (by Gwadar in the west) to 73km (by Hub River in the east), beyond which the shelf edge drops rapidly to 1,000m and then deeper to the Oman Abyssal Plain. By contrast the Sindh coast, which extends for 250km bordering India in the east, is dominated by sandy-muddy shores with innumerable creeks and deltaic tributaries often colonised by mangrove forest (Meynell, 1999; Quraishee, 1988). It has a broader continental shelf, ranging from about 77km wide by Karachi to 160km wide near Kori Creek mouth, except where a narrow trench 'The Swatch' that reaches 200m deep, extends shorewards in the southern part (see Fig. 1). The salinity along the Karachi coast ranges from 35.5 to 36.9ppt, but can reach 41–42ppt in tidal creeks (Ahmed and Rizvi, 1980). Oxygen levels are normally 4.0–4.5ml^{-1} in the well mixed zones, but levels as low as 1.5ml^{-1} can occur in shallow areas during the SW monsoon (Haq *et al.*, 1978). Tides are semi-diurnal with a range of about 3.5m.

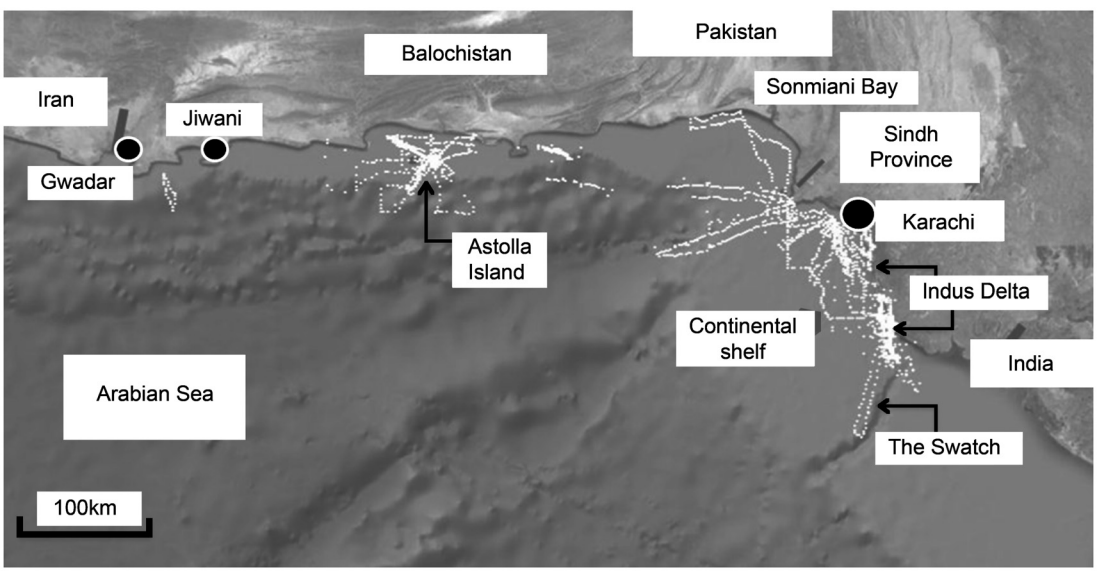

Fig. 1. Morphological and bathymetric map of the Pakistani coast and adjacent marine areas showing the regions and locations mentioned in the text together with, as a series of white dots, the majority of tracks generated during boat survey work (each dot representing a GPS location recorded during a survey).

Coastal weather contrasts sharply between NE and SW monsoon periods, which occur during November to February and June to September respectively, being separated by shorter Spring and Autumn Inter-monsoonal Periods (Kidwai and Amjad, 2000). The SW monsoon is characterised by greater wind speeds (*ca*. 25kt as opposed to <10kt) that extend water mixing below the thermocline (Wyrtki, 1973) and produce extensive upwelling over a variable portion of the central Pakistan coast (Quraishee, 1988). This results in increased nutrient availability and high plankton biomass values (Qasim, 1977; Smith, 1988), although pelagic fish including mackerel, sardine and anchovy also occur along the coast during the NE monsoon (Majid, 1988).

Methods

Surveys to assess the abundance of cetaceans were conducted: (a) by boat; (b) by foot along the coastline; and (c) by interviewing fishers. Species identification guides used included Jefferson *et al.* (1993), (Perrin *et al.*, 2008) and Reeves *et al.* (2002), with a simpler identification leaflet being produced for distribution to fishers and the interested public.

Boat-based cetacean surveys

A total of 63 days of transect surveys for cetaceans were conducted by boat between 16 November 2005 and 11 December 2009. Surveys were conducted both inshore and offshore along different sections of coast, and in every month except July and October (Table 1); they were however more frequently undertaken during the NE monsoon than the SW monsoon or the inter-monsoon periods, since sea conditions are much more favourable at that time. Due to varying location and vessel availability several different platforms were employed, including a 12m fishing launch (used for longer surveys or further offshore), 5m wooden 'horas' (used largely in the Indus Delta area), and a 5m rigid inflatable boat (used both in the Indus Delta and along the coastline under more predictable conditions). Only single observation areas were available on each boat giving observer eye heights above the water of 2.5, 1.7 and 1.7m respectively.

During surveys data were collected on effort, species occurrence, relative abundance, behaviour and groupings (Ballance *et al.*, 2001; Weir *et al.*, 2001) in relation to four marine habitat zones: near shore (0–50m depth); continental shelf (50–200m depth); shelf edge (>200–1,000m depth) and pelagic (>1,000m depth). For a combination of logistical and security reasons it was not feasible to survey the whole study area either homogenously or through a random sampling design (for discussion of this issue see Cañadas *et al.*, 2002). Instead courses were pre-selected: (a) to cover as much as possible of the full length of the coast largely within sight of the shore; and (b) in selected sections to cover different marine zones by surveying along transects perpendicular to the depth contours (see Dawson *et al.*, 2008) (see Fig. 1). Normally surveys were initiated only when sea-state was equivalent to Beaufort wind scale force 3 or less with accompanying swells of 0.5m or less, and in weather conditions where there was little or no rain, and good or excellent visibility. Boat surveys were normally carried out over full days, with the earliest time that a survey commenced being 06:57 and the latest that one ended 19:24. Survey effort was measured as the distance (km) travelled per day with the length and route of the survey track being logged using a handheld Garmin GPS unit.

During surveys a 3-person observer team was stationed forwards on the vessel. Two scanned the water to the horizon with both the unaided eye and 7 × 50 binoculars, one observer sweeping an arc from the bow to beam on the port side, and the other likewise to starboard. The third member of the team acted both as recorder and between-times as a back-up observer. To avoid tiredness or eyestrain observers rotated their role every half hour, with each being replaced by another crew member and taking a full rest after every 1.5hrs on watch. 'Closing-mode' was adopted (Dawson *et al.*, 2008) with the search along the transect route being maintained until one or more cetaceans were sighted, at which point the vessel's course was changed to approach the animals for closer observation. At the end of the sighting, the survey track was regained at the point of departure. Data collected during sightings included: location; distance and bearing from boat at first sighting; time of day; species; group size (minimum/maximum/best estimate); group composition (adults/female and young/mixed age group); direction of travel; and observed behaviour (surface active/feeding/travelling/social interaction/interaction with vessels).

Otherwise, the following data were logged by the team recorder at ten minutes intervals throughout the duration of the survey: sea-state; apparent modal swell height in meters; speed and heading of boat; and latitude and longitude as determined by GPS. Weather conditions including wind strength (Beaufort scale) and direction, cloud cover and visibility were recorded hourly. Boat survey speed was 8–15kt [15–25km h^{-1}] dependent upon sea conditions and boat type. In addition to sightings of cetaceans, all piscivorous seabirds to a distance of 250m were recorded, as were all passing vessels to a distance of *ca*. 10km, for their potential influence on cetacean occurrence. Mean sea state was 1.8 in Sindh and 1.9 in Balochistan, with mean swell heights being 0.33 and 0.40m respectively. Mean air temperature was

Table 1

Days of boat-based survey undertaken by month, season and province (NE = northeast monsoon; IMS = spring inter-monsoonal period; SW = southwest monsoon; IMA = autumn inter-monsoonal period).

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Season	NE	NE	IMS	IMS	IMS	SW	SW	SW	SW	IMA	NE	NE	Total
Sindh	1	0	3	4	4	1	2	2	2	0	7	12	38
Balochistan	3	18	1	0	0	0	0	0	0	0	2	1	25
Total	4	18	4	4	4	1	2	2	2	0	9	13	63

slightly higher in Balochistan than in Sindh (25.6°C vs. 23.2°C), but mean sea surface temperatures were similar (24.1°C vs. 24.0°C). During boat-based surveys numerous small fishing vessels were recorded in both provinces, but large cargo vessels and tankers were observed only in the Near Shore zone of Sindh. No military or seismic survey vessels were observed at any time.

In addition to sightings of cetaceans made while on-effort, other sightings made during transit at higher speed, during breaks, or in closing mode during surveys, were also recorded. The data on distance and bearing of first sightings have not yet been analysed to give estimates of absolute population density, but the numbers of individuals sighted per km of trackline has been used to provide a measure of relative abundance and distribution across the study area (Weir *et al.*, 2001). The data were analysed in relation to species type, abundance and grouping patterns, province, season, marine habitat type and human activity present. A general linear model was used to assess the statistical significance of trends, with the Unequal *N* Honest Significant Difference test being used as a *post hoc* test.

In addition to data from the above boat-based survey work, unpublished data from boat-based observations undertaken during an offshore seismic survey for gas and oil were provided to the authors and have been incorporated in the present study with the permission of those concerned (Pickering, 2004). This survey work took place in 320–1,300m of water approximately 190km offshore of Sindh between 11 October 2003 and 13 December 2003, in an area of 5,147 km^2 bounded by the points 23.70°N 66.62°E to the NW, 23.68°N 66.10°E to the NE, 23.42°N 65.62°E to the SW and 23.40°N 66.10°E to the SE. There was a single observer present throughout the daylight period who had a 180° view at 15.3m height on the bridge of a 86.9m vessel. A continuous scan was made by both unaided eye and binoculars and distance to the cetaceans was estimated. The total watching time was 746h, of which 452h 39min was during gun firing.

Shore-based surveys for beachcast specimens

A band transect method was used to survey beaches for beachcast cetaceans or their remains. Teams of surveyors walked in line abreast the full length of each beach with individual surveyors being placed approximately 4m apart, so that each observer carefully scanned 2m to either side, looking for signs of skeletal or other remains. On wider beaches the team covered the remaining width of the beach on the return journey. Observers noted their location (latitude and longitude) every ten minutes. When remains were found the date and time, the species of cetacean and condition (state of decomposition if recently dead) were also recorded and skeletal specimens and where possible tissue samples taken. Those sections of coast not surveyed were generally those that were either difficult to access, or where government permission to work the area was withheld for security reasons.

To complement field surveys and involve local communities, a community reporting scheme was established, with fishers, senior villagers and other personnel located on the coast being requested to alert the research team in the event of any stranded or beachcast cetaceans being found. When dead specimens were encountered, body measurements and photographs were taken, and samples of tissues and teeth recovered and preserved. The authors also visited several institutions (including non-scientific ones) where cetacean skeletons were housed or on display to take measurements and check species identification.

Fisher community-based surveys

Fishing communities along the full length of the Pakistan coast were visited both to sample local knowledge through interviews with fishers, and to explain the work of the team to local people. The methods used were guided by the experience of community-surveys undertaken elsewhere (developing countries: Aragones *et al.*, 1997; the Caribbean: Grant and Berkes, 2007; the UK: Howard and Parsons, 2006; Kenya: McClanahan *et al.*, 2005; Indonesia: Teh *et al.*, 2005). A simple questionnaire was designed and used to interview a sample of fishers in each community, along with a pictorial guide to the cetacean species likely to be present, copies of which were distributed in each community. In Sindh, 197 interviews were carried out (by BH) in 46 communities between 5 December 2005 and 12 July 2008, and in Balochistan, 105 fishers were interviewed (by UW) in 28 communities between 6 March 2007 and 30 April 2008. In addition approximately 50 fisher community leaders were invited to a workshop in each province; at each further information and feedback on project findings were provided and wider issues relating to cetacean conservation discussed.

RESULTS

Boat-based cetacean surveys

Species overview

The species recorded during boat surveys were humpback whale, Risso's dolphin (*Grampus griseus*), killer whale (*Orcinus orca*), humpback dolphin, spinner dolphin (*Stenella longirostris*), bottlenose dolphin (*Tursiops* sp.), and finless porpoise (Table 2). The most numerous species observed was spinner dolphin, which was more abundant in Balochistan than in Sindh (GLM Genus by Province: $F_{(6,518)} = 3.76$, $p = 0.001$), and also more numerous than any other species (as shown by post-hoc tests). Excluding spinner dolphins, statistical analysis showed no significant difference in relative abundance between species or between provinces (GLM Genus by Province: $F_{(5,449)} = 1.62$, $p = 0.15$).

Finless porpoise

Finless porpoises were observed only during the NE monsoon and Near Shore, but in both provinces (Table 2). They were recorded mainly between mid-morning and early evening (mean time = 15.14 hrs +/– 0.3hrs), and in good sea conditions (mean sea state = 0.8 +/– 0.1). In an analysis of factors including both time of day and sea state, as well as swell, depth and province, only time of day (GLM $F_{(1,20)} = 5.40$, $p = 0.031$) and sea state ($F_{(1,20)} = 11.53$, $p = 0.0028$) were significant predictors of the number of finless porpoises recorded per distance surveyed ($R^2_{adj} = 0.29$, $df_{model} = 5$, $F = 3.02$, $p = 0.034$), whereas swell ($F_{(1,20)} = 0.55$, $p = 0.5$), depth ($F_{(1,20)} = 0.24$, $p = 0.6$) and province ($F_{(1,20)} = 1.10$, $p = 0.3$) were not. Finless porpoises were observed in groups of 1–18, but were mostly encountered in small groups (mean size 2.86+/–0.5) (Table 3); Groups could be composed of adults

Table 2
Numbers of sightings and individuals of different cetacean species recorded during different zones and seasons (abbreviations as for Table 1).

Province	Genus	Season	Habitat	Total no. sightings	Mean no. sightings per km	SE of mean	Mean no. individuals per km
Sindh	Finless porpoise	NE	Near shore	23	0.054	0.008	1.251
Sindh	Bottlenose dolphin	NE	Near shore	5	0.311	0.135	1.554
Sindh	Humpback dolphin	NE	Near shore	64	0.080	0.014	5.126
Sindh	Humpback dolphin	IMS	Near shore	17	0.051	0.006	0.868
Sindh	Humpback dolphin	SW	Near shore	5	0.089	0.028	0.444
Sindh	Unidentified dolphin	NE	Near shore	10	0.024	0.004	0.240
Balochistan	Finless porpoise	NE	Near shore	12	0.064	0.028	0.767
Balochistan	Bottlenose dolphin	NE	Near shore	3	0.410	0.053	1.231
Balochistan	Bottlenose dolphin	NE	Continental shelf	2	0.121	–	0.242
Balochistan	Bottlenose dolphin	NE	Pelagic	1	–	–	0.081
Balochistan	Spinner dolphin	NE	Near shore	1	–	–	0.121
Balochistan	Spinner dolphin	NE	Shelf edge	8	5.101	2.949	40.804
Balochistan	Spinner dolphin	NE	Pelagic	3	3.404	1.668	10.211
Balochistan	Humpback dolphin	NE	Near shore	1	–	–	0.040
Balochistan	Risso's dolphin	NE	Continental shelf	1	–	–	0.141
Balochistan	Risso's dolphin	NE	Pelagic	1	–	–	2.018
Balochistan	Killer whale	NE	Near shore	1	–	–	0.202
Balochistan	Humpback whale	NE	Near shore	2	0.020	–	0.040
Balochistan	Unid. dolphin sp.	NE	Near shore	4	0.056	0.035	0.222
Balochistan	Unid. dolphin sp.	NE	Shelf edge	1	–	–	0.020
Balochistan	Unid. dolphin sp.	NE	Continental shelf	1	–	–	0.040

or a mixture of ages (Table 4), but some compositions were more frequent than others (GLM $F_{(3,31)} = 3.92$, $p = 0.017$), with groups of adults being more likely to be observed than singletons (post-hoc test $p = 0.023$). The species was found both in locations where fishing nets or traps, and fishing boats or larger ships (cargo/tankers) were present, as well as where no human activity was absent, although most often fishing boats were in fact present ($F_{(3,31)} = 3.02$, $p = 0.044$) when the species were observed.

Bottlenose dolphin

Bottlenose dolphins were observed only during the NE monsoon, when they were recorded near shore in both provinces, and in the Continental Shelf and Pelagic zones in Balochistan (Table 2). Using Model A, sea state ($F_{(1,4)} = 33.35$, $p = 0.0044$) and swell ($F_{(1,4)} = 30.34$, $p = 0.0053$) were found to be significant predictors of the numbers of bottlenose dolphin observed per distance surveyed ($R^2_{adj} = 0.79$, $df_{model} = 5$, $F = 7.98$, $p = 0.033$), but time of day ($F_{(1,4)} = 5.24$, $p = 0.08$), depth ($F_{(1,4)} = 0.20$, $p = 0.7$) and province ($F_{(1,4)} = 0.75$, $p = 0.4$) were not. Bottlenose dolphins were observed in a wide range of depths and there was no significant effect of habitat type on abundance (GLM Habitat type: $F_{(2,8)} = 1.27$, $p = 0.3$). The species was observed in small to medium-sized groups, (range 4–41, mean size 14.0 +/– 3.4), with groups sometimes consisting of a mixture of age groups (Sindh only) and sometimes of adults only. Bottlenose dolphins occurred where fishing nets/traps, fishing boats and/or cargo vessels/tankers were present, but there was no significant effect of human activity on their occurrence (GLM human activity: $F_{(2,8)} = 3.33$, $p = 0.09$).

Table 3
Total numbers of sightings and individuals, and group sizes, of each species recorded during boat surveys.

Species	Total no. sightings	Total no. individuals	Mean group size (±S.E.)	Range of group size
Finless porpoise	35	100	2.86 ± 0.5	1–18
Bottlenose dolphin	11	154	14.0 ± 3.4	4–41
Spinner dolphin	13	2,535	195.0 ± 92.6	1–1,000+
Humpback dolphin	87	321	3.7 ± 0.5	1–35
Risso's dolphin	2	107	53.5 ± 46.5	7–100
Killer whale	1	10		10
Humpback whale	2	2	1	1
Unidentified dolphin	15	25	1.7 ± 0.5	1–8

Spinner dolphin

Spinner dolphins were observed only in Balochistan during the NE monsoon (Table 2); they were encountered in Near Shore, Shelf Edge and Pelagic zones but always in relatively deep water (>300m). None of the factors included in Model A was a significant predictor of their relative abundance (GLM time observed: $F_{(1,6)} = 0.63$, $p = 0.5$; sea state: $F_{(1,6)} = 0.17$, $p = 0.7$; swell: $F_{(1,6)} = 1.86$, $p = 0.2$; depth: $F_{(1,6)} = 0.002$, $p = 0.9$). Spinner dolphins mostly occurred in very large groups of up to 1000 or more individuals (Table 3), that could be either be composed only of adults or include a mixture of age classes (Table 4), although no factors were a significant predictor of group composition (GLM $F_{(2,10)} = 0.83$, $p = 0.5$). They were sighted both in the absence of human activity and where fishing boats were present, but more were recorded when fishing boats were present than in their absence ($F_{(1,11)} = 4.33$, $p = 0.06$).

Humpback dolphins

Humpback dolphins were recorded during both NE and SW monsoons and during the spring inter-monsoon period. All sightings were in the Near Shore Zone, and all save one in Sindh (Table 2). They were observed throughout the day in waters up to 30m (mean 9.1m ± 0.7) deep with a notably wide range of sea surface temperatures (12–31°C; mean 23.1°C +/–1.2). However, none of the factors – time observed, sea state, swell, depth or weather – predicted the relative abundance of humpback dolphins (GLM time

Table 4

Frequencies of different group compositions for each species in each province (as number of sightings per 100km).

Province	Species	Single animal	Adults only	Mixed ages	Juveniles only	Mothers and young	Unknown
Sindh	Finless porpoise	0.33	0.84	0.48	0	0	0.59
Sindh	Bottlenose dolphin	0	0.84	1.50	0	0	0.48
Sindh	Humpback dolphin	1.17	3.56	3.85	1.47	0.95	0.70
Sindh	Risso's dolphin	0	0	0	0	0	0
Sindh	Killer whale	0	0	0	0	0	0
Sindh	Humpback whale	0	0	0	0	0	0
Balochistan	Finless porpoise	0.18	1.21	0	0	0	0
Balochistan	Bottlenose dolphin	2.82	0	0	0	0	0
Balochistan	Spinner dolphin	0	1.87	9.10	0	0	0
Balochistan	Humpback dolphin	0	0	0.07	0	0	0
Balochistan	Risso's dolphin	0	3.92	0	0	0	0
Balochistan	Killer whale	0	3.92	0	0	0	0
Balochistan	Humpback whale	0	0.37	0	0	0	0

observed: $F_{(1,70)} = 0.34$, $p = 0.6$; sea state: $F_{(1,70)} = 1.64$, $p = 0.2$; swell: $F_{(1,70)} = 0.02$, $p = 0.7$; depth: $F_{(1,70)} = 0.87$, $p = 0.4$: weather: $F_{(1,70)} = 0.04$, $p = 0.8$). Humpback dolphins were observed either as singletons or in groups of up to 35 individuals (mean 3.7 ± 0.5) (Table 3) composed either of adults or a mixture of different aged individuals or mothers and calves (Table 4). Mixed age groups were encountered significantly more often than singletons (GLM: $F_{(5,81)} = 5.23$, $p = 0.0003$; *post hoc* test: $p = 0.004$). The species was recorded both when nets/traps and fishing boats were present, and when these were absent, with human activity not being a significant predictor of their presence (GLM: $F_{(3,161)} = 0.36$, $p = 0.8$).

Risso's dolphin, killer whale and humpback whale

Risso's dolphins, killer whales and humpback whales were all observed only in Balochistan and only during the NE monsoon. Killer whales and humpback whales were recorded only in the Near Shore zone (in 19m and 9–11m of water respectively), while Risso's dolphins were recorded in deeper water (360–750m) in the Continental Shelf and Pelagic zones (Table 2). The humpback whale sightings were of single animals, the Risso's dolphins of medium to large size groups (mean 53.5 +/–46.5) of adults, and the killer whales were a group of about 10 adults (Table 3). The killer whales when encountered were pursuing a large group of rays under the vessel and onward, and the groups of Risso's dolphins also appeared to be hunting on both occasions. All sightings of these species were between late morning and late afternoon, but there were too few sightings of these species to draw conclusions on the influence of other environmental factors.

Seismic surveys

During cetacean observations undertaken during the offshore seismic survey both bottlenose and spinner dolphins were recorded both in shelf edge and pelagic zones, while there were single observations of Risso's dolphins on the shelf edge and of common dolphin in the pelagic zone (Table 5). Mean group size varied considerably between species, from one for Risso's dolphin (observed associated with a pod of bottlenose dolphin) to 92.3 for spinner dolphin (Table 5). Bottlenose and spinner dolphins were observed both when the seismic airgun was firing (on 7 and 6 occasions respectively) and when it was not (on 7 and 4 occasions respectively), while common dolphins were seen when the airgun was not firing (2 occasions) and the Risso's dolphin when it was (1 occasion). All cetaceans observed were adults except for one group of juvenile bottlenose dolphins and one group of juvenile spinner dolphins, both seen on the shelf edge.

Human activity

Table 6 shows the frequency with which all cetacean species combined were recorded in the presence and absence of different forms of human activity in each habitat zone. While a variety of fishing and shipping activities were common in the Near Shore Zone, in the other zones fishing vessels were the only human activity recorded. In general cetaceans were observed whether human activity was present or not, but it is noticeable that mean relative abundance tended to be slightly higher in the absence of human activity.

Shore-based surveys and strandings reports

No live strandings were found during the shore-based surveys, but the remains were encountered of 12 dolphins

Table 5

Numbers of sightings and of individuals and range and mean of group sizes of cetacean species recorded during the 2003 offshore seismic survey (abbreviations as per Table 1).

Season:	NE monsoon				Autumn IM			
Zone:	Shelf edge		Pelagic		Shelf edge			
Species	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals	Range of group sizes	Mean group size
Bottlenose dolphin	3	32	6	130	5	107	4–50	24.5 ±5 .6
Spinner dolphin	9	898	1	25			1–600	92.3 ± 49.0
Common dolphin			2	13			10–15	
Risso's dolphin	1	1					1	

Table 6
Comparison of cetacean abundances per km in different marine zones (habitats) in the presence and absence of different human activities.

Marine zone (habitat)	Type of human activity	Total no. cetacean sightings	Mean abundance of all cetaceans	Mean abundance per single species
Near shore	None	90	0.069	0.001
Near shore	Nets/traps	16	0.029	0.002
Near shore	Fishing boat(s)	39	0.044	0.001
Near shore	Cargo/tanker	2	0.001	0.001
Continental shelf	None	4	0.047	0.012
Shelf edge	None	9	8.344	0.927
Shelf edge	Fishing boat(s)	1	8.125	–
Pelagic	None	3	2.123	0.708
Pelagic	Fishing boat(s)	1	0.970	–

(six in Sindh and six in Balochistan), and of a sperm whale in Balochistan (see Gore *et al.*, 2007a). None of the dolphin specimens was in a condition to be identified *in situ*, but samples of tissue and teeth are currently being analysed to determine species and gender.

Between 2005 and 2008 a total of 57 stranded animals were reported through the strandings network (Table 7). These included in both Sindh and Balochistan, finless porpoises, humpback dolphins, bottlenose dolphins, spinner dolphins, sperm whales, and Bryde's and other unidentified baleen whales, and in Sindh only, a Cuvier's beaked whale (see Gore *et al.*, 2007a; 2007b). There were more strandings reported during the NE monsoon than in other seasons. It was observed that many of the finless porpoise had their flukes cut off. The pre-existing skeletal material located in institutions in Sindh and Balochistan mostly constituted large baleen whales, including notably two blue whales.

Fisher community-based surveys

Forty six fishing communities were identified in Sindh and 28 in Balochistan. 302 fishers were interviewed; all were male. In Sindh the men were largely of a single ethnic group, while in Balochistan there were at least 6 ethnic/language groups present. The men ranged in age from 12 to 80yrs but their distribution among age categories (<20, 20–29, 30–39, 40–49, 50–59 and 60+yrs) was similar for the two provinces (Wilcoxon Matched Pairs Test: $t = 10.0$, $z = 0.104$, $p = 0.9$, $n = 6$) and there were no significant differences between age categories in their responses (Kruskall-Wallis ANOVA by ranks: $H_{(5,N=352)} = 9.88$, $p = 0.08$). When asked about the species they encountered, the local names used and the size of groups and body sizes, most fishers identified and reported bottlenose dolphins (local name *hum*) occurring in groups of five or more, humpback dolphins (*malhar*) seen in groups of 1–10 individuals, and finless porpoises (*tabi*) seen in groups of 5–10. Whales were more frequently encountered by fishers in Balochistan than Sindh, although the four local names (*whiser, leare, leed* and *abroo*) were known in both provinces. Spinner dolphins (*goco* or *tooshunk*) were not seen often, and although common dolphins occur in both Oman (Baldwin, 2003) and Iran (Braulik *et al.*, 2010b), were not reported by fishers in either province.

Table 7
Numbers of beachcast cetaceans recorded between 2005 and 2008 by species, province and season (abbreviations as for Table 1).

Species	Sindh				Balochistan			
Season:	NE	IMS	SW	IMA	NE	IMS	SW	IMA
Bryde's whale	–	1	–	–	2	–	–	–
Unid. baleen whale	1	2	–	–	2	1	–	–
Sperm whale	1	1	–	–	1	–	1	1
Cuvier's beaked whale	–	–	1	–	–	–	–	–
Killer whale	1	–	–	–	–	–	–	–
Humpback dolphin	3	–	6	–	4	2	–	–
Spinner dolphin	–	2	–	–	–	–	–	–
Bottlenose dolphin	2	1	–	–	2	–	–	–
Unid. dolphin	–	–	7	–	1	2	–	–
Finless porpoise	1	1	–	–	6	1	–	–

However when fishers were asked whether cetaceans impacted on their fishing there was a significant difference between the provinces (Mann Whitney U test: $Z_{adj} = -2.57$, $p = 0.01$, $N_{Sindhi} = 177$, $N_{Balochi} = 175$), with more Balochis responding that cetaceans did cause problems. Their complaints included that cetaceans competed for and/or were depleting fish stocks, and that dolphins and porpoises becoming entangled in and damaged fishing nets. In addition it was claimed that large dolphins and whales could capsize small fishing boats.

Fishers did not describe finding live stranded cetaceans but Balochi fishers did describe finding bones of cetaceans on the shore throughout the year. They also described their interaction with cetaceans and commented on cetacean behaviour much more frequently than did Sindhi fishers. Ten fishers (six from Balochistan and four from Sindh) spread evenly across the age groups 20 to 59 yrs, reported that they or others had killed or used cetaceans. The purposes reported included: to free fishing nets; as bait for fish or sharks; for food (apparently by 'Somalis'); for medication (for example to ease pain in the legs); and for sexual gratification (finless porpoise). In relation to the damage caused to nets it was noted that while locally a fishing net cost 4,000 Pakistani Rupees (Rs.), the wholesale price for a dolphin was only Rs 4.

DISCUSSION

This study, covering most of the 1,050km coastline of the country over a four year period, represents the first systematic survey of marine cetaceans in Pakistan. In addition to boat-based surveys, shore-based surveys were undertaken for stranded or beachcast specimens and a strandings reporting scheme established, which revealed the occurrence of several further species.

Species occurrence

Finless porpoise

During inshore boat surveys finless porpoises were recorded relatively frequently, more often in Sindh than in Balochistan, but finless porpoise remains were also found on beaches, mainly in Balochistan. During boat survey work they were almost invariably recorded under calm sea conditions during the NE monsoon (which may partly reflect the difficulty in detecting them when waves are present), and in shallow water near shore. Finless porpoises have previously been reported from both the Indus Delta and Balochistan. Pilleri and Gihr (1972a, 1973–1974) had records of live porpoises at Gadani, Dahm and Sonmiani, all in Balochistan, and they encountered small groups in the Indus Delta creeks, although by 1979 fewer were being recorded (Pilleri and Pilleri, 1979). Roberts (1997) also noted that finless porpoises were found in mangrove creeks along the Baluchistan coast between September and April, since when a number of other records have been collated by Collins *et al.* (2005). The species has also been reported in neighbouring Oman (Braulik *et al.*, 2010a; Collins *et al.*, 2005).

Bottlenose dolphin

In the present study bottlenose dolphins were observed in both Balochistan and Sindh, and beachcast specimens were also found in both provinces. The species is known from adjacent countries: Baldwin (2003) describes them as present in Yemen, Oman and the Arabian Gulf, while Braulik *et al.* (2010a) recorded a skull of the Indo-Pacific bottlenose dolphin in the Sistan/Baluchistan area of Iran, and Afsal *et al.* (2008), using a fisheries-oceanographic ship as a vessel of opportunity, recorded Indo-Pacific bottlenose dolphins in the Arabian Sea off the coast of India at depths of up to 50m.

Two forms of bottlenose dolphin are found in the Indian Ocean, the Indo-Pacific bottlenose dolphin (*T. cf. aduncus*), and the larger, globally more widespread, common bottlenose dolphin (*T. tursiops*). In general, *T. cf. aduncus i*s thought to be a coastal form found in near-coastal tropical waters, while *T. truncatus* also occurs in temperate waters and offshore (Hale *et al.*, 2000). Hale *et al*. compared the morphology of the two forms; the separation into two distinct species was said to be unresolved, although genetic analysis may show a degree of divergence, which would be consistent with them being distinct species.

In the present study bottlenose dolphins were recorded in a wide range of habitats including near shore, continental shelf and shelf edge, from shallow water to ocean over 1,000m deep. It seems possible that the groups observed inshore in both Sindh and Balochistan were *T. cf. aduncus*, while those observed offshore in Balochistan may have been *T. tursiops*. Similarly, Baird *et al*. (2009) found that in the Hawai'ian Islands bottlenose dolphin close inshore remained resident and did not mix with the offshore inter-island population. However in the present study no clear difference in visual appearance of inshore and offshore animals was evident and consequently bottlenose dolphins recorded in the present study have been classed as *Tursiops* spp. There is a case for further study and a genetic analysis is underway.

Bottlenose dolphins were observed when fishing gear or boats were present as well as when there was no other human activity evident. In fact on at least one occasion the pod sometimes present near Clifton Beach (near Karachi, Sindh) appeared to be driving fish towards drift nets deployed by fishers, a manoeuvre from which both dolphins and fishers could potentially benefit. Bottlenose dolphins were also recorded during the seismic survey in both shelf edge and pelagic zones, when the airgun was firing and when it was not, although the numbers recorded per sighting were slightly greater when there was no firing. From these data it would appear that the bottlenose dolphin is relatively insensitive to human disturbance, although this is not to imply that the animals are not impacted, since clear propeller damage was observed on members of the bottlenose dolphin pod sometimes encountered near Karachi Harbour.

Spinner dolphin

Our data on spinner dolphins complement records of the species from adjacent waters. Afsal *et al*. (2008) found spinner dolphins in water between 1,000 and 3,000m deep in the Arabian Sea area off India; Ponnampalam (2009) has studied a population resident off the coast of Muscat, Oman; and Braulik *et al*. (2010b) recorded the species in Iran, based on a stranding, in the Sistan/Baluchistan area. Spinner dolphins were observed in both Pakistani provinces, usually in very large assemblages of adults or mixed age individuals and invariably on the outer shelf or around the shelf edge. These observations match evidence that the species is specialised in feeding on meso-pelagic squid and fish around the shelf edge (Ponnampalam, 2009). Like bottlenose dolphins, spinner dolphins were often observed despite human activities, including seismic airgun firing, occurring locally. Fishing boats were also often present, perhaps because both dolphins and fishers were attracted independently to a common potential resource.

Indo-Pacific humpback dolphin

In the present study humpback dolphins were frequently recorded in both NE and SW monsoons and also in the Spring Inter-monsoon period, but only in specific coastal areas (around the Indus Delta and in bays along the coast of Balochistan) in waters less than 30m deep. These observations match those from adjacent regions. Sutaria and Jefferson (2004) found humpback dolphins along the west coast of India, as far north as the Gulf of Kutch, just south of the border with Pakistan, as did Afsal *et al*. (2008) who reported humpback dolphins along the Arabian Sea coast of India in depths of up to 50m. Humpback dolphins were also the most frequently recorded cetacean in Oman (Baldwin *et al.*, 2004), occurring principally in coastal waters with soft sediments and low-energy sandy shorelines. However the species was not recorded during a survey of the Sistan/Baluchistan area of Iran (Braulik *et al.*, 2010a).

Two species of Indo-Pacific humpback dolphin have been distinguished: *Sousa plumbea* and *S. chinensis*. The animals observed in Pakistan had phenotypic characteristics of both forms, with a very distinctive hump but often heavy spotting on the head and hump areas. Jefferson and van Waerebeek (2004) studied skull morphology of *Sousa* spp. and suggested that Indo-Pacific specimens should be referred to a single species, *S. chinensis*, until further molecular genetics and morphological studies are undertaken. The Pakistan

population may thus represent an intermediate form within a single species cline. As noted by Jefferson and van Waerebeek (2004), irrespective of their taxonomic status, each geographic form should be treated as an evolutionary significant unit for conservation and management purposes.

The restricted use of selected coastal areas by this species has been described from other regions. In Zanzibar, Stensland *et al.* (2006) found that humpback dolphin concentrate their activities within only 2–11.5% of their range. In Mozambique humpback dolphins were found to be resident within selected bays, for example Maputo Bay (Guissamulo and Cockcroft, 2002). In Algoa Bay, South Africa, Karczmarski *et al.* (2000) mainly found humpback dolphins in water less than 15m deep and within 400m of shore. Similarly in Richards Bay, South Africa, humpback dolphins were found to stay within 2km (rarely 3km) of the shore and in water less than 20m deep (Atkins *et al.*, 2004); important feeding areas were around breakwaters and an estuary mouth, with resting areas being located further off shore.

Mean group size in the present study was small (3.7 animals), but larger, often mixed aged groups of up to 35 animals were sometimes seen, with groups being commoner than singletons. These data are comparable with those from other studies. On the west coast of India, Sutaria and Jefferson (2004) found that in shallow water (≤10m) mean group size was 3.9 (median 2), but in deeper water (≤30m) mean group size was 9.5. Similarly Parsons (1998) recorded group size of humpback dolphins in Goa, western India, as ranging from single individuals to nine, with a mean group size of 2.6. However, Razafindrakoto *et al.* (2004) found that humpback dolphins in west Madagascar had a mean group size of 13, and Guissamulo and Cockcroft (2002) reported that those resident in Maputo Bay, Mozambique, had a mean group size of 14.9, irrespective of season, daylight or tidal state.

Despite the fact they are sometimes exploited in Pakistan, humpback dolphins did not seem to avoid fishers, given that there was no significant difference in rate of sightings with presence or absence of fishing gear or boats.

Risso's dolphin, common dolphin and killer whale

Risso's dolphins were observed offshore and strandings were recorded in both provinces. The species is also known from neighbouring countries. Afsal *et al.* (2008) recorded them in depths of *ca*. 2,000m in the Arabian Sea off India, and Baldwin (2003) describes them as widespread in the Arabian Sea, Gulf of Aden and Gulf of Oman, where exceptionally large groups of up to 800 individuals are occasionally seen. Braulik *et al*. (2010a) recorded the species stranded in the Sistan/Baluchistan area of the Gulf of Oman. Baumgartner (1997) describes Risso's dolphins as being associated with steep areas of the upper continental slope, possibly due to the concentration of their prey (squid) along fronts that form in such areas. In the present study however, matching Baldwin's (2003) observation that they are more common seawards of the continental shelf, we recorded more Risso's dolphins in the pelagic than the shelf edge zone, although in Pakistan both areas possess a relatively steeply sloping sea floor.

Long-beaked common dolphins, generally recognised as a distinct subspecies, *Delphinus capensis tropicalis*, are regarded as abundant in the Arabian Seas and Gulf of Aden (Baldwin, 2003). They have also been reported in the Gulf of Oman (Braulik *et al.*, 2010b) and western India, although not from the area adjacent to Pakistan (Afsal *et al.*, 2008). The species was observed twice during the seismic survey reported in the present study but not during the dedicated boat-based surveys, although the species may be among the unidentified dolphin remains collected during beach surveys and currently undergoing genetic analysis.

A single pod of killer whale was observed off Astola Island, Balochistan (by MG), apparently pursuing rays beneath the survey boat. Their presence is in keeping with other records from the northwest Indian Ocean region, where it appears to be rare but widespread. They have been observed only infrequently in Oman (Baldwin *et al.*, 1999) and there is one report from the Gujerat coast of India (James and Lal Mohan, 1987). However they were not recorded during the boat-based survey of the Indian Arabian Sea by Afsal *et al.* (2008), nor in the review for the Gulf of Oman by Braulik *et al.* (2010a). These reports may represent sightings of only one or two pods that travel very widely through the region.

Whales

The Bryde's whale is regarded as common in Southern Arabian waters (Baldwin, 2003), but none were observed with certainty during our boat surveys. Likewise James and Mohan (1987) failed to record Bryde's whales from the coastal waters of western India, although they did report the skeleton of a sei whale (*B. borealis*), which could possibly be a misidentified Bryde's. However in the present study a stranding of a Bryde's whale was recorded, as did Braulik *et al*. (2010a) in the Sistan/Baluchistan area of Iran; thus it is likely that Bryde's whales do occur regularly off the Pakistan coast, but perhaps mainly during the southwest monsoon when their food would be more abundant, but when it is very difficult to undertake small boat work.

Although a live Bryde's whale was not recorded in this study, a humpback whale was encountered in relatively shallow waters off the coast of Balochistan. Similarly humpback whales in the Arabian Sea are usually seen in water of less than 50m deep (Baldwin, 2003), so they are perhaps more likely to be encountered during inshore small boat surveys.

A blue whale was sighted off the Sindh coast northwest of the Swatch in the late 1960s (M. Khan and S.H.N. Rizvi, pers. comm.) and they have also been reported by Ahmad and Ghalib (1975). None were seen during the present survey work, but a locally-collected skeleton present in the Zoology Department Museum of Karachi University was inspected.

A Cuvier's beaked whale was identified from a skull found during a beach survey of Khobar Creek, Sindh (Gore *et al.*, 2007b), but the species was not observed during boat work. To date there have been about a dozen records of the species from the northwest Indian Ocean, all from the Gulf of Oman and the south-eastern coast of Arabia (Baldwin, 2003), although James and Mohan (1987) also reported the species from the Lakshadweep Islands off Calicut, south-west India, and it is uncommon in the Maldives (Anderson, pers. comm). Their restricted distribution may reflect long-term site fidelity to areas of preferred habitat, such as McSweeney *et*

al. (2007) recorded in Hawai'i, where known individuals were observed over at least 15 yrs. When seen, the species is almost always encountered over very deep water in which it is presumed to feed, and Baird *et al.* (2008) noted that in Hawai'i they spend less time near the surface during the day, probably to avoid predation.

A single sperm whale was recorded, a young individual cast on Manjar beach, Sindh (Gore *et al.*, 2007a). Sperm whales were exploited commercially in the Arabian Sea off the coast of Southern Arabia during the 19th century and again briefly in the 1960s (Baldwin, 2003). More recently the species has been reported by Baldwin *et al.* (1999) off Oman, by Afsal *et al*. (2008) in the south-eastern Arabian Sea off India, and by Braulik *et al.* (2010a) (from a stranding) in the Sistan/Baluchistan area of Iran. Thus the species is still present in the region, though to what extent it is recovering from past exploitation remains unknown.

Confirmed cetacean species for Pakistan

Given the above data and information, the occurrence in Pakistan of 12 species of marine cetaceans can be confirmed, including a single porpoise species, six dolphin species (including killer whale) from six different genera, and five whale species representing four further genera, including both odontocetes and mysticetes (Gore *et al.*, 2007a; 2007b). Of these species, two are listed as endangered (blue and humpback whales) and two as vulnerable (sperm whale and finless porpoise) in the International Union for the Conservation of Nature Red List[1]; eight are included within the Appendix to the Convention on Migratory Species[2].

As also remarked by Mikhalev (2000), the occurrence of good numbers of some of these species in this range may reflect the relatively high productivity of Pakistani waters. While during the NE monsoon there is thermohaline stratification both near and offshore, during the SW monsoon the waters become well mixed, returning nutrients to surface waters. As a result there is high primary productivity, especially in October and November (Rivzi *et al.*, 1995; Saeed *et al.*, 1995), and high secondary productivity and biomass of zooplankton, higher than that further south on the South Asian coast or in the Bay of Bengal.

Anthropogenic impacts

Direct evidence of anthropogenic impact was found on shore-stranded cetacean specimens, particularly finless porpoises, from which the flukes had been removed, presumably to facilitate removal from fishing nets in which they had become entangled. Baldwin (2004) likewise described not infrequent entanglement, especially of whales and of humpback dolphins, in inshore fishing nets in Oman. Similar mortalities have also been described from elsewhere in the Western Indian Ocean, for example affecting humpback dolphins in Maputo Bay, Mozambique (Guissamulo and Cockcroft, 2002). Bottlenose dolphins, a species that feeds in shallow water, may be affected, because when they focus on sonar echoes from their prey they suppress echoes from other objects (such as the nets) and so may not detect them (Goodson, 1994 *in* Atkins *et al.*, 2004).

Occasional reports were received of both dolphin bycatch and intentional kills for bait, especially in Balochistan, or medicine or other purposes, particularly in Sindh. Baldwin *et al.* (2004) have likewise noted that opportunistic hunting of dolphins may occur in southern Arabia. Reports of cetacean meat being used as bait for shark fishing are of particular concern, since shark fishing has been intensifying as a consequence of the demand for shark for the Asian restaurant trade. More regular targeting of humpback dolphins as a source of meat in west Madagascar has been reported by Razafindrakoto *et al.* (2004). It is not easy to assess whether in Pakistan such intentional and unintentional exploitation will cause population decline, but Stensland *et al.* (2006) studying bottlenose and humpback dolphins in Zanzibar estimated that across the two species bycatch generated an annual mortality of about 12%.

Occasional boat strikes were also described to us during the present study, though whether such strikes or the more general disruption caused by boat activity generate the greater impact remains unclear. Ng and Leung (2003) investigated the effect that vessel traffic might have on humpback dolphins. The dolphins increased their dive duration and performed avoidance behaviour when oncoming vessels were detected; slow-moving vessels appeared not to cause immediate stress, but fast-moving vessels did disrupt behaviour.

In Pakistan various forms of pollution also seem likely to have affected inshore dolphin populations. There are very high levels of chemical pollution in creeks and tributaries near Karachi (such as Korangi and Gizri Creeks and Port Qasim), and around the Hub River and the ship-breaking area of Gadani, Balochistan (Ali and Jilani, 1995; Khan and Saleem, 1988; Rivzi *et al.*, 1988). Around Karachi untreated industrial effluents input toxic metals, pesticides, PCBs (polychlorinated biphenyls) and lubricating oils, while untreated municipal sewage causes high biological oxygen demand (BOD), and inputs organic nitrogenous compounds, suspended solids, soaps and detergents, nutrients, phenols, sulphur compounds and pathogenic bacteria (Ali and Jilani, 1995; Saleem and Kazi, 1995). At Gadani, up to 100 ships per year are dismantled leading to the release of large amounts of heavy metals, asbestos, dioxins and other persistent organic pollutants. The effects of such pollution on local dolphins have yet to be studied, but Parsons (2004) studied contaminants of humpback dolphins in similarly polluted Hong Kong and found very high levels of organochlorines and mercury.

In addition to pollution from terrestrial sources, chronic low-level oil pollution is generated by busy nearby shipping lanes, and there have since the 1980s been two major oil spills affecting the Sindh coast: 700 tons of crude oil in 1984; and 30,000 tons in 2003. Another potential impact in open water may be harmful algal blooms (HAB) due to phytoplankton such as *Gonyaulax* and *Lingulodinium* spp.; extensive blooms are common in coastal waters, as well as in more enclosed areas such as Korangi Creek and Manora Channel (Baig, 2004; Chaghtai and Saidullah, 2001), but have been a feature of the coast since before it became industrialised (M. Khan, pers. comm.).

[1] IUCN Red List website *http://www.iucnredlist.org* [Accessed April 2010]
[2] CMS website *HTTP://WWW.CMS.INT/ACCOBAMS/ACC_SPP.HTM* [Accessed 2008]

Views of fishers

The responses of fishers to our questionnaires suggested that many of them were observant of cetaceans, noting species, group size, body size and behaviour, and sometimes taking pleasure in their presence. The Balochi fishers were noticeably more knowledgeable, which may reflect the finding that Balochis interviewed were more likely to be full-time (rather than part-time) fishers. It was also noted, as also described by Grant and Berkes (2007), that in general fishers were very keen to improve their knowledge of marine life especially when relevant to fishing activities. Howard and Parsons (2006) have explored this effect in Scotland where they found that while noise pollution was of interest to the wider community, water pollution was of special concern to fishers. Likewise we found fishers concerned about water quality, particularly in Sindh and near the Gadani ship breaking area. In addition to the individual interviews, the Fisher Workshops provided valuable comment on species occurrence and the range of current threats to cetacean populations, pointing out for example that discarded nets could be a significant problem.

Conservation and management

The results of this study have been used in support of both national and regional cetacean conservation and management initiatives. Hitherto marine cetaceans have not been gazetted as protected species in either Sindh or Balochistan, largely because neither the species concerned nor their status were known. Consequently the findings of this study have been provided to the Convention on Biodiversity Working Group within the Ministry of Environment for further action. In addition, following discussion with the then Minister of the Environment for Pakistan during his visit to Astola/Haft Talar Island, the area proposed for Pakistan's first marine protected area (MPA), a proposal was developed (in collaboration with WWF-Pakistan and the government's own Pakistan Wetlands Programme) for extending full protection to all cetaceans within the MPA.

To further promote effective protection measures, an Action Plan for the Conservation of Marine Cetaceans of Pakistan (Gore, 2008) was agreed and circulated to the relevant government departments and non-government organisations. Recommendations included the establishment of a national cetacean conservation group (as a result of which the Pakistan Whale and Dolphin Society was established on 11 February 2007), and the trialling of whale and dolphin watching trips (the first of which was organised by WWF-Pakistan in 2008). It is intended that both activities should increase public awareness of whales and dolphins in Pakistan and involve an expanding cross-section of the local community in their conservation.

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