

First Records of the Striped Dolphin (*Stenella coeruleoalba*) and Rough-Toothed Dolphin (*Steno bredanensis*) in Pakistani Waters: A Review of Occurrence and Conservation Status in the Indian Ocean

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Abstract.- The skull of a striped dolphin *Stenella coeruleoalba* (Meyen, 1833) was found in the Indus delta creek system of Pakistan during a beach survey. The subsequent morphometric investigations revealed that the skull was that of a juvenile/subadult striped dolphin. Coincidentally, a video of two live individuals and pictures of an entangled animal of the same species were captured in the open sea by the crew of a tuna fishing vessel off the same general area where the skull was retrieved. This video clearly depicts the species' unique colour pattern and supports the skeletal evidence of presence of striped dolphins in Pakistani waters. In addition, three videos of a small pod of rough-toothed dolphins *Steno bredanensis* (G. Cuvier in Lesson, 1828) were received from a captain of another tuna fishing vessel. This account documents the only records of these two species from Pakistan. Other records from the Indian Ocean region are discussed. Issues pertaining to conservation in Pakistan such as rampant and illegal use of very long gillnets by tuna fishers and overfishing are examined.

Key words: Morphometric, Indus delta, striped dolphin, rough-toothed dolphin.

INTRODUCTION

The striped dolphin *Stenella coeruleoalba* (Meyen, 1833) is known to occur in tropical, subtropical and warm temperate waters of the world in both hemispheres (Archer and Perrin, 1999; Van Waerebeek *et al.*, 1999). The species can be seen in the deeper waters, including those that are close to the coastline. The species belongs to the family Delphinidae and is generally gregarious in nature; however, smaller group sizes are recorded from the Mediterranean (Notarbartolo di Sciara *et al.*, 1993). The species is usually observed in deep offshore waters (Perrin *et al.*, 1994; Gannier, 2003). The literature reveals that striped dolphins may be more susceptible to pollutants, heavy metals and parasite infestations (Aguilar, 2000; Cardellicchio, 2000) which make them important for conservation and management studies.

Several stocks but no subspecies are identified throughout its range (Mitchell, 1975; Perrin, 1975; Mead and Brownell, 1993). The genus

Stenella is considered paraphyletic according to recent genetic analyses, therefore there is a possibility that this species might be moved to a different genus (Leduc *et al.*, 1999). The IUCN Red List of Threatened Species classifies the species as 'Of Least Concern' (Hammond *et al.*, 2008). The species is listed in Appendix II of Convention on the International Trade in Endangered Species (CITES) which means, that the species is not necessarily threatened with extinction at present but it may happen unless the trade is carefully controlled.

The rough-toothed dolphin is found in tropical and subtropical waters from the western Pacific to the Mediterranean in deeper waters, rarely seen beyond 40° N and 35° S (Jefferson, 2002). The species is reported from semi-enclosed waters and also shallow coastal waters in some areas, for example off Brazil and West Africa (Ritter, 2002; Hammond *et al.*, 2012). The IUCN Red List of Threatened Species classifies the species as 'Of Least Concern' (Hammond *et al.*, 2012). The species is also listed under Appendix II of CITES.

No previously documented records of occurrence and/or strandings of either of these species are known for Pakistan (de Boer *et al.*, 2002). Although de Silva (1987) mentions the rough-toothed dolphin as a species occurring in

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Pakistani waters based on several stranding records provided by Dr. Farooq (ex-Director of the Zoological Survey Department of Pakistan), but later Dr. Farooq confirmed that these records were not reported by him and their inclusion in de Silva (1987) is erroneous. Miyazaki and Perrin (1994) also mentioned the presence of rough toothed dolphin in waters of the Pakistan coast, but no verification is available (Van Waerebeek *et al.*, 1999).

MATERIALS AND METHODS

Recovery of skull of striped dolphin from the Indus delta

A dolphin skull was collected from a beach between Chhan east mouth and Khuddi creek (24°38'229N, 67°11'825E) of the Indus delta during a 11.94 km long beach survey on 15 April 2009 (spring inter-monsoonal period) (Fig. 1).

The skull was identified using guidelines by Perrin (1975). The identification is made on the basis of measurements and morphological features. Literature consulted and used for comparison: Van Waerebeek *et al.*, 1998; Ott and Danilewicz, 1996; McFee *et al.*, 1998. In addition, the species identification was also confirmed by W. F. Perrin at the Southwest Fisheries Science Center in La Jolla California, USA. The skull was photographed and archived in the laboratory at the Centre of Excellence in Marine Biology, University of Karachi (Fig.1).

Measurements were made using a vernier calliper and ruler. Methods developed by Perrin (1975) for measurement of skull morphometrics were followed.

Sightings of striped dolphins as supporting evidence

A live sighting of 2-3 striped dolphins was recorded by a captain of a tuna fishing vessel (Gul-e-Muhammad No. 14623-B) off the Indus delta in the Swatch area (23°18.750'N 67°12.566'E) on 20 December, 2012 at 1350 PM (Fig. 2a). An animal of the same species became entangled and died in a tuna gillnet in deep waters off the Indus delta well beyond the shelf (GPS coordinates: 20° 49.172'N 65°16.150'E) on 16 January 2013, also shown in Figure 2b.

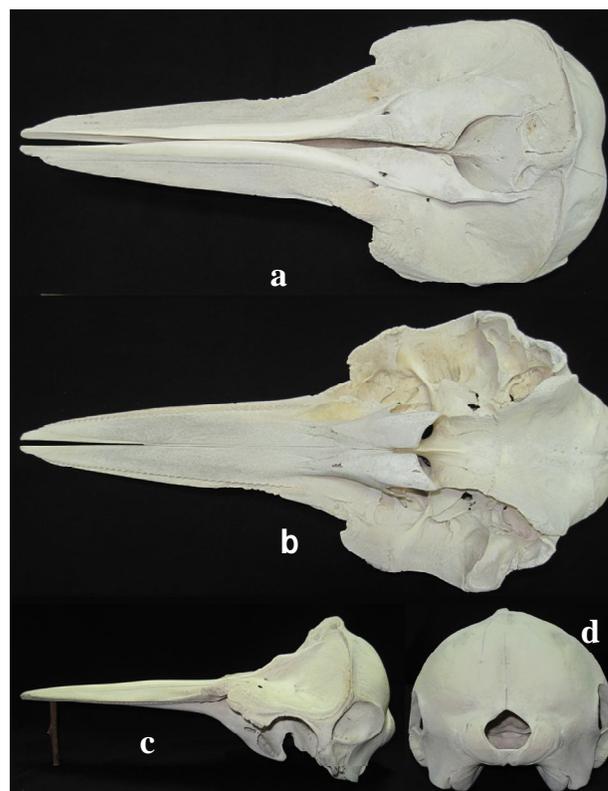


Fig. 1. Skull of striped dolphin: (a) dorsal view, (b) ventral view, (c) lateral view and (d) posterior cranial view. **Note:** the lack of distal fusion of pre-maxilla and maxilla shows that the specimen was a juvenile/subadult (Calzada *et al.*, 1997 and W. F. Perrin, pers. comm.).

Rough-toothed dolphin

Three short videos by a tuna fishing vessel (Al-Saira No. 10319-B) depict a small pod (6 animals) of rough-toothed dolphins in deep waters, well beyond the continental shelf edge, on 21 January 2013 (21°47.141'N 65°21.416'E) at 11 AM.

RESULTS

Striped dolphin

No lower jaw bones or any other parts of the skeleton were recovered. The skull showed a series of small serrations/ cuts visible at 1/4th length of the upper jaw on both right and left sides.

The skull measurements revealed it to be a juvenile or subadult striped dolphin. A total of 32 measurements were taken (Table I).

Table I.- Measurements and meristics (in mm) for striped dolphin (*Stenella coeruleoalba*) skull compared with reported ranges (McFee *et al.*, 1998).

S. No.	Measurements	(mm)	Range
1	Condylbasal length - from tip of rostrum to hindmost margin of occipital condyles	437	442-479
2	Length of rostrum - from tip to line across hindmost limits of antorbital notches	257	233-293
3	Width of rostrum at base - along line across hindmost limits of antorbital notches	114	93-120
4	Width of rostrum at ¼ length of rostrum	69	N/A
5	Width of rostrum at mid length	63	51-67
6	Width of premaxillaries at midlength of rostrum	29	N/A
7	Width of rostrum at ¾ length, measured from posterior end	45	36-54
8	Distance from tip of rostrum to external nares (to mesial end of anterior transverse margin of right nares)	314	N/A
9	Distance from tip of rostrum to internal nares (to mesial end of posterior margin of right pterygoid)	309.5	N/A
10	Greatest preorbital width	184	178-213
11	Greatest postorbital width	198	189-233
12	Least supraorbital width	182	N/A
13	Greatest width of external nares	51	N/A
14	Greatest width of internal nares	55	N/A
15	Greatest width across zygomatic processes of squamosal	198	193-227
16	Greatest width of premaxillaries	85	77-92
17	Greatest parietal width, within posttemporal fossae	187	147-200
18	Vertical external height of braincase (from midline of basisphenoid to summit of supraoccipital)	114.5	N/A
19	Internal length of braincase from hindmost limit of occipital condyles to foremost limit of cranial cavity along midline	121	N/A
20	Greatest length of left posttemporal fossa, measured to external margin of raised suture	60	N/A
21	Greatest width of left posttemporal fossa at right angles to greatest length	40	N/A
22	Major diameter of left temporal fossa proper	36	N/A
23	Minor diameter of left temporal fossa proper	31	N/A
24	Projection of premaxillaries beyond maxillaries (tip of rostrum to line across foremost tips of maxillaries)	21	N/A
25	Distance from foremost end of junction between nasals to hindmost point of margin of supraoccipital crest	30.1	N/A
26	Length of left orbit-from apex of preorbital process of frontal to apex of postorbital process	54	N/A
27	Length of antorbital process of left lacrimal	55	N/A
28	Greatest length of left pterygoid	82	N/A
29	Length of upper left tooth row - from hindmost margin of hindmost alveolus to tip of rostrum	227	216-254*
30	Number of teeth - upper left	46	39-53
31	Number of teeth - upper right	47	N/A
32	Deviation of skull from symmetry in dorsal view, in degrees	8°	N/A

* =(Perrin *et al.*, 1981)

The evidence provided for sighting of striped dolphin was a video which is available as supplementary material for reference with lead author of this publication. According to information gathered from the captain, more than 50 dolphins were around the boat at various distances. The identification of the more distant animals is not confirmed.

Rough-toothed dolphin

Three short videos by a tuna fishing vessel

(Al-Saira No. 10319-B) depict a small pod (6 animals) of rough-toothed dolphins in deep waters, well beyond the continental shelf edge, on 21 January 2013 (21°47.141'N 65°21.416'E) at 11 AM (Fig. 3). The videos are available as supplementary material for reference with lead author of this publication. The dolphins can be seen swimming very actively just under the surface and skimming through the water. They stayed close to the slow moving tuna fishing boat for more than an hour and engaged in bow-riding most of the time. The

animals remained in a tight group formation exhibiting a synchronous swimming and surfacing pattern with frequent tactile associations.



Fig. 2: a) A striped dolphin in the Swatch, 20 December 2012 (photo: M. Ismail) and b) A dead striped dolphin that died due to entanglement in a tuna gillnet in deep waters, 16 January 2013 (photo: Shahzameen Khan).



Fig. 3. Rough-toothed dolphin (Photo: Shahzameen Khan).

Rough-toothed dolphins have white colouration on their undersides, lower jaws and lips. A darker marking extends over the eyes to the upper part of their flanks. Additionally, a very obvious and

distinct feature is the shape of head, which slopes gently to the beak tip. This character is diagnostic if the dolphins are observed at a close distance, but at a distance they may be confused with bottlenose (*Tursiops* sp.), spinner (*Stenella longirostris*) or pantropical spotted (*Stenella attenuata*) dolphins. A map showing the locations of recovery of skull and sightings of both species are given below (Fig. 4).

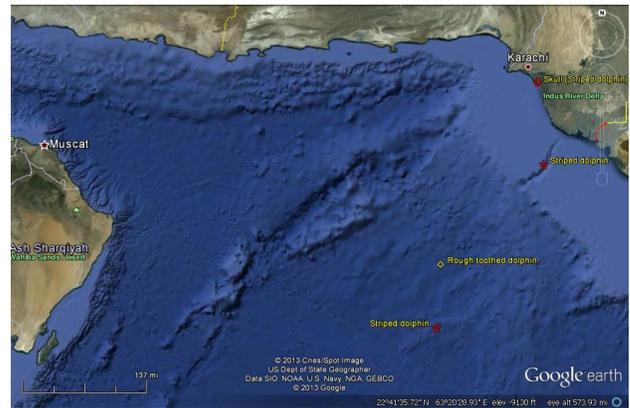


Fig. 4. Map showing location of recovery of skull and sightings of striped dolphin and rough-toothed dolphin.

Review of previous records in Indian Ocean Striped dolphin

The striped dolphin is well known from all the ocean basins particularly the Mediterranean Sea (Reeves and Notarbartolo di Sciara, 2006). However, the information on this species from the Indian Ocean is very limited due to absence of species-focused research. This may also be due to the preference for the oceanic domain by this species that makes it difficult to study. The areas in the Indian Ocean from where the information is available on the striped dolphin include Australia (Bannister *et al.*, 1996; Ross, 2006), Thailand (Chantrapornsyl *et al.*, 1999; de Boer *et al.*, 2002), Maldives (Ballance, *et al.*, 1996; Ballance *et al.*, 2001; Anderson, 2005), Sri Lanka (Mead, 1986; Alling, 1986; de Silva, 1987; Alling, 1988; Leatherwood and Reeves, 1989; Dayaratne and Joseph, 1993; Ballance, *et al.*, 1996; Ilangakoon, 1997 and 2002; De Vos *et al.*, 2012), India (Ballance *et al.*, 1996; Kumaran, 2003; Afsaal *et al.*, 2008; Kumaran, 2012 and references therein), Iran

(Braulik *et al.*, 2007; Braulik *et al.*, 2010), Oman (Alling, 1983 and 1986; Leatherwood, 1986; Ballance and Pitman, 1998; Gallagher 1991; Ponnampalam, 2009), UAE (anecdotal reports), Somalia (Ballance, *et al.*, 1996; Ballance and Pitman, 1998), Seychelles (Ballance and Pitman, 1998), Mauritius (Corbett, 1994) Madagascar (Ballance *et al.*, 1996), Kenya (Wamukoya *et al.*, 1996), Mozambique (de Boer *et al.*, 2002; Everet *et al.*, 2008), South Africa (Ballance *et al.*, 1996). Ballance *et al.* (1996) reported sightings from south of Socotra and in the Arabian Sea. Ballance and Pitman (1998) reported that *S. coerulealba* was the second most abundant species sighted in the western tropical Indian Ocean (14% of all cetaceans) in their survey. Striped dolphins are rare in the Gulf of Oman and the Arabian Sea and appear to be more common in northern and central Indian Ocean according to Baldwin (2003). However, recently a mass stranding (73 striped dolphins) was reported that occurred on October 24, 2007, 60km west of Jask port, southern Iran. In addition, a striped dolphin skull (reported from the same vicinity) is archived at the Department of Environment, Jask, Iran (Braulik *et al.*, 2010). This species is not known through sightings and/or strandings but expected to be present in the territorial waters of Indonesia, Malaysia, Myanmar, Bangladesh, Yemen, Union of Comoros, Mayotte (France), Tanzania and Reunion Island. There are extralimital records from the Persian Gulf and the Red Sea (J. Gordon and C. Smeenk, pers. comm. in Frazier *et al.* 1987; Hammond *et al.*, 2008).

Rough-toothed dolphin

The status of information on the rough-toothed dolphin in the Indian Ocean is not very different from that for the striped dolphin. Although it is known from the Indian Ocean, only a handful of records of sightings are available. Most of the information comes from beach-cast remains from many of the coastlines bordering the Indian Ocean. No active research is being carried out in any of the regional nations on this species, possibly due to its offshore distribution. The available records from the Indian Ocean include Australia (Bannister *et al.*, 1996; V.M. Peddemors and R. Harcourt 2006 pers. comm.), Indonesia (de Boer *et al.*, 2002), Thailand

(Chantrapornsyl *et al.*, 1995; Chantrapornsyl *et al.*, 1996; de Boer *et al.*, 2002), Maldives (Ballance *et al.*, 2001; Anderson, 2005); Sri Lanka (Leatherwood and Reeves, 1989; Dayaratne and Joseph, 1993; Illangakoon, 2002); India (Blanford, 1888-91; Leatherwood, 1986; De Silva, 1987; Afsaal *et al.*, 2008; Kumaran, 2012), Oman (Ballance *et al.*, 1996; Leatherwood, 1986; Ballance and Pitman, 1998; Van Waerebeek *et al.*, 1999; Minton, 2004; Ponnampalam, 2009, Minton *et al.*, 2011, Oman Whale and Dolphin research Group unpublished data), Iran (Braulik *et al.*, 2010), South of Socotra (Ballance *et al.*, 1996), Gulf of Aden and Red Sea (Hershkovitz, 1966; Miyazaki and Perrin, 1994; Frazier *et al.*, 1997), Seychelles (Ballance and Pitman, 1998), Madagascar (Ballance *et al.*, 1996), Tanzania (Chande *et al.*, 1994; Berggren *et al.*, 2001), Zanzibar (Berggren *et al.*, 2001), Mozambique (Peddmors *et al.*, 1997), South Africa (Peddmors, 1999). There is no evidence of rough-toothed dolphins occurring in the Persian Gulf, and it is unlikely that this is suitable habitat for this deep-water species (Robineau, 1998). Though occurrence of this species is unknown in Malaysia, Myanmar, Bangladesh, UAE, Yemen, Somalia, Kenya, Comoros, Mauritius and Reunion, but it is expected to be present in their territorial waters.

DISCUSSION

Knowledge on marine cetaceans in Pakistan has improved considerably since 2005 when a dedicated cetacean research project, Cetacean Conservation Pakistan (CCP), was initiated jointly by the Centre of Excellence in Marine Biology (CEMB), University of Karachi, World Wildlife Fund (WWF)-Pakistan and University Marine Biological Station Millport (UMBSM), Scotland. As a result, information on already known species from Pakistan was updated with more recent knowledge (Gore *et al.*, 2012), and in addition three new species, sperm whale *Physeter macrocephalus* (Gore *et al.*, 2007a), Cuvier's beaked whale *Ziphius cavirostris* (Gore *et al.*, 2007b) and pantropical spotted dolphin have been confirmed to occur in the Pakistani EEZ (Kiani *et al.*, 2011). Since completion of the CCP project in 2008, an action plan has been prepared (Gore, 2008) and efforts have been

directed to ensure the continuity of research on marine cetaceans of Pakistan to facilitate the process of development of a proper national cetacean conservation policy and also for promoting their sustainable use through whale and dolphin watching ecotourism by highlighting the need for their conservation. As an extension of such efforts regular beach surveys are organized by CEMB of the University of Karachi along different sections of the Pakistan coastline for collection of first-hand information on beach cast remains of cetaceans. Information on threats being faced by local marine cetaceans, causes of mortality and areas of conflict with fisheries is also collected.

Striped dolphin

The area from where the skull of a striped dolphin was retrieved is very near to a famous deep water area “the Swatch” along the Sindh coast (Figure 1). This area is very interesting as it spans over the Indus river delta with a total length of about 117 km, having depth ranging from ca. 41 to 727 m. The Swatch starts ca. 12 km from the coast. This area attracts deep-water species of fish, cetaceans and other large marine vertebrates (Ahmed, 1985; Mikhalev, 1997 and 2000; Aziz Agha, a local game fisher, pers. comm.). Large whales such as the famous but endangered Arabian Sea humpback whale (*Megaptera novaeangliae*) are well known from this area, specifically from Russian illegal whaling data (Mikhalev, 1997 and 2000). It is possible that the striped dolphins may be using “the Swatch” area for their nearshore incursions in order to benefit from the rich food resources offered by rich mangrove ecosystem of the Indus delta. This is in agreement with Archer (2002) who states that the habitat of the striped dolphin is mainly oceanic but some occurrences over the continental shelf are also recorded throughout the range of the species. Moreover, the depths found in the Swatch area fall in the preferred foraging and diving range of the striped dolphin *i.e.* 200-700m. However, species’ diving and foraging behaviour has not been extensively studied (Archer, 2002). Its distribution also seems to be associated with areas where seasonal changes in thermocline depth occur, as reported from the eastern tropical Pacific (Reilly and Fiedler, 1993). The literature also indicates that

striped dolphins are commonly recorded from riverine mouth areas, which is in line with findings of the present study (Perrin, 1975 and references therein). Striped dolphins are known to feed on a wide variety of small, midwater and pelagic or benthopelagic fish, especially lanternfish (*Myctophidae*), cod (*Gadus morhua*) and cephalopods (Archer, 2002). Lanternfish and squids are present in the Pakistani EEZ (FAO, 2011) and thus can support a striped dolphin population.

The pattern of wind driven circulation in the Indus delta favours deposition of dead cetaceans, and their remains, on the beaches just before the start of the turbulent southwest monsoon (mid June to September) which is thought to wash these specimens from the beaches. Fishing activities also decrease considerably during this period, which reduces the chances of cetaceans and other large marine vertebrate entanglements in fishing gear. The present specimen was found before the onset of the SW monsoon in the spring intermonsoonal period (March to May). Salm (1991) states that many beaches are swept clean during the annual SW monsoonal period and the peak abundances of dead dolphins and other taxa on the Arabian Sea coasts are just before the onset of the SW monsoon.

The skull measurements were compared with those in MeFee *et al.* (1998) and were found to be within the reported range. Though it is difficult to establish the cause of death of this dolphin, a series of serrations on rostrum are visible which may be an indication of negative interaction with fisheries (e.g. entanglement and/or a propeller strike). This pattern of injuries is similar to those found in some other dead dolphins found during beach surveys (Kiani, M.S. and Pervaiz, I., unpublished data). The Swatch area is one of the most important fishing grounds along the Pakistan coastline, being very productive due to its close proximity to the nursery grounds found in the world’s largest arid mangrove ecosystem. Due to this reason fishers come from several different locations to this area, *e.g.* from Karachi to Keti Bunder (Indus delta) and from India as well. This results in concentration of more fishing activities in a small area during the peak fishing season, *i.e.* predominantly during the northeast monsoon (November to February) and increases the chances of entanglement of cetaceans and other

large marine vertebrates in fishing gear.

Some commonly practiced fishing methods in this area include gillnets of various kinds/sizes and trawling. There is no or little information that shrimp trawling is associated with cetacean by-catch in Pakistan (Niazi, 1990; M. Moazzam Khan, ex-Director General Marine Fisheries Department of Pakistan MFD, pers. comm.). The gillnets are the most harmful fishing gear for cetaceans in Pakistani waters, as reported from other parts of the world (Jefferson and Curry, 1994; Perrin *et al.*, 1994). The lengths of medium (100-120mm) and large mesh (150-240mm) sized gillnets, used for catching pomfrets, groupers, snappers, grunts, queenfish, seabreams, shads, catfish, croakers, tuna and other scombrids respectively in shelf and high seas, exceed the limits set by the United Nations General Assembly Resolution 44/225 1991 (M. Moazzam Khan, pers. comm.). According to the resolution, the length of gillnets should not exceed 2.5km on the high seas. However, the nets being used in Pakistan range from 7 to 10 km in length and can be up to 26 km long (M. Moazzam Khan, pers. comm.). These nets are functioning as “walls of death” and causing mortality of cetaceans of all sizes, turtles and other non-target species. Striped dolphins are not frequently associated with tuna and thus small numbers are killed in tuna fisheries (DeMaster *et al.*, 1992; Perryman and Lynn, 1994). The live sighting reported in this paper (Figure 2a) and a dead specimen that died as a result of entanglement (Figure 2b) were recorded by a captain of a boat catching large pelagic fish, including tuna. This demonstrates that the species may get entangled in the large gillnets being used by such boats in Pakistani waters and that striped dolphins are getting affected by tuna fishing operations in Pakistan. The extent of this issue is still to be studied.

Rough toothed dolphin

The absence of information on rough-toothed dolphins in Pakistan is possibly due to lack of effort in deep offshore waters previously as well as in recently conducted surveys by the CCP project. As in the case of the present sighting, it is possible that the fishers fishing in offshore waters interact with this species frequently but due to lack of experience

in proper species identification none of the fishers mentioned having seen them in a comprehensive fisher community interviews conducted by the CCP project 2005-2008 (Gore *et al.*, 2012; Kiani, Ph.D. thesis). Such close interactions with fishing vessels render this species vulnerable to entanglements in fishing gear as well as boat strikes. Although no information on by-catch levels of this species are in hand, the animals may be getting killed in deeper waters and the carcasses may be sinking at sea instead of reaching the coastline due to the great distances involved. This may be the reason for absence of this species in beach cast remains data (Kiani, M.S. and Pervaiz, I. unpublished data). The first record of this species is a new consideration for Pakistan’s Biodiversity Action Plan and for future development of a proper strategy for cetacean conservation in Pakistan since this new record is reported by a tuna gillnet fishing vessel which are cause of high levels of by-catch of non-target species specifically marine turtles and cetaceans (M. Moazzam Khan, pers. comm.). Proper mitigation measures are required for their future survival.

Strict implementation of relevant laws to disperse the concentration of fishing activities, particularly in the Swatch, is important for conservation of cetaceans in Pakistan. Data on by-catch have not been accumulated by any of the relevant departments, and observer programmes by the Marine Fisheries department are not effective in recording cetacean interactions, being focused only on monitoring illegal fish catch and enforcement of fishing area restrictions. Detailed observations on the status, diversity, distribution of marine mammals, especially offshore cetaceans should be done extensively with the collaboration of relevant departments of the country and regionally active research groups.

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