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Diversity and Conservation of Cetaceans in Pakistan

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Abstract

Pakistan has total coastline of about 990 km, while diversity, distribution and abundance of cetaceans are not well understood. All historic and most recent information are based on opportunistic stranding or incidental bycatch in fishing nets, which has been a big obstacle in formulating any conservation strategy for cetaceans in Pakistan. Recent initiatives were taken and conducted surveys along the entire coastline. Although, some species have been identified well, however, still, lack of detail studies on population biology and ecology of these species. Many other species are still lack of the expertise for identification or they were misidentified. So far, a total of 18 cetacean species have been recorded in Pakistan, consisting of 3 endangered species namely blue whale (*Balaenoptera musculus*), Arabian sea humpback whale (*Megaptera novaeangliae*) and Indian Ocean humpback dolphin (*Sousa plumbea*), 2 vulnerable such as the sperm whale (*Physeter macrocephalus*) and Indo-Pacific finless porpoise (*Neophocaena phocoenoid*) and others 13 species are listed as data deficient. Future studies should be focused to systematic investigations on stock identification, distribution, and also evaluate the anthropogenic threats to the cetaceans. As the cetaceans has unique evolutionary history among mammals and top predator in the aquatic ecosystem. The national policies and legislations should be revised to declare them as protected species. More protected areas should be established in some important areas, such as Indus delta along the Sindh coastline to sustain the integrity of habitat and long-term conservation and management of cetaceans along the entire coastal area of Pakistan.

Key words: Astola island, Blue whale, Conservation, Humpback Dolphin, Humpback whale, Northern Indian Ocean

Introduction

In Pakistan, there lacks a systematic information about the distribution, species richness and abundance of cetaceans. Most of the information that is available from opportunistic or bycatching records from fishing nets. By collating all of the published information on newspapers, local and international academic journals (De Silva 1987; Roberts 1997; Boer et al. 2002), data from an illegal soviet whaling off hunted whales for three years (Mikhalev 1997, 2000), and some records published by Pilleri and Gihr (1972a, 1972b), showed that the coastal area of Pakistan supported a considerable diversity of cetaceans.

The gap on the data of cetacean diversity, distribution and abundance specifically for some threatened species from the coastal area of Pakistan has been a hindrance in formulating a practical and robust national policy for conservation of biodiversity (Kumarran 2002, 2009). Thus, it was an urgent need to collect such information along the entire coastal area of Pakistan, which will facilitate the development of plans for the conservation of species in the Indian Ocean sanctuary (Rizvi et al. 1995). In recent past, there has been few initiatives taken to fill this gap. For example, a project Cetacean Conservation Pakistan (CCP) was initiated from 2004 to 2009. During this project, long- term boat based surveys were conducted along the inshore and offshore areas by joint collaboration among the Centre of Excellence for Marine Biology (CEMB) at University of Karachi (Pakistan), WWF-Pakistan, and Department of Environment Food and Rural Affairs (DEFRA) of the UK Government under its Darwin Initiative (Gore et al. 2012). The beachcast surveys were conducted to collects specimens, with soft tissues and skeletal materials, later were used for collecting additional information on species identification, age and gender determination using molecular techniques (Gore et al. 2017). Another long-term crew based observation, which was conducted by WWF Pakistan from 2012-2020, collected some information on baleen whales (Moazzam and Nawaz 2014, 2016, 2017; Moazzam et al. 2020).

Thus, this review with aim to compiled historic records and up to date information on diversity, distribution, population abundances of some species, hotspot areas of the baleen whales, challenges regarding conservation including species identifications, causes of mortalities, strandings, threats from the different anthropogenic activities, conservation status and conservation efforts done so far in Pakistan. This information is valuable not only for our

understanding of this important biodiversity of Pakistan, but for better research and conservation in the future especially for the endangered cetacean species.

Material and methods

Pakistan has a total coastline of about 990 km, bounded by Balochistan Province and Sindh Province (Fig. 1) respectively constituting 72.7% and 27.3% of the entire coastline (MFF Pakistan 2016). The climate can be distinguished by four periodic seasons of North East (NE) monsoon from November-February, following by Intermonsoon spring (IMS) from March-April, and South Western (SW) monsoon from June-September following by Intermonsoon autumn (IMA) of October only (Kidwai and Amjad 2000). We have collected all data on whales, dolphins and porpoise from various sources such as unpublished reports of different projects by WWF-P, published information in newspapers shared by focal persons of WWF-P, reports presented in local and international seminars, including published historic and most recent information in international and local journals. The conservation status of each species followed by the IUCN classification criteria (IUCN 2020). We have also compiled and reconstructed most important maps on Geographic Information System (GIS) to show geographic locations of live encountered of baleen and toothed whales, the areas where species were unable to identified, locations of mortalities and where stranded dead specimens were collected, including locations of protected areas along the entire coastal area of Pakistan.

[**Figure 1**. is about here]

Results

Species diversity

A total of 18 cetacean species, three of Mysticeti and 15 species of Odontoceti were reported in coastal area of Pakistan (Table 1 and 2). All these species belong to the six families and fourteen genus (Table 1). Two of the coastal species, the Indian Ocean humpback dolphin (*Sousa plumbea*) and Indo-Pacific finless porpoises (*Neophocaena phocaenoides*) were normally occurring whole of the year along the entire coastline. The Bryde's whale (*Balaenoptera edeni)* was observed only during the North Eastern monsoon, and three species the (Indian Ocean

humpback whale (*Megaptera novaengliae*), Risso's dolphin (*Grampus griseus* and the killer whale *Orcinus orca*) were rarely sighted. All of the confirmed species and their current status are summarized in Table 1. According to IUCN (2020), these species were also categorized into 3 endangered, 2 vulnerable and 13 data deficient species.

Other species might also be occurring along the coastal area of Pakistan. For example, Ranjbar et al. (2016) stated that the Omura's whales (*B. omurai*) was most likely to be present here, Ahmed and Ghalib (1975) and Ahmed and Rizvi (1985) reported the live sightings of the melon headed (*Pepanocephala electra*) in Sonmiani (Balochistan), and fin whales (*B. physalus*) along the Sindh and Balochistan coastline. Moazzam and Nawaz (2014) stated the presence of false killer whale (*Pseudorca crassiden*) in Pakistan coastal waters.

[**Table 1.** is about here]

[**Table 2**. is about here]

Arabian sea humpback whale

In Pakistan the Arabian sea humpback whale (ASHW) is locally famous as "Karambo", live sightings were recorded whole of the year (Kiani 2015a). A distinct species with possible distribution range from the Northern area the Gulf of Aden, Iraq, Iran, entire coastline of Pakistan and extensively included the Western coastal area of India and Sri Lanka (Al Robaae 1974; Braulik et al. 2010). According to the United States Endangered Species Act, this genetically unique and non-migratory population is still designated as endangered species (NOAA 2016) and at the high risk of extinction (Minton et al. 2008; IWC 2016). Although this species lacks the population size estimation from Pakistan, they were very well understood from the neighboring coastal area of Oman, where capture mark recapture based photo-identification counted a total of 100 individuals (Minton et al. 2011).

During earlier 1960s, the ASHW was hunted for three years along the Sindh coastal area (Mikhalev 2000). A very first reported stranded specimen was dated back in 1873 by Mathew (1873), and more subsequent stranding cases were reported (de Silva 1983; Ahmed 1985; Kiani 2015b; Moazzam 2016). Only two live sightings were recorded from 2005 to 2009 (Gore et al. 2012), and three additional live sightings were recorded by Kiani (2015b), afterwards records increased by crew based observer program with cumulative records of 74 sightings, with locations of live sightings from 2015-2019 (Moazzam and Nawaz 2014, 2017; Moazzam et al.

2020) shown in Fig. 2. The documented positions over the years for this endangered species along the coastal area of Pakistan could be the valuable source of information for future studies, to locate them and identify the individuals by capture mark recapture method or by the recording of acoustic signals.

[**Figure 2**. is about here]

Blue whale

Three populations of blue whales were reported worldwide, and the population in Northern Indian Ocean is a distinct population of pygmy blue whale (Blyth 1859; Branch et al. 2007b; Yochem and Leatherwood 1985). During earlier 1960s, the Soviet whaling hunted nearly 1,294 blue whales from the Arabian Sea (Mikhalev 1996, 2000) with 31 catches along the India and Pakistan border (Mikhalev 2000). The population extent has been increased and recently recovered (Branch et al. 2007b). However, the pygmy blue whales lack of any population survey in Pakistan. During earlier 1970s, the first live sighting of pygmy blue whale in Pakistan came from the Sindh coastal area reported by Ahmad and Ghalib (1975). Since then, no direct information on this species has been available 2010s, except for some opportunistic sightings or records of stranded specimens along the coastal area of Pakistan. One stranded blue whale with a total length of 18-19 m was reported by Moazzam and Nawaz (2014), and a total of 67 live sightings were reported from 2012-2019 (Moazzam 2020) (Fig. 2). The frequent sighting and stranding cases were recorded round-year likely to be resident along the coastal area of Pakistan.

Bryde's whale

This species lacks of detailed information in Pakistani waters compared with other two species of baleen whales, i.e., ASHW and blue whale. However, it is believed that the Bryde's whale was regularly present along the entire coastal area of Pakistan. This species could be sighted all around the year, but most frequent sightings were recorded during South Western monsoon season (Gore et al. 2012). The historic records such as stranding, beachcast specimens or live sighting were sporadic, although its recent sighting records are increasing. From 2007 to 2020, a total of 15 live sightings of the Bryde's whales have been recorded so far (Gore et al. 2012; Moazzam et al. 2020), and sightings records of their locations are shown in Fig. 2. Besides sightings records, two dead specimens have been recovered (Braulik et al. 2010; Moazzam et al.

2020), whereas one stranded specimen of Bryde's whale was entangled in gillnet and finally rescued and released safely (Moazzam and Nawaz 2014).

Sperm whale

The sperm whale is reported from the neighboring coastal areas of Iran, Iraq and India (Minton 2004). This species lacks any historic record based on Pakistan, first indirect information was provided by Gore et al. (2007a) they discovered a skull on the Soneri Beach near Manjar Goth. The total length of the skull was 2.18 m, which suggested its body length as 9.5 m and it was calf. The skull is preserved at the Center of Excellence in Marine Biology (University of Karachi). Afterwards, the information on this species has been updated, a total of 6 live sightings were recorded by Cetacean Conservation Project (CCP) (Gore et al. 2012), and 24 live sightings from 2012-2019 during crew based observation (Moazzam and Nawaz 2019b; Moazzam et al. 2020) were recorded, with some sightings with geographic locations shown in Fig. 2.

Kogia spp. and beaked whales

The genus Kogia only contains two species, dwarf sperm whale (*K. sima*) and pygmy sperm whale (*K. breviceps*), both species lack any detailed information and also poorly known worldwide, probably due to their inconspicuous shy behavior and their living in the deep offshore areas. The occurrence and distribution of both species are only estimated from stranding or bycatch records (Carwardine 1995). Similarly, in Pakistan the occurrence of both species was confirmed by bycatch records. The specimen of dwarf sperm whale was incidentally captured in fishing net on March-19-2013 (Moazzam and Nawaz 2014). The first occurrence of the pygmy sperm whale was from an unconfirmed historic record in 1985, but recently this species was confirmed twice by bycatch. One of which was 8.2 feet in length with body mass of 400 kg (WWF-P 2015). Since 2015, there has been no update for these two species.

Several authors claimed the presence of beaked whale in Pakistan's coastline after collecting few skeletal materials (Pilleri and Gihr 1972; Roberts 1997; Boer et al. 2000). A complete skull was discovered on June-30-2006, a comparative analysis confirmed the presence of Cuvier's beaked whale in Pakistan, with the specimen preserved at the Centre of Excellence in Marine Biology (University of Karachi) (Gore et al. 2007b). Recently, three different cases of incidental bycatch of Cuvier's beaked whales were reported by Moazzam (2019).

Killer whale

The killer whale had rare live sighting records along the entire coastal area of Pakistan. Only a pod of killer whales was spotted in pursuing their preys by Gore et al. (2012), and recent live sighting of one individual was reported by Moazzam et al. (2020) (Figure 2). A dead specimen was collected during beachcast survey along the coastal area of Pakistan by Gore et al. (2012).

Indian Ocean humpback dolphin

The Indian Ocean humpback dolphin is an endangered species (IUCN 2014), distributed along the entire coastline of Pakistan, with more information than any other marine cetacean species. The highest encounter rate of this species was recorded along the Sindh coastal area. The population abundance of this species has never been documented along the entire coastline, although a total of 112 sightings were recorded with cumulative population of 439 individuals along the Indus coastal area of Sindh Province. Only 36 sightings were recorded in two sections (Miani Hor and Sonmiani Bay) along the Balochistan coastal area (Fig. 3) (Gore et al. 2012; SDO 2012; Kiani 2014). The Indus delta support the largest population of the Indian Ocean humpback dolphin in its entire distributional range (Karczmarski 1999, 2000). The individual identification and population abundance were estimated by capture mark recapture method based photo-identifications, with 87 individuals captured but lowest number of 5% individuals were successfully recaptured (Kiani 2014).

[**Figure 3.** is about here]

[**Figure 4.** is about here]

Bottlenose dolphin

In Pakistan, bottlenose dolphins or genus *Tursiops* were commonly encountered species (Bladwin 2003) with cumulative population size of 154 individuals. Although bottlenose dolphins from different waters showed insignificant morphological distinctions, only differences in their habitat selection assigned them as separate species: the common bottlenose dolphin *(T. truncatus)* only found along the deep offshore area of the Balochistan, and the Indo-pacific bottlenose dolphin (*T. aduncus*) with larger distribution along the entire inshore waters of Pakistan (Gore et at. 2012, 2017).

Risso's dolphin, long beaked common dolphin and rough-toothed dolphin

In Pakistan, there were a total of five live sightings records of Risso's dolphins from 2003 to 2009 only along the Balochistan coast (Gore et al. 2012), and three cases of bycatches were reported by Moazzam and Nawaz (2014).

A distinct subspecies of common dolphins (*D.c.tropicalis*) is recorded along the Arabian Sea and nearby area along the Gulf of Aden (Baldwin 2003), Oman (Braulik et al. 2010b), Western India and Pakistan (Afsal et al. 2008). In Pakistan a total of 2 live sightings were reported during seismic survey in 2003 by Gore et al. (2012). Since then, no records of this species along the entire coastal area of Pakistan has been available.

For the rough toothed dolphins, information of occurrence lacked of any historic or recent strong evidences. However, a video clip 6 individuals is the only record to claim the presence of this species in Pakistan (Kiani 2013).

Pantropical spotted dolphin, spinner dolphin and striped dolphin

Pantropical spotted dolphins are widely distributed in the Indian Ocean, which has been reported from the Pakistan, Bangladesh, India, Maldives, Oman, and Sri Lanka (Leatherwood 1986; Gallagher 1991; Leatherwood et al. 1991; Salm et al. 1993; Ballance and Pitman 1998; Kumaran 2002). The historic information based on the observation collected from local people and fishermen communities was reported by Niazi (1990). However, the occurrence of this species has been recently confirmed after a mass stranding event of 200-250 individuals of mixed ages. All of the stranded individuals were rescued and returned back in the deep water, except that two individuals died, and necropsies was performed. The specimens were preserved at the Centre of Excellence in Marine Biology (CEMB) in Karachi (Pakistan) (Kiani et al. 2011).

The spinner dolphin is locally famous as goco or tooshunk in Pakistan. There were two detailed records, a total of 9 groups with cumulative population of 923 individuals in 2003, while another record of 12 groups with cumulative population of 2,535 individuals were recorded during boat based surveys from 2005-2008. This species was recorded only along the Balochistan coast. Additionally, two corpses of stranded specimens were also recovered by Gore et al. (2012).

The striped dolphin did not have any record from the western neighboring coast of Iran (Owfi et al. 2014), or the Eastern coast of the India (Kumaran 2002). However, the occurrence of this species in Pakistan was confirmed from one record of complete skull of a juvenile, with

specimen preserved at the Center of Excellence, University of Karachi. In addition, video was recorded as live sighting and one specimen was incidentally captured in fishing net reported by Kiani (2013).

Indo-Pacific finless porpoise

Indo-Pacific finless porpoises are common and most encountered species along the entire coastline of Pakistan (Pilleri and Gihr 1973-74; Roberts 1977; Gore et al. 2012). This species has been reported in upstream area of Indus river from the delta (Kasuya 1999), and seasonal shifting of habitat were also recorded, during winter they prefer inshore areas in winter season, and offshore area in summer seasons (Pilleri and Gihr 1972; Roberts 1997). Indo-Pacific finless porpoises are most frequently found the North East monsoon season (Gore et al. 2012). Recently, genetic study did not reveal any genetic distinction of this species in Pakistani water (Gore et al. 2017), future studies should be focused on combination of comparative morphology and genetics may also helpful for the stock identity in Pakistani water.

Unidentified species

In Pakistan, limited resources are available to conduct long-term studies at local or domestic scales (Gore et al. 2012). Current limited information on the diversity of cetaceans are the results of joint collaborations under the supervision of international experts, and financially sponsored from the foreign funding resources, with the main aiming to assess the diversity of cetaceans along the coastal area of Pakistan. Published records suggested a common problem in the identification of the species, which made the diversity of cetaceans in Pakistan poorly understood. The inability of identification or incorrect identification could be a serious problem (Ephrick 2008; Fransworth 2013) to take informed decisions for the conservation and management of species (Rodrigues 2006; Fritzpatrick 2009; Butchart 2010).

In Pakistan the Bryde's whale was misidentified as the Sei whale, and one bycaught specimen of the Indo-Pacific finless porpoise which was misidentified as the Risso's dolphin was published in newspaper (Ilyas 2020). Gore et al. (2012) conducted long-term boat based and beachcast surveys from 2005-2009, they reported a total of 16 live sightings but some animals were not successfully identified at species level. A regular monitoring and frequent sightings of baleen whales were reported from 2012-2020 (Moazzam and Nawaz 2014, 2017; Moazzam et al. 2020), with some unidentified baleen whale species Fig. 5.

Two species, i.e. the melon headed dolphin (Ahmad and Rizvi 1985) and fin whale (Ahmad and Ghalib 1975), had some historic live sightings, bycatch or stranding records based on Pakistan. Due to the existence of suitable habitat, probably the Omura's whale also occurred in Pakistan (Ranjbar et al. 2016). However, these species had no recently updated information, despite that their occurrences were confirmed in the Northern Indian Ocean. Most probably the melon headed dolphin, fin whale and Omura's whale did occur in the coastal waters of Pakistan, but they might have not been correctly identified at species level due to lacks expertise.

The stranded specimens were collected during the beachcast surveys or informed by the local people from 2005-2008, few of them could be identified due to highly putrefaction. Molecular techniques were used on soft and skeletal tissues to conduct their species identification (Gore et al. 2017). Although some species in Pakistan have been well identified, but still lack of the expertise for identification of many more species.

[**Figure 5.** is about here]

Awareness among public and local fishermen

Indigenous communities are the effective source to play a key role in the conservation and management of species. The Cetacean Conservation Project (CCP) developed harmony among local people and fishermen communities, conducted workshops to train the local fishermen how to mitigate and control the mortalities of cetaceans while fishing. They also conducted interviews with local people to assess the challenges for the conservation of cetaceans in Pakistan. The Indigenous communities from the Balochistan coastal areas were up to date regarding cetacean species and their identifications (Gore et al. 2012). A temporary stranding network was established with the help of local people and fishermen communities from 2005-2008, which reported several stranded or bycatch specimens, and the corpses were collected to confirm the occurrence of species in the Pakistan (Gore et al. 2017). A dolphin safari has been initiated along the coastal area of the Sindh, with aim to educate the people by providing a chance of close encountered and observe the different cetacean species in their natural habitat (Gore et al. 2012).

Threats

The increasing anthropogenic activities, such as development along the coastal areas, expanding of small and big industries, may have added pollution in the coastal water of Pakistan (Rizvi et al. 1988; Sayied 2007; Saher and Siddiqui 2016). Increasing fisheries practices and

associated anthropogenic activities also had some detrimental impacts on cetacean species (Kirkwood et al. 1994; Moore et al. 2014). These issues have been addressed from the different areas for the conservation and management of cetaceans.

Negative impacts of fisheries

The mortalities of cetaceans induced by fisheries were highlighted after 2004. The high demand of sea foods and export of fishes from Pakistan resulted in the increase in fishing trends at commercial scales. The tuna fisheries alone is the biggest threat to the offshore cetaceans, and the recent census showed that a total of 820 registered tuna catching boats were operating at smaller and larger commercial scales (Khan 2018). Commercial fishing in the hotspot areas were commonly observed, which has increased the chances of bycatch mortalities of cetaceans (Moazzam and Nawaz 2014). The pelagic gillnet was the major cause of cetacean bycatch in the range of fisheries, with two peaks of cetacean mortalities were recorded around the year, the first in March and the second from September to November (Moazzam and Nawaz 2014).

The Indian Ocean humpback dolphin, bottlenose dolphin and spinner dolphin were observed to be attracted by fishing boats. Some events of boat striking were also reported during boat based surveys of CCP. The injuries on bottlenose dolphins by boat propellers were sighted along the Sindh coastal area, but the detailed information lack on the conflict with fisheries, origin of injuries after striking with boats or their post survival among cetaceans. However, mortalities due to tuna fisheries from 2005-2008 were monitored, with eleven specimens of baleen whales (ASHW and Bryde's whales) and 37 specimens of toothed whales were reported from the entire coastal area of Pakistan. The Indian Ocean humpback dolphin and finless porpoise were two most common species in coastal waters and the spinner dolphin, bottlenose dolphin and the pantropical spotted dolphin were most common in offshore waters (Gore et al. 2102).

The mortalities due to fisheries, only 12000 mortalities from 2013-2014 and 10150 mortalities in 2015 were reported from the coastal area of Pakistan. There were 20-35 dolphins/month and a mean of 1-4 dolphins in each fishing trip (Moazzam and Nawaz 2014; Shahid 2016), with most common areas of dolphins' mortalities are shown in Fig. 6. For baleen whales, the mortality of 1-2 baleen whales per year were reported by Moazzam and Nawaz (2014). The overall reports on the mortalities of cetaceans in Pakistan were different or contradicting with one another, especially high mortalities rate was found in the recent reports.

[**Figure 6**. is about here]

Water Pollution

In Pakistan, pollution in marine environment originated from the land based resources such as domestic wastes, toxic chemicals from the agriculture and different industries and oil seepage from the transportation of ships and oil tankers (Rizvi et al. 1988; Sayied 2007; Saher and Siddiqui 2016). The Sindh coastal area has much more human settlements to provide the economic benefits. Karachi is the largest industrial and highly populated city of the Pakistan, covers 167 km along the Sindh coast (Rizvi et al. 1988; Saher and Siddiqui 2016). In 2016, it was estimated that the Karachi city discharged approximately 8000 tons of solid wastes on daily basis. Due to the expanding human population, discharged wastes could be 16000-18000 tons/day in 2020 (MFD 2016). The domestic and industrial sewage of the upstream Southeastern part were directly drained into the Indus river, which ultimately ended up in the Indus delta coastal water (Zaigham 2004). The small and big industries cumulatively drained approximately 300 million gallons of effluent wastes on daily basis (WWF 2002; MFD 2016), and it was estimated the annual drainage of 1500 million m^3 from only five big industries, including one steel mill and four other power plants (HDIP 2008; Khalil 1999). It was estimated that, approximately 37,000 tons/ annum of the solid wastes from the industries are dumping along the Sindh coastal area (Kiani 2014). There were two incidents of oil spill along the Sindh coastal area from 1980-2003. A busy trafficking of ships and the transportation of oil tankers are the source of oil seepage directly into the coastal waters (Baig 2004; Chaghtai and Saidullah 2001).

By contrast, the Balochistan coastal zone is much safer and healthier, due to sparse distribution of human settlements in small towns and villages, and the lack of any big city or industry (Ali and Jilani 1995) except ship graveyard or ship breaking industry located at Gaddani. It could be the biggest threats for biodiversity by discharging some toxic chemicals and heavy metals into the coastal waters (Baig 2004; Chaghtai and Saidullah 2001).

The negative impacts of pollution might be a cause of reduce productivity of food resources for the coastal species (Kiani 2014), however, the negative impacts of pollutions on cetaceans and their primary preys have never been studied in Pakistan up to date.

Stranding cases

The stranding cases of cetaceans are regularly reported worldwide. Multiple reasons have been investigated so far, among them the natural causes are diseases or parasites or sudden

changes in optimal environmental conditions (Dhermain et al. 2002). Physiological conditions while animals were unable to echolocate for navigation, communication and hunting (Bompar 1996; Perrin and Geraci 2002) or escaping from predators or chasing prey might be also leave them stranded (Casinos and Vericad 1976; Nores and Perez 1988). Some other causes included anthropogenic activities such as injuries after striking with boats or fisheries interactions (Laist et al. 2001; Jensen and Silber 2003), or pollutions in water (Kannan et al. 1993). The standing cases provided significant contribution towards species occurrence and their abundances (Berrow 2001), especially for those areas where resources were limited (Gore et al. 2017). Also, it could provide the baseline data for the causes of mortalities and threats on habitats to take decisions for the conservation and management of species and their habitats (Mignucci-Gianonni et al. 1999; Norman et al. 2004).

During 2005-2008, a total of 57 stranding cases were reported (Gore et al. 2012) (Table 3), with morphometric data, ages and genders collected in the field at spot. Some corpses were not found in good conditions and were unable to identify species accurately or confirm their gender. Their species identifications and genders, therefore, were identified by using molecular techniques with soft and skeletal tissues and their ages were determined with teeth. Three species, i.e. the Bryde's whale, pantropical spotted dolphin, and long-beaked common dolphin, which were not observed during the field surveys from 2005-2008 were identified in this way (Gore et al. 2017), whereas two species, the sperm whale (Gore et al. 2007a) and Cuvier's beaked whale (Gore et al. 2007b), were confirmed by their skeletons. In overall cases, juvenile males were commonly stranded (Gore et al. 2017). It was estimated that, a total of 9.3 individuals/year were stranded mainly along the Balochistan coastal area (Gore et al. 2017), with major causing agents as pollutions along the coastal areas and creek systems (Chaghtai and Saidullah 2001) and regular naval exercises as main causing agents for the stranding of cetaceans along the coastal area of Pakistan (Gore et al. 2017).

[**Table 3**. is about here]

A mass stranding case was for the pantropical spotted dolphin at Gaddani beach in 2009, with approximately 200–250 individuals recorded. It was the first confirmed record of this species in Pakistan. The exact cause of mass stranding event was not identified, which could be

the pollution from the nearby Gaddani ship breaking area (Geo Pakistan 2009), or a multinational-naval exercise (AMAN 09) of warships in offshore water of Pakistan (Kiani 2011).

[**Figure 7**. is about here]

Direct killing

In Pakistan, local people have never been interested in hunting any cetaceans species to use as food. One of the local old fisherman from the Balochistan coastal area shared his personal experiences as he was an eye witness of the killing of coastal cetaceans species such as finless porpoises, spinner dolphins and humpback dolphins by using harpoons. Later those specimens were used for medicinal purposes, caulking their boats and using as bait for sharks. Now, the effect of overfishing along the coastal area of Pakistan has already reduced the shark stocks, and fishermen are having no interest in killing any species of cetaceans (Kiani 2014, A. Rahim, Coastal Scientific Society Gwadar Balochistan, personal communication to M.S. Kiani, December 2012; A. Shah, IUCN, personal communication to M.S. Kiani, June 2012). Recently, the corpses of finless porpoises were recovered, while flukes were removed. Apparently it might be the fishermen who cut the flukes to free their bodies from fishing nets (Gore et al. 2012).

Conservation status

A four-year joint project by Cetacean Conservation Project conducted 63 surveys along the entire coastal area to assess the diversity and abundance of cetaceans in Pakistan. They also conducted the beachcast surveys to collect skeleton and remaining of each cetacean specimen. Furthermore, they developed the awareness among the local people and fishermen communities regarding how to reduce the mortalities of cetaceans. Twelve cetaceans were reported in Pakistan during their long-term field surveys. According to IUCN Red list of threatened species, three species are endangered, including two baleen (blue whale and humpback whale) and one toothed (Indian Ocean humpback dolphin) whales, whereas other two species (sperm whale and finless porpoise) are vulnerable and eight species are included in the Appendix of the Convention on Migratory species. This study was the first initiative to support the national and regional management to take decisions for the conservation of cetaceans in Pakistan (Gore et al. 2012). A crew based observer program was carried out from 2012-2019 to monitor the occurrence of baleen whales along the entire coastline of Pakistan, adding some valuable information to identify the hotspot areas for two endangered baleen whale species (ASHW and blue whale)

(Moazzam 2020). There are three permanent hotspot areas along the Sindh Province (Greater Khori Bank, Indus coastal area, and Hawks Bay-Cape Monz) and four hotspot areas (Churna Island, Phor-Ormara Area, Astola Island, Gwader-Ganz) are located in Balochistan coastline. Some other areas are also important for frequent sightings of cetacean species such as off Karachi, Gaddani, Taq, Pasni Bay, Ras Shumal Bundar, Darran and Jiwani (Moazzam and Nawaz 2014).

Protected Area

In the recent decades, there was a rapid development in the socio-economic sectors accompanying with the exploitation of natural resources in Pakistan. However, their negative impacts on biodiversity and their habitats have never been quantified precisely. A big debate was started among scientific communities for the conservation and protection of biodiversity with the establishment of protected areas (Ehrlich 1983; OECD 1993; Vedeld 1994). The coastal area of the Pakistan is a part of the Indian Ocean Sanctuary which was established in 1979 to protect whales from hunting (Marine Fisheries Department 2006), and the Northern area of the Arabian sea is an important migratory route and provide feeding ground for cetaceans (Roberts 1997). The Marine Protected Areas (MPAs) is a highly important conservation tools (Ward et al. 1999) to reduce the anthropogenic threats (Agardy 1994), to increase the productivity of natural habitats, provide nurseries for juveniles (Bell 1983; Russ and Alcala 1998; Garcia–Charton et al. 2004) and abundant food for cetaceans (Keller 1999). Presently, the most important thing in the protected areas is the implementation of legislations and law enforcement (Karczmarski et al. 1998; Simmonds and Hutchinson 1996) for rapid reviving population to mitigate all the threats (Gell and Roberts 2003; Lubchenco et al. 2003) and reversing the detrimental effects (Dugan and Davis 1993; Roberts and Hawkins 2000).

A recent increase of fishes export from the coastal area of Pakistan (Marine Fisheries Department 2006) might be a big threat to reduce the fish stocks and their varieties as the primary prey for cetaceans. To meet the increasing demand, it may increase the conflicts with fisheries such as bycatch in fishing nets, injuries due to striking with boats, and mortalities (Niazi 1990). The Pakistan National Conservation Strategy realized it and proposed an urgent need to identify the hotspot areas for cetacean conservation, to establish the Marine Protected Area (MPA) or upgrade the already protected areas under project ‘‘Protecting Water Bodies and Sustaining Fisheries’’ and ‘‘Conservation of Biodiversity’’ (Siddiqui et al. 2008). The protected

areas along the coastal area of Pakistan are listed in Table 4. There are three hotspot areas along the Sindh coastal area, namely the Greater Khori Bank, mouth of the Indus River, and Hawks Bay-Cape Monz, whereas there are four hotspot areas along the Balochistan coast, the Churna Island, Phor-Ormara, Astola Island, and Gwader-Ganz. So far, no official protected cetacean species have been recorded in the Sindh or Balochistan coastal areas (Moazzam and Nawaz 2014).

[**Table 4**. is about here]

The Astola is the largest island along the Balochistan coastal area, which is the Ramsar site for reptiles and birds (Fig. 5) (Ilyas 2017). The Government of Balochistan declared it as the first MPA protected area of Pakistan for the conservation of mainland biodiversity (Rohi et al. 2018). The Indus river delta is the most important coastal area along the Sindh coastal region (Ahmad 1998), which is the core habitat for the endangered Indian Ocean humpback dolphin (Gore et al. 2012; Kiani 2014). It was declared as the Ramsar site in November-5-2002 (Ahmad 1998; Siddiqui et al. 2008).

Protection laws

The Pakistan National Action Plan for Conservation of Marine Cetaceans (Gore et al. 2008) asserted that cetaceans had never been clearly defined under any specific definition in the law of Pakistan. Cetaceans has never been described as protected mammal species either in “The Balochistan Wild Life Protection Act (No. XIX of 1974) or under the term “game” in “The Balochistan Gazette (No. 64, 1974)”. Only the freshwater Indus river dolphin (*Platanista minor*) was declared as protected species under the Sindh Wildlife Act of 1972. For marine cetaceans it is more similar to Balochistan Province where cetaceans have never been accounted or listed in “The Sindh Wildlife Protection Ordinance 1972”. All cetaceans in Pakistan were legally under the term “Fish” under Act No. 35 of 1997, which covered all kinds of aquatic animals. This Act assured the quality for the export of fish and fisheries products. The “Paragraph 5 (Export Restriction Point c)” has clearly stated that Whales, dolphins and porpoises were not allowed to export, and their consumption were completely forbidden. There is an urgent need to specifically define cetaceans, revise the national policies and their legislations for the long-term conservation of endangered cetaceans (Kiani 2015).

As a highly specialized mammalian lineage, cetacean have evolved a very special fully aquatic lifestyle as top predators in the aquatic ecosystem. However, they are endangered threatened from different anthropogenic activities such as pollution, development along the coastal areas and fisheries in their distribution range. Thus, all cetacean species in Pakistan should be declared as protected species under relevant wildlife legislations.

Conclusion

In Pakistan, only few studies have been conducted to provide limited information regarding cetacean diversity. A total of 18 cetacean have been reported, consisting of 3 endangered, 2 vulnerable and 13 data deficient species under IUCN Red List of threatened species. Although some species such as the Indian Ocean humpback dolphin, Indo-Pacific finless porpoise, bottlenose dolphins, pantropical spotted dolphin, and the spinner dolphin has sufficient records to confirm their occurrence. Still, scarcity of updated information regarding their distribution and abundance. Other species such as the sperm whale, killer whale, dwarf sperm whale, pygmy sperm whale and beaked whale have insufficient records. It is necessary to conduct systematic surveys to understand the stock identities in Pakistani water, through collaboration with national and international experts and educational institutes to understand their population biology, ecology and promote their conservation. The unique population of two baleen whales (ASHW and blue whale) should be taken as top priority for conservation and management to save them from extinction.

The negative impacts of intensified commercial fishing and other anthropogenic activities such as pollution on abundance of fish stocks are needed to focus. More importantly fishing along the coastal areas should be monitored to overcome the mortalities of coastal species. The original and reliable data on the bycatches and mortalities from the entire coastline will be helpful to take decisions for the conservation and management of species and their habitats.

The Astola island is a recently established first MPA along the Balochistan coast, for the conservation of mainland biodiversity, it is not enough to support such diversity of endangered or vulnerable cetacean species in Pakistani water. The species living in the coastal areas are in more danger due to development of coastal areas, heavy trafficking of ships, increasing tuna fisheries, human interventions and pollution (e.g. oil seepage during transportation, some toxic chemicals from the different industries). The Ramsar sites along the Balochistan and Sindh coast

specially the Indus delta should be declared as MPA for the conservation of coastal dwelling cetacean species and the overall biodiversity of that area.

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Declarations

Conflict of Interest

The Authors have declared that no competing interests exist.

Ethical approval

No animal used in this study.

Data availability

All data is available in this manuscript.

Authors' Contributions

Idea was developed by GY, manuscript was designed by BYC, AI collected the data and wrote the manuscript. All other authors (AI, HA, and AQ) reviewed the final manuscript.

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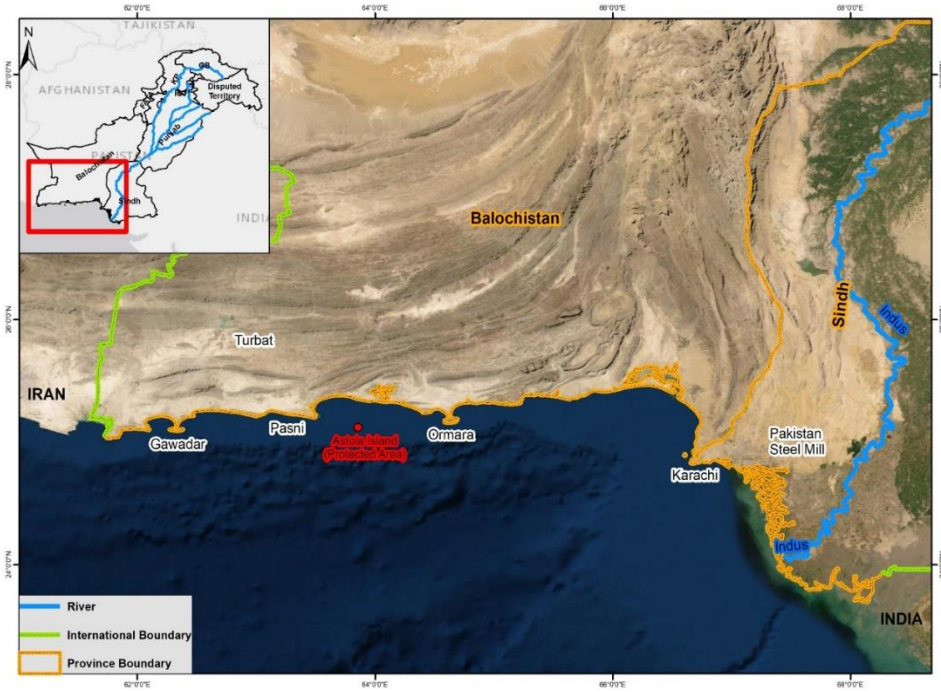
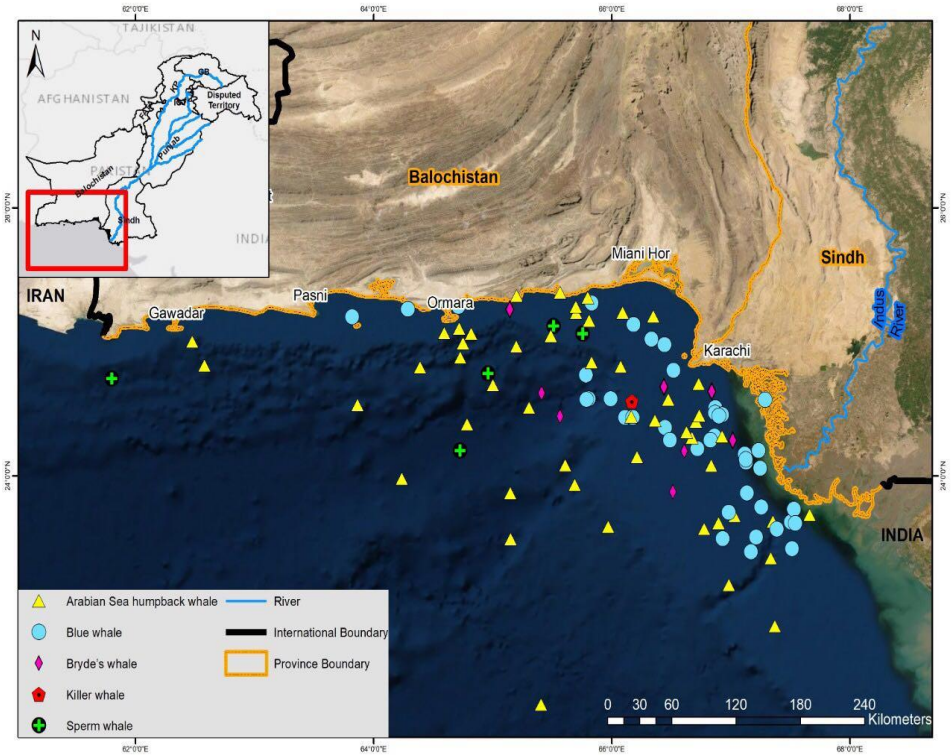


Figure 1. Coastal area of Pakistan bounded by two Provinces (Balochistan and Sindh)



1094 **Figure 2**. Reconstructed map of live sightings records of cetaceans along the coast of Pakistan
1095 during 2015-2019 (from Moazzam et al. 2020)

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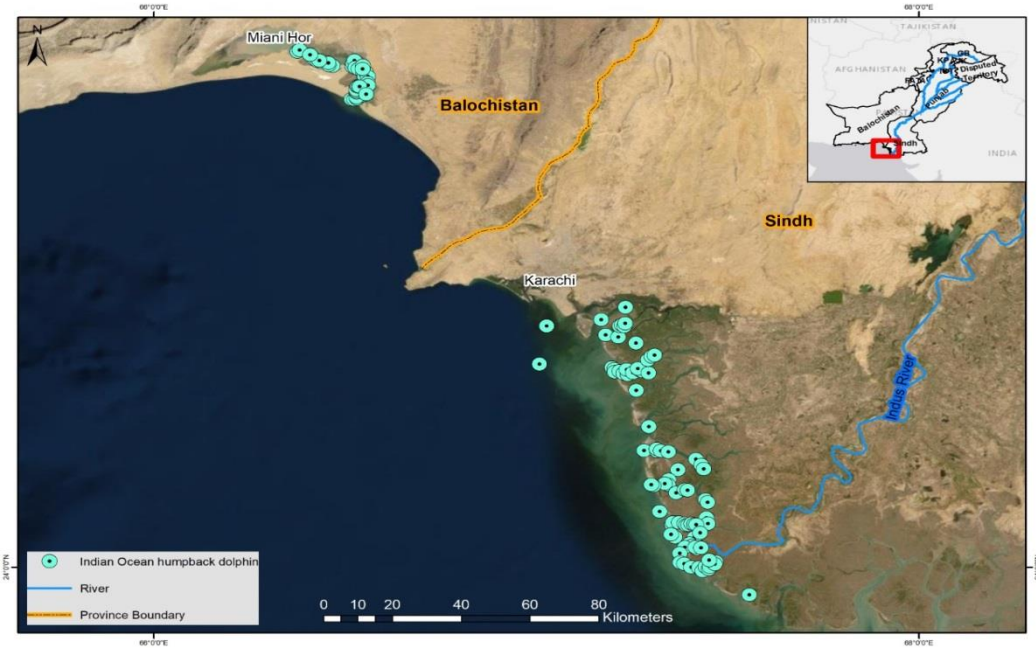

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1099 **Figure 3**. Reconstructed map of live sightings recorded of Indian Ocean humpback dolphins along
1100 the Indus delta creek systems of Sindh coastal area (from Gore et al. 2012; Kiani 2014), and
1101 Miani Hor, Sonmiani Bay (Balochistan coastaline) (from SDO 2012)

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1104 **Figure 4**. Two Indian Ocean humpback dolphins (mother and calf) in their natural habitat in
1105 Balochistan coastal area. Photo by Mehrban Ali Brohi

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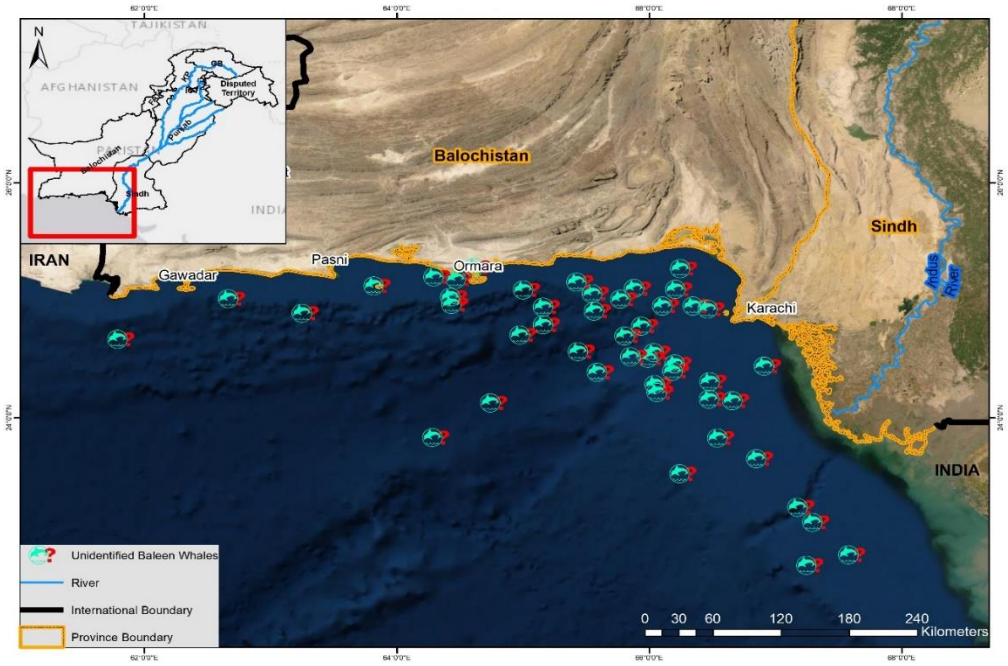

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1111 **Figure 5**. Reconstructed map of the unidentified baleen whales along the coast of Pakistan
1112 during crew based observations (from Moazzam and Nawaz 2014)

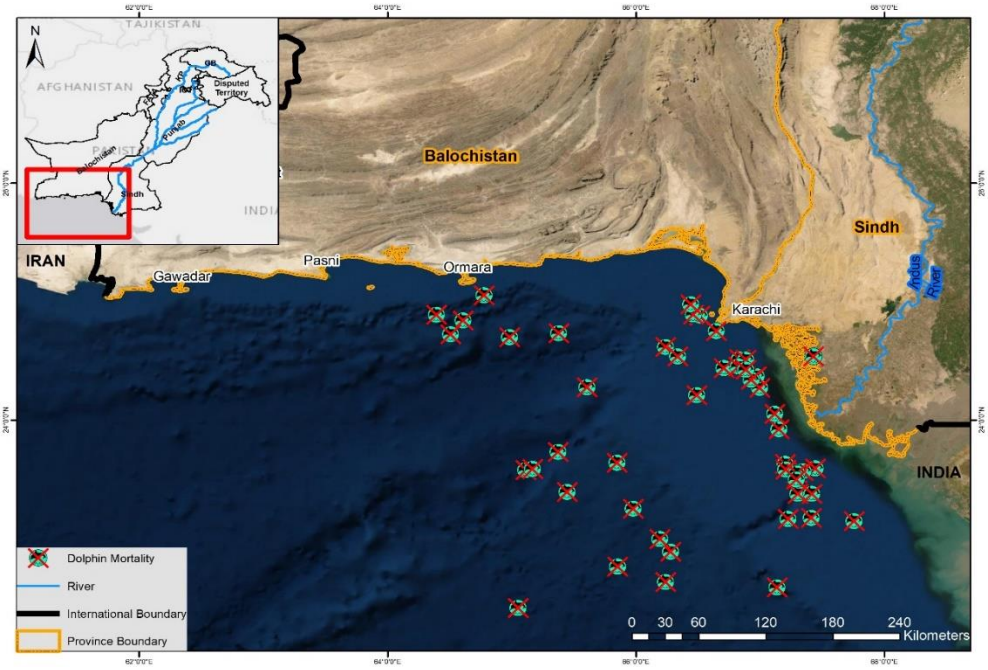

Figure 6. Reconstructed map showing the location of dolphin mortalities in Pakistan coastal waters (from Moazzam and Nawaz 2014)

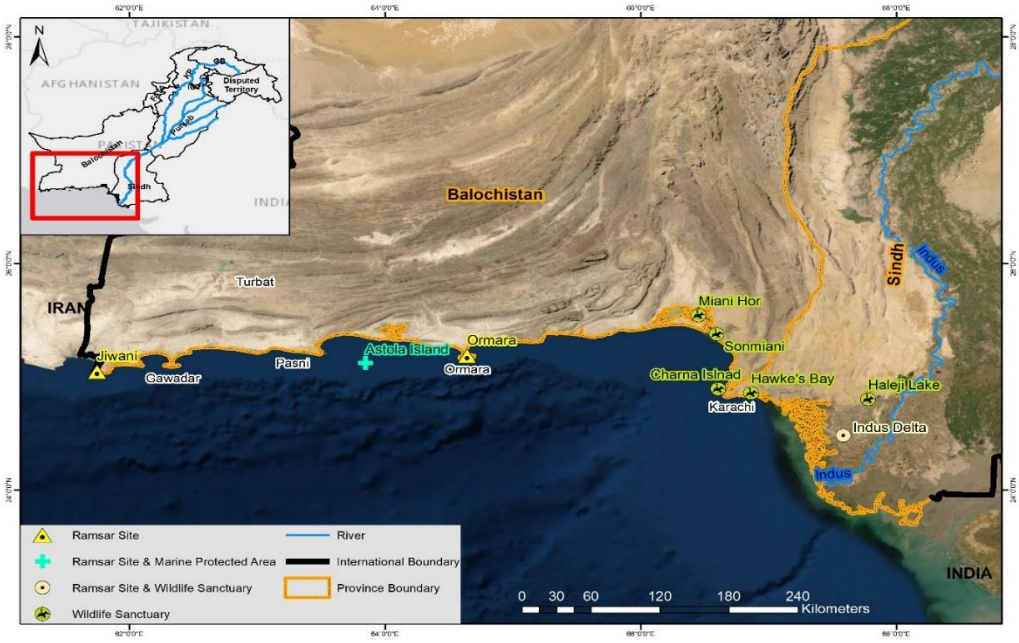

Figure 7. The location of protected areas along the coastal area of Pakistan from (Siddiqui et al. 2008)

1122 **Table 1**. A list of cetacean species reported in Pakistan.

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Family	Scientific name	Common name	IUCN Red List category
Balaenopteridae	*Megaptera novaeangliae*	Arabian sea humpback whale	Endangered
	Balaenoptera musculus	Blue whale	Endangered
	B. edeni	Bryde's whale	Data deficient
Physeteridae	*Physter macrocephalus*	Sperm whale	Vulnerable
Kogiidae	*Kogia breviceps*	Lesser sperm whale	Data deficient
	K. sima	Pygmy sperm whale	Data deficient
Ziphiidae	*Ziphius cavirostris*	Cuvier's beaked whale	Data deficient
Delphinidae	*Orcinus orca*	Killer whale	Data deficient
	Sousa plumbea	Indian Ocean humpback dolphin	Endangered
	Tursiops truncatus	Common bottlenose dolphin	Data deficient
	Tursiops aduncus	Indo-Pacific bottlenose dolphin	Data deficient
	Grampus griseus	Risso's dolphin	Data deficient
	Delphinus capensis tropicalis	Long beaked Common dolphin	Data deficient
	Steno bredanensis	Rough-Toothed dolphin	Data deficient
	Stenella attenuate	Pantropical spotted dolphin	Data deficient
	Stenella longirostis	Spinner dolphin	Data deficient
	Stenella coeruleoalba	Striped dolphin	Data deficient
Phocoenidae	*Neophocaena phocaenoides*	Indo-pacific finless porpoise	Vulnerable

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1131 **Table 2**. The occurrence of species and their confirmation from different records in Pakistan.

Species	Sightings	Stranded	Bycatch	Rescued	Remains of body	References
Arabian sea humpback whale, Blue whale, Bryde's whale	Yes					Mathew 1873; de Silva 1983; Ahmed 1985; Ghalib 1975; Braulik et al. 2010; Gore et al, 2012; Moazzam and Nawaz 2014; Kiani 2015a, 2015b; Moazzam, 2016, 2017, 2020
Sperm whale, pygmy sperm whale, lesser sperm whale	Yes			No	Yes	Gore et al. 2007a, 2012; WWF-P 2015; Moazzam 2019b, 2020
Cuvier's beaked whale	No		Yes	No		Pilleri and Gihr 1972; Roberts 1997; Boer et al. 2000; Gore et al. 2007b, 2012; Moazzam 2020
Killer whale	Yes	No				Moazzam and Nawaz 2014; Gore et al. 2012; MFF Pakistan 2016
False killer whale	No					
Indian Ocean humpback dolphin	Yes				Yes	Gore et al. 2012; IUCN 2014; Kiani 2014
Bottlenose dolphins	Yes			No		Gore at al. 2012, 2017
Pantropical spotted dolphin	No	Yes	No		No	Niazi 1990; Kiani 2011
Risso's dolphin, long beaked common dolphin	Yes	No	Yes			Afsal et al. 2008; Gore et al. 2012; Kiani 2013; Moazzam and Nawaz 2014
Rough toothed dolphin, spinner dolphin, striped dolphin			No			

Indo−Pacific finless porpoise	Yes		Pilleri and Gihr 1973-74; Kasuya 1999; Roberts 1977; Gore et al. 2012, 2017

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1136 **Table 3**. A list of species that were found stranded along the entire coastal area of Pakistan from
1137 2005-2008 (Gore et al. 2012).

Species	Location		Number
	Sindh	Balochistan	
Bryde's whale	1	2	3
Sperm whale	2	3	5
Cuvier's beaked whale	1	-	1
Killer whale	1	-	1
Humpback dolphin	9	6	15
Spinner dolphin	2	-	2
Bottlenose dolphin	3	2	5
Finless porpoise	2	7	9
Total	21	20	41

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1150 **Table 4**. A list of protected area along the coastal area of Pakistan (from Siddiqui et al. 2008).
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Name	Status	Category	Specifications for conservation	Date of establishment
Indus Delta	Sindh	Ramsar site and wildlife sanctuary	Mangroves forests area, cetaceans, birds, nursery, grounds for shrimps and fish	5 November 2002
Haleji		Wildlife sanctuary	Natural rocky shore fauna	23 July 1976
Charna Island			Corals reefs	10 May 2001
Miani Hor (Sonmiani Bay)			Mangroves forest, birds	10 May 2001
Sandspit/Hawks Bay			Green turtle, mangroves	10 May 2001
Ormara	Balochistan	Ramsar site	Green Sea Turtles	10 May 2001
Astola Island			Green Sea Turtles, birds and corals reefs	10 May 2001 designated as Ramsar site and 15 June 2017 as MPA
Jiwani Coastal			Mangroves forest , birds and turtles	10 May 2001

wetland				

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