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Review Article

Diversity and Conservation of Cetaceans in Pakistan

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ABSTRACT

The diversity, distribution, and abundance of cetaceans in Pakistan are poorly understood. Owing to data provision by individual researchers, and from opportunistic strandings or incidental bycatches in fishing nets, and lack of a unified strategy, formulating and implementing conservation plans for cetaceans in Pakistan has been hampered. To rectify this critical knowledge gap, the Cetaceans Conservation Project (CCP) and crew-based observation by WWF-P were launched to survey cetaceans along the entire coastline of Pakistan. Additionally, inaccurate species identification and characterization appeared to be misguiding many species names or even complicating well-articulated conversation plans. Based on existing data gathering, a total of 20 cetacean species have been recorded in Pakistan, which fall into the following IUCN Red List of threatened species categories: three endangered species namely blue whale (*Balaenoptera musculus*), Arabian Sea humpback whale (*Megaptera novaeangliae*) and Indian Ocean humpback dolphin (*Sousa plumbea*); two vulnerable species, sperm whale (*Physeter macrocephalus*) and Indo-Pacific finless porpoise (*Neophocaena phocaenoides*); two near threatened *Tursiops* spp., while remaining species are listed as least concern or data deficient. Given the lack of detailed studies on these species' characteristics, future studies should be focused on systematic investigations with improved methodologies, stock identification, distribution, habitat selection, population biology, behavioural ecology, and on evaluating threats from constructions along the coastal areas, ship traffic, transportation, oil seepage, pollution, and other causes of mortality and stranding. The increasing trends of tuna fisheries, pollution and development along the coastline are the major threats for conservation of cetaceans in Pakistan. It is now a national urgency to preserve cetaceans especially with the recent official declaration of all cetaceans as "protected species". There is only one marine protected area in the country, and many more are needed to sustain the integrity of habitat and long-term conservation and management of cetaceans along the entire coastal area of Pakistan. Finally, the strict implementation of laws and national policies are necessary for a long-term conservation of this unique aquatic mammalian taxa.

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Key words
Arabian Sea humpback whale, Blue whale, Indian ocean sanctuary, Indian ocean humpback dolphin, Astola island

INTRODUCTION

The Pakistan constitutes Indian Ocean Sanctuary by covering an area of approximately 1050 kilometre. The sanctuary is primarily (76%) surrounded by Balochistan Province, and 24% is covered by the entire coastline of Sindh Province of Pakistan (Quraishee, 1988; Meynell, 1999) (Fig. 1). The climate of Pakistan can be distinguished categorically into four periodic seasons. The Northeast monsoon runs from November-February, following by intermonsoon spring from March-April. The Southwestern monsoon spans from June-September and

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the intermonsoon autumn usually occurs during October (Kidwai and Amjad, 2000). Systematic information pertaining to the distribution, species richness and abundance of cetaceans is currently in scarce in Pakistan. Therefore, most of the available information comes from opportunistic or bycatching records from public online resources. Collating all published information in newspapers, local and international academic journals (Roberts, 1977; De Silva, 1987), from soviet whaling (Mikhalev, 1997, 2000), and historical records published by Pilleri and Gihr (1972a, b), revealed that the coastal area of Pakistan carry a considerable diversity of cetaceans.

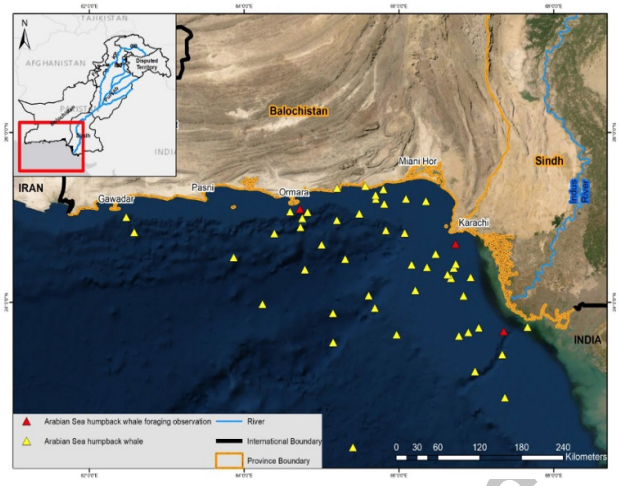

Fig. 1. Reconstructed map of live sightings records of ASHW during 2015-2019 (from Moazzam *et al*., 2020).

The data gaps around cetacean diversity, distribution, and abundance from the Northern Indian Ocean (Kumarran, 2002, 2009) specifically related to threatened species from the coastal area of Pakistan appeared a primary barrier in formulating a practical and robust national policy for conservation of biodiversity (Rizvi *et al*., 1995). In recent past, few initiatives were undertaken to fill these gaps on cetaceans from Pakistani coastline. For example, a project called Cetacean Conservation Pakistan was initiated in 2004 and ran until 2009. During this project, long-term boat-based surveys were conducted along the inshore and offshore areas by a joint collaboration among the Centre of Excellence for Marine Biology at University of Karachi, Pakistan, WWF-Pakistan, and Department of Environment Food and Rural Affairs of the UK Government under its Darwin Initiative (Gore *et al*., 2012). The beach cast surveys were conducted to collect specimens (soft tissues and skeletal materials) which were later used for collecting additional information on species identification, age and gender determination using molecular techniques (Gore, 2008; Gore *et al*., 2007a, 2017). Another long-term crew-based observation was initiated by WWF Pakistan from 2012 to 2020 provided important information on baleen whales (Nawaz and Moazzam, 2014; Moazzam and Nawaz, 2018; Moazzam *et al*., 2020).

Thus, this review aims to compile historic records and the up-to-date information on diversity, distribution, population abundances of some species, and hotspot areas of the baleen whales. Additionally, we aim to survey challenges regarding species identifications, causes of mortalities, strandings, threats from the different anthropogenic activities, conservation status and conservation efforts practiced so far in Pakistan. This comprehensive analysis would be valuable not only for our understanding of important aquatic fauna in Pakistan, but also likely to provide better research and conservation strategies in future for the endangered cetacean species.

CETACEAN SPECIES DIVERSITY

A total of 20 species, three of Mysticeti and 17 species of Odontoceti were reported in the coastal area of Pakistan. According to IUCN (2021), these species were categorized into 3 endangered, 2 vulnerable, 2 near-threatened, 10 least concern and other data deficient species (Table I).

All these species belonged to six families and sixteen genera, three species of baleen whales (Arabian Sea humpback whale, blue whale and Bryde's whale) and toothed whales (Indian Ocean humpback dolphin and bottlenose dolphins). These species were also characterised with highest evidence and strong records. The sperm whale, pygmy sperm whale, dwarf sperm whale, Cuvier's beaked whale, pantropical spotted dolphin and Indo-Pacific finless porpoise carried only sufficient and moderate records. While the Risso's dolphin, striped dolphin, rough toothed and spinner dolphins were found to have low records. On the other hands, the killer whale, false killer whale, long beaked common dolphin and Longman's beaked whale showed lowest records amongst all analysed species (Table II). However, it is plausible that additional species, not identified as yet, might also be occurring along the coastal area of Pakistan. For example, Ranjbar *et al*. (2016) stated that the Omura's whales (*Balaenoptera omurai*) was most likely to be present, and Ahmed and Ghalib (1975) and Ahmed and Rizvi (1985) have also reported the live sightings of the melon headed (*Pepanocephala electra*) in Sonmiani (Balochistan), and fin whales (*Balaenoptera physalus*) along the Sindh and Balochistan coastlines of Pakistan.

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Table I. Cetacean species reported from Pakistan.

Family	Scientific name	Common name	IUCN red list category 2021
Balaenopteridae	*Megaptera novaeangliae*	Arabian sea humpback whale	Endangered
	Balaenoptera musculus	Blue whale	Endangered
	B. edeni	Bryde's whale	Least concern
Physeteridae	*Physeter macrocephalus*	Sperm whale	Vulnerable
Kogiidae	*Kogia breviceps*	Lesser sperm whale	Least concern
	K. sima	Pygmy sperm whale	Least concern
Ziphiidae	*Ziphius cavirostris*	Cuvier's beaked whale	Least concern
	Indopacetus pacificus	Longman's beaked whale	Least concern
Delphinidae	*Orcinus orca*	Killer whale	Data deficient
	Pseudorca crassidens	False killer whale	Near threatened
	Sousa plumbea	Indian Ocean humpback dolphin	Endangered
	Tursiops truncatus	Common bottlenose dolphin	Near threatened
	T. aduncus	Indo-Pacific bottlenose dolphin	Near threatened
	Delphinus capensis tropicalis	Long beaked Common dolphin	Least concern
	Grampus griseus	Risso's dolphin	Least concern
	Steno bredanensis	Rough-toothed dolphin	Least concern
	Stenella attenuata	Pantropical spotted dolphin	Least concern
	S. longirostis	Spinner dolphin	Least concern
	S. coeruleoalba	Striped dolphin	Least concern
Phocoenidae	*Neophocaena phocaenoides*	Indo-Pacific finless porpoise	Vulnerable

Table II. The record of cetacean species in Pakistan based on live sightings, stranded, bycatch, rescued, and remains of body (yes), absence (no).

Species	Sightings	Stranded	Bycatch	Rescued	Remains of body	References
Arabian Sea humpback whale	yes	yes	yes	yes	yes	Mathew, 1873; de Silva, 1983; Ahmed and Rizvi, 1985; Ahmed and Ghalib, 1975; Braulik *et al*., 2010a; Gore *et al*., 2012; Nawaz and Moazzam, 2014; Kiani, 2015b; Moazzam *et al*., 2020
Blue whale	yes	yes	yes	yes	yes	
Bryde's whale	yes	yes	yes	yes	yes	
Dwarf sperm whale	yes	yes	yes	No	yes	Gore *et al*., 2007a; 2012; WWF-P, 2015; Nawaz and Moazzam, 2014
Pygmy sperm whale	yes	yes	yes	No	yes	
Cuvier's beaked whale	yes	yes	yes	No	yes	Pilleri and Gihr, 1972; Roberts, 1997; Gore *et al*., 2007b; 2012; Moazzam *et al*., 2020
Longman's beaked dolphin	No	No	No	yes	No	
Killer whale	yes	No	No	No	yes	Nawaz and Moazzam, 2014; Gore *et al*., 2012; MFF Pakistan, 2016
False killer	No	No	yes	No	No	
Indian Ocean humpback dolphin	yes	yes	yes	yes	yes	Gore *et al*., 2012; IUCN, 2021; Kiani, 2015a
Bottlenose dolphins	yes	yes	yes	yes	yes	Gore at al., 2012; 2017
Rough toothed dolphin	yes	No	yes	yes	No	Niazi, 1990; Kiani *et al*., 2011
Risso's dolphin	yes	No	yes	yes	No	Afsal *et al*., 2008; Gore *et al*., 2012; Kiani *et al*., 2011, 2013; Nawaz and Moazzam, 2014; Gore *et al*. (2012, 2017); Kiani, 2013
Long beaked common dolphin	yes	No	No	yes	yes	
Pantropical spotted dolphin	yes	yes	yes	No	Yes	
Spinner dolphin	yes	No	yes	No	yes	
Striped dolphin	yes	No	yes	No	Yes	
Indo-Pacific finless porpoise	yes	yes	yes	No	yes	Pilleri and Gihr, 1974; Roberts, 1977; Kasuya, 1999; Gore *et al*., 2012, 2017

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Arabian sea humpback whale

The Arabian Sea humpback whale (ASHW), famous as Karambo in Pakistan (Kiani and Koen, 2015a), is potentially distributed across 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 (Braulik *et al*., 2010b). According to the United States Endangered Species Act, this genetically unique and non-migratory whale is still considered as endangered species (NOAA, 2016) and at the high risk of extinction (Minton *et al*., 2008). It has been estimated that approximately 200-250 Arabian sea humpback whale were found in Indian Ocean Sanctuary. Additionally, from the neighbouring coastal area of Oman <100 individuals were counted based on capture mark recapture photo-identification approaches. However, population size estimation of ASHW is currently lacking in Pakistan (Minton *et al*., 2011).

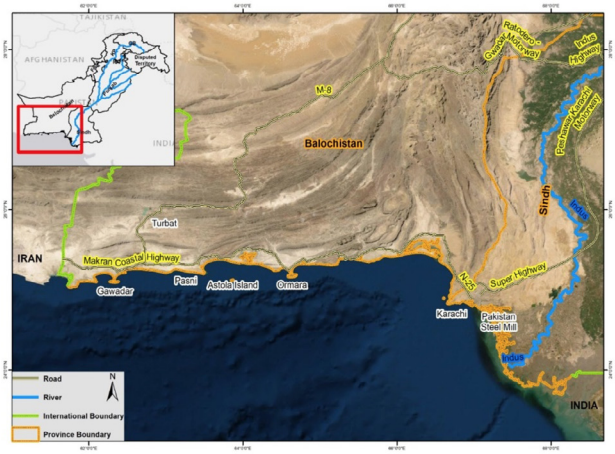

Fig. 2. The coastline of Pakistan bounded by Balochistan Province and Sindh Province.

During earlier 1960s, the ASHW was hunted for three years along the Sindh coastal area (Mikhalev, 2000). A very first reported stranded specimen dates back to 1873 by Mathew (1873) during British rule, and more subsequent stranding cases were reported recently (de Silva, 1983; Ahmed and Rizvi, 1985; Kiani, 2015b; Moazzam and Nawaz, 2018; Moazzam *et al*., 2020). The live sightings were reported after 2005 (Gore *et al*., 2012; Kiani, 2015b) and crew-based observer program documented with cumulative records of 74 sightings over the years, along the shallow coastal areas few observations of foraging upon shrimps and sardines (Fig. 2). There is a high probability that the temperature and prey availability may drive seasonal distribution and abundance of ASHW. Mainly, sightings are observed along the Balochistan coastline on the continental shelf and slope areas from April to May, whereas it is noticed during September to December along the Sindh coastline of Pakistan (Nawaz and Moazzam, 2014; Moazzam and Nawaz, 2018; Moazzam *et al*., 2020). 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 and identify them by capture mark recapture method or by the recording of acoustic signals. Moreover, the behavioural aspects such as lunge types, and laterality should be assessed to decide usage of either bubble net to trap or approach for their prey.

Blue whale

Three subspecies of blue whales were widely recognized globally, however, the species in Northern Indian Ocean appeared to be a distinct population or additional subspecies 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, 1997, 2000) and 31 catches were made along the India and Pakistan borders (Mikhalev, 2000). The population of blue whale has increased and recently recovered (Branch *et al*., 2007b) around the world. However, the population size and distribution of blue whales is currently lacking in Pakistan. During earlier 1970s, the first live sighting of blue whale in Pakistan was observed from the Sindh coastal area as reported by Ahmad and Ghalib (1975). Since 2010, information on this species is increasing, for example live sightings or records of stranded specimens along the coastal areas of Pakistan. One stranded blue whale with a total length of 18-19 m was reported by Nawaz and Moazzam (2014). Cumulatively, a total of 67 live sightings were documented from 2012-2019 (Nawaz and Moazzam, 2014; Moazzam and Nawaz, 2018; Moazzam *et al*., 2020) (Fig. 3). Owing to frequent sighting and stranding cases along the coastal areas of Pakistan, it is plausible that these whales are resident.

Bryde's whale

This species lacks 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, however, most frequent sightings were recorded during South Western monsoon season (Gore *et al*., 2012). The historic records such as stranding, beach cast specimens or live sighting were sporadic, although its recent sighting records are progressively increasing. From 2007 to 2020, a total of 15 live sightings of the

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Bryde's whales have been recorded so far (Gore *et al*., 2012; Moazzam *et al*., 2020), and sightings records of their locations have been mapped (are shown in Fig. 3). Besides sightings records, two dead specimens have been recovered (Braulik *et al*., 2010b; Moazzam *et al*., 2020), whereas one stranded specimen of Bryde's whale was entangled in gillnet and finally rescued and released safely (Nawaz and Moazzam, 2014).

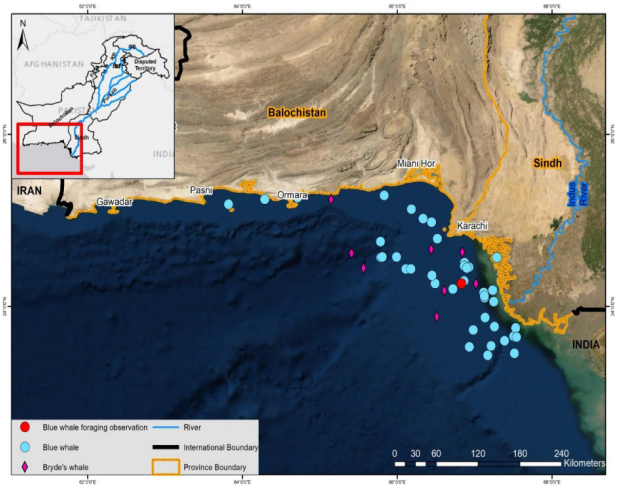

Fig. 3. Reconstructed map of live sightings records of blue whale and Bryde's whale along the coast of Pakistan during 2015-2019 (from Moazzam *et al*., 2020).

Sperm whale

The sperm whale is reported from the neighboring coastal areas of Iran, Iraq and India (Minton, 2004). Unfortunately, this species lacks any historic record from Pakistan. The first indirect information was provided by Gore *et al*. (2007a) who have discovered a skull on the Soneri Beach near Manjar Goth, Pakistan. The total length of the skull was 2.18 m, which suggested its body length of 9.5 m and that it was a calf. The skull is preserved at the Center of Excellence in Marine Biology, University of Karachi, Pakistan. Afterwards, the information on this species has been made available with a total of 6 live sightings were recorded by CCP (Gore *et al*., 2012). Additionally, a total of 24 live sightings were documented during crew-based observation (Moazzam *et al*., 2020) from 2011-2019, and occasional sightings were recorded in diverse geographic locations of Pakistan (Fig. 4).

Kogia *spp. and beaked whales*

The genus *Kogia* contains two species including dwarf sperm whale (*K. sima*) and pygmy sperm whale (*K. breviceps*). Both species lack any detailed information and are also poorly known worldwide, probably due to their inconspicuous shy behavior and their natural habitat of deep offshore areas. Interestingly, 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 using bycatch records. The specimen of dwarf sperm whale was incidentally captured in fishing net on 19 March 2013 (Nawaz and Moazzam, 2014). The first occurrence of the pygmy sperm whale was from an unconfirmed historic record in 1985. Recently, this species was confirmed twice by bycatch where one of which was 8.2 feet in length with body mass of 400 kg, and another was adult bycatch specimen was reported by Moazzam and Nawaz (2018).

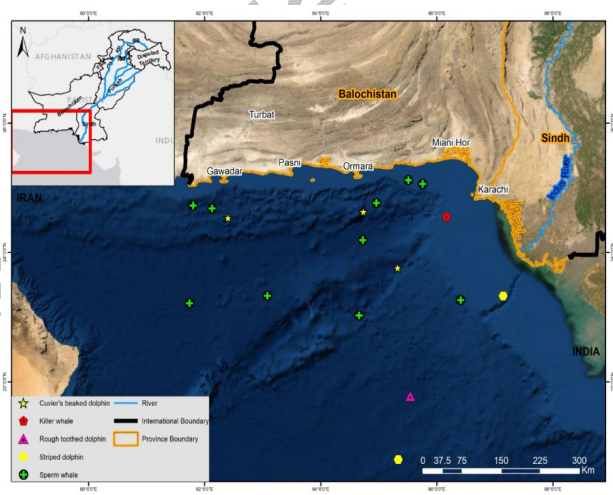

Fig. 4. Reconstructed map of live sightings records of toothed whales along the coast of Pakistan during 2011 to 2020 (from Kiani *et al*., 2011, Kiani, 2013, Nawaz and Moazzam 2014, Moazzam *et al*., 2020).

Several authors claimed the presence of beaked whale in Pakistan's coastlines after collecting few skeletal materials (Pilleri and Gihr 1972a; Roberts, 1977; de Boer *et al*., 2003). A complete skull was only discovered on June-30-2006. A comparative analysis of these specimens confirmed the presence of Cuvier's beaked whale in Pakistan. The specimen is preserved at the Centre of Excellence in Marine Biology (University of Karachi) (Gore *et al*., 2007b). Recently, three live sightings of Cuvier's beaked whales were also reported by Moazzam *et al*. (2020) (Fig. 4), indicating the presence of the whale in national waters.

The Longman's beaked whale was once bycatch during tuna operation at Indus canyon in Sindh coastline. The animal was caught live and was subsequently released safely (Moazzam *et al*., 2020).

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Killer whale and false 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). Recently, one set of pods (n = 3) was observed feeding on school of Talang queenfish (*Scomberoides commersonnianus*) (Moazzam and Nawaz, 2018) and one live sighting of an individual was reported by Moazzam *et al.* (2020) (Fig. 4). A dead specimen was collected during beachcast survey along the coastal area of Pakistan by Gore *et al.* (2012). Currently, the available data from Pakistan, except from Nawaz and Moazzam (2014), did not support the presence of false killer whale in Pakistani waters (Table II).

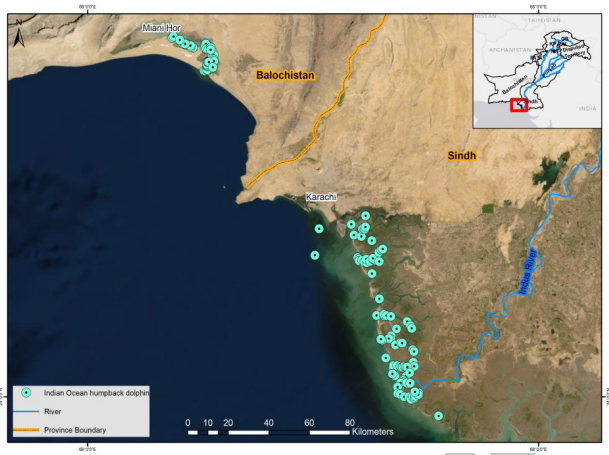

Fig. 5. Reconstructed map of live sightings recorded of Indian Ocean humpback dolphins along the Miani Hor, Sonmiani Bay (*Balochistan coastaline*) (from SDO, 2012), and Indus delta creek systems of Sindh coastal area (from Kiani and Koen, 2015a).

Indian ocean humpback dolphin

The Indian Ocean humpback dolphin is an endangered species (IUCN, 2014), and is distributed along the entire coastline of Pakistan. There is availability of more information of Indian ocean humpback dolphin than any other marine cetacean species. The highest encounter rate of this species was recorded along the Sindh coastal area. The exact population abundance of this species has never been documented along the entire coastline, although a total of 112 sightings of 439 individuals were recorded 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 (Figs. 5 and 6) (Gore *et al.*, 2012; SDO, 2012; Kiani and Koen, 2015a). The Indus delta carry the largest population of the Indian Ocean humpback dolphin in its entire distributional range (Karczmarski, 1999, 2000). The individual identification was estimated by capture mark recapture method based on photo-identifications, where 87 individuals were captured, however, only 5% individuals were successfully recaptured (Kiani and Koen, 2015a). The Indian Ocean humpback dolphins were commonly sighted at Jiwani and Gawadar bay (Balochistan). However, the sightings are reducing possibly due to anthropogenic threats such as using its meat as bait for hunting sharks and saturation of speed boats traffic between Iran and Pakistan in Gawadar bay (U. Waqas personal communication).

Fig. 6. The Indian Ocean humpback dolphins in their natural habitat in Balochistan coastal area. Photo by Mehrban Ali Brohi.

Bottlenose dolphins

In Pakistan, bottlenose dolphins (*Tursiops* spp.) were commonly reported (Baldwin, 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)* was 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). Several bycatch specimens in tuna gillnet were also reported previously by Nawaz and Moazzam (2014).

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

In Pakistan, there were a total of five live sightings of Risso's dolphins from 2003 to 2009 only along the Balochistan coast (Gore et at., 2012), and three cases of

bycatches were reported by Nawaz and Moazzam (2014).

A distinct subspecies of common dolphins (*Delphinus capensis tropicalis*) was 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 two live sightings were reported during seismic survey in 2003 by Gore et at. (2012), and frequently bycatch specimens reported by Nawaz and Moazzam (2014). Currently, there is limited information on the existence of rough toothed dolphins in Pakistan. However, a video clip showing 6 individuals claimed the presence of this species in Pakistan (Fig. 4; Kiani, 2013) compounded by several bycatch specimens documented by Nawaz and Moazzam (2014).

Pantropical spotted dolphin, spinner dolphin and striped dolphin

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

The spinner dolphin is locally famous as Goco or Tooshunk in Pakistan. On one occasion during 2003, it has been reported that a total of 9 groups with cumulative population of 923 individuals were observed in Pakistan. However, on another situation, a 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 of Pakistan. Additionally, two corpses of stranded specimens were also recovered by Gore *et al*. (2012, 2017).

The striped dolphin has not been reported from the western neighboring coast of Iran 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, and the specimen was preserved at the Centre of Excellence in Marine Biology, University of Karachi. In addition, video of more than 50 individuals was recorded as live sighting (Fig. 4) and one specimen was incidentally captured in fishing net as 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, 1974; Roberts, 1977; Collins *et al*., 2005; Braulik *et al*., 2010a; 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, these animals prefer inshore areas and prioritize offshore area in summer seasons (Pilleri and Gihr, 1972; Roberts, 1977). Indo-Pacific finless porpoises are most frequently found from November to February (Gore *et al*., 2012). Recently, genetic study fail to reveal any genetic distinction of this species in Pakistani water (Gore *et al*., 2017). These facts highlight that future studies should be conducted on the combination of comparative morphology and genetics which may facilitate accurate 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). Currently, limited information on the diversity of cetaceans are the results of joint collaborations under the supervision of international experts, and financially sponsored by the foreign funding resources. 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 to take informed decisions for the conservation and management of species.

In Pakistan, a Bryde's whale was misidentified as the Sei whale, and one bycaught specimen of toothed whale was misidentified as the Risso's dolphin (Ilyas, 2020) while it was actually the Indo-Pacific finless porpoise. Gore *et al*. (2012) have conducted long-term boat based and beachcast surveys from 2005-2009 and reported a total of 16 live sightings. However, some animals were not successfully identified at species level. A regular monitoring and frequent sightings of baleen whales were reported from 2012-2020 (Nawaz and Moazzam, 2014; Moazzam and Nawaz, 2018; Moazzam *et al*., 2020), with some unidentified baleen whale species (Fig. 7). Two species, including the melon headed dolphin (Ahmad and Rizvi, 1985) and fin whale (Ahmad and Ghalib, 1975) had some historic live sightings, bycatch or stranding records in 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

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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 a lack of expertise.

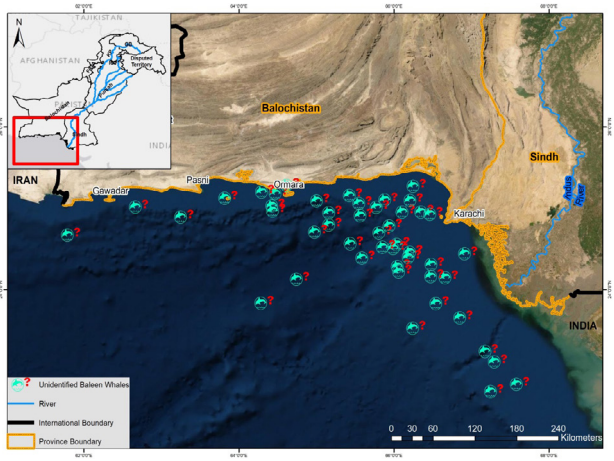

Fig. 7. Reconstructed map of the unidentified baleen whales along the coast of Pakistan during crew based observations (from Nawaz and Moazzam 2014).

In Pakistan, most stranded specimens remained unattended and are unreported. The stranded specimens were collected during the beachcast surveys or informed by the local people from 2005-2008. Inevitably, few of them could not be identified due to putrefaction. Molecular techniques were used to conduct their species identification using soft and skeletal tissues (Gore *et al.*, 2017). Although some species in Pakistan have been well identified, expertise are lacking for identification of species and reported species could be far beyond their actual existence.

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 CCP has been working closely with local people and fishermen communities and conducted workshops to train the local fishermen regarding mitigation and controlling the mortalities of cetaceans during 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 TO CETACEANS

The increasing anthropogenic activities such as developmental projects along the coastal areas and 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 (Niazi and Moazzam, 1990; Kirkwood *et al.*, 1994; Moazzam, 2012; Nawaz and Moazzam, 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 has been highlighted since 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 are the biggest threat to the offshore cetaceans, and the recent census estimated 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. A whole year data except June and July of the fishing fleet showed fishing operation mainly along the Sindh coastline which has increased the chances of bycatch mortalities of cetaceans (Figs. 8 and 9). Cumulatively, it has been observed that the pelagic gillnet was the major cause of cetacean bycatch in the range of fisheries, with two peaks of cetacean mortalities (March and September-November) (Moazzam and Nawaz, 2018).

The Indian Ocean humpback dolphin, bottlenose dolphin and spinner dolphin were commonly observed to be attracted by fishing boats. Some anecdotal events of boat striking, and injuries were informed during CCP. However, detailed information on the conflict with fisheries, origin of injuries (striking with boats) and their post survival is still lacking. The mortalities due to tuna fisheries from 2005-2008 were monitored, with some specimens of baleen whales (ASHW and Bryde's whales) and toothed whales were reported from the entire coastal area of Pakistan. The Indian Ocean humpback dolphin and

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finless porpoise were two most common species in coastal waters and the spinner dolphin, bottlenose dolphin and the pantropical spotted dolphin were from offshore waters (Gore *et al*., 2102).

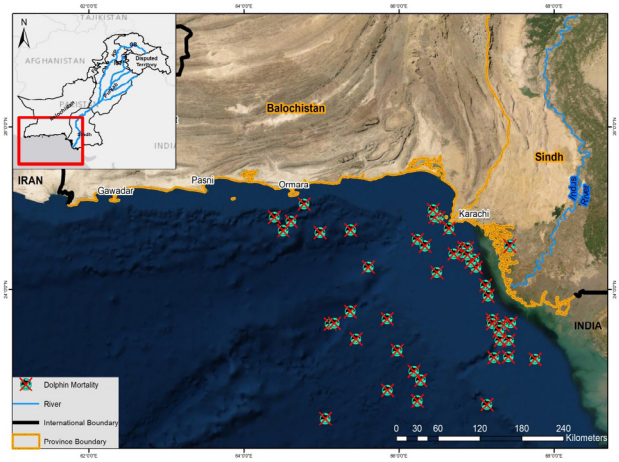

Fig. 8. Reconstructed map showing the location of toothed whales mortalities due to tuna fisheries in Pakistan coastal waters (from Nawaz and Moazzam, 2014).

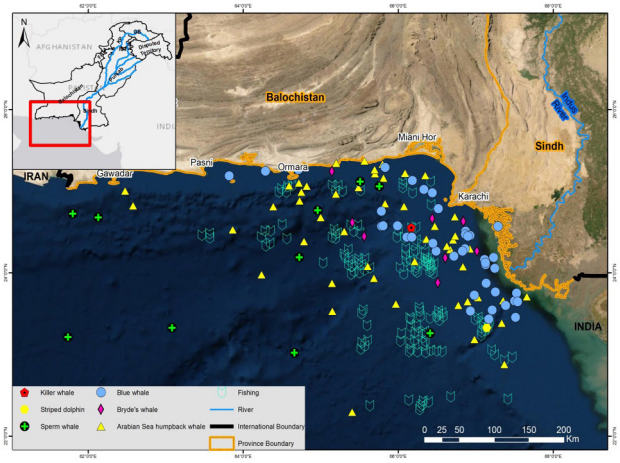

Fig. 9. Fishing along the hotspot areas where live sightings of different cetaceans were commonly observed along the coastal area of Pakistan (based on one year data of one tuna catching trawler, from Nawaz and Moazzam, 2014).

Assessing the recent losses due to fisheries, a total of 12,000 mortalities have been recorded during 2013-2014 and 10,150 mortalities only 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, 2012; Niazi and Moazzam, 1990; Nawaz and Moazzam, 2014; Shahid *et al*., 2016), with most common areas of toothed whales mortalities are shown in Figure 8. For baleen whales, the mortality of 1-2 baleen whales per year were reported by Nawaz and Moazzam (2014). In these recent reports, there was contradiction in data and figures that showed lack of coordination among researchers and also major flaws in methodologies were noticed. The efforts are needed to collect original and reliable data to investigate spatial and temporal overlap resources and conflict between fisheries and cetaceans.

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 is currently holding intensive human settlements and Karachi is the largest industrial and highly populated city of the Pakistan, covering 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 8,000 tons of solid wastes on daily basis. Due to the expanding human population, discharged wastes could be 16,000-18,000 tons/day in 2020 (MFD, 2016). The domestic and industrial sewage of the upstream South-eastern part was 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 (MFD, 2016), and it was estimated that the annual drainage of 1500 million m^3 was 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 being dumped along the Sindh coastal area (Kiani and Koen, 2015a). Additionally, 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 main 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 established industry (Ali and Jilani, 1995) except ship graveyard or ship breaking industry located at Gaddani. Discharging of some toxic chemicals and heavy metals into the coastal waters could be the biggest threats to aquatic biodiversity (Baig, 2004; Chaghtai and Saidullah, 2001). The negative impacts of pollution may result in reduced productivity of food resources for the coastal species (Kiani and Koen, 2015a). In Pakistan, although water pollution is a topic of investigation since

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1980s, the negative impacts of pollutions on cetaceans and their primary preys have never been investigated at length.

Stranding cases

The stranding cases of cetaceans are regularly reported, worldwide. Multiple reasons have been investigated including the natural causes such as diseases or parasites or sudden changes in optimal environmental conditions (Dhermain *et al*., 2002). Physiological conditions in which animals are unable to echolocate for navigation, communication and hunting (Bompar, 1996) or escaping from predators or chasing prey might be also leave them stranded (Casinos and Vericad, 1976; Nores and Perez, 1988). Additional causes include anthropogenic activities such as injuries after striking with boats or fisheries interactions (Laist *et al*., 2001; Jensen and Silber, 2003), or pollution. The stranding cases provided significant contribution towards species occurrence and their abundance (Berrow, 2001), especially for those areas where resources are limited (Gore *et al*., 2017). Also, it could provide the baseline data for 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).

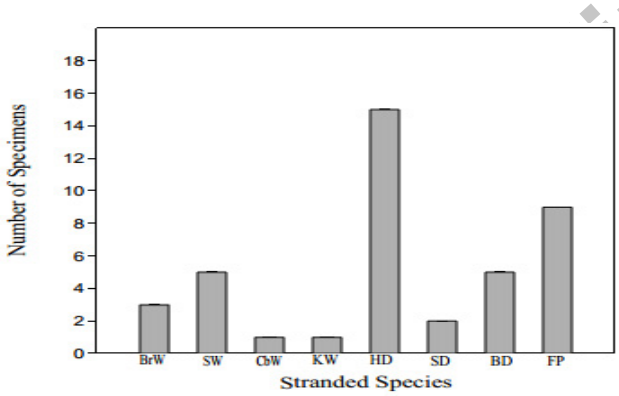

Fig. 10. The details of species (BrW; Bryde's Whale, SW; Sperm Whale, CbW; Cuvier's beaked whale, KW; Killer Whale, HD; Humpback dolphin, SD; Spinner Dolphin, BD; Bottlenose dolphins, FP; Finless porpoise) that were found stranded along the entire coastal area of Pakistan from 2005-2008 (Gore *et al*., 2012).

During 2005-2008, various stranding cases of baleen and toothed whales were reported (Gore *et al*., 2012) (Figs. 10 and 11) where morphometric data, animal ages and genders were collected in the field. Some carcasses were found in bad conditions and therefore their genders were not identified accurately. Inevitably, species identifications and genders were instead identified using molecular techniques on soft and skeletal tissues. Their ages were determined through teeth. Three species including 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 using this approach (Gore *et al*., 2017). In contrast, two species such as the sperm whale (Gore *et al*., 2007a) and Cuvier's beaked whale (Gore *et al*., 2007b) were confirmed by their skeletons. It was generally observed that juvenile males were commonly stranded (Gore *et al*., 2017).

Mass stranding cases of the pantropical spotted dolphin were identified at Gaddani beach (Balochistan) during 2009 where approximately 200–250 individuals were reported (Kiani *et al*., 2011). It was estimated that a total of 9.3 individuals/year were stranded mainly along the Balochistan coastal area (Gore *et al*., 2017) probably due to pollutions along the coastal areas and creek systems (Chaghtai and Saidullah, 2001) and regular naval exercises along the coastal area of Pakistan (Gore *et al*., 2017).

Direct killing

In Pakistan, local people have never been interested in hunting any cetaceans species for food purposes. Once in the Balochistan, the coastal species such as finless porpoises, spinner dolphins and humpback dolphins were intentionally killed and used for medicinal purposes, caulking their boats and using as bait for sharks. The effect of overfishing has already reduced the shark stocks, and fishermen having no interest in killing any species of cetaceans (Gore *et al*., 2012; Kiani and Koen, 2015a). However, it has been noticed that a recovered corpses of finless porpoises without flukes could apparently be due to fishermen intentional removal of flukes to free bodies from fishing nets (Gore *et al*., 2012).

CONSERVATION STATUS

In four-year joint project of CCP, 63 surveys were conducted along the entire coastal area to assess the diversity and abundance of cetaceans in Pakistan. They also conducted the beach cast surveys to collect skeleton and remaining of each cetacean specimen. Furthermore, they developed the awareness between local people and fishermen communities to reduce the mortalities of cetaceans. This 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, 2017). Moreover, 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). During this program, some new species

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were also reported from the coastal area of Pakistan (Nawaz and Moazzam, 2014; Moazzam and Nawaz, 2018; Moazzam *et al*., 2020). There were 20 cetaceans reported in Pakistan and their conservation status was followed by the IUCN. The Red List of threatened species is summarized in Table I. 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) along the Balochistan coastline. Some other areas are also important for frequent sightings of cetacean species such as Karachi, Gaddani, Taq, Pasni Bay, Ras Shumal Bundar, Darran and Jiwani (Nawaz and Moazzam, 2014). According to the wildlife legislation of Sindh and Balochistan Governments, all cetacean species are protected species. It is necessary to collect data on those species which have limited data. It is critically important to widen the protected areas in promoting the conservation of cetacean in Pakistan.

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. According to the MFF Pakistan (2016), the coastal area of the Pakistan is a part of the Indian Ocean Sanctuary which was established in 1979 to protect whales from hunting, and the Northern area of the Arabian sea is an important migratory route and provide feeding ground for cetaceans (Roberts, 1977). The Marine Protected Areas (MPAs) is a highly important conservation tool (Ward *et al*., 1999) to reduce the anthropogenic threats (Agardy, 1994), to increase the productivity of natural habitats, to 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 consideration 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 in fish export from the coastal area of Pakistan (MFF Pakistan, 2016) is a serious threat to conservation of 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 subsequent mortalities (Niazi and Moazzam, 1990). The Pakistan National Conservation Strategy has embraced the complications and proposed an urgent need to identify hotspot areas for cetacean conservation in establishing the Marine Protected Area (MPA) or upgrade 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 outlined in Figure 12. 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 (Nawaz and Moazzam, 2014).

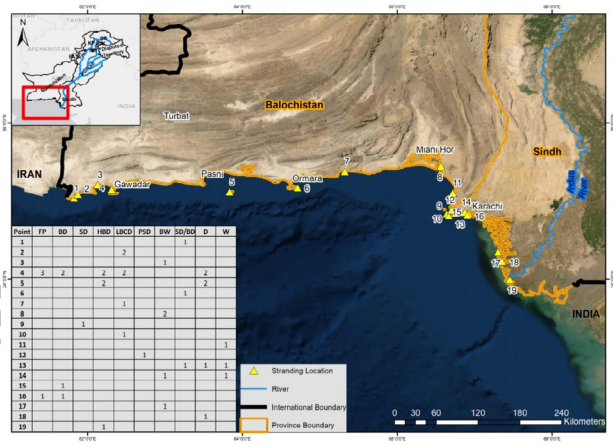

Fig. 11. The location of collected stranded specimens along the entire coastal area of Pakistan from 2005-2008 (Gore *et al*., 2017).

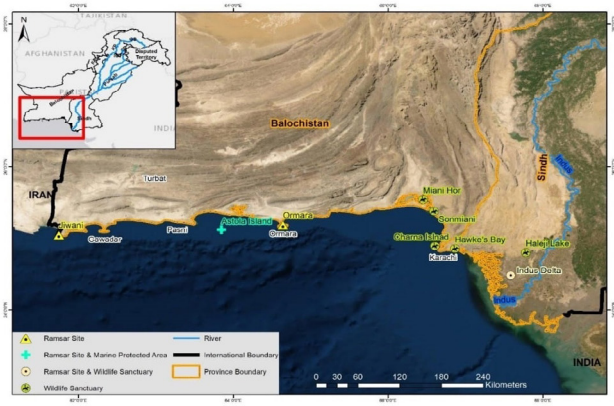

Fig. 12. Protected areas along the entire coastline of Pakistan (Balochistan and Sindh Provinces).

Astola is the largest island along the Balochistan coastal area, which is the Ramsar site for reptiles and birds (Fig. 12) (Ilyas, 2017). The Government of Balochistan

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declared this site as the first MPA protected area of Pakistan for the conservation of mainland biodiversity (Kanwal *et al*., 2018). Conversely, 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, 2013). It was declared as the Ramsar site on 5th November, 2002 (Ahmad, 1998; Siddiqui *et al*., 2008).

Protection laws

In Pakistan, the freshwater Indus River dolphin (*Platanista minor*) was declared as protected species in 1972. Gore (2008) has proposed to the Pakistan National Action Plan for Conservation of Marine Cetaceans and asserted that status of cetaceans should be clearly defined under specific definition in wildlife legislations of Pakistan since the provincial wildlife legislation "The Balochistan Wildlife Protection Act (No. XIX of 1974) was included cetaceans under the game animals (The Balochistan Gazette (No. 64, 1974; Kiani and Koen, 2015a). Recently, revised policies and wildlife legislations according to The Balochistan (Wildlife Protection, Preservation, Conservation and Management) Act 2014 (Act NO. XV of 2014) have declared all cetaceans as protected mammals and listed under Schedule-III, which clearly state cetaceans as Protected Animals where hunting, killing, trapping, capturing, possession or trade is not allowed.

The Sindh Wildlife Protection Ordinance 1972 define marine cetaceans under "Fish" within Act No. 35 of 1997, which covered all kinds of aquatic animals (Kiani and Koen, 2015a). However, the "Paragraph 5 (Export Restriction Point c)" did not allow their export and forbidden their consumption. Recently, revised policies by "The Sindh Wildlife Protection, Preservation, Conservation and Management Act, 2020", placed all whales and dolphins in "First schedule (2(li))" protected animals under Act No. XXIII of 2020.

As a highly specialized mammalian lineage, cetacean have evolved a very special and fully aquatic lifestyle as top predators in the aquatic ecosystem. However, they are threatened from different anthropogenic activities such as pollution, development along the coastal areas and fisheries in their distribution range. Strict implementation of relevant laws is necessary for the conservation of cetaceans in Pakistan.

CONCLUSION

In Pakistan, recent initiatives such as CCP and crew-based observation have provided current information on the existence and characterization of cetacean. Collectively, a total of 20 cetacean have been reported consisting of 3 endangered, 2 vulnerable, 2 near threatened, 12 least concern and others are data deficient species according to IUCN Red List of threatened species. While some species has sufficient record, there is scarcity of updated information pertaining to their distribution pattern, habitat preferences, and updated population abundance. It is necessary to continue exploring inshore and offshore water to conduct well-organized surveys with improved methodologies. The available data clearly show there is lack of coordination among working scientists and institutions. The collaboration with national and international experts and educational institutes will be helpful to promote the conservation of cetaceans in Pakistan. 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 species living in the coastal areas are in higher danger due to development of coastal areas, heavy trafficking of ships, increasing tuna fisheries, human interventions and pollution (e.g., oil seepage during transportation, toxic chemicals from the different industries). The data on negative impacts of direct and indirect anthropogenic activities, intensified commercial fishing in offshore and inshore areas will be helpful in devising and acting decisions for the conservation and management of species and their habitats. The bycatches and stranded dead specimens should be recovered and preserved to understand the stock identities in Pakistani water with genetic and morphological approach.

The Astola Island is a recently established first MPA along the Balochistan coast for the conservation of mainland biodiversity. However, it is insufficient to support diversity of endangered or vulnerable cetacean species in Pakistani water. The Ramsar sites along the Balochistan and Sindh coasts 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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Data availability

All data is available in this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

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