Bycatch of deep dwelling cetacean in gillnet fisheries of Pakistan

Muhammad Moazzam
WWF-Pakistan, 35-D, PECHS, Block-6, Karachi 75400, Pakistan
(mmoazzamkhan@gmail.com)

ABSTRACT

Gillnet being deployed for catching tuna and tuna like species is known to be marred with high bycatch of non-target species including cetaceans. Studies have indicated that small cetaceans mainly dolphins frequently get entangled and die in gillnets that are placed on the surface of the sea. However, introduction of subsurface gillnetting (placing net 2 m below sea surface) led to major reduction in the entanglement of cetacean. This mode of gillnet operation was adopted by entire tuna gillnet fleet in Pakistan which eliminated mortality of cetaceans in Pakistan. Studies have, however, revealed that subsurface gillnetting is not effective against deep dwelling cetaceans. Species belonging to family Delphinidae (Risso's dolphin), Family Kogiidae (dwarf sperm whales and pygmy sperm whales) and Family Ziphiidae (Longman's beaked whale, *Mesoplodon sp*. and Cuvier's beaked whale) were reported to get entangled in gillnets placed on both surface and subsurface of sea. These deep dwelling species dive to deep sea (possibly deeper than 300 to 500 m) to feed mainly on meso- and bathypelagic cephalopods, fish and crustaceans. It seems that while surfacing, these cetaceans cannot avoid gillnet placed on surface or even subsurface. The study further revealed that entanglement of Risso's dolphin (*Grampus griseus*), dwarf sperm whales (*Kogia sima*) and pygmy sperm whale (*Kogia breviceps*) has an increasing trend since 2015 till 2019. Main entanglement of these species were observed during Pre-Southwest Monsoon Period (March and April) whereas limited entanglements were observed in other parts of the years. Study has further revealed that the entanglement of all deep dwelling cetaceans were more frequent between 1,000 and 2,000 m. The study also reports for the first time entanglement and release of Longman's beaked whale *Indopacetus pacificus*, an unidentified species of *Mesoplodon* sp. and Cuvier's beaked whale (*Ziphius cavirostris*) in subsurface gillnets deployed along Pakistan coast. The study also suggests that Murray Ridge and continental slope along Indus Swatch seems to be hotspot of deep dwelling cetaceans.

INTRODUCTION

Gillnets are important fishing gear being used for catching tuna and tuna like fisheries globally and are known for high bycatch of non-target species including cetaceans (Anderson *et al*., 2020; Kratzer *et al*., 2020; 2021; Northridge, 1984; 1990; 1991; Vidal, *et al*., 1994). Cetaceans were also observed to be important part of the bycatch of tuna gillnet fisheries in Pakistan (Kiani *et al.* 2022; Kiszka, *et al*., 2021; Moazzam, 2013; 2021; Moazzam and Nawaz, 2013; 2014; Nawaz and Moazzam, 2013; Niazi, 1990). Studies have reported major entanglement of small cetaceans including dolphin species along the coast of Pakistan (Kiszka *et al*., 2021; Moazzam, 2013; 2021; Moazzam and Nawaz, 2013; 2014; Nawaz and Moazzam, 2013).

Kiani *et al*. (2022), Kiszka *et al*. (2021), Moazzam (2013; 2021), Moazzam and Nawaz (2013; 2014) and Nawaz and Moazzam (2013) reported presence of deep dwelling cetaceans in the bycatch of the tuna gillnet fisheries of Pakistan. Kiszka, *et al*. (2021), Moazzam (2013, 2021), Moazzam and Nawaz (2013, 2014) and Nawaz and Moazzam (2013) reported entanglement of Risso's dolphin (*Grampus griseus*) whereas Kiszka, *et al*. (2021) reported dwarf sperm whale (*Kogia sima*) and Kiani *et al*. (2022) reported Longman's beaked whale *Indopacetus pacificus* and an unidentified species of *Mesoplodon* sp. as bycatch of tuna gillnet fishing in Pakistan.

Present provides details of entanglement of deep dwelling cetaceans in the gillnet fisheries of Pakistan.

MATERIAL AND METHODS

The information presented in the present study is based on the information generated through WWF-Pakistan's Crew Based Observer Programme under which observers were posted on about 75 tuna gillnetters during October 2012 and September 2019 (Moazzam, 2019). All records of deep dwelling cetaceans recorded by the observers were examined in detail. Based on this information, distribution and seasonality of occurrence of these cetacean were reported in this paper.

RESULTS AND DISCUSSIONS

Six species of deep dwelling cetaceans were reported by WWF-Pakistan's Crew-based Observer Programme during October 2012 and September 2019. These include Risso's dolphin (*Grampus griseus*), dwarf sperm whale (*Kogia sima*), pygmy sperm whale (*Kogia breviceps*), Longman's beaked whale (*Indopacetus pacificus*), an unidentified species of mesoplodont beaked whales (*Mesoplodon sp.*) and Cuvier's beaked whale (*Ziphius cavirostris*).

Risso's Dolphin-*Grampus griseus* (G. Cuvier, 1812) (Fig. 1-2)

Risso's dolphin prefer environment off the continental shelf on steep banks, with water depths varying from 400–1,000 m (Baird, 2009). It is globally distributed in temperate and tropical waters, preferring deep, steeply sloping habitats over continental slopes and around oceanic islands (Jefferson *et al*. 2014). It is known to range extensively across the tropical western Indian Ocean, including the Gulf of Aden, the Sea of Oman, the wider Arabian Sea and the Red Sea (Notarbartolo di Sciara *et al.* 2021). From Pakistan it was reported by Gore *et al*. 2012; Kiszka *et al*., 2021; Moazzam and Nawaz, 2014).

During October, 2012 and September, 2019, a total of 24 cases of entanglements of Risso's dolphins were reported from tuna gillnet fisheries of Pakistan. In addition, there was a record of entanglement of Risso's dolphin in coastal gillnet fisheries whereas a stranding of this species was reported from Clifton Karachi which is possibly died due to entanglement in gillnet.

Fig. 1. Entanglement of the Risso's dolphin (*Grampus griseus*) in tuna gillnet on 3 April, 2013.

<u>Distribution of Entanglement</u>

Entanglement of Risso's dolphin was reported from out continental shelf, along continental slope, along oceanic ridge and deep oceanic basin along Sindh and Balochistan coast (Fig. 3). A major part of the entanglements of Risso's dolphin were recorded from Murray Ridge. This ridge forms the boundary between the Indian and Arabian plates in the northern Arabian Sea

(Minshull *et al*., 2015). Entanglements of Grampus *griseous* were also reported along continental slope facing Indus Swatch (Canyon). No entanglement is reported in the coastal waters.

Fig. 2. Entanglement of the Risso's dolphin (*Grampus griseus*) in tuna gillnet on 11 February, 2019.

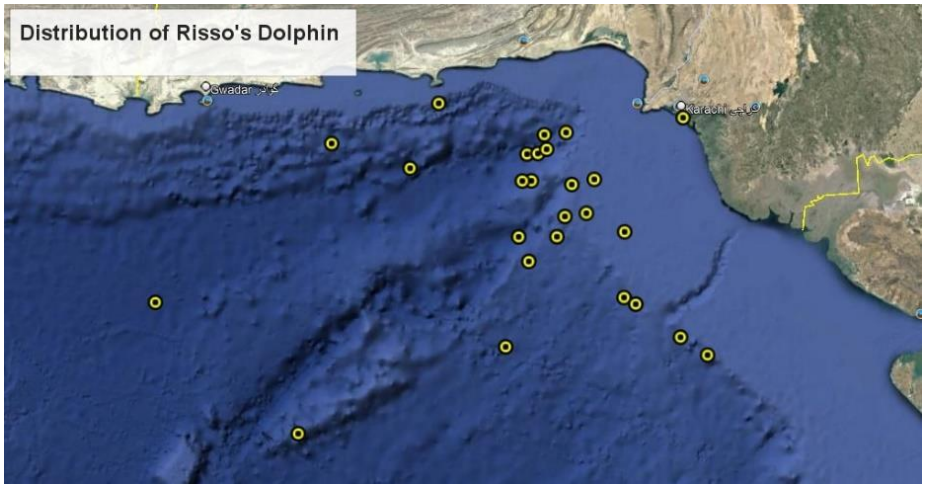

Fig. 3. Map of Pakistan showing locations of entanglement of the Risso's dolphin (*Grampus griseus*).

Bathymetric Distribution of Entanglement

Entanglement of Risso's dolphin in the tuna gillnets is reported from the area that has a depth between 500 and 3,500 m (Fig. 4). Highest numbers of entanglement were reported from the areas that have depth between 500 and 2,000 m with maximum entanglement reported from the area that has depth of 1,000 m with another minor peak at 2,000 m. Risso's dolphin is recorded to dive to depths of 600 metres in pursuit of prey (Visser, *et al*., 2021).

Seasonality of Entanglement

A marked seasonality in the entanglement of Risso's dolphin (*Grampus griseus*) was observed during the present study (Fig. 5). Entanglement of Risso's dolphin was observed to be high during Northeast Monsoon (December to February) and Pre-southwest Monsoon calm period (March and April). Maxima of entanglement was observed in March with another minor peak in April. No entanglement was reported in May, October and November. It may be added that June and July are observed as voluntary close season, therefore, no record to entanglement was observed during these two months. It may be added that Gore *et al.* (2012) reported occurrence of Risso's dolphins along Balochistan coast during Northeast Monsoon whereas during the

present study only a few records of entanglements of Risso's dolphins were reported during Northeast Monsoon period (December to February).

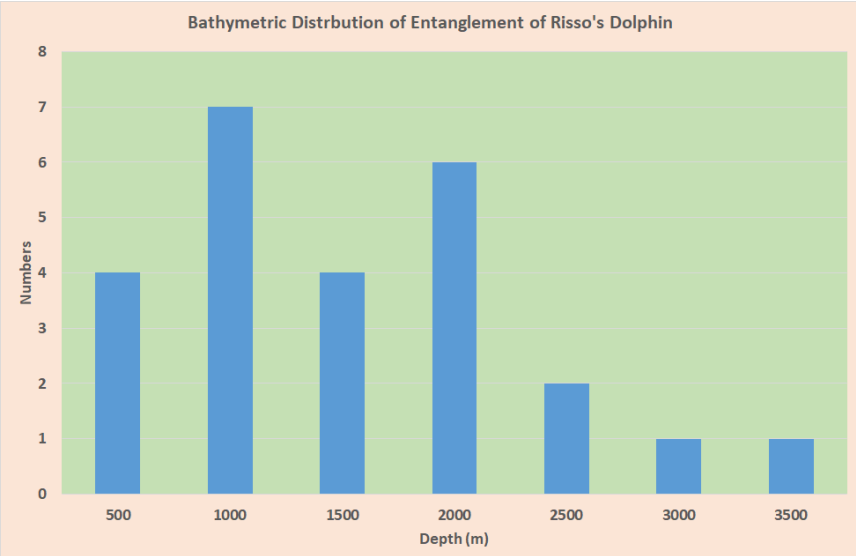

Fig. 4. Bathymetric distribution of entanglement of the Risso's dolphin (*Grampus griseus*).

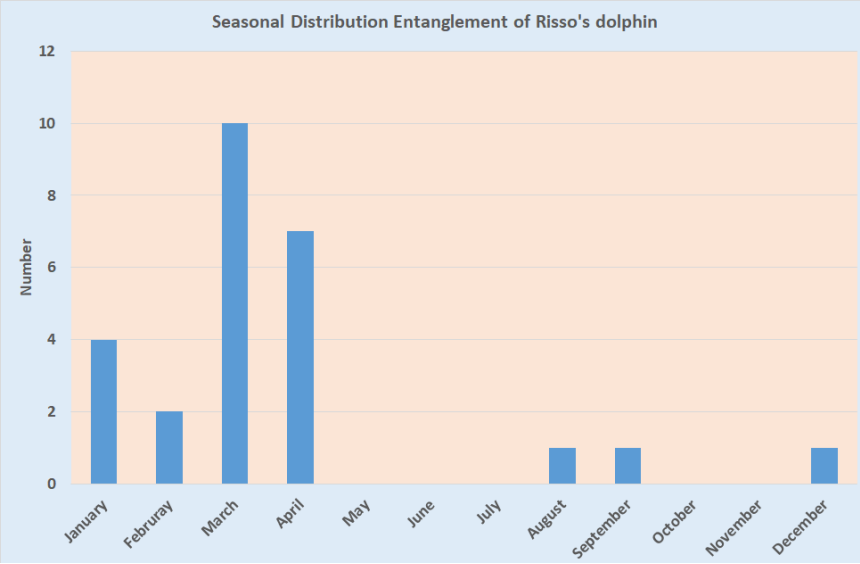

Fig.5. Seasonal changes in the entanglement of the Risso's dolphin (*Grampus griseus*).

Year-wise Changes in Entanglement

Fig. 6 presents changes in entanglement of Risso's dolphin during 2012 and 2019. There seems to be a gradual increase in the number of entanglements of Risso's dolphin from 2014 onward. It may be added that during 2012 and 2014, there were only 4 crew-based observers that were deputed on fishing vessels and reported the events of entanglements. The number of observers were increased and reached a level of 75 till the end of 2015. Between 2012 and 2015, only surface tuna gillnets were used by fishermen whereas sub-surface gear was introduced in 2016 and a major reduction in the entanglement of cetaceans was noticed in subsurface gillnets (Kiszka *et al*., 2021, Moazzam, 2019, 2021) whereas a major increase in the entanglement of Risso's dolphin was observed in the subsurface gillnet operation during this period.

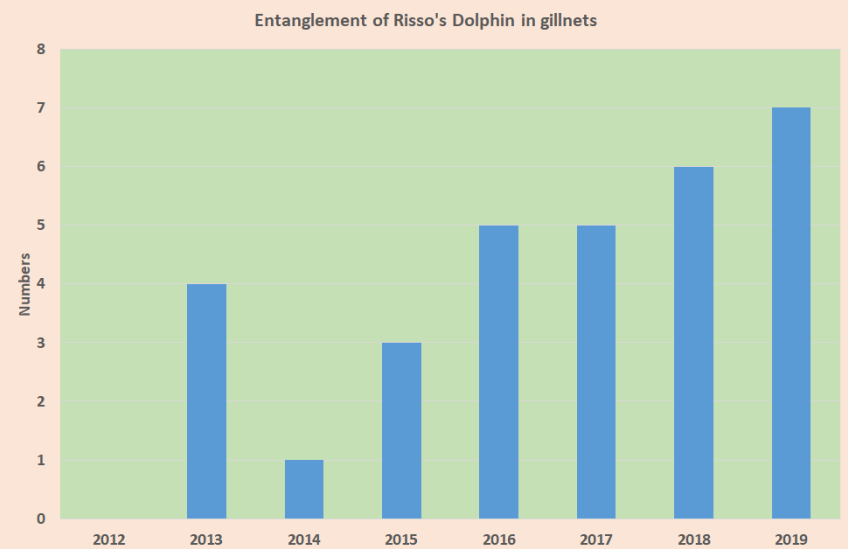

Fig. 6. Year-wise changes in the entanglement of the Risso's dolphin (*Grampus griseus*).

Dwarf sperm whales *Kogia sima* (Owen, 1866) and Pygmy sperm whales-*Kogia breviceps* (Blainville, 1838) (Fig. 7-8)

Dwarf and pygmy sperm whales have a similar overlapping worldwide distribution in tropical to warm-temperate waters, particularly over continental shelf and slope waters (Jefferson *et al*. 2015; Notarbartolo di Sciara *et al*. 2021). In the western Indian Ocean, dwarf sperm whales are uncommon but widely distributed; they occur from South Africa to the Gulf of Aden, the Sea of Oman and the Arabian Seas (Ballance and Pitman 1998; McAlpine, 2018). Gore *et al*. (2012) reported *Kogia sima* from offshore of the Indus Delta in Pakistan whereas Nawaz and Moazzam (2014) and lyas (2015) mentioned about entanglement of a dwarf sperm whale in a gillnet in Pakistan. A pygmy sperm whale was reported from Somniani, Pakistan, and is the only record of this species from the region (Gore *et al*. 2012). However, it is based on a third party report, and there are no substantiating photographs or other evidence to conclusively confirm its occurrence.

Kogia sima and *Kogia breviceps* were included in various checklists and reports from Pakistan but these seems to be based mainly on speculation of wider occurrence of these species (Ahmad and Ghalib, 1975; de Silva,1987; Roberts, 1997). These are, however, found widely over temperate and tropical waters of the Atlantic, Pacific, and Indian Oceans (McAlpine, 2018), however, of rare occurrence in Pakistan.

During October, 2012 and September, 2019, a total of 18 cases of entanglements of dwarf sperm whales (*Kogia sima*) and 5 cases of entanglements of pygmy sperm whales (*Kogia breviceps*) were reported from tuna gillnet fisheries of Pakistan.

Distribution of Entanglement

Entanglement of dwarf sperm whales (*Kogia sima*) and pygmy sperm whales (*Kogia breviceps*) was reported from out continental shelf, along continental slope, along oceanic ridge and deep oceanic basin along Sindh and Balochistan coast (Fig. 9). A major part of the entanglements of *Kogia sima* and *Kogia breviceps* were recorded from Murray Ridge. Entanglements of dwarf sperm whales and pygmy sperm whales were also reported along continental slope facing Indus Swatch (Canyon). No entanglement is reported in the coastal waters.

Fig. 7. *Kogia sima* from Khori Great Bank, off Sindh Coast entangled in tuna gillnet on January 3, 2019.

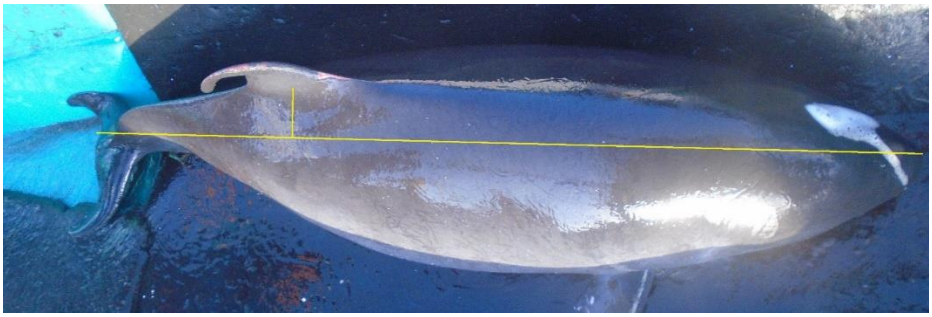

Fig. 8. *Kogia breviceps* from Murray Ridge, off Balochistan Coast entangled in tuna gillnet on March 31, 2018.

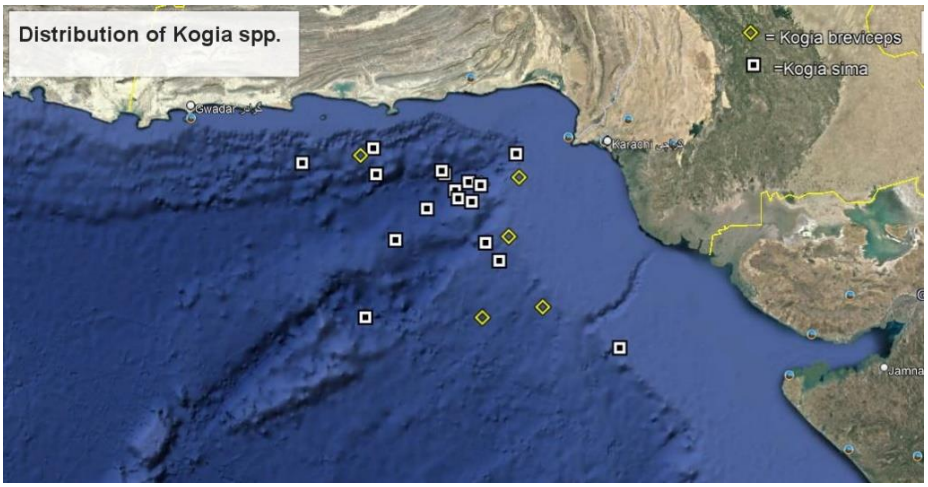

Fig. 9. Map of Pakistan showing locations of entanglement of the dwarf sperm whales (*Kogia sima*) and pygmy sperm whales (*Kogia breviceps*)

Bathymetric Distribution of Entanglement

Entanglement of dwarf sperm whales and pygmy sperm whales in the tuna gillnets is reported from the area that has a depth between 500 and 3,000 m (Fig. 10). Highest numbers of entanglement were reported from the areas that have depth between 2,000 and 3,000 m with maximum entanglement reported from the area that has depth of 2,000 m Entanglements of pygmy sperm whales (*Kogia breviceps*) were recorded from the areas which has a depth of 500 and 2,000 m. According to Dunphy-Daly and Heithaus (2007), *K. sima* can dive to average depth of

around 250 m the Bahamas whereas according to Baird (2005) both *Kogia* spp. were sighted most frequently in deeper portions along the main Hawaiian Islands where mean depth was 1,425 m. *K. breviceps* were most frequently sighted in waters ranging from 400 to 1,000 m in depth in the north-central and western Gulf of Mexico (Davis, *et al.* 1998).

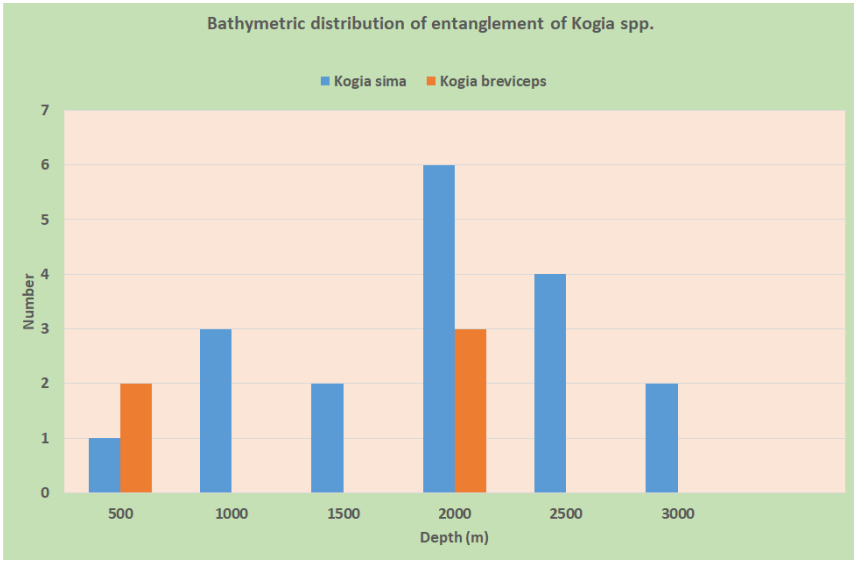

Fig. 10. Bathymetric distribution of entanglement of the dwarf sperm whales (*Kogia sima*) and pygmy sperm whales (*Kogia breviceps*)

Seasonality of Entanglement

A marked seasonality in the entanglement of dwarf sperm whales (*Kogia sima*) and pygmy sperm whales (*Kogia breviceps*) was observed during the present study (Fig. 11). Entanglement of both species was observed to be high during Pre-southwest Monsoon calm period (March and April). Maxima of entanglement was observed in March with another minor peak in April. No entanglement was reported in August, October and November. June and July is observed as voluntary close season, therefore, no record to entanglement of *Kogia spp.* was observed during these two months.

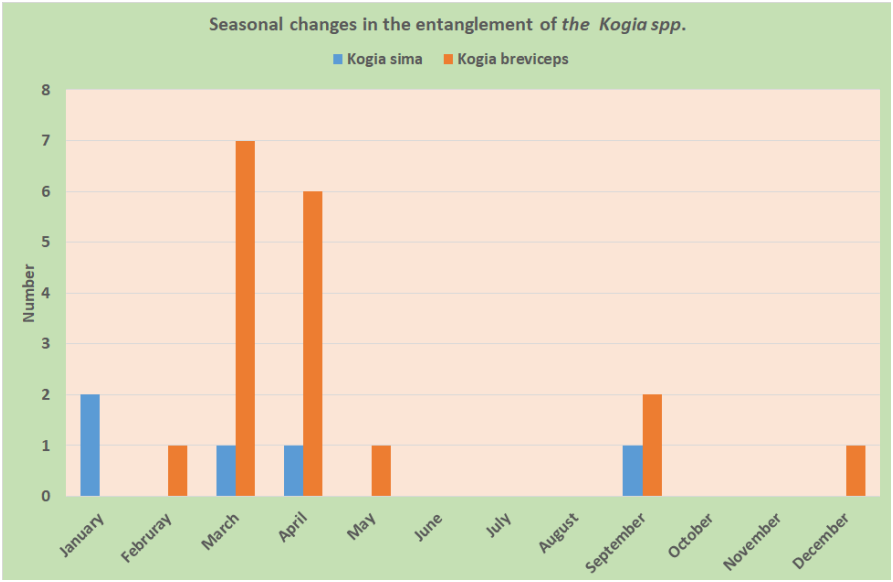

Fig.11. Seasonal changes in the entanglement of the *Kogia spp.*

Year-wise Changes in Entanglement

Fig. 12 presents changes in entanglement of dwarf sperm whales (*Kogia sima*) and pygmy sperm whales (*Kogia breviceps*) during 2015 and 2019. No entanglement of both species were recorded during 2012 and 2014. There seems to be a gradual increase in the number of entanglements of dwarf sperm whales (*Kogia sima*) from 2017 onward. It may be added that sub-surface gear was introduced in 2016 and a major reduction in the entanglement of small cetaceans was noticed in subsurface gillnets, however, on the contrary a major increase in the entanglement of *Kogia spp.* was observed in the subsurface gillnet operation.

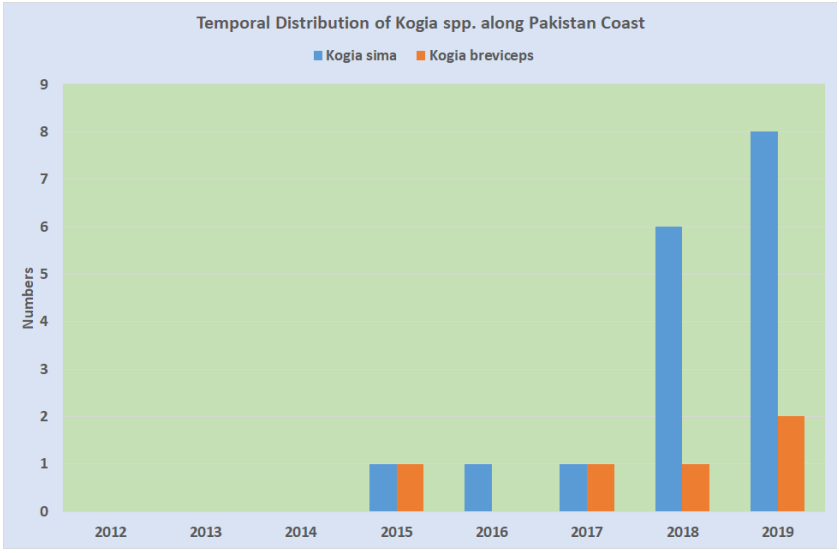

Fig. 12. Year-wise changes in the entanglement of the dwarf sperm whales (*Kogia sima*) and pygmy sperm whales (*Kogia breviceps*)

Both *Kogia spp*. have a balloon-like intestinal structure filled with a reddish-brown slurry. This may be ejected from anus into the water when these whales are disturbed or threatened (Staudinger, *et al.*, 2013; Yamada, 1954. Scott and Cordaro, 1987). The cloud produced by this startle response may cover an area of 100 square meter and serve to temporarily conceal the animal or operate as a decoy (Scott and Cordaro, 1987). Crew-based observers have reported that almost all entangled *Kogia spp,* are covered by a reddish brown slimy liquid like substance (Fig. 13-14) which has nauseating smell. This slimy liquid is very difficult to wash, as it sticks to net and ropes. The fishermen have observed that once entangled, most *Kogia* specimen struggle hard and get wrapped up in the fishing net (Fig. 13). Since they are under stress therefore, they release reddish brown slurry. The stench despite cleaning may persist for a few days making it difficult to work in the area of boat where it was place for disentanglement and discard. Staudinger, *et al.*, (2013); Yamada (1954) and Scott and Cordaro (1987) have reported ejection of red-brown slurry from anus into the water when these whales are disturbed or threatened but it seems that this is also being done to avert predators which is supported by nauseating smell of the ejected slurry.

Longman's beaked whale- *Indopacetus pacificus* (Longman, 1926) and *Mesoplodon sp.*
(Fig. 15)

On 10 February, 2015, a specimen of Longman's beaked whale (*Indopacetus pacificus*) was entangled in the tuna gillnets (Fig. 16) off the coast of Sindh (depth 1571 m). This was first record of this species from the Arabian Sea (coast of Pakistan). This was later on detailed by

Kiani *et al.* (2021) who reported its length to be 5-6 m. This whale was safely released by the fishermen. In addition, Kiani *et al*. (2021) reported an unidentified species of mesoplodont beaked whales (*Mesoplodon sp.*) from offshore waters of Pakistan (Fig. 16). First record of *Mesoplodon sp.* was reported on March 31, 2017 from offshore waters of Indus Swatch (depth 2,960 m). The entangled whale having a length of about 4 m was released.

Fig. 13. *Kogia sima* completely rolled up in the net at off Ormara, off Balochistan Coast on April 20, 2018. Fishermen trying to wash out the slimy slurry before disentanglement

Fig. 14. *Kogia sima* covered with slimy slurry at Murray Ridge, off Balochistan Coast reported by Ghani Gul (Observer) on March 26, 2018.

Fig. 15. Entanglement of Longman's beaked whale- *Indopacetus pacificus* in tuna gillnet on 11 February, 2015

Like other beaked whale, Longman's beaked whales live in generally in about 1,000 m depth in pelagic waters of tropical and subtropical regions in the Indian and Pacific Oceans. It is believed to feed on deep dwelling cephalopods like other beaked whales. *Mesoplodon sp.* also is beaked whale which is known to be deep divers and suction feeders taking mainly mesoplagic fish and squid. They are small whales ranging in size from 3.0 to 6.2 m and are found around the world in offshore waters from the subarctic to the subantarctic. Genus *Mesoplodon* currently comprises 15 species of beaked whales, making it by far the most diverse cetacean genus. However, because of insufficient information, none of Pakistani specimen could be assigned to any species.

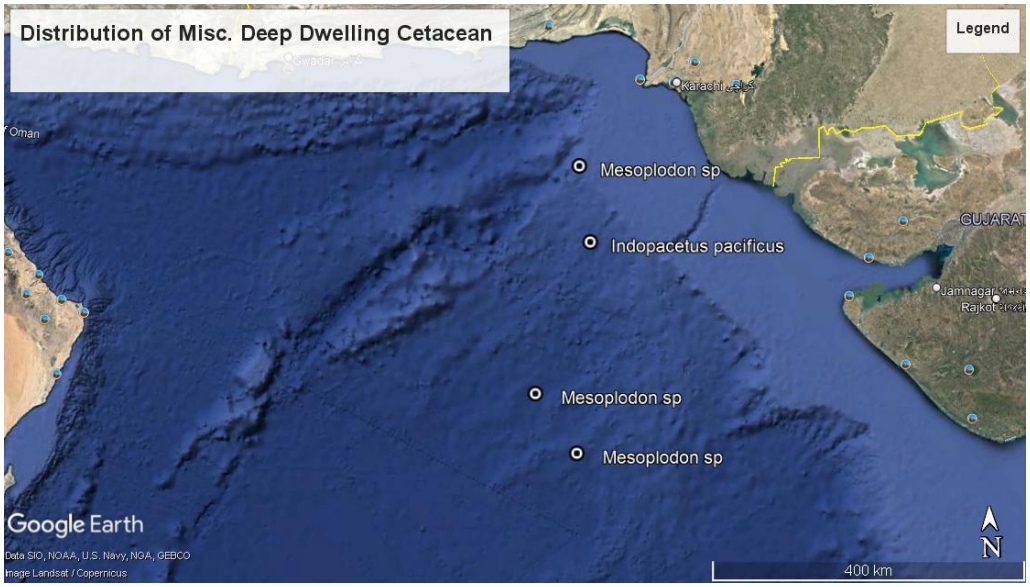

Fig. 16. Map of Pakistan showing locations of entanglement of Longman's beaked whale- *Indopacetus pacificus* (Longman, 1926) and *Mesoplodon sp.*

Cuvier's beaked whale- Ziphius *cavirostris* Cuvier, 1823 (Fig. 18)

Cuvier's beaked whale (*Ziphius cavirostris*) was reported Pakistan by Pilleri and Gihr (1972) based on a vertebra found near Damb, Miani Hor, Balochistan. They very tentatively identified this as a *Z. cavirostris* bone. Based on the Pilleri and Gihr (1972) article, both Roberts (1997) and de Boer *et al*. (2000) included *Z. cavirostris* in the checklist of cetacean recorded in Pakistani waters. Gore *et al*. (2007) authentically reported this species from Pakistan based on skull, some vertebrae and ribs from Khobar Creek, Indus Delta. A stranding of Z. *cavirostris* was reported from Gwadar Balochistan on 15 August 2017 whose cranial morphology is being described by Shafiq *et al*. (2022).

A specimen of *Z. cavirostris* was entangled in the tuna gillnet on 13 January 2019 from off Indus Swatch at a depth of 2,574 m (Fig.17). This specimens (Fig. 18) seems to have a length of 4.3 m was later on released by fishermen. There are two other unauthentic records of entanglement of Cuvier's beaked whale in the gillnets which are being examined to ascertain their identity and record other details.

Cuvier's beaked whales hold the records for both the deepest dive (2,992 m) ever documented for any mammal and the longest dive ever documented for any mammal (Baird, 2018). Like other beak whales it also feed on mesopelagic and bathpelagic squids and other cepahlopods and sometimes fish and crustaceans.

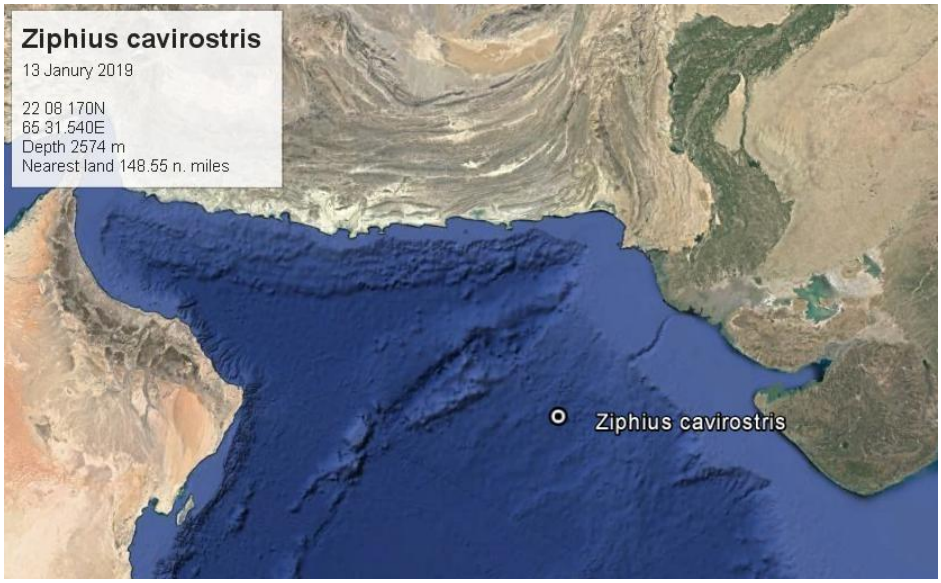

Fig. 17. Map of Pakistan showing location of entanglement of Cuvier's beaked whale (*Ziphius cavirostris*).

Fig. 18. Cuvier's beaked whale (*Ziphius cavirostris*) entangled in the tuna gillnet on 13 January 2019 from off Indus Swatch.

DISCUSSION

Gillnet is an important fishing gear being used for catching tuna and tuna like fishes in coastal and offshore waters of many countries including Pakistan, however, this gear is known to be marred with high bycatch of non-target species. Cetaceans are reported to be an important component of the bycatch of gillnets including in the Indian Ocean (Anderson *et al*., 2020; Kiszka, *et al*., 2021; Moazzam, 2013; 2021; Moazzam and Nawaz, 2013; 2014; Nawaz and Moazzam, 2013).

Most of the studies reported entanglement of small cetaceans including dolphin species already known to widely distributed along the coast of Pakistan (Kiszka *et al*., 2021; Moazzam, 2013; 2021; Moazzam and Nawaz, 2013; 2014; Nawaz and Moazzam, 2013). Surface dwelling cetaceans that includes both baleen whales as well as toothed whales mainly dolphin are highly prone to entanglement in gillnets which are mainly placed on the surface of the sea (Moazzam, 2013). Experiments were conducted by WWF-Pakistan on use of subsurface gillnetting (placing net 2 m below sea surface) yielded positive results and major reduction in the entanglement of cetacean was noticed (Moazzam and Nawaz, 2017; Kaszka *et al*., 2021). Subsurface gillnet was adopted by entire tuna gillnet fleet in Pakistan which eliminated mortality of cetaceans in Pakistan (Moazzam, 2021), however, it was noticed that some species

of deep dwelling cetaceans that surface to inhale air but dive to greater depth for feeding were observed be get entangled in even subsurface gillnets.

Species of cetaceans belonging to family Delphinidae (Risso's Dolphin), Family Kogiidae (dwarf sperm whales and pygmy sperm whales) and Family Ziphiidae (Longman's beaked whale, *Mesoplodon sp*. and Cuvier's beaked whale) were reported to get entangled in gillnets placed on predominantly subsurface. These deep dwelling species feed mainly on meso- and bathypelagic squid, and also fish and crustaceans, however, cephalopods are their staple diet (Baird, 2009, 2018; Beatson, 2007; Bloodworth and Odell, 2008; Davis *et al*., 1998; dos Santos and Haimovici, 2001; Jefferson, et *al*. 2015; Ross 1979; Staudinger, *et al*., 2013).

It is interesting to note that Murray Ridge and continental slope along Indus Swatch seems to be hotspot of deep dwelling cetaceans including Risso's dolphin (*Grampus griseus*), dwarf sperm whales (*Kogia sima*) and pygmy sperm whale (*Kogia breviceps*), Longman's beaked whale *Indopacetus pacificus,* species of *Mesoplodon* and Cuvier's beaked whale (*Ziphius cavirostris*). Further studies are required to investigate distribution of these deep dwelling cetaceans in these areas as well as along the continental shelf and continental slope along Pakistan coast as well as in the Murray Ridge area and deep Arabian Sea basin.

REFERENCES

Ahmed, M. F. and S. A. Ghalib (1975). A checklist of mammals of Pakistan. Records of Zoological Survey of Pakistan. 7: 1–34.

Anderson, R. C., M. Herrera, A. D. Ilangakoon, K. M. Koya, M. Moazzam, P. L. Mustika and D. N. Sutaria (2020). Cetacean bycatch in Indian Ocean tuna gillnet Fisheries. Endangered Species Research 41: 39–53.

Baird, R. W. (2005). Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. Pacific Science 59: 461-466.

Baird, R. W. (2009). Risso's Dolphin. In: *Encyclopaedia of Marine Mammals (2nd Ed.)*. (W. F. Perrin, B. Wursig, and J. G. M. Thewissen Eds.). Academic Press. Burlington Massachusetts pp. 975.

Baird, R. W. (2018). Cuvier's Beaked Whale: *Ziphius cavirostris*. In: Encyclopaedia of Marine Mammals (3rd Ed.). B. Würsig, J.G.M. Thewissen and Kit M. Kovacs Eds). Academic Press. Burlington Massachusetts 234-237.

Balance, L. T. and R. L. Pitman (1998) Cetaceans of the western tropical Indian Ocean: distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. Marine Mammal Science 14: 429–459.

Beatson, E. (2007). The diet of pygmy sperm whales, *Kogia breviceps*, stranded in New Zealand: implications for conservation. Review of Fish Biology and Fisheries17:295–303.

Bloodworth, B. E. and D. K. Odell (2008). *Kogia breviceps* (Cetacea:Kogiidae). Mammalian Species. 819: 1–12.

Davis, R.W., G. S. Fargion, N. May, T. D. Leming, M. Baumgartner, W. E. Evans, L. J. Hansen and K. Mullin (1998). Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. Marine Mammal Science 14: 490–607.

de Silva, P. H. D. H. (1987). Cetaceans (whales, dolphins and porpoises) recorded off Sri Lanka, India, from the Arabian Sea and Gulf, Gulf of Aden and from the Red Sea. Journal of Bomaby Natural History Society. 84: 505-525.

dos Santos, R. A. and M. Haimovici (2001). Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21- 34º S). Fisheries Research 52: 99-112.

Dunphy-Daly, M. M. and M. R. Heithaus (2007). *Temporal Variation in Dwarf Sperm Whale (Kogia sima) Habitat Use and Group Size off Great Abaco Island, the Bahamas*. FIU Electronic Theses and Dissertations. 3101: 28p

Gore, M. A., E. Ahmed, Q. M. Ali, R. M. Culloch, S. A. Hasnain, S. A, B. Hussain, P. Iqbal, S. Kiani, C. D. Macleod, E. C. M. Parsons, P. J. Siddiqui, R. F. Ormond and U. Waqas (2007). Cuvier's beaked whale, *Ziphius cavirostris*, remains recovered on the Pakistani coast. Journal of Marine Biological Association U.K. Biodiversity records online, 5920.

Gore, M. A., R. M. Culloch, H. W. I. Gray, R. Hoelzel, C. Lockyer, M. S. Kiani, U. Waqas, B. Hussain, A. Rahim, A. Shah and R. F. G. Ormond (2017) Assessment of beach-cast cetaceans in Pakistan: implications for conservation and management. Journal of Cetacean Research and Management 16:1–7.

Gore, M. A., M.S. Kiani, E. Ahmad, B. Hussain, R. F. Ormon, J. Siddiqui, U. Waqas and R. Culloch (2012). Occurrence of whales and dolphins in Pakistan with reference to fishers' knowledge and impacts. Journal of Cetacean Research and Management 12: 235–247.

Ilyas, F. 2015. Rare whale caught off Karachi Coast dies. Dawn epaper March 7, 2015.

Jefferson, T. A., C. R. Weir, R. C. Anderson, L. T. Ballance, R. D. Kenney and J. J. Kiszka (2014). Global distribution of Risso's dolphin *Grampus griseus*: a review and critical evaluation. Mammal Review 44:56–68.

Jefferson, T. A., M. A. Webber and R. L. Pitman (2015) Marine mammals of the world. A comprehensive guide to their identification, 2nd ed. Academic Press, Oxford

Kiani. M. S., R. Nawaz, M. Moazzam, B. Shafiq and K. van Waerebeek (2022). Longman's beaked whale *Indopacetus pacificus* and *Mesoplodon sp.* entanglements off Pakistan: Are pelagic gillnet fisheries a potential threat? Preprints doi:10.20944/preprints202110.0051.v1

Kiszka, J. J., M. Moazzam, G. Boussarie, U. Shahid, B. Khan and R. Nawaz (2021). Setting the net lower: A potential low-cost mitigation method to reduce cetacean bycatch in drift gillnet fisheries. Aquatic Conservation: Marine and Freshwater Ecosystems, 1–9

Kratzer, I. M. F., M. Elizabeth Brooks, S. Bilgin, S. Özdemir, L Kindt-Larsen, F. Larsen and D. Stepputtis (2021). Using acoustically visible gillnets to reduce bycatch of a small cetacean: first pilot trials in a commercial fishery. Fisheries Research 243: 106088.

Kratzer, I. M. F., I. Schäfer, A. Stoltenberg, J. C. Chladek, L. Kindt-Larsen, F. Larsen and D. Stepputtis (2020) Determination of Optimal Acoustic Passive Reflectors to Reduce Bycatch of Odontocetes in Gillnets. Frontiar. Of Marine Science 7: 1-19.

McAlpine, D. F. (2018). Pygmy and Dwarf Sperm Whales: *Kogia breviceps* and *K. sima*. Encyclopaedia of Marine Mammals (Third Edition). 786-788.

Minshull, T. A. R.A. Edwards and E. R. Flueh (2015). Crustal structure of the Murray Ridge, northwest Indian Ocean, from wide-angle seismic data. Geophysical Journal International 202, 454–463.

Moazzam, M. (2013). An assessment of cetacean mortality in the gillnet fishery of the northern Arabian Sea. Report no. IOTC-WPEB09-28. Indian Ocean Tuna Commission, Victoria.

Moazzam, M. (2019). Crew based observer programme of WWF-Pakistan-A source of data collection on cetacean bycatch. IWC Scientific Committee Meeting- The Subcommittee on Unintentional Human Induced Mortality (HIM). SC/68A/HIM/12. 15p.

Moazzam, M. (2021). Subsurface gillnetting: What motivated fishermen to Change. Report no. IOTC-2021-WPEB17(AS)-20. Indian Ocean Tuna Commission, Victoria.

Moazzam, M. and R. Nawaz (2014). By-catch of tuna gillnet fisheries of Pakistan: A serious threat tonon-target, endangered and threatened species. *Journal of the Marine Biological Association of India*, 56: 85-90.

Moazzam, M. and Nawaz, R. 2017. Major bycatch reduction of cetaceans and marine turtles by use of subsurface gillnets in Pakistan. IOTC-2017-WPEB13-19.

Nawaz, R. and M. Moazzam (2014). An assessment of cetacean mortality in the tuna fisheries of Pakistan. Report no. IOTC-2014-WPEB-10-INF25. Indian Ocean Tuna Commission, Victoria.

Niazi, M. S. (1990). A brief on major fisheries of Pakistan and mortality of dolphins in different fishing gear. Document SC/090/63 presented to the IWC Workshop on mortality of cetaceans in passive fishing nets and traps, La Jolla, California.

Northridge, S. P. (1984). World review of interactions between marine mammals and fisheries. FAO Fisheries Technical Report 25: 1-190.

Northridge, S. P. (1990). Drift net fisheries and their impact on non-target species. IWC Symposium on Mortality of Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps, La Jolla, California October 1990. International Whaling Commission SC/090/G35. 100p.

Northridge, S. P. (1991) Driftnet fisheries and their impacts on non-target species: a worldwide review. FAO Fisheries Technical Paper 320: 1−115.

Notarbartolo di Sciara, G., R. Baldwin, G. Braulik, T. Collins, and A. Natoli (2021). Marine Mammals of the Arabian Seas. In: *The Arabian Seas: Biodiversity, Environmental Challenges and Conservation Measures* (L. A. Jawad Ed.). Springer Nature Switzerland AG. pp. 637-678.

Roberts, T. J. (1997). *The Mammals of Pakistan: revised edition*. Oxford University Press, London and Tonbridge.

Ross, G. J. B. (1979). Records of pygmy and dwarf sperm whales, genus *Kogia*, from southern Africa, with biological notes and some comparisons. Annals of Cape Provincial Museum (Natural History) 11: 259-327.

Scott, M. D. and J. G Cordaro (1987). Behavioral observations of the dwarf sperm whale *Kogia simus.* Marine Mammal Sciences 3: 353-354.

Shafiq, B. M. S. Kiani, M. Laghari, M. Moazzam and A. Rahim (2022). Cranial Morphometry of a Cuvier's beaked whale *Ziphius cavirostris* (Cuvier, 1823) stranded along the Makran Coast of Pakistan (manuscript).

Staudinger, M. D., R. J. McAlarney, W. A. McLellan and D. A. Pabst (2013). Foraging ecology and niche overlap in pygmy (*Kogia breviceps*) and dwarf (*Kogia sima*) sperm whales from waters of the U.S. mid-Atlantic coast. Marine Mammal Sciences 30: 626–655.

Vidal, O., Waerebeek, K. V. and Findley, L. T. (1994). Cetaceans and Gillnet Fisheries in Mexico, Central America and the Wider Caribbean: A Preliminary Review. Report of International Whaling Commission (Special Issue 15). 221-233.

Visser, F., O. A. Keller, M. G. Oudejans, D. P. Nowacek, A. C. M., Kok, J. Huisman and E. H. M. Sterck (2021). Risso's dolphins perform spin dives to target deep-dwelling prey. Royal Society Open Science 8:202320.

Yamada, M. (1954). Some remarks on the pygmy whale, *Kogia.* Scientific Report of Whale Research Institute 9: 33-58.