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Beaked whales (Cetacea: Ziphiidae) gillnet entanglements in the Northwestern Indian Ocean (Pakistan, Iran): are pelagic tuna fisheries a threat?

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Beaked whales (Family Ziphiidae) are rarely reported in the Northwestern Indian Ocean. This study presents seven new records involving eight individuals from the deep offshore waters of the northern Arabian Sea (N=5) and the Gulf of Oman (N=2), encompassing areas under the jurisdiction of Pakistan and Iran. Observations primarily resulted from fishermen video-recording incidental entanglements in the pelagic tuna drift gillnet fishery between 2015 and 2018. Additional data from Iran were sourced through interviews with fishermen, video evidence, and media reports from 2013. Due to the non-specialist nature of the graphic evidence, most identifications were limited to higher taxonomic levels: three cases were attributed to *Mesoplodon* spp., three to unidentified Ziphiidae, and one was confirmed as *Indopacetus pacificus* from Pakistani waters. An additional ziphiid from Iran was identified as either *I. pacificus* or *Ziphius cavirostris*. Notably, one *I. pacificus*, one *Mesoplodon* sp., and one unidentified ziphiid displayed erupted apical tusks, indicating they were adult males. The successful release of all live-entangled beaked whales and the simultaneous entanglement of two *Mesoplodon* individuals are unprecedented observations. These findings suggest that ziphiids may be more prevalent in the Northwestern Indian Ocean than previously indicated in the literature. However, continued bycatch in the expansive tuna fishery poses potentially unsustainable threats to their conservation status.

Keywords: Arabian Sea; bycatch; citizen science; Longman's Beaked Whale; *Indopacetus*; *Mesoplodon*; tuna drift gillnet fishery

Introduction

Beaked whales (Ziphiidae) are some of the least known cetaceans due to their close ecologic association with deep oceanic waters, spending little time near the surface, and generally inconspicuous and elusive nature. Some species have not, or rarely, been visually confirmed at sea, and ziphiid taxonomy continues to be in flux, with new species described or nomenclature revised every few years (e.g., Dalebout et al., 2002, 2014; van Helden et al., 2002; Carroll et al., 2021). Much of the available knowledge on ziphiids is derived from strandings, beach-cast remains, opportunistic sightings, and anecdotal records (Reeves et al., 2002; Pitman, 2018a, b). One species, the Peruvian or

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Lesser Beaked Whale *Mesoplodon peruvianus* Reyes, Mead & Van Waerebeek, 1991, was described based mainly on by-caught specimens (Reyes & Van Waerebeek, 2018). The number of dedicated research programs on beaked whales is limited due to the logistical difficulties in studying some of the most cryptic mammals, hence any well-supported new evidence merits reporting.

One of the least known ziphiids, the Longman's Beaked Whale *Indopacetus pacificus* (Longman, 1926), also named the Indo-Pacific beaked whale, because found exclusively in the tropical and subtropical Indo-Pacific region (Reeves et al., 2002; Pitman, 2018a), is suspected to occur off Pakistan and Iran. First classified in the genus *Mesoplodon*, it was re-assigned to the monotypic genus *Indopacetus* based on its morphological features, later confirmed by molecular genetics (Dalebout et al., 2003). Our knowledge of this species was long based only on two skulls, one found in Queensland, Australia, in 1882, and another from Somalia in 1955 (Pitman et al., 1999). However, more information has since been collected from about a dozen strandings in various localities in the Indo-Pacific region and about 65 sightings, previously often identified equivocally as Southern Bottlenose Whale *Hyperoodon planifrons* Flower, 1882 (Pitman et al., 1999; Dalebout et al., 2003; Pitman, 2018a). Recently, more strandings of *I. pacificus* have been reported from the Philippines, Maui (Hawaii), Taiwan, Myanmar, Andaman Islands (Pitman, 2018a), South Africa (Best, 2007), and Japan (Kobayashi et al., 2021). The IUCN Red List of Threatened Species categorised Longman's Beaked Whale as "Data Deficient" (Taylor et al., 2008). While further information led the Red List to reassess the species as "Least Concern" in 2020, there is still no information on the global trend and abundance of this species, and information on its specific threats is sparse (Pitman & Brownell, 2020).

Encountering cetaceans accidentally during fishing activities offers a cost-effective opportunity for data collection that is crucial for marine mammal conservation and management research. Fisheries observer programmes in many parts of the world are generating information on by-catch, which assist in fisheries monitoring and management and ecosystem and biodiversity conservation (e.g., Porter, 2009; Mangel et al., 2010). Ancillary data collected by observers (citizen science) helps in updating knowledge on various marine species and completing biodiversity records in poorly studied areas.

Pelagic drift gillnet fisheries for tuna (Thunnidae) are notorious worldwide for a high rate of by-catch of various taxa of large marine vertebrates including cetaceans, particularly in the western Indian Ocean (Lewison et al., 2004; Kiszka et al., 2009; Reeves et al., 2013; Temple et al., 2018; Anderson et al., 2020; Elliott et al., 2024). This type of fishery is widespread in both Pakistan and Iran and can provide information on cetacean distribution, especially of evasive offshore species like beaked whales (Nawaz & Moazzam, 2014). We report herein unusual gillnet entanglements of ziphiids in offshore Pakistani and Iranian waters. We document the circumstances and underscore the threat that the large-scale tuna gillnet fisheries may pose to beaked whales in the Arabian Sea and generally the Northwestern Indian Ocean.

Material and Methods

In Pakistan, through a joint project with WWF-Pakistan, some of the authors (M.S.K., R.N., M.M., and B.S.) established good working relationships with fishermen on pelagic gillnet tuna vessels in November 2012, de facto introducing a 'citizen science' strategy (Irwin, 1995). Fishermen were trained by WWF-Pakistan personnel (M.M. & M.S.K.) to collect data on cetacean by-catches during fishing operations, resulting in reports of net entanglements of beaked whales.

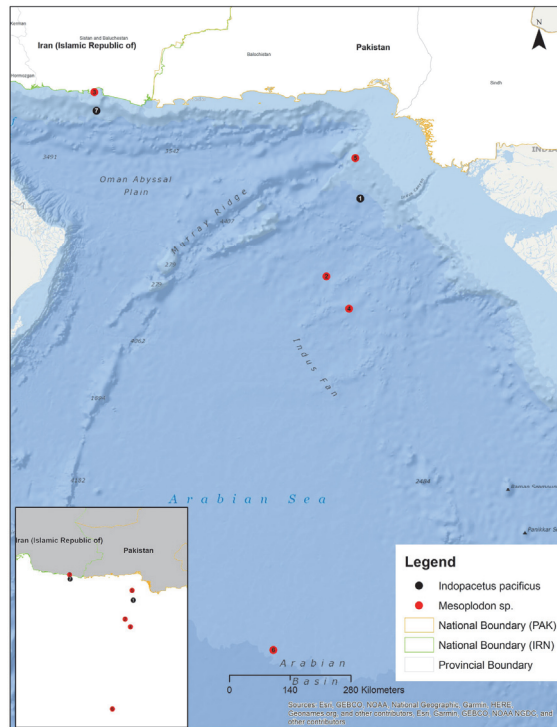


Figure 1. The study area in the northern Arabian Sea and the Gulf of Oman. Numbered positions of documented gillnet entanglements of beaked whales (Cases 1–7) in offshore areas under the jurisdiction of Pakistan and Iran (EEZ, i.e. *Exclusive Economic Zones*, and offshore Arabian Sea). Case 7 is a possible *Indopacetus pacificus*. Cases 3 and 5 are probable *Mesoplodon* sp.

In Iran, a low-cost approach was employed to uncover new cases of fisheries–marine wildlife interactions. Two of the authors (M.R-A. and H.A.A.) conducted interviews with fishers during February and March 2022. Additionally, since 2018, they have performed regular reviews of national and local mass media, which have provided evidence of several bycatch incidents. All videos were recorded with standard cellphones, and image resolution was low. The videos were analysed frame-by-frame by K.V.W. with expertise in cetacean taxonomy, using the open-source VLC Media Player (v.3.0.11 Vetinari). Key external features were studied, including colouration, scar type and density, relative body size and shape, presence/absence of visible tusks and morphology of the rostrum, melon, and dorsal fin. However, not all features were evident from the available evidence.

Results

A total of seven cases (eight individuals) of Beaked Whales incidentally entangled in tuna gillnet fisheries in offshore waters in the Arabian Sea ($n=5$) and the Gulf of Oman ($n=2$) were recorded in this study (Figure 1). Cases were recorded off Pakistan or off Iran and one record in offshore Arabian Sea.

Case 1 (Pakistan). On 10 February 2015, early morning, Pakistani fishermen onboard tuna fishing vessel *Al-Azaan* found a live beaked whale entangled in their tuna gillnet at about 95 km west of the southern tip of the ‘Swatch’ or Indus undersea Canyon (Kolla & Coumes, 1985) and approximately 177 km from the nearest Pakistan’s Sindh coast

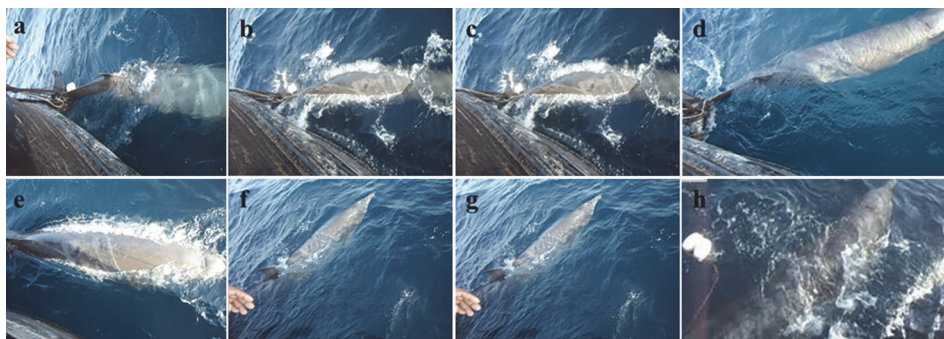


Figure 2 (a-h). Successive steps in gillnet disentanglement operation of a Longman's Beaked Whale *Indopacetus pacificus* in Pakistani waters (Case 1). Note the head with moderately bulbous melon (e, h), long rostrum (f, g, h) tubular in dorsal view (h), limited linear scarring (e) and large falcate dorsal fin (f, g). Selected frames were taken from a video.

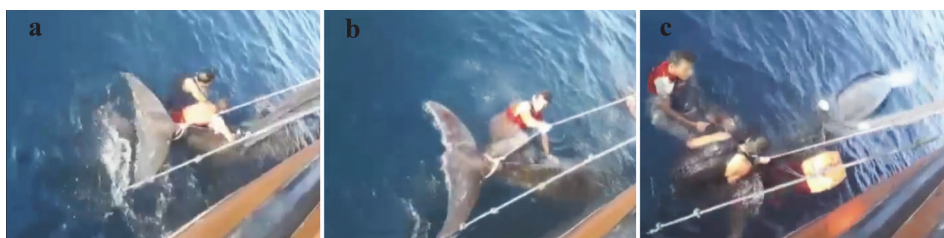


Figure 3. An unidentified middle-sized beaked whale (Case 3), with a melon of unclear bulbosity, net-entangled within Iran's EEZ waters off Sistan and Baluchistan Province, northern Gulf of Oman, in August 2017. (a, b) flukes without central notch and tailstock; (c) the only registered blow and vague view of the head. Both *Mesoplodon* sp. and *Indopacetus pacificus* would be possible.

baseline, at 23°09'N, 065°57'E (Figure 1). The water depth at the location of first encounter was >1,500 m. A video (Case 1 in the Supplementary Material), showed a fairly large beaked whale, estimated to measure 5–6 m in length, with a slender body, moderately prominent melon, and a long distinct rostrum ('beak'), without protruding teeth. The lack of visible teeth, the limited linear body scarring (tooth rakes), and the low bulbosity of the melon (Figure 2) suggest a female, confidently assuming an adult animal, considering the large body size. The slightly paler head contrasted against an otherwise plain brownish-grey dorsal colouration. The whale showed a large, falcate and dolphin-like dorsal fin, set two-thirds of the way along the dorsum (Figure 2). These morphological features, in combination with the tropical Indian Ocean biotope, are strongly indicative for *I. pacificus*. Cookie-cutter shark (*Isistius* sp.) bite scars were not evident, but the abdomen was not visible. The whale reportedly became entangled during net retrieval, allowing fishers to respond in time. The crew initiated a 30 min rescue operation by cutting a part of the gillnet, resulting in the successful release of the animal without any apparent injury. However, reportedly, one of the rescuers was slightly injured when disentangling the flukes of the whale.

Case 2 (Pakistan). On 31 March 2017, an unidentified beaked whale became live entangled in a drift gillnet in deep offshore water (approximately 3,066 m) at 21°31'N,

65°15'E, some 207 nautical miles (nm) from the nearest Pakistan coast baseline (Figure 1). Its release was filmed by the fishermen (Case 2 in the Supplementary Material). This record is located offshore in the 'Swatch' area, yet it remains within the Pakistan continental shelf. Its body length was estimated 4 m. It had a noticeable but non-bulbous melon, a moderately long, poorly defined rostrum, and a fairly low, medium-sized, sub-triangular dorsal fin, only slightly falcate at the tip and set backwards. Dorsally and on the flanks, the colouration was an even grey, darker on the tailstock, without any visible linear (tooth-rake) scars, cookie-cutter shark bites, or other marks. The small head appeared only slightly paler than the upper trunk. The beaked whale showed morphological features consistent with *Mesoplodon* spp., although species identification was not possible. Zoogeographical aspects would require considering Deraniyagala's Beaked Whale *Mesoplodon hotaula* Deraniyagala, 1963 and Ginkgo-toothed Beaked Whale *Mesoplodon ginkgodens* Nishiwaki & Kamiya, 1958, although for the latter no genetically confirmed records exist in the Indian Ocean (R. L. Brownell, pers. comm.). Unlikely is Ramari's Beaked Whale *Mesoplodon eueu* Carroll et al., 2021, whose adults show a distinctly lighter coloured tailstock and posterior dorsum. Also as a cold-temperate water species it has not been recorded in the western Indian Ocean north of Mozambique (23°51'S, 35°32'E). The video demonstrates, as the fishermen reported, that the animal was released alive.

Case 3 (Iran). On August 2017, a fisherman from Bandar-e-Konarak Town at the eastern Iranian coastline of the Gulf of Oman (Figure 1) sent a video to IRIB News, the Iranian national news agency, of a beaked whale which recently entangled in their gillnet, but was released without incident. As the news agency did not record the observer's contact information, the exact location and date of the by-catch remained unknown. Based on the information presented in the caption of the news, it happened within Iran's Exclusive Economic Zone (EEZ) waters of Sistan and Baluchestan Province in the Gulf of Oman, and probably in Bandar-e-Konarak coastal waters (Figure 1). The video (Case 3 in the Supplementary Material) showed mostly the flukes and tailstock (Figure 3 a, b). Only one respiration (blow) was graphically registered (Figure 3 c) which subtly suggested a beaked whale head of unclear bulbosity with invisible teeth. The well-documented flukes lacked a median notch, confirming the cetacean as a ziphiid. Based on the relative size of a fisher's forearm, the fluke width (tip-to-tip) of the specimen was photogrammetrically estimated at 140 cm, which suggests, the animal's total length may be roughly estimated to range between 470 and 490 cm (see Reeve-Arnold et al., 2021). We conclude that Case 3 is an unidentified, middle-sized beaked whale.

Case 4 (Pakistan). On 18 January 2018, a moderately small to mid-sized beaked whale was reported alive in a gillnet at 20°51'N, 65°43'E in deep, far offshore waters (3,194 m), 256 nm from the nearest Pakistani coastline (Figure 1). Body size was estimated at 3.5–4.5 m, with a medium-length rostrum (excluding short-rostrum *Ziphius*) and a non-bulbous head, consistent with *Mesoplodon* sp., to which we here assign it. The small melon, combined with relatively small body size, practically excludes *Indopacetus*, *Hyperoodon*, *Berardius* and *Tasmacetus*. The flukes showed absence of a median notch. Colouration, as well as the absence or presence of tooth rakes and other scars, could not be determined because of adverse lighting conditions and low resolution of the video evidence (see Case 4 in the Supplementary Material). However, the rostrum appeared to be slightly paler than the body. The Pakistani fishermen who filmed the event reported that the whale was successfully disentangled and released in good condition.

Case 5 (Pakistan). On 19 March 2018, a unique incident of two beaked whales (cf. absence of fluke notch) entangled alive simultaneously in the same gillnet at 23°59'N,



Figure 4. An unidentified *Mesoplodon* sp. (Case 6) bycaught in far offshore waters of the northern Arabian Sea, 700 nm from Bandar-e-Beris at the eastern side of Iran's Sistan and Baluchestan Province, in February 2022. (a, c) two erupted (sub)apical mandibular teeth indicate an adult male. (b) dolphin-like, medium-length rostrum, gently sloping melon and smallish dorsal fin.

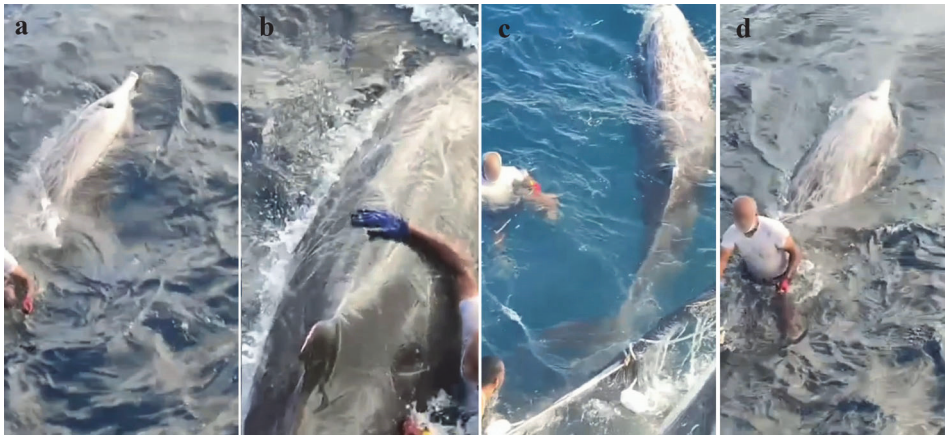


Figure 5. An adult male Beaked Whale (Case 7) being liberated after accidental entanglement in tuna gillnet in coastal waters of the Gulf of Oman, some 20 nm from Chabahar, Iran, in early June 2023. (a) Large body size with two erupted teeth at the apex of the mandibula; (b) a tall, erect, falcate, dolphin-like dorsal fin, a moderately long and well-defined rostrum; (c) with numerous tooth rakes on anterior body; and (d) some degree of bulbosity in the melon. The morphology of the beaked whale is congruent with *Indopacetus pacificus*, but *Ziphius cavirostris* cannot be excluded.

065°51'E in continental slope waters (depth 295 m) off Churna Island (west of Karachi) and 51.7 nm from the nearest Pakistani coastline (Figure 1). The estimated body size of the smaller animal, most probably a calf, was comparable to, or only slightly larger than, an adult common bottlenose dolphin *Tursiops truncatus*, i.e. 3.0–3.5 m. The size of the larger individual could not be estimated, but probability suggests it may have been a maternal individual and certainly conspecific. The dark grey dorsum of the small animal contrasted with its whitish abdomen. Its rostrum was very short, and there was no indication of a bulbous melon. The dorsal fin of the small whale was falcate. Except for its flukes, the body of the larger animal is not shown in the footage (see Case 5 in the Supplementary Material). Hence, we identify these beaked whales as most likely *Mesoplodon* sp., also since there are no indications for the genera *Indopacetus*, *Hyperoodon*, *Berardius*, *Tasmacetus* and *Ziphius*. The fishers reported successfully disentangling these ziphiids from the gillnet.

Case 6 (offshore Arabian Sea). In February 2022, Iranian fishermen recorded an incident where a beaked whale became entangled in a drift gillnet set for tuna fishing. It

was successfully released at 13°47'N 64°09'E in far offshore waters of the Arabian Sea, 700 nm from Bandar-e-Beris at the east side of Iran's Sistan and Baluchestan Province (Figure 1). The fishers shared video and spatial and temporal information with one of the authors (H.A.A.) during an interview in March 2023. The video (see *Case 6* in the Supplementary Material) shows a medium-sized beaked whale with a medium-length, dolphin-like beak and a non-steeply sloping melon indicative of *Mesoplodon* sp. (Figure 4), not concordant with *Indopacetus*, and definitely excluding *Hyperoodon*, *Berardius*, *Tasmacetus*, and *Ziphius* (cf. different shape of head and rostrum). Several frames showed two apical or slightly sub-apical mandibular teeth (as white spots) (Figure 4a, b), indicative of an adult male. A dark eye patch was present. The mouthline appeared to be non-arched if not entirely straight. The dorsal fin was relatively small and moderately falcate (Figure 4c). Combined, these features effectively discard Blainville's Beaked Whale *Mesoplodon densirostris* (de Blainville, 1817), *M. hotaula* and *M. ginkgodens*. True's Beaked Whale *Mesoplodon mirus* (True, 1913), which has apical teeth, has not been confirmed outside the North Atlantic. In the Southern Hemisphere, its sister species *Mesoplodon eueu* has a distinctly light tailstock (absent in *Case 6*) and its distribution is restricted to warm-temperate waters with a single exception from the cold-temperate waters off New Zealand (Carroll et al., 2021). The whale's body length could not be determined photogrammetrically; however, an estimate based on the fishermen visible in the water suggests it was approximately 4.5–5.5 meters long (Figure 4 c). We conclude *Case 6* to be a *Mesoplodon* sp.

Case 7 (Iran). In early June 2023, a large beaked whale entangled in a tuna fishery drift gillnet at 24°58'N, 60°29'E in coastal waters of the Iranian Gulf of Oman, 20 nm from Chabahar seaport, at the east side of Iran's Sistan and Baluchestan Province. The animal, which was released from the net, was an adult male considering the presence of numerous tooth rakes, especially on the anterior body, and erupted teeth apically (Figure 5). A combination of characteristics observable in the video (see *Case 7* in the Supplementary Material) suggests the animal as either an *I. pacificus* or a Cuvier's Beaked Whale *Ziphius cavirostris*. Morphology includes a tall, erect, and falcate bottlenose dolphin-like dorsal fin (Figure 5b) (in contrast with the typical mesoplodont "low, triangular" dorsal fin), large body size (cf. to the rescuers in the water, a guesstimate is about 580-600 cm), an overall brownish-grey colour of the dorsal field and anterior flanks with extensive linear scarring, and lighter coloured head. However, the darker area of the head behind the melon is not very pronounced and is not located immediately behind the blowhole as often depicted for *I. pacificus* (see Best, 2007). The rostrum ('beak') is moderately long and well-defined, and the head is somewhat bulbous, but not at all pronounced (Figure 5d). Two smallish, erupted teeth at the apex of the mandibula are visible as glistening white spots in several video frames (Fig.5 A).

Discussion

Longman's Beaked Whale. *Case 1* represents the first documented record of *I. pacificus* in Pakistan's offshore waters. *Cases 5* and, especially, *7* may represent potential records; however, overlapping external features and poor video resolution prevent a conclusive identification, leaving the possibility of *Mesoplodon* sp. and an adult male *Ziphius cavirostris* undetermined. *Indopacetus pacificus* has not been reported from the Persian Gulf, as expected, due to its mostly shallow waters and has neither been encountered in Iranian, Omani or UAE waters of the Gulf of Oman (Baldwin et al., 1999; Braulik et al., 2010). Furthermore, the species has no mention in preliminary catalogs of

marine mammal species of Pakistan and neither was found during recent boat and beach surveys carried out in Pakistan from 2005 to 2008 (Pilleri & Gühr, 1972; Gore et al., 2012; Kiani, 2014; Iqbal, 2014). Fisher community interviews conducted during the same period neither resulted in any evidence of *I. pacificus* in the Pakistani EEZ waters (Gore et al., 2012; Kiani, 2014). Moreover, considering the earlier stranding at Veraval, Gujarat coast of India (Kaladharan et al., 2014), the Case 1 of this study, in Pakistan, is the second for the northern Arabian Sea, which until recently was considered merely 'possible range' (Pitman, 2018a). Other records of *I. pacificus* from the Arabian Sea and adjoining water bodies include a skull from Danane, Somalia (Azzaroli, 1968), one sighting in the Gulf of Aden, off Socotra Island, Yemen (Mörzer Bruyns, 1971) and in the southern Bay of Bengal, India (Afsal et al., 2009), five records from Sri Lanka, of which three were 'probable' according to Pitman (2018a), reported as by-catch (Dayaratne & Joseph, 1993; and see below), and two as live sightings (Anderson et al., 2006). Finally, 15 records from the Maldives included one stranding and 14 sightings (Anderson et al., 2006). The Gujarat coast specimen (Kaladharan et al., 2014) represented the only previous case of this species from the Arabian Sea *sensu stricto*.

Three incidental captures of small beaked whales were reported from Sri Lanka in 1991–1992, initially identified as Southern Bottlenose Whales (*Hyperoodon planifrons*), with body lengths ranging from 270 to 330 cm (Dayaratne & Joseph, 1993). However, this identification is incongruous, as Southern Bottlenose Whales are much larger, reaching up to 780 cm, are adapted to cold waters, and have not been confirmed in (sub)tropical waters (Best, 2007). Dozens of reported cases of "tropical bottlenose whales" have since been re-assigned, almost by default, to *I. pacificus* (Pitman et al., 1999; Dalebout et al., 2003; Best, 2007). However, in some instances, convincing morphological evidence was lacking, and excluding other possible ziphiids, particularly *Mesoplodon* sp., may have been premature. Calves of *I. pacificus* may be just under 3 m at birth, with the smallest known live neonate measuring 291 cm (Best, 2007). If indeed *I. pacificus*, then all three Sri Lanka specimens had to be neonates or small calves, the likelihood of which seems remote. By-catches of this age cohort are extremely scarce in the global ziphiid record. For instance, none are registered for *M. peruvianus*, the most frequently net-entangled mesoplodont (Reyes & Van Waerebeek, 2018). We conclude that these Sri Lankan specimens cannot be positively identified; however, Anderson et al. (2006) and Pitman (2018a) described them as 'probable' Longman's Beaked Whales.

Finally, regarding the potential Longman's Beaked Whale from Iranian waters (Case 7), the darker area of the head behind the melon is not very prominent and is not located immediately behind the blowhole. In addition, while the melon is bulbous, it is not pronounced, as also seen in Case 1. These characteristics differ somewhat from the 'typical' adult *Indopacetus* (Dalebout et al., 2004) and inspired the alternate identification hypothesis of *Z. cavirostris* with heavy tooth rake scarring on the forebody. However, Anderson et al. (2006) reported that some Longman's Beaked Whales may have specific characteristics like these. Beaked whales of the Northwestern Indian Ocean are poorly studied, and some geographic variation is to be expected. Perspective distortion may also play a role in obscuring the head bulbosity, as frontal views of the heads are lacking.

Mesoplodont beaked whales. The mesoplodonts described in this study (Cases 2, 4, 6, and probably 5) are the first *Mesoplodon* sp. records for Pakistan's and Iran's EEZ waters. No earlier authenticated records exist in the study area (Pilleri & Gühr, 1972; Baldwin et al., 1999; Braulik et al., 2010; Gore et al., 2012; Kiani et al., 2013). Unfortunately, the photographic evidence is insufficient to allow species level identifications. In Case 5, because the identification is based on a small calf, even *I. pacificus* cannot

confidently be discarded. External features of Case 6, especially erupted (sub)apical teeth, dorsal fin and melon morphology, as well as a mid-sized body, are consistent with *Mesoplodon eueu*, but the lack of a whitish tailstock and its capture location are not. For Cases 2, 4, 5, other middle-sized mesoplodonts distributed in the tropical parts of the Indian Ocean, i.e. *M. ginkgodens* and *M. hotaula* (Dalebout et al., 2014; Pitman, 2018b) need to be considered. The apparent absence of erupted tusks and of a strongly arched mandible line, plus the lack of noticeable tooth rakes in Cases 2, 4, and 5 strongly suggest none of these were adult males.

Pelagic gillnet fisheries in Northwestern Indian Ocean: conservation implications.

Major anthropogenic threats to beaked whales include underwater noise related to seismic surveying and military activities, plastic debris, and directed takes of some of the larger species (Cox et al., 2006; Yang et al., 2008; Kaladharan et al., 2014; Pitman, 2018b). Gillnet entanglements have not been thought to rank among the top threats to ziphiids in general, with the notable exception of *M. peruvianus* (Reyes & Van Waerebeek, 2018). However, Carretta et al. (2012) also reported interactions with mesoplodonts in the California large mesh drift gillnet fishery. Other ziphiids that suffer a certain level of by-catch in gillnets globally include Cuvier's Beaked Whale, Baird's Beaked Whale *Berardius bairdii* and Ginkgo-toothed Beaked Whale (Reeves et al., 2002). Pitman (2018b) called by-catch in high-seas fishing gear an important threat for *Mesoplodon* spp.

Concerns were raised previously about beaked whale entanglements in gillnet fisheries in the Arabian Sea and contiguous waters based on the above-mentioned incidents off Sri Lanka (Dayaratne & Joseph, 1993; Anderson et al., 2006). Our seven cases support these insights and add Longman's Beaked Whale to the danger list. While Pitman and Brownell (2020) mentioned longline and gillnet fisheries through Longman's Beaked Whale range may raise concern of some by-catch, this specific threat has never been documented for the species before this study. Indeed, drift gillnets deployed in pelagic waters of the Northwestern Indian Ocean are an apparent threat to beaked whales (Anderson et al., 2006; Pitman, 2018b; this paper), considering that true levels of mortality and severe injuries are unknown.

Iran, representing 38% of the total Indian Ocean gillnet tuna catch, is known as the second largest tuna producer (after Indonesia) in the entire Indian Ocean and the largest one in the Northwestern Indian Ocean (FAO, 2023). The fleet consists of small boats with a capacity of less than three gross tonnage (GT), comprising over 70% of gillnetters, and artisanal dhows with a capacity ranging from 3 to over 100 GT. For instance, in 2020, the total production of gillnet catch was 264,414 metric tons (mt), with the main caught tuna species including *Thunnus tonggol*, *Katsuwonus pelamis*, *Thunnus albacares*, *Euthynnus affinis*, and *Scomberomorus commerson*. Gillnet fisheries are an important threat to cetaceans in Iranian waters (Braulik et al., 2010; Anderson et al., 2020), with an estimated mean annual by-catch of over 30,000 individuals (Anderson et al., 2020). No national monitoring of cetacean by-catch has been developed.

In Pakistan, tuna fishery is equally important, contributing about 40,000 mt annually. Fishing starts in mid-August and peaks in March-April while no fishing is carried out in June and July due to the peaking of the southwest monsoon (Nawaz & Moazzam, 2014). The Pakistan tuna gillnet fleet consists of about 700 locally manufactured wooden boats. The boats operating in the east, from Karachi, Sindh coast, are usually large, 15–20 m in length, and fully equipped, as compared to smaller boats, some 10–15 m, in Balochistan at the western Pakistani coast (Moazzam & Nawaz, 2014). The lengths of multifilament gillnets vary from 2.4–12 km in neritic waters and up to 6.0–12.6 km in offshore waters. The depth of the nets is uniform i.e. 14 m. Only five species of tuna are

caught in commercial quantities, including *Thunnus albacares*, *Thunnus tonggol*, *Katsuwonus pelamis*, *Euthynnus affinis* and *Auxis thazard* (Moazzam & Nawaz, 2014).

Drift gillnets are considered the most harmful fishing gear for cetaceans in Pakistan (Niazi, 1990; Moazzam & Nawaz, 2014), as elsewhere (e.g., Jefferson & Curry, 1994; Perrin et al., 1994; Mangel et al., 2010; Anderson et al., 2020). A voluntary monitoring program was started in 2012, through which four observers were posted on tuna gillnetters operating in Pakistani waters (Nawaz & Moazzam, 2014; Moazzam & Nawaz, 2014). It provided insights into the extent of mortality of cetaceans and other large marine vertebrates. An estimated 12,000 cetaceans, mainly dolphins and occasionally large whales, are killed annually off Pakistan (Nawaz & Moazzam, 2014). Other affected species included *Sousa plumbea*, *Tursiops* spp., *Stenella longirostris*, *Stenella attenuata*, *Grampus griseus*, *Balaenoptera brydei/edeni* and *Megaptera novaeangliae* (Moazzam & Nawaz, 2014). All entangled cetaceans were found dead in the nets except on a few occasions when the captured animals were rescued by fishers. Compared to delphinids, beaked whales have the advantage of withstanding longer periods of forced apnea following entanglement, considering their normal prolonged deep diving (Pitman, 1999), allowing fishermen a window of opportunity to liberate the animals in time before asphyxiation occurs.

No evidence of utilization of dead cetaceans as bait or food is available from Pakistan. To date, no beaked whales have been reported dead by tuna fisheries observers rather all of the known entangled beaked whales have been successfully released. However, this may be different on tuna gillnetters having no trained observers on board. Generally, the chances of use of dead cetaceans as bait are remote considering the fact that long-lining still does not constitute a considerable proportion of tuna fisheries in Pakistan (Moazzam Khan, pers. obs.). However, in some locations cetaceans were targeted specifically as bait for artisanal shark long-lining (Gore et al., 2012; Kiani, 2014). Currently, the shark long-lining is no more viable in Pakistan due to the sharp decline in shark populations (Khan, 2011, Hornby et al., 2014). Occasional opportunistic use for other purposes, e.g. oil extraction for smearing the boats and extraction of 'ambergris' from sperm whales is known for beached specimens of any mortality cause (Kiani, 2014). Regionally, dolphin blubber has at least occasionally been used as bait in shark longline hooks, for example off Oman (K. Van Waerebeek, pers. obs.).

The by-catch of *I. pacificus* off Pakistan, and possibly Iran, document the first documented successful rescue and release of Longman's Beaked Whale entangled in fishing gear anywhere in the world. The location in Pakistan's EEZ (Figure 1) is oceanic and in the relative vicinity (*ca.* 90 km) of the 'Swatch' or Indus undersea Canyon (Kolla & Coumes, 1985), which along with its surrounding deep waters are not only known as a very important fishing ground for tuna and other large pelagic fishes, but also as an important habitat for deep water fish species, cetaceans, and other large marine vertebrates (e.g., Ahmed, 1985; Mikhalev, 1997; Kiani et al., 2013). The location off Iran is also a biodiverse and important fishing ground, mainly because of Arabian Sea upwelling currents (Ershadifar et al., 2023).

The overlapping distribution of beaked whales with commercial tuna fishing grounds off Pakistan and Iran is a matter of concern. In order to obtain more robust data to devise a mechanism of preventing or mitigating conflict with fisheries, trained fisheries observers of Marine Fisheries Department of Pakistan or provincial fisheries departments should be placed onboard tuna gillnet vessels. Also, a substantial increase in spatial and temporal coverage is necessary, as suggested by the National Plan of Action for Conservation of Marine Cetaceans of Pakistan (Gore, 2008). Similar actions, especially developing training programs, are also greatly needed in Iran.

Fishers allege that one of the factors that may cause entanglements of toothed cetaceans in tuna drift gillnets is their tendency to depredate targeted catch. However, no beaked whales are known to feed on tuna or other large fishes (Pitman, 2018a, 2018b), but may share with tuna prey species such as mesopelagic squid or small schooling fishes, which could explain the apparent association. These accumulating ziphiid by-catch incidents are a new cetacean conservation challenge for both Pakistan and Iran.

While the successful rescue/release actions by fishers are a welcome sign for cetacean conservation and welfare in Pakistan and Iran, they also highlight the need for greater awareness among fisher communities about an efficient methodology to safely release entangled cetaceans. The iconic crew-based observer program run by WWF-Pakistan from 2012 to 2019 engaged over 100 (>10% of the fleet) observers at its peak. Unfortunately, regular observer efforts on tuna vessels are not implemented. A preliminary study in Pakistan indicated that a slight adjustment in the gillnetting operation, i.e. setting the net ~2 m subsurface reduced the incidental entanglements of delphinids without causing any major loss in fish catch (Kiszka et al., 2021). However, it is unlikely to help ziphiids, which spend little time at the surface. Dedicated surveys for cetacean abundance are needed before the impact of by-catch can be assessed in the region. Expanding large-scale awareness programs that enable fisheries managers and fishermen to collaborate in evaluating and, if necessary, adjusting current fishing techniques and gear could significantly reduce bycatch impacts on rare ziphiids and other cetaceans in the Northwestern Indian Ocean.

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