

Chapter 3

Marine mammal interactions in fishing systems and their mitigation

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Introduction

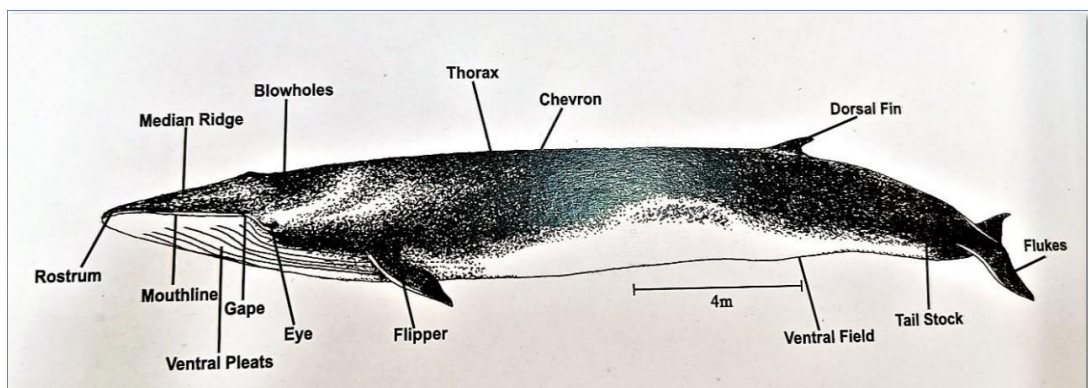
The ocean covers 70% of the earth's surface and is the largest living space that accommodates varieties of flora and fauna. Marine biodiversity is very complex and special. It ranges from single-celled or microscopic communities to the gigantic blue whale. The known species diversity in the ocean is less than 13% of all living species currently described. The oceanic environment plays a direct and indirect role in human life by regulating the earth's system, providing social and economic goods and services, supply of living and non-living resources, etc. Fisheries is one of the major resources which play an important role in ocean biodiversity, growth, and development of many countries and also ensure the food security of millions of coastal communities (Srinivasan et al., 2010; FAO, 2011). Unlike other natural resources, they are renewable (capable of growth) if managed properly. Due to several factors, fishery resources are difficult to manage effectively (Munro and Scott, 1985). There are several issues associated with the management of fishery resources, which include over-exploitation of targeted and non-targeted species, ecosystem degradation, ghost fishing, pollution, as well as the carbon footprint of the fishing operations (Ardill and Gillett 2011). The interaction of marine megafauna with fisheries is one of the recent critical issues addressed by fishery managers and marine biologists around the globe. The incidence of protected marine species in the Indian gillnet fishery is estimated as 0-3 number per operation (Koya et al., 2018). Fisheries is the major reason for the non-natural mortality of large marine vertebrates such as marine mammals, turtles, sharks, rays, skates, etc. among these, marine mammals are the charismatic animals that exert a major influence on the marine food web, structure, and function of the marine ecosystem. Many marine mammals are categorized as protected species. In a complex fishery with varieties of vessel gear combinations, the chances of mammal interaction with the fishery are very high. The balance between the conservation of vulnerable species and the responsible utilization of fishery resources is a challenging topic. Which need to be taken care rightly with proper management measures.

Biological features of marine mammals

Mammals are highly developed animal groups that stand on the apex of the animal kingdom. They have a diverse distribution with suitable adaptation to living in the respective geographical realms. Mammals who live in the aquatic environment are Morphologically and anatomically adapted for life in water. Hydrodynamic body, modified appendages for reducing drag and maximizing propulsion, efficient respiratory system with high oxygen retention, better thermoregulatory mechanisms, specialized sensory and communication mechanism etc. Making them unique from other groups of mammals. ‘Marine mammal’ is a general term to address the members of 5 different groups Viz Cetaceans, sirenians, pinnipeds, sea otters, and polar bears. A common feature for all marine mammals is that they spent their entire life in the ocean or nearby related ecosystems and derive all of their food from aquatic habitats (Jefferson et al 1993).

Table: 1 Classification of Marine mammals

Kingdom: Animalia	
Phylum: Chordata	
Class: Mammalia	
Order: Cetacea	Whales, Dolphins and porpoises
Order: Sirenia	Dugongs and Manatees
Order: Carnivora	Pinnipids (Seals, Sea lions and walrus) and other marine carnivore (Polar bear, Otters)



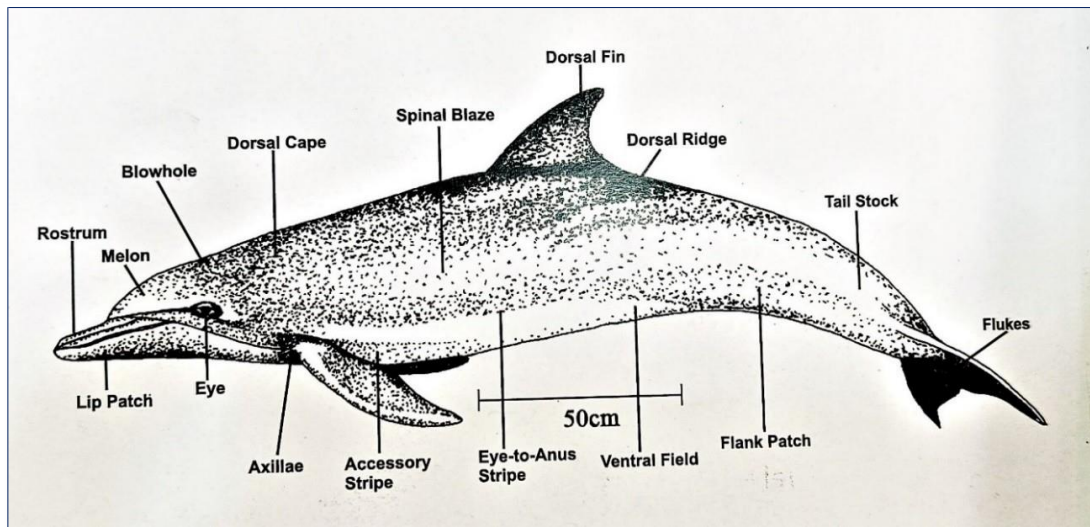


Fig: 1 Morphological features of a typical cetaceans (Vivekanandan and Jeyabaskaran, 2012)


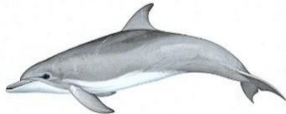


Marine mammals of India

Worldwide 130 species of marine mammals are identified from various oceanic regions viz. tropical, subtropical, temperate, and polar regions (Jefferson et al 2008). Indian seas accommodate varieties of marine mammals belonging to two orders, cetaceans and sirenians. Which includes baleen whales, toothed whales, dolphins porpoises, and dugongs. (Vivekanandan and Jeyabaskaran,2012). Out of 130 species reported worldwide, 25 species of cetaceans are reported from Indian waters of which five are Mysticeti (Baleen whales) and the rest are Odontoceti, which includes Delphinidae, Physteridae, Kogiidae, Ziphiidae, Phocoenidae and Platanistidae (Kumaran, 2002). Only one species of sirenian (Dugong dugon) is reported. All the marine mammals of India are protected by law and positioned under Wildlife (Protection) Act, 1972. Out of which three species Gangetic dolphin (*Platanista gangetica*), Irrawaddy dolphin (*Orcaella brevirostris*), and dugong (*Dugong dugon*) are protected under Schedule I, and the rest are placed under Schedule II. As per the act, Schedule I and Part II of the Schedule provide absolute protection. Capture, use, and trade of animals under this schedule prescribed the highest penalties. India is the first country in the world to have cetacean fauna as a National aquatic animal. Gangetic dolphin *Platanista gangetica gangetica* is declared as the National Aquatic Animal by the Prime minister of India in the First Meeting of the National Ganga River Basin Authority (NGRBA) on the 5th of October 2009.

Interaction of marine mammals with fishing systems

Cetaceans coming under the family Dephinidae shows more interaction with coastal fisheries in India. Dolphins are members of this family. Active movement, overlapping with the feeding and activity zones of other commercially targeted nektonic groups are some of the reasons for this higher interaction. While analyzing the depth-wise and zone-wise distribution of marine mammals in India, there are several species with active distribution in the coastal fishing zones. Four species of dolphins viz *Stenella longirostris* (Spinner dolphin) *Tursiops aduncus* (The Indo-Pacific bottlenose dolphin), *Delphinus capensis* (The long-beaked common dolphin) *Sousa chinensis* (The Indo-Pacific humpback dolphin) are the four major dolphin species abundant in the coastal waters (Jayapraksh et al., 1995). (Table: 2).

Table: 2: Major dolphin species with higher interaction with fishing systems

Species	
	<i>Stenella longirostris</i>
	<i>Tursiops aduncus</i>
	<i>Delphinus capensis</i>
	<i>Sousa chinensis</i> -

The mammal-fishery interactions are of several kinds viz. biological/ ecological and direct/operational interactions (Wickens, 1994). In mammal-fishery interaction, most of the interactions are reported as predatory type. Fish is one of the most important diets of marine mammals and many are competing with fishermen for the catch. Some of the dolphins forage exclusively on fish (Barros & Wells, 1998, Panicker and Sutaria, Sule et al 2015).

Major pelagic fishing systems with marine mammal interaction

Indian fisheries are multispecies-multi gear in nature and characterized by a heterogeneous fishery management system (Najmudeen and Sathiadhas, 2008). Fishing is carried out with more than 20 gear and vessel combinations. Out of the various gear operated, gillnets and seine nets are more vulnerable to marine mammal interaction (Cockcroft & Krohn, 1994; Perrin et al., 1994; Archer et al., 2001; Wise et al., 2001; Read et al., 2006, Joseph et al., 2021).

Gillnets have either a single shot/unit of the net or a number of units tied end to end to form a full fleet of length ranging from 600 to 16500 m with a hung depth of 3 to 20 m. Based on mesh size, Indian gillnets are classified into small meshed nets with 14 to 45 mm mesh size and large meshed nets with 45 to 500 mm mesh size which target varieties of species viz. sardine, mackerel, anchovy, seer fish, shark, tuna, pomfret, hilsa, barracuda, billfish, carangid, perch, elasmobranch. etc. Fishing is normally conducted at a depth of 20-1000 m. The study by ICAR-Central Institute of Fisheries Technology, Cochin from 20 major fishing harbors along the Indian coast reports, coastal gillnets are more prone to cetacean interaction. As gill nets are stretched wall of the net with very low visibility in the water, the net will obstruct the movement of animals that comes in the range of operation and lead to entanglement. Depredation may another reason for the interaction. There are many reports that marine mammals feed on fish caught by fishing gear (Gonener and Ozdemir, 2012). While examining the inshore and offshore gill net bycatch composition, finless porpoise, humpback dolphin, and Indo-Pacific bottlenose dolphins are caught in the coastal gillnet targeting tuna and seer fishes. Whereas spinner dolphins, Risso's dolphin, and dwarf sperm whales are the species reported from the offshore drift gillnet (Anderson et al. 2020, Yousuf et al. 2009)

Marine mammal interaction in gillnets

Almost 84% of the global cetacean bycatch is reported from gill net fishery (Read et al., 2006). Most of the fishery-mammal interactions are reported during the late 1980s (Northridge, 1984). Due to increase in incidental catch of protected species in gill nets, the operation of gillnets in the high seas is banned by many countries by laws (He, 2006). In India, technological advancement and modernization in the gillnet sector resulted in an increase in the quantum of gillnets taken for operation even in distant and oceanic waters (Thomas, 2019). These escalations in the size of the gillnets increased the chances of marine mammal encounters. The modernization also resulted in the shifting of area operation of gillnets from coastal waters to deep sea so there has

been a change in the species composition of cetacean bycatch in drift gillnets also (Anderson, 2014). Almost three decades of observation from Indian waters report 98.8 % of mammal mortality reported were due to entanglement in gillnets (Jeyabaskaran et al. 2016). Among the major fishing systems operated along the Indian coast, cetacean interaction is reported maximum from gillnets (57.7%), particularly in the small meshed gillnets operated in the coastal waters. Joseph et al. (2021). In India finless porpoise, humpback dolphin, and Indo-Pacific bottlenose dolphins must have been caught in tuna/seer gillnets operated in inshore waters while spinner dolphins, Risso's dolphin, and dwarf sperm whales among other species dominated the offshore drift gillnet bycatch (Anderson et al. 2020, Yousuf et al. 2009). The annual cetacean mortality caused by the Indian gillnet fishery is estimated in the range of 1000-10,000/year (Lal Mohan. 1994, Yousuf et al. 2009, Kumaran, 2002) and most of the mortalities are associated with the pelagic fishery of yellowfin tuna (*Thunnus albacares*), sharks, and seerfish (*Scomberomorus commerson* and *S. guttatus*).

Marine mammal interaction in seine nets

In India, after gillnets, seine nets are most prone to marine mammal interaction (Joseph et al, 2021). Unlike gillnet fishery, seine fishery in India is highly regional and restricted to the southern coast. Surrounding nets are mainly employed to catch the shoaling pelagic fishes like sardines, mackerel, tuna, etc. Purse seines and Ring seines (mini purse seines) are the two major seine nets in India. Ring seines, otherwise known as mini-purse seines, are a group of lightly constructed seines adapted for operation in the traditional motorized sector. The total length of a seine net ranges from 600-1000 m with a depth of 83-100 m and its operation is confined to a depth of less than 75 m. The operation of a seine net consists of all the aspects of hunting, scouting the fish, chasing, and interception of the fish school, etc. cetaceans are the major bycatch reported in seine fisheries, especially the members belonging to the family Delphinidae (dolphins) are more vulnerable to fishery interaction.

The dolphin species which has more access to coastal waters showed more interaction with fishing systems. 84.8% of the interaction with fishing systems was exhibited by four species *Stenella longirostris*, *Tursiops aduncus*, *Delphinus capensis*, and *Sousa chinensis*, which are abundant in the coastal waters (Table.2). (Joseph et al. 2021, Raphael et al., 2017; Edwin et al., 2017; Koya et al., 2018). Larger herd size, active swimming behavior, and sharing of common ecological niche with the fishes which are targeted by seine fishing makes dolphins more

susceptible to capture and entanglement in the fishing nets. There are reports of targeted capture and landing of dolphins from seine nets in India (Jayaprakash et al. 1995, Yousaf et al., 2009). In 1984, almost 42 common dolphins, *Delphinus delphis* were landed in Kochi by 12.5m purse seiner and animals were sold to the local market for 27.5 INR/specimen. Similarly, in 1995 and 2009, finless porpoise, *Neophocaena phocaenoides* were landed by purse seines from off the Mangalore coast of Karnataka and the Gulf of manner region. Dolphin fishery interaction in India is mainly associated with small pelagic fishery (especially oil sardines) in near-shore shallow waters (Yousaf et al., 2009). The majority of the cetaceans-seine net interactions were reported from the states like Kerala, Karnataka, and Goa where the higher landing of small pelagic are reported. (Prathibha et al., 2018, Yohannan and M. Sivadas, 2003, Joseph et al.2021, Yousaf et al., 2009, Edwin et al.2017, Raphael et al., 2017, Prajith et al 2014).

Depredation is another reason for the mammal-seine net interaction. Cetaceans especially dolphins considered fishing nets as an easily accessible and available source of food. when the catch concentrates on the bund area of the net, dolphins approach the net and remove the catch by biting and tearing off the net. Removal or damage of the harvested catch in commercial or recreational fishing by predators which leads to the damage of the fishing gear is referred to as depredation. Depredation directly causes economic loss by damaging fishing gear. The indirect loss is by reducing the quality of the catch.

Mitigation

The mitigation measures to minimize the marine mammal fishery of active and passive types. Making alterations in the structural features, increasing the visibility of fishing gear by means of using thick twines, incorporating add-on reflectors, and colouring the netting panels are the major passive methods. Whereas mechanical sound generation using crackers, explosives, gunshots, etc. are come under the active type (Jeffersons and Curry, 1996). Indian fishermen follow both active and passive mitigation measures to deter marine mammals from the fishing operation and to safeguard their catch and gear. which can be further classified as indigenous and modern methods. The major indigenous mitigation strategies adopted by the Indian fishermen to minimize cetacean bycatch/interaction are the selection of suitable grounds, structural modifications in the gear, sound generation using crackers, vessel chasses, use of boat noises making a loud noise, throwing bait to distract the mammals and jumping into the water to scare them. While practicing these indigenous methods, fishers are cautious to avoid injury to

the animals. They even patrol the fishing ground with small boats and alter the attention of mammals with the help of objects like tyres, boat anchors, stones covered in plastic bags, etc. The major modern mitigation methods are the use of acoustic deterrent devices like pingers. Besides this several government agencies and research institutes of the country are engaged in various outreach programs to create awareness among fishers about the protected marine species and their importance in the ecosystems.

Dolphin wall nets (DWN)

Dolphin wall nets are the indigenously fabricated wall of nets that creates a barrier between the seine net and the dolphins during fishing operations. The net is 1000-1500m long with plastic cans as float and large steel rings as sinkers. The DWN is an innovation from the side of local fishers of Kerala, the Southernmost state of India which reduce the operational damages and results in catch loss during fishing. besides this, unknowingly the net ensures the protection of mammals from incidental catch and mortality (Prajith et al. 2014)

Medina panels

This is a panel of relatively small mesh netting (50 mm or less) sewn into the purse seine at the distance of about 1/3 of the float line length from the bunt-end tip, to surround the apex of the backdown area where porpoises are most likely to come in contact with the net. Usually, it is one or two strips deep and 330 m long. The longer the Medina panel the more effective it is, specially fitted into the net throughout the bunches area and as near the bunt as practical. The system is named after the Californian skipper who first used it. (FAO 2022)

Pingers

Sound has a significant role in the lives of marine mammals and sound is the prime mode of information transformation used for communication. As an adaptation to living in a vast aquatic environment, the acoustic system of marine mammals is well developed. Understanding this advantage of communication mechanisms using sound, the use of aquatic pingers is the most suitable and efficient mechanism to distract cetaceans from the fishing gears (Fig. 3). Pingers sometime referred to as net alarms are one of the best options to reduce injury and mortality in marine mammals. Dolphin pingers are devices that produce ultrasound which alert and keep the dolphins and porpoises away from the nets. Pinger is designed to work by emitting a sound wave signal beyond 70 kHz that is known to be in the best hearing range of most dolphin species. The signal acts as an alarm; in some cases, the pinger stimulates dolphins to use their

echolocation, which alerts them to the presence of the pingers and fishing nets. This sound wave is not audible to human beings, but it creates a disturbance to dolphins and alerts dolphins to the presence of nets. Pingers are efficient to minimize cetacean interaction both in gillnets and seine nets.



Fig:2 A typical banana pinger used in gill nets and seine nets

Conclusion

A global survey by the United Nations in 2005 reports that 70% of dolphin species are at risk due to various human activities. Removal of the apex predators like cetaceans by incidental or purposeful killing may lead to an imbalance in the ecosystem. Marine mammal fishery research in India is still in the infancy stage. Most of the studies are based on stranding events. Research to formulate suitable mechanisms to reduce or avoid mammal interaction with the fishing system is the need of the hour. Marine cetaceans' ecology, behavior, and biology need a better understanding. To reduce marine mammal incidental catch and kill, there should be a management system or consortia which comprises government agencies, academicians, researchers, and fishermen. Understanding the fishermen's perception is essential while formulating the research. A refinement in the existing indigenous mitigation measures by the application of a suitable scientific approach with the involvement of fishermen is needed. Besides this awareness about the importance of marine mammals and another megafauna should be created among fishers, the general public, school students, etc. through various outreach and extension programmes.

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