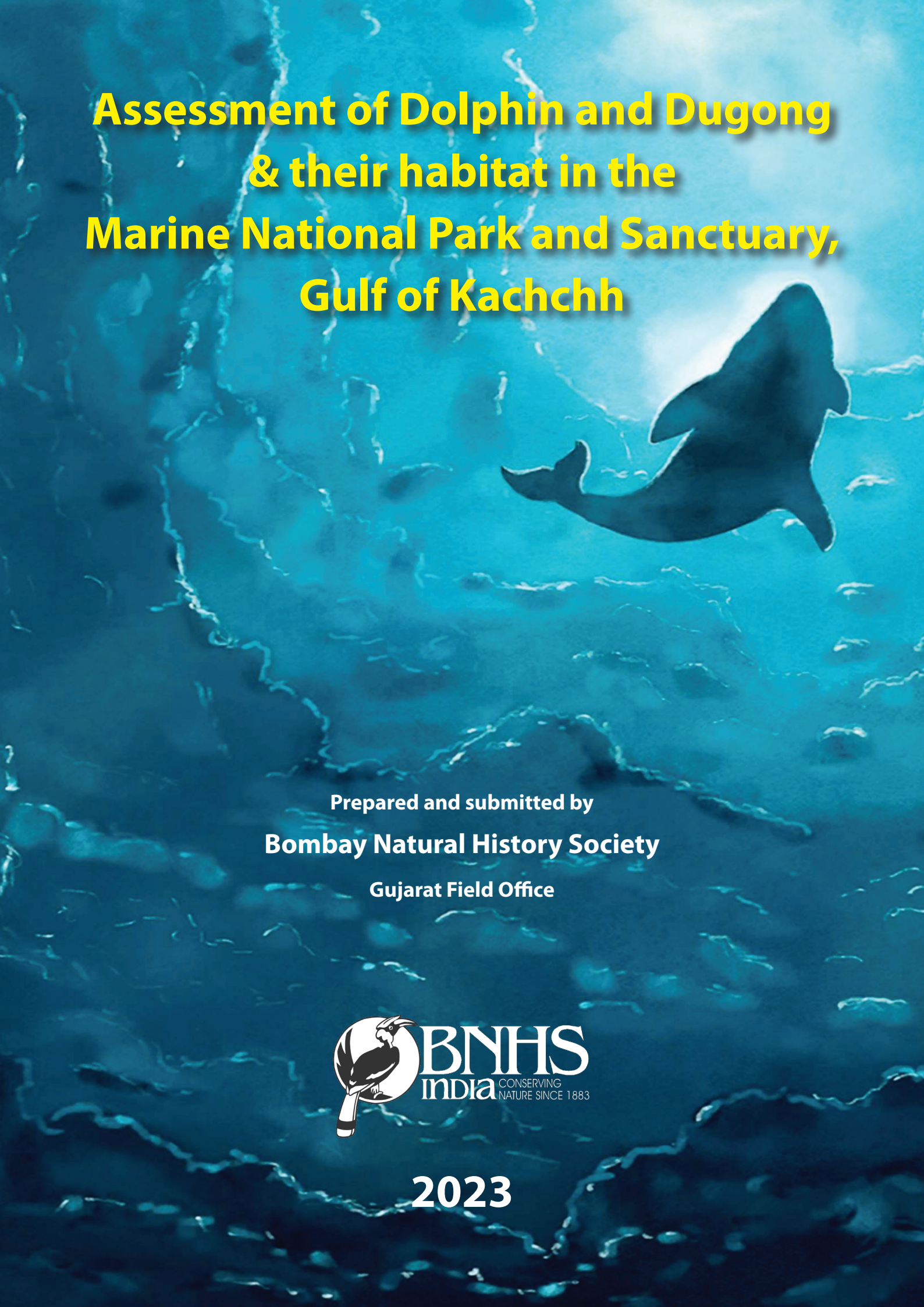
Assessment of Dolphin and Dugong & their habitat in the Marine National Park and Sanctuary, Gulf of Kachchh



Prepared and submitted by

Bombay Natural History Society

Gujarat Field Office

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Project Report On
Assessment of Dolphin and Dugong & their habitat in the Marine National Park and Sanctuary, Gulf of Kachchh

Project for:

Gujarat Forestry Research Foundation (GFRF)

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1. INTRODUCTION

1.1 Marine Mammals

Marine mammals rely on the ocean and other marine ecosystems for their existence. They include animals such as seals, whales, manatees, sea otters and polar bears. They are an informal group, unified only by their reliance on marine environmentsfor feeding and survival. Marine mammalogy is a diverse field that often involve the study of marine mammal's behavior, communication, evolution, physiology, ecology, and zoology. The study of marine mammals has been fascinating most of the marine scientistsfor majority two reasons. First and foremost is these animals play a very clear role in structuring marine ecosystems and secondly competitively less study had been done as majority of them found in open water. Marine mammals represent a variety of ecological roles, including herbivores (manatees), filter feeders (baleen whales), and top predators (killer whales). Mammals believe to evolved on land around 160 million years ago. Each taxonomic marine mammal group evolved from a different group of land mammals, whoseancestors separately ventured back into the ocean environment. Despite these different origins, many marine mammals evolved similar features —— streamlined bodies, paddle- like limbs and tails —— through convergent evolution. Monitoring, ecological researching and learning more about marine mammals provide an in-depth understanding into the whole marine ecosystem, especially open sea. Therefore, majority of scientists think certain marine mammals as a keystone species to estimate the health of the ecosystem as well as to ensure overall health of it, just like Tiger is considered in forest ecosystem. In the addition to this noteworthy role these mammals play in the marine ecosystem and their distribution throughout the world, the present study was undertaken to investigate population the status of marine mammals, especially Dugong, Delphine, and Porpoise, as well as the feeding ground status in the Marine National Park, Gulf of Kachchh. This study is also included study carbon sequestration capacity of Sea Grass. Because of Marine Mammals faces various threats like accidental capture in fishing gear, habitat destruction, poaching, pollution, harassment, ship strikes etc. it is now the need of the hour to carry out an in-depth evaluation on the current status of the marine mammals along our coasts with a strong emphasis on Environmental Protection and Wildlife Conservation in the State of Gujarat.

Many people are unaware that the word "marine mammal" is a catch-all term for mammals that have returned to life in the "sea." (Webber et al. 2015). The most significantneed is that they must obtain all or nearly all of their nutrition from the aquatic environment (Webber et al. 2015). Marine mammals are a diverse group of highly specialized animals,globally accounting for 129 to 134 species (Pompa et al., 2011; Jefferson et al., 2015; SMM Committee on Taxonomy, 2016). They include Cetacea (order-Cetartiodactyla) (dolphins, porpoises and whales), Sirenia (dugongs and manatees) and Carnivora (including Pinnipedia i.e. seals, sea lions and walruses, Family Mustelidae i.e. sea ottersand Family Ursidae i.e. polar bears) (Pompa et al., 2011; Jefferson et al., 1993; 2008; 2015). Several Scientists (Reynolds et al., 1999; Agnarsson and May-Collado, 2008) have observed that Cetaceans are closely related to artiodactyls, sirenians to elephants and to other subungulates, and marine carnivores presumably derived from ursid bear and mustelid ancestors. Their diversity and close relations with other mammals make these sea creatures an important and vital constituent of ocean life. Any alteration, change or threat to their habitat automatically leads to pressure and risk of their survival.

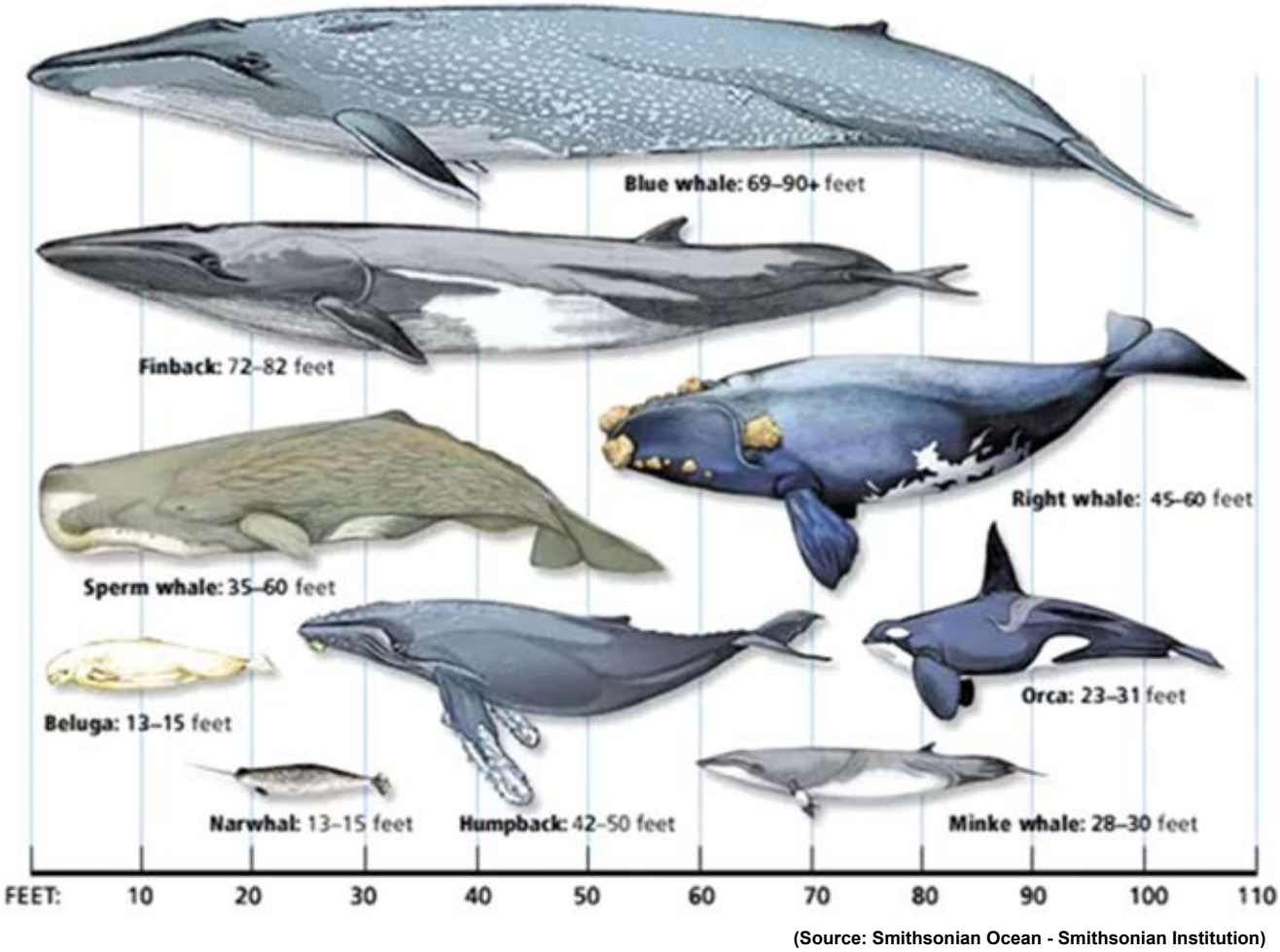
A). Adaptation

Marine mammals, to a certain degree share an ensemble of anatomical adaptations for aquatic life, which include a streamlined body, modification and reductionof appendages, for thermal insulation a thick layer of blubber and a multiple of physiological adaptations for diving, navigation, communication and osmoregulation. Cetaceans appear to be the most anatomically modified among the other groups of marine mammals. They have long, fusiform bodies and lack elevations or extensions suchas ears and external reproductive organs which would impede movement in a water body.The front limbs are modified into paddle-like flippers, and the hind

limbs are powerful tailflukes; they have a dorsal fin or a ridge; the nares have migrated to the top of the head, the skull is telescoped, and a thick layer of blubber among other adaptations (Reynolds et al., 1999). The hair is only present during fetal development. But all these adaptationsare species specific also which depends further on the type of life style of any particular species. For an example Semiaquatic group which consist of seals and sea lions spend the most of their time in the water, but must come to land for critical behaviors including mating, reproducing, and molting have strong fore limbs than Cetaceans and sirenians which are obligatory water dwellers since they are entirely aquatic. On the other hand, Otters and polar bears, though marine mammals, are not well adapted to life in water.

B.) Size

They also vary greatly in size, ranging from the small harbor porpoise i.e. *Phocoena phocoena*, (1.45–1.6 m) (Bjørge and Tolley, 2002) to the gigantic blue whale i.e. *Balenoptera musculus*, (26.8–33.6 m) (Sears, 2002). Concentration of Haemoglobinin blood is high in marine mammals. They also have specific pigment in their muscles called myoglobin which enables their muscles to store large quantities of oxygen.



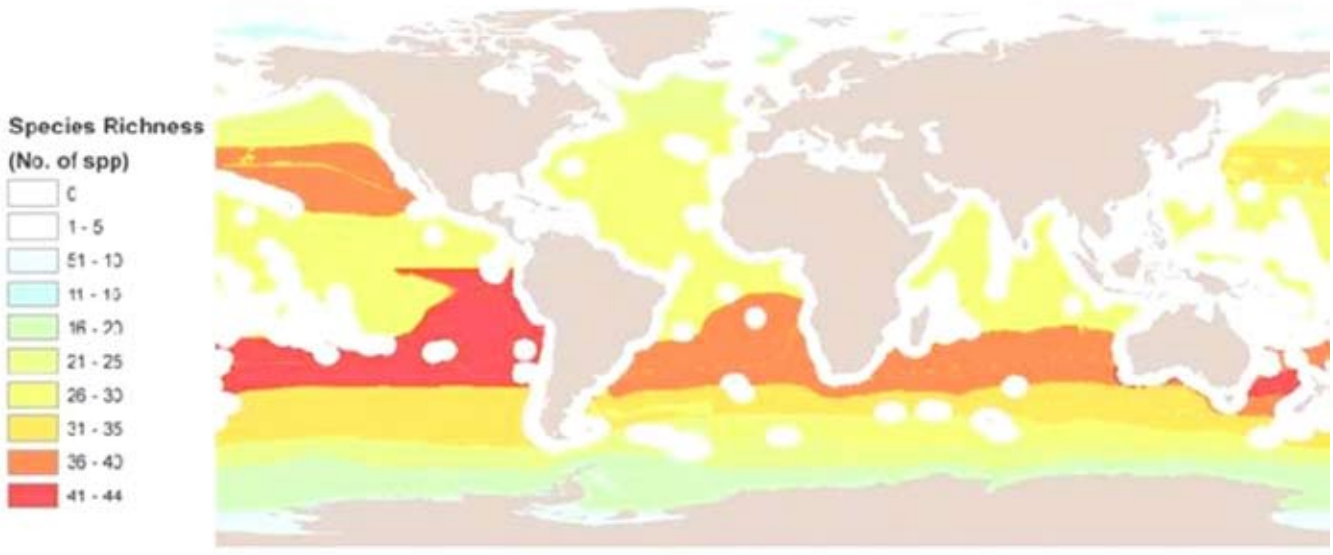
(Source: Smithsonian Ocean - Smithsonian Institution)

Image 1: Size of different species of marine mammals

C). Distribution

Marine mammals can be found throughout the world, though is not random but little is known about the specific variables that cause species to be found in one region and not in another that looks to be similar in quality. (Webber et al. 2015); but in general the highest concentration of marine mammals (40%) is found at or around 40° both north and south of the equator. These species inhabit a diverse range of habitats from brackish, mangrove and estuarine habitats, to coastal shallows and pelagic seas, with some even foraging at

the edge of the abyssal plain. Cetaceans are highly mobile animals with complex habitat requirements and are distributed unevenly across oceans ranging from temperate, tropical, subtropical and polar water of the deep ocean. Some habitats, such as tropical, subtropical and temperate, maintain extremely diverse cetacean species assemblages, whereas Polar Regions support a restricted range of species (Gaston, 2003; Mohan and Sojitra, 2018). Pattern of main ocean currents is one key factor determining food productivity, and thus indirectly impacting the distribution of marine animals. The "Coriolis Forte" modifies the impacts of prevailing winds, which drive these currents. (Webber et al. 2015). Simply put, main surface currents move clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere due to the earth's rotation. For species on the east and west borders of ocean basins, this has various ramifications. Warm tropical seas flow north along the east coastlines of continental land masses in the Northern Hemisphere, and warm-water species are frequently discovered unexpectedly far north. Cold arctic waters flow northward along the west coastlines of continents in the Southern Hemisphere, allowing cold-water marine mammals to wander closer to the equator (Webber et al. 2015). By upwelling (the vertical turning over of deep and surface waters) and in drift, the interaction of these surface currents and subsurface motions of significant water bodies distributes nutrients around (the bringing in of nutrients by horizontal currents). Because these nutrients and sunlight are the foundations of productivity, locations with a lot of mixing are often more productive than areas with little or no mixing (Webber et al. 2015). Wherever oceanic circumstances favor high nutrient content, marine mammals are likely to be present to take advantage of the abundance. As a result, the existence of marine mammals and other high-order predators and consumers in a given location is primarily determined by the availability of prey, followed by the water conditions that sustain that production. The movements of pagophylic (ice-loving) marine mammals are inextricably linked to the production and movement of sea ice (Webber et al. 2015). Depth is also a major factor on which distribution of Marine mammals are depends. Most cetaceans live in the open ocean. Certain species like the sperm whale may dive to depths of 1,000 to 2,500 feet in search of food (Whitehead, 2003). Sirenians live in shallow coastal waters, usually living 30 feet below sea level. However as mentioned by Marsh et al. (2002), they have been known to dive to depths up to 120 feet to forage deep-water seagrass.



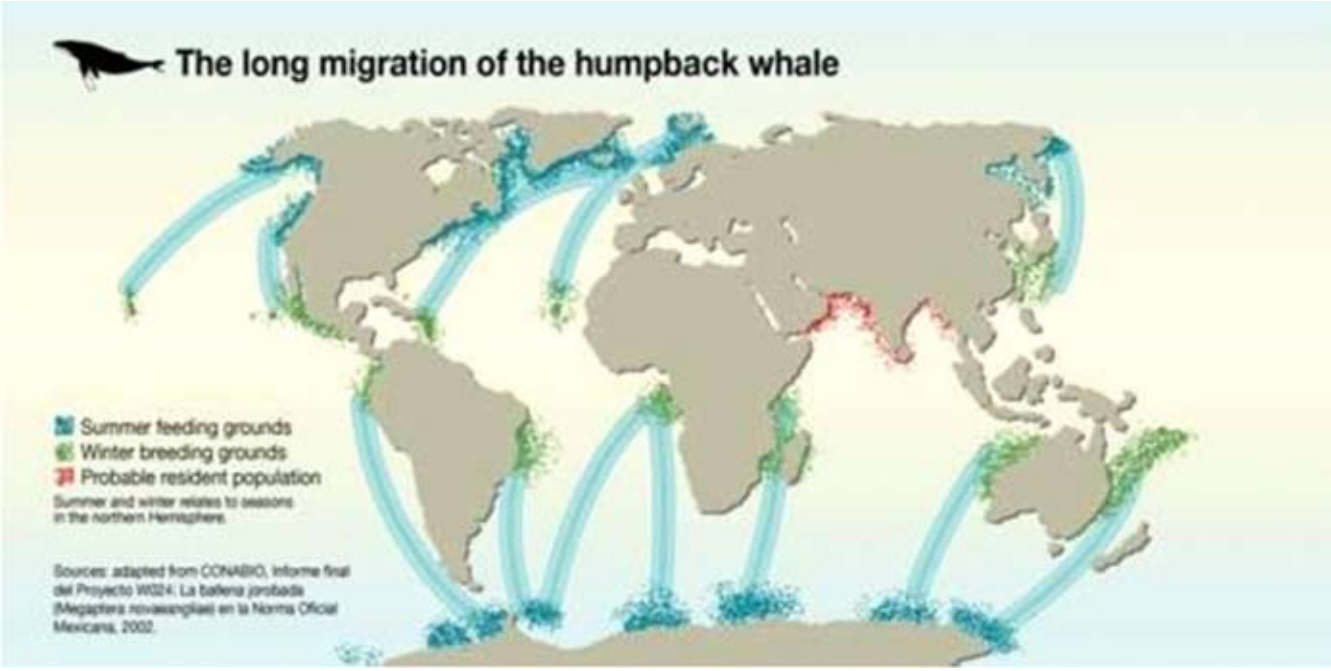
(Source: Cheung et al. 2005)

Image 2: Distribution of Marine Mammals in the World

D). Migration

Migration in marine mammals is common. Certain marine mammals migrate in relation to the changing temperature of waters or availability of food. Some migrate to escape or possibly to prevent predation by killer whales (Perrin et al., 2009). The gray whale has the longest recorded migration of any mammal, with one

traveling 14,000 miles(23,000 km) from the Sea of Okhotsk to the Baja Peninsula (Lee, 2015). During the winter, manatees living at the northern end of their range migrate to warmer waters (Deutsch et al., 2008). Dugong movements were observed more than 100km (Marsh et al., 2002).



(Source: Riccardo Pravettoni, GRID-Arendal)

Image 3: Migration map of marine mammals

E). Food and Feeding Ecology

Adaptation and distributions of marine mammals are also based on their food sources. Marine mammals require an abundant food supply and depend upon a diverserange of food items, such as seagrass, zooplankton, crustaceans, small invertebrates, fish, penguins and other marine mammals. Many cetaceans have fully adapted to livein almost all marine ecosystems and have evolved to exploit a wide variety of species as prey (Jefferson et al., 2015). Being top level predators, cetaceans have the potentialto be important indicators of marine diversity and give them significant role as indicatorsof marine ecosystem conservation state. In general, cetaceans are believed to have a major influence on marine food webs as well as the structure and function of some aquatic communities because of their large body size, high metabolic rates, and large numbers (Bowen, 1997; Croll et al., 1998). As a result of their diverse niches, they exhibita wide range of feeding behavior (Jefferson et al., 2015). As they have diverse adaptations, all groups of marine mammals have different feeding ecologies. Mysticetes (baleen whales), which are among the largest species feed on comparatively smaller feed like shoaling fishes and small invertebrates. They are batch feeders, taking in largeamounts of prey and filtering them from the waters with the fringes on the inside of theirbaleen plates. The gray whale employs yet a different feeding strategy and feed througha sucking mechanism (Perrin et al., 2009; Jefferson et al., 2015). The toothed whales feed at shallow depths prey on many pelagic fishes and squids. These cetaceans tend to have a high tooth count, pointed teeth and pointed snouts, all adaptations for pursuingfast, individual prey. Some cetaceans prey on large, solitary fishes and squid. These aremost often found in deep waters throughout the world's oceans. Some of the cetaceans(Killer whale, false killer whale and pilot whales) prey on at high trophic levels on predatory fishes (tunas, sharks, salmonids), marine birds, pinnipeds and cetaceans. (Pitman et al., 2007; Jefferson et al., 2015). The toothed whales, dolphins and porpoisesfeed mostly on fishes and squids, which are located and captured with the aid of echolocation or sonar. Polar bear and Sea otter are feeds on penguin, other sea mammals and shellfish respectively. The sirenians are all herbivores and therefore do not need to be particularly fast or maneuverable to catch prey. Manatees feed mostly on water hyacinths and other aquatic

plants that may be submergent or emergent. Dugongs are mostly seagrass specialists, uprooting whole plants when they are accessible, leaving long serpentine furrows depleted of seagrass in seagrass meadows.When the whole plant cannot be uprooted, dugongs feed only on the leaves. Dugongs forage for the rhizomes of some seagrass, presumably because seagrass rhizomes tendto have higher starch concentrations than seagrass leaves, which tend to be higher in nitrogen (Perrin et al., 2009).

F). Life span and reproduction.

Life spans of the marine mammals are varied. Several marine mammals i.e. the larger toothed whales, baleen whales, certain dolphins and the sirenians have been recorded to have very long life spans. However, several other species, like porpoises, have relatively shorter life spans, rarely reaching more than 20 years of age (Jefferson etal., 2015). Cetaceans and sirenians are the only groups of marine mammals that undertake all of their reproductive activities in the water. Newborns are also capable of swimming as soon as they exit the womb. Gestation period of major marine mammal species is around one year. Lactation period is highly different between only a few days in some seals to many years in some toothed whales. While seasonal breeding is the rulein all temperate and high-latitude species, some marine mammals that live in the tropics year-round have a protracted breeding period, with at least some births scattered throughout the year. In general, in most marine mammal's species twinning is considered rare, only a single newborn is born under normal circumstances. Generally, mammals having a post-reproductive period (or period of reproductive senescence) in females. It is observed in some of the longer-lived toothed cetaceans. Other species may reproduce until they die (Jefferson et al., 2015).

G). Behavior And Social Organization

The majority of cetacean species live in social groups, schools or herds but commonly called as pods. There are few species, like polar bear, which relatively solitary,and only gather together for breeding or in feeding aggregations. Living in the pods behavior is commonly display by whales, dolphins, seals etc. The size of pods, ie. Numberof individuals, are also varies from species to species. Large whales generally number less than a dozen or so, but oceanic dolphin may number several thousand. The stabilityof social groups are also depend on species and ranges from the very stable, long-term pods of killer whales to very ephemeral and short-lasting associations of many smaller dolphins and porpoises (Jefferson et al., 2015). The herbivore marine mammals like manatees and dugong generally live in relatively small groups which call herds and are in fact often seen alone. They do gather into feeding and breeding groups, but these aregenerally short-lasting. The only stable social bond is likely between mother and calf. Sirenians are generally relatively slow-moving, passive creatures (Jefferson et al., 2015).

H). Significance Of Marine Mammals

Marine mammals are fascinating animals and often referred to as keystone or umbrella species because of the change they can bring in to marine ecosystem. They areconsidered as keystone because their disappearance may lead to the loss of otherspecies (Paine, 1969;1995) and umbrella because conservation actions that mitigatethreats to them are expected to improve the protection of other organisms and theecosystem itself (Mann et al., 2000). Majority marine Mammals are top predators (feedingon other marine mammals, on fish, benthic invertebrates) that maintain a coordinatedbalance in the ocean ecosystem. In terms of survival and maintenance of the food chain,marine mammals play a large role in sustaining a healthy marine ecosystem. Theelimination of one species could significantly decrease the chances of survival for another species, especially among species that rely on their prey for survival. This leads to thedevelopment of new ecosystems and an increase in marine fauna density and diversity.Kanwisher and Ridgway (1983) speculated that some cetaceans may have an importantecological role in the recycling of nutrients by feeding at depth and then defecating in theeuphotic zone. Some marine mammals may play a role in the physical restructuring of

the benthos. Nerini (1984) estimated that gray whales turn over between 9 and 27% ofthe benthic substrate in the northern Bering Sea annually. This disturbance may help tomaintain early colonizing species at higher abundance than would otherwise be the caseand may be important in providing habitat for the young of their primary amphipod prey.

I). Exploitation and Threats

Marine mammals are used to be a significantly lucrative natural resource and the principal target as a good source of oil, fur and several other commercial products. Owingto their large size and relatively slow speed, in case of whales, they have been the focusof human exploitation. Large-scale hunting of North Atlantic right whale was so effective that they decimated that species in Basques, in the first millennium AD. Norse and Icelandic whalers also hunted in the North Atlantic and the Japanese began their cultureof whale hunting in the 1600s (Jefferson et al., 2015). Being the most abundant of all thelarge whales, Minke whales are still killed in thousands every year by countries such as Japan and Norway. More than 330,000 blue whales *Balaenoptera musculus* were slaughtered for meat, skin, oil, etc. from the Antarctic between 1904 and 1978 (Tonnessen and Johnsen, 1982). Due to increasing awareness in recent decades, threatsfrom the direct killing has become much less important but the threats from the indirect deaths of especially in the case of dolphins and porpoises have increased. It has been observed that more cetaceans die incidentally in fishing nets each year than from any other threat, including whale and dolphin hunting. In the last few decades there are new threats emerging because of development which leads to habitat degradation and loss, environmental contamination, noise pollution and damage and even live captures for captive display and research. Seismic survey noise and intense sounds created by military sonars have been cause serious problems like mass stranding of whales and dolphins (Jefferson et al., 2015). Sirenians seem to be hunted for their flesh and their relative ease of capture. All species of manatees and dugong have been threats to extinction in the next few decades. This is largely due to hunting for food. The fifth speciesof recent sirenian, the giant Steller's sea cow of the cold waters of the North Pacific and Bering Sea was wiped out by sealers and fur traders in the late 1700s, only a few decadesafter its discovery (Marsh et al., 2002). Apart from these predation, parasites, disease, oilspills, industrial pollution, agricultural runoff, climate change, capturing for entrainment purpose, increasing of tourism and change in feeding habit due to it, plastic and other marine debris, heavy metal contamination of food source especially of sea grass etc. arepounding on marine mammals and their survival in its natural habitat.

Photo 1: Dolphin faces increasing competition of resources with fishermen

J). Protection

In India all species of marine mammals are protected under the Wildlife (Protection) Act, 1972 (Rajagopalan and Menon, 2003). Generally, every country has their own protections act for protecting marine mammals and other species. The International Whaling Commission (IWC), United Nations Environmental Programme (UNEP), International Union for Conservation of Nature and Natural Resources (IUCN), etc. have played pioneer roles in protection, conservation and management of marine mammals in the world's oceans. NGOs and institutes like Whale and Dolphin Conservation Society, UK; Western Whale Research, Australia; Centre for Whale Research, Australia; The Wildlife Conservation Society, USA; Dolphin Research Institute,Australia, etc (Venu and Malakar, 2015) are playing a major role in research andconservation of marine mammals. The International Whaling Commission created the Indian Ocean Sanctuary (IWC, 1980) for marine mammals, especially for whales (Kannanand Rajagopalan, 2013). Whales are given protection from commercial whaling (Venu and Malakar, 2015). Recently Conservation for Migratory Species (CMS) passed severaldecisions in order to protect marine mammals and its natural habitat. (Table 1)

Table 1: CMS initiatives for Marine Mammal Conservation

Decision Number	Details
12.2 (Rev.COP13)	Concerted Action for Sperm Whales (*Physeter macrocephalus*) of the Eastern Tropical Pacific
12.3 (Rev.COP13)	Concerted Action for the Atlantic Humpback Dolphin (*Sousa teuszii*)
12.4 (Rev.COP13)	Concerted Action for the Humpback Whales (*Megaptera novaeangliae)* of the Arabian Sea
13.7	Concerted Action for the Harbour Porpoise (*Phocoena phocoena)* in the Baltic Sea and the Iberian Peninsula
13.54 to 13.57	Detailing of Important Marine Mammal Areas (IMMAs)
13.58 to 13.60	Adverse Impacts of Anthropogenic Noise on Cetaceans and Other Migratory Species
13.66 to 13.68	Species-specific Guidelines for Boat-based Wildlife Watching
13.74 to 13.75	Live Capture of Cetaceans from the Wild for Commercial Purposes
13.80 to 13.83	Global Programme of Work for Cetaceans
13.84 to 13.85	Conservation and Management of Whales and Their Habitats in the South Atlantic Region

K). Marine Mammal Classification

Marine mammals are classified into four different taxonomic groups: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees and dugongs), and marine fissipeds (polar bears and sea otters). Out of thesegroup Gujarat water harbor species from cetaceans and sirenians, hence we only discussthem in this study.

Cetaceans:

Cetaceans spend their entire lives in water (Gaskin, 1982). They live in all of the world's oceans and most of its seas, and their distribution patterns differ within and withinfamilies. The majority of delphinids can be found in both tropical and temperate seas in both hemispheres. More tropical Delphinidae are *Stenella attenuata*, *S. longirostris*, *S. frontalis*, *Steno bredanensis*, *Sotalia fluvi-atilis*, *Globicephala macrorhynchus*, *Pseudorcacrassidens*, *Peponocephala electra*, and *Feresa attenuata*. All Delphinidae of the genus Cephalorhynchus reside in the Southern Hemisphere's temperate seas. The Amazon River dolphin, *Inia geof-frensis*, is a river dolphin that dwells

in the Amazon and Orinoco basins' big lakes and tributaries. The franciscana (*Pontoporia blainvillei*) is found in the mouths of rivers and the ocean watersaround estuaries in South America's coastal central Atlantic waters. Likewise, the tucuxi can be found in both fresh and salt water. The baiji (*Lipotes vexillifer*) lives in the Yangtzeand formerly lived in some of the lakes along this extremely large inland river system, andthe two subspecies of the family Platanistidae (*Platanista gangetica gangetica* and *P. g. minor*) live in the major rivers of India and Pakistan, the Indus and Ganges (Gaskin, 1982).

Sirenians:

Sirenians can only be found in tropical or subtropical waters (Reynolds and Odell, 1991). In different oceans and river systems, manatees have limited ranges. Reynolds and Odell (Reynolds and Odell, 1991). The west Indian manatee (*Trichechus manatus*) lives in the western Atlantic, from southern North America and the Caribbean to northern South America, and the Amazon manatee (*Trichechus inunguis*) lives in the Amazon drainage (Reynolds and Odell, 1991). The African manatee (*T. senegalensis*) is found in western Africa, from Senegal to Angola, in the eastern Atlantic. Manatees are found in coastal areas, but they can also be found in continental shelf waters in the Caribbean, migrating between islands (Reynolds and Odell, 1991). The Dugong (*Dugong dugon*) is the most extensively distributed sirenian, with a penchant for shallow coastal bays in the Indian and western Pacific oceans (Reynolds and Odell, 1991).

L). Marine Mammals of World

Marine mammals can be found in nearly every type of marine environment, and their distribution varies depending on the physical, chemical, and biological features of the water masses. To characterize distribution, consider the influence of oceanographic phenomena, wind-induced motions (e.g., water currents, local divergence, and upwellingzones and sea fronts), and topography. Pinnipeds' distribution is also characterized by their breeding and molting habitats on land or ice. Breeding and cub-rearing sites are alsoimportant for polar bears (Isaksen & Wiig,1995). Coastal (in estuarine or near-shore waters), neritic (in continental shelf waters), or oceanic can all be found in marine habitats(in waters beyond the continental slope, in the open seas or oceans). Bottlenose dolphins(*Tursiops* spp.), Sea otters (*Enhydra lutris*), and Dugongs are examples of marine mammals that live largely in coastal waters (*Dugong dugon*). Gray whales (*Eschrichtius robustus*), harbor porpoises (*Phocoena phocoena*), and California Sea lions are all neriticspecies (*Zalophus californianus*). The Sperm (Physeter macrocephalus) and Beaked whales are two oceanic species (family Ziphiidae). Because many species occur in numerous habitats, these generalizations should be used with caution. Gray whales, for example, migrate from neritic feeding grounds to coastal migratory routes and breeding areas on a seasonal basis. Some species, such as the bottlenose dolphin, have populations that live in a range of habitats, including coastal, neritic, oceanic, and, on rareoccasions, riverine habitats (Reynolds and Odell, 1991).

M). Marine Mammals of India

There are 26 species of marine mammals known to exist in India, out of around 130 species identified worldwide. The largest barrier to their protection has been a lack of understanding about the distribution and abundance of most of these species in Indian waters. The ever-increasing manmade impact on the aquatic domain has put these magnificent creatures in jeopardy. Proper habitat planning and management, as well as committed marine mammal research, will lead to a better understanding of these amazingcreatures, assisting in their protection and conservation. The conservation of India's marine animals can be aided by raising awareness and training fishermen (Venu, Bitopan,2014). India has a rich and illustrious maritime history. The Arabian Sea, Bay of Bengal, and Ocean encircle the peninsula, and the country's territory includes 1256 islands. The mainland and islands have a combined shoreline of nearly 7,500 kilometers. Wetlands, backwater estuaries and creeks, mangroves, mudbanks, wedge banks salt pans, salt marshes, lagoons, sea grass beds, and coral reefs are among the ecosystem/habitat types found along the Indian coast. A diverse range of plants and animals can be found

on small or inaccessible islands and beaches. Diverse economic development activities are supported by the marine environment. The Exclusive Economic Zone (EEZ) of the country covers 2.02 million km^2 (Apte, 2012). The Indian oceans are home to 25 speciesof cetaceans and one species of sirenian, according to stranding and sighting records. Five of the 25 species of cetaceans are Mysticeti (baleen whales), with the remainder belonging to the Odontoceti family, which includes the Delphinidae, Physeteridae, Kogiidae, Ziphiidae, Phocoenidae, and Platanistidae families (Kumaran, 2002). Many authors have recorded the sea whale Balaenoptera borealis in stranding episodes,however this has been proven as a misidentification. The Indo-Pacific humpback dolphin (*Sousa chnensis*, Osbeck, 1765) is found in coastal waters throughout the Indian and western Pacific Oceans, but the species has not been studied in detail along the coast ofIndia. The distribution, group size, and an index of abundance for *Sousa chnensis* in thetwo regions are evaluated. The sighting rate was over six times higher in Goa. (Sutharia and Jefferson, 2004). Indian Ocean humpback dolphins (*Sousa plumbea*) are obligate shallow-water dolphins that occur exclusively in the near-shore waters of the Indian Ocean, from South Africa to the Bay of Bengal. *Sousa plumbea* has been recognized asa species since taxonomic revision of the genus Sousa in 2014. They have a narrow habitat preference, restricted distribution and do not appear very abundant across any part of their range. There is no estimate of total species abundance; all populations that have been quantitatively evaluated have been small in size, usually fewer than 200 individuals. *Sousa plumbea* is also the most numerous in incidental catch records from the coast, owing to the large overlap in space use with nearshore fisheries like small gillnets, trawls, shore seines and purse seines. Along many coastal sites, humpback dolphins are known to cause damage and depredation of fish catch of certain fishing gears, making them unpopular. At the same time, many fishers along the west coast havedeveloped local dolphin-watching programmes as an alternate source of livelihood, providing positive impetus for conservation. None of the threats have been adequately addressed in any part of the species' range, even though threat levels are increasing virtually everywhere (Gill T. Braulik, et al. 2015). However, research on the long-term effects of dolphin watching and its management is required. Some recommendations formore effective management of this species are made (Sutariya et al. 2015).

N). Marine Mammals of Gujarat

Gujarat has the longest coastline in India, with a total length of 1650 km (21.9 percent of the Indian coastline). Its continental shelf covers 165,000 Km^2 or 35.3 percentof the Indian Continental Shelf's 468,000 Km^2, The Exclusive Economic Zone (EEZ) of India covers over 200,000 Km^2 (9.9% of the country's EEZ). The Gulfs of Khambhat and Kachchh are two indentations on the coastline. The Rann of Kachchh (25082.6 km^2) is one of the largest coastal wetlands in India. The principal ecosystems of the coastal wetlands in Gujarat are mangroves (1031 km^2), coral reefs (130.2 km^2), mudflats (21913.7 km^2), sands/beaches (106.1 km^2), salt marshes (1003.9 Km^2), other vegetated area (1059.9 km^2), stony area (20.7 km^2), and salt pans (459.5 km^2). Due to richness of the marine habitats, diversity of marine life is also good in the State (Singh, 2003).

O). Marine Mammals of Gulf of Kachchh

The Gulf of Kachchh is a wedge-shaped extension of the Arabian Sea that piercesthe Saurashtra and Kachchh landmasses. It has an east-west direction and covers 7350km^2. The Gulf of Kachchh is 58 kilometers wide at seaward (western) and gradually narrows eastwards, extending for about 170 kilometers. The Gulf's depth varies from lessthan 20 meters (at the head) to more than 60 meters (in the middle). In the interior of Gujarat, the Gulf of Kachchh is the only place with coral reefs and dense mangrove flora,as well as creeks and alluvial marshy tidal flats. Because there is no continuous river drainage and rainfall is scarce, this area has a negative water balance. The gulf containsa large intertidal zone, maybe one of the largest along the Indian coast, due to the high tidal amplitude. The tide, wind speed, and rainfall are all stronger in the head, slightly less so in the middle, and almost non-existent at the mouth. In the Gulf, the average tidal range is 4 meters, ranging from 3.06 meters to 5.89 meters (Singh, 2003). Zoological Survey of India (ZSI) has recorded 13 species of

sea mammals Blue whale (*Balaena musculus*), Humpback whale (*Magaptera novaeangliae*), Common Dolphine (*Delphinus delphis*), Short-finned pilot whale (*Globicephala macrorhynchus*), Melonheaded whale (*Peonocephala electra*), Orca whale (*Ornicus orca*), False killer whale (*Peudorca crassidens*), Indo-Pacific humpbacked dolphin (*Sousa chinensis*), Common bottlenose dolphin (*Tursiops truncates*), Indo-Pacific finless porpoise (*Neophocaena phocaenoides*),Pygmy sperm whale (*Kogia breviceps*) and Dugong (*Dugon dugon*) form seawater of Gujarat. The species and abundance of sea mammals visiting the coast have not been documented because an exhaustive survey was not conducted using a scientific manner.Although dead whales have been found near the MPA on the coast of Dwarka, large whales do not come to shallow water and are not dependent on the region of the Gulf MPA. Some whale species may visit the deep waters of the Gulf, but they do not come tothe intertidal zone during high tide. Four species of sea mammals were recorded in and near the MPA: two species of dolphin, one species of porpoise, and a dugong. Although the common dolphin (*Delphinus delphinus*) is still prevalent in Gujarat's shallow waters, determining the population trend is challenging, despite local fishermen admitting to a population drop. They've been spotted off the coasts of Kachchh and Jamnagar, as well as in south Gujarat. Animal sightings are prevalent in Okha and Poshitra. Singh (2003) concluded that majority of his sighting were of Common Dolphin (*Delphinus delphinus*). However, he also mentions the probability of Bottlenose Dolphin (*Tursiops truncates*) and Hump-backed (*Sousa chinensis*). Although dolphins and porpoises (*Neophocaena phocaenoides*) are not true coral reef species, they are frequently seen in the area. Dolphins are very gregarious animals that are usually drawn to human activity. It is quiterare to come across a single person. Unlike in several parts of the world, where big groupsof common dolphins thrive, they live in tiny groups in the Gulf. Porpoise sightings are uncommon; however, some fishermen are familiar with the animal. Another important mammal that can be found near coral reefs is the Dugong (*Dugon dugon*), also known asthe sea cow. This mammal has been spotted in India in the Gulf of Mannar and the Andaman and Nicobar Islands' shallow waters. They are most commonly found in shallowmeadows of seagrass, which is their primary food source. The dugong rises to the surfacefor air frequently while feeding (Singh,2003).

Photo 2: Humpback Dolphin (*Sousa chinensis*) in Gulf of Kachchh

1.2. Seagrass

Seagrasses are submerged flowering plants found in shallow marine waters, suchas bays and lagoons and along the continental shelf. Seagrass meadows represent a distinct habitat in shallow coastal and estuarine ecosystems, from intertidal to 90 m depth(Short et al., 2016). Seagrasses are not true grasses. Although they are all monocotyledons, they do not have a single evolutionary origin, but are a polyphyletic group of >70 species of flowering plants that spend their lives submerged in tropical andtemperate ocean. Seagrasses descended from terrestrial plants that reentered the oceanbetween 100 and 65 million years ago. The development of different seagrass lineages occurred at least three different times during evolution as determined by chloroplast DNAprofiles (Waycott et al. 2006)**.** The seagrasses were first scientifically noted in 1753 whenCarolus Linnaeus described the species *Zostera marina*, (Short et al., 2016). Typically, seagrasses grow in areas dominated by soft substrates such as sand or mud, but some species can be found on more rocky substrates (e.g., *Phyllospadix spp*.) (Short et al., 2016). Sea grass are vital part of the marine ecosystem due to their productivity level; seagrasses provide food, habitat, and nursery areas for numerous vertebrate and invertebrate species. The value of seagrass was detailed in 1898 by C. G. J. Petersen through the construction of a trophic pyramid with *Z. marina* as the base and higher trophic levels supporting codfish and brant at the apex (Milne and Milne 1951). The vast biodiversity and sensitivity to changes in water quality inherent in seagrass communitiesmakes seagrasses an important species to help determine the overall health of coastal ecosystems. Most seagrasses root in shallow sediment bottoms, where sufficient light penetrates to support growth. Seagrasses form the foundation of submerged grassland ecosystems in shallow coastal waters from the equator to high latitudes on all continentsexcept Antarctica. Seagrass meadow playing a vital role in marine ecosystem function with following roles.

A). Stabilization

Ocean bottom areas that are devoid of seagrass are vulnerable to intense wave action from currents and storms. The extensive root system in seagrasses, which extendsboth vertically and horizontally, helps stabilize the sea bottom in a manner similar to the way land grasses prevent soil erosion. With no seagrasses to diminish the force of the currents along the bottom, beaches, businesses, and homes can be subject to greater damage from storms.

Photo 3: Sandy-lomy patch at Kalubhar Island, perfect of Sea Grass habitat

B). Ecosystem support

Seagrasses provide food, shelter, and essential nursery areas to commercial and recreational fishery species and to countless invertebrates living in seagrass communities. Some fish, such as seahorses and lizardfish, can be found in seagrasses throughout the year, while other fish remain in seagrass beds during certain life stages.

C). Food

While some organisms, including the endangered dugong and green sea turtle, graze directly on seagrass leaves, others use seagrasses indirectly to provide nutrients. Bottlenose dolphins are often found feeding on organisms that live in seagrass areas. Detritus from bacterial decomposition of dead seagrass plants provides food for worms, sea cucumbers, crabs, and filter feeders such as anemones and ascidians. Further decomposition releases nutrients (such as nitrogen and phosphorus), which, when dissolved in water, are re-absorbed by seagrasses and phytoplankton. One of the study marine mammals of this project is Dugong and it require 30- 40 kg of seagrass shoots a day whereas another common reptile of the study area, i.e. the green turtles require 40- 50 kg a day for foraging (D'Souza et al., 2015).

D). Habitat

While seagrasses are ideal for juvenile and small adult fish for escape from largerpredators, many animals living in soft sea bottom sediments also live within seagrass meadows. Species such as clams, worms, crabs, and echinoderms, like starfishes, sea cucumbers, and sea urchins, use the buffering capabilities of seagrasses to provide a refuge from strong currents. The dense network of roots established by seagrasses alsohelps deter predators from digging through the substratum to find infaunal prey organisms. Seagrass leaves provide a place of anchor for seaweeds and for filter-feedinganimals like bryozoans, sponges, etc.

E). Water Quality

Seagrasses help trap fine sediments and particles that are suspended in the watercolumn, which increases water clarity. When a sea floor area lacks seagrass communities, the sediments are more frequently stirred by wind and waves, decreasing water clarity, affecting marine animal behavior, and generally decreasing the recreationalquality of coastal areas. Seagrasses also work to filter nutrients that come from land- based industrial discharge and stormwater runoff before these nutrients are washed out to sea and to other sensitive habitats such as coral reefs.

F). Economics

Although seagrass is not a commodity that is directly contribute in economy but itseconomic value can be measured through other industries, such as commercial and recreational fisheries and nature and wildlife tourism, which rely on this habitat to survive.Since most of fishery species spend at least part of their life cycle within seagrass communities, seagrasses are vital to the survival of these fishing industries.

G). Sea Grass Blue Carbon

Seagrass meadows are considered important natural carbon sinks due to their capacity to store organic carbon (Corg) in sediments. There is a growing awareness of "seagrass blue carbon," referring to the fact that seagrasses sequester and store carbonin their roots and sediments. Although seagrasses represent only a small area (0.2 % of the oceans' surface), it is estimated that they store 20 % of oceanic blue carbon (Short etal., 2016). It is estimated that seagrass meadows sequester between 0.012 to 1.33 metrictons of carbon per hectare per

year (tC/ha/yr). The amount of CO_2 that is sequestered byseagrasses differs greatly and depends on species, whether it is fast or slow growing, thelocal environment and the time of year. Sea grass not only absorbed CO_2 but also produce O_2, 10 lit./m^2/day (CSIR-NISCAIR, 2013). However, the spatial heterogeneity of carbon storage in seagrass sediments needs to be better understood to improve accuracyof Blue Carbon assessments, particularly when strong gradients are present. Rate of CO_2absorption is different in different species of sea grass. A study carried out by Kaladharan,et.al (2018) indicate that light harvested CO_2 fixation rate is maximum of 8.03 kg C/ ton wet weight/day for *Halophila ovalis*, commonly found in the study area of this project, anda minimum of 1.63 kg C/ton wet weight/day for *Enhalus acoroides*. Study also shows thatSeagrass carbon storage in sediment in the form of rhizome and root wet biomass showed maximum for *Enhalus acoroides* (1.173 kg/ m2) followed by *Cymodocea serrulata* (0.945 kg/m2) and the lowest by *Halophila ovalis* (0.535 kg/ m2), commonly found in the study area of this project.

H). Sea Grass Status in World

Widespread seagrass habitat, which are often referred to as seagrass beds or meadows, ranging in size from a few square meters to hundreds of square kilometers. Asvirtually no seagrass species is fully investigated as to global occurrence or genetic diversity across its range, so far marine botanist found relatively few species of seagrass,only 72 species which are further classified in 6 families and 14 genera. High seagrass diversity typifies the western side of the Tropical Indo-Pacific, with 12–14 species currently identified for the tropical areas of the Indian Ocean (Short et al., 2016). While the global species diversity of seagrasses is low, seagrass species can have ranges thatextend for thousands of kilometers of coastline. The northern and southern hemispheresshare ten seagrass genera, having only one unique genus each. There are roughly the same number of temperate and tropical seagrass genera as well as species. *Ruppia maritima*, only recently classified as a seagrass, is one of the most widely distributed of all flowering plants on Earth, occurring in both tropical and temperate zones and a wide variety of habitats. As determining diversity of sea grass is difficult, the estimation of seagrass habitat area around the globe is also difficult because less than a quarter of theworld's seagrasses have been mapped. The majority of seagrass information consists ofobservations of seagrass for specific locations with no determination of meadow size (Green and Short 2003). Globally, total seagrass area is estimated to be 1,77,000 km^2 based on actual mapped areas and inference of unmapped areas where seagrass occurrence has been documented (Spalding et al. 2003).

I). Sea Grass Status in India

Species of seagrass flora in India is varies in number of studies. A study carried out by CSIR-NISCAIR (2013) claimed that there are 13 species of sea grass in Indian coastal waters, 52. Sulochanan B (2012) claimed that there are 14 species of sea grassin India and a study by Patro et.al. (2017) shows that there are 16 species represented by 2 families into 6 genera. Out of this east coast of India reported the maximum speciesdiversity. State of Tamil Nadu reported 14 species, followed by Andhra Pradesh with 6 species and Odisha, 5 species. West coast of India reported 6 species and all of them are found in the Gujarat. Island ecosystems of India, Andamand & Nicobar and Lakshadweep Islands, reported 9 species of Sea Grass. *Halophila beccarii* is the most commonly distributed species in India as was reported from all coastal states except the islands, followed by *H. ovalis, H. ovata* and *Halodule uninervis*. *Halophila stipulacea* and *H. ovalis sub sp. ramamurthiana* are reported only from Tamil Nadu, while *Ruppia maritima* and *Zostera marina* are reported to be restricted to Karnataka (only in estuaries)and Gujarat, respectively. Distribution of seagrass is recorded from all the coastal statesand union territories (UT islands) of India except Maharashtra, Daman and Diu, West Bengal and Puducherry. In Goa, a tiny patch of 0.01 km^2 is recorded from Mandovi estuary with two species of seagrass. In Karnataka, seagrass meadows are reported fromKarwar, Swarna-Sita and Chakra Patro et.al. (2017). The estimated area of seagrass in Palk Bay and Gulf of Mannar is 175.2 km2 and 55.15 km^2, respectively (Manikandan et al. 2011; Raja et al. 2012). In Odisha, seagrass distribution is limited only to Chilika lake and is spread across an area of 80

km^2 (Kannan et al. 1999; Pati et al. 2014a, b). Seagrass area recorded in Lakshadweep is 12 km2 (Jagtap 1998) and Andaman NicobarIsland is 2943.3 ha, and about 1619.4 ha of seagrass area have been denuded during 1996–2007 (Nobi et al. 2013).

J). Sea Grass Status in Gujarat

In Gujarat, seagrass meadows are reported mainly from the Gulf of Kachchh (Anand et al. 2012; Kamboj 2014). Majority of seagrass patches found in the GoK are located at Paga Reef, Kalubhar Reef, Narara Reef, Pirotan Island, Bhaidar Island, ChankIsland, Ajad Island, Sika/Vadinar Reef Patro et.al. (2017). As per study of Kamboj (2014)and Anand et.al (2012) Gujarat is home of total 6 sea grass species which are *Halophilabeccarii, Halophila ovalis, Halodule uninervis, Halophila ovata, Zostera marina* and *Thalassia hemprichii*. Six species of seagrass are reported from the region, constituting 10% of the total number described worldwide (Phillips & Menez, 1988), making this region an important region for sea grass conservation. Jagtap (1991) reported the occurrence offour species of seagrass from Gulf of Kachchh: *Halophila beccarii* was reported to be common while *Halodule uninervis, Halophila ovalis* and *Halophila ovata* were very rare. Nair (2002) reported three species, *Halodule univervis, Halophila ovate* and *Halophila beccari* on sandy regions of Narara and Kalubhar reefs. A comprehensive study on biodiversity and management issues of the MNP&S by Singh et al. (2004) indicates the status of seagrass in different locations. Areas without seagrass included Bet Dwarka Island, Khara Chusna Island, Dedeka Island, Mundeka Island, Okha Village and Arambhda Village (Kamboj 2014). The total seagrass area in the Gulf of Kachchh is estimated as 2432.31 ha, but it's being degraded. One of the major threats to the seagrass meadows in Gulf of Kachchh MNP&S is pollution, due to various industries, andsedimentation affecting the water quality. Because sea grass meadows are dependent on sunlight for photosynthesis, water clarity and quality are important for the productivityof this ecosystem. Excessive sedimentation and turbidity often occur after dredging and coastal development (Kamboj 2014).

Photo 4: *Halophila ovalis* (R.Brown) Hooker f., 1858 is common in the Study area

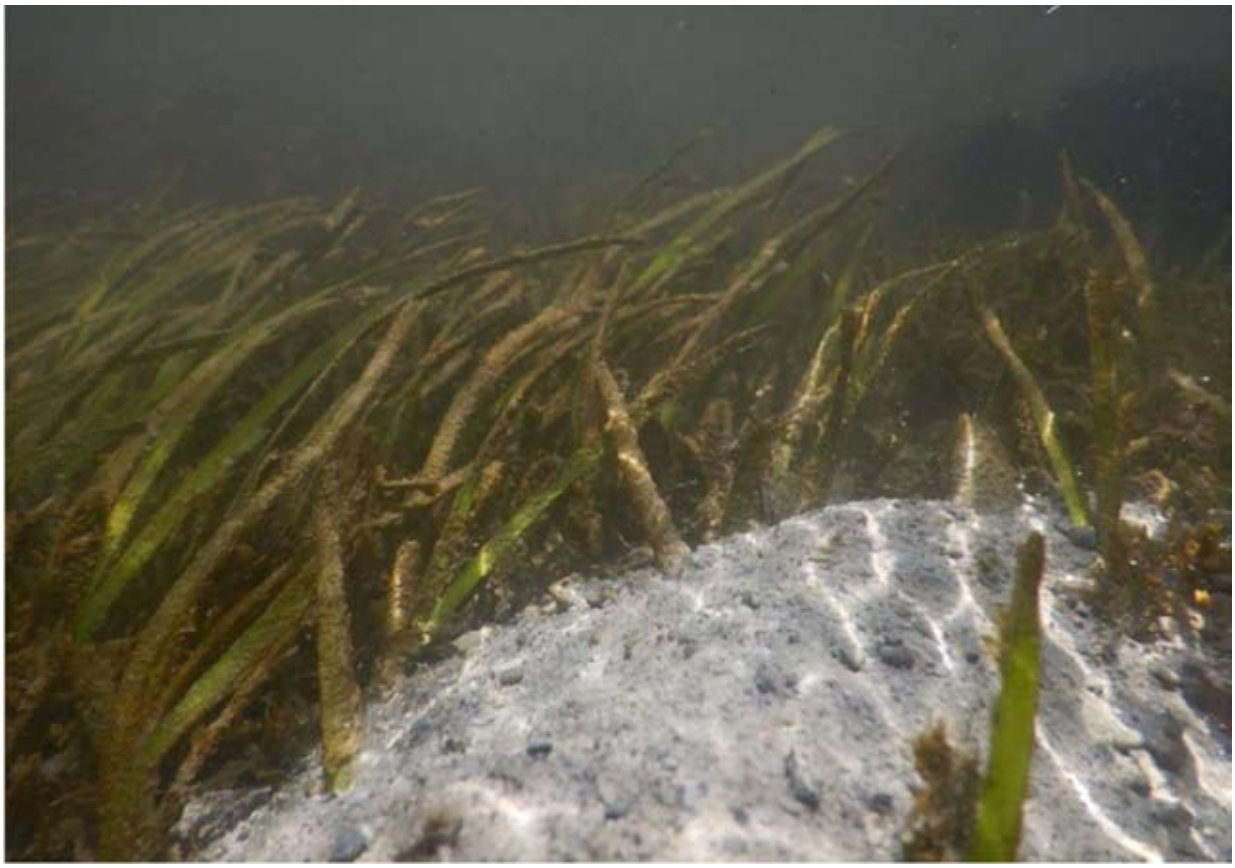


Photo 5: *Halodule uninervis* (Forssk.) Asch. is common in the Study area

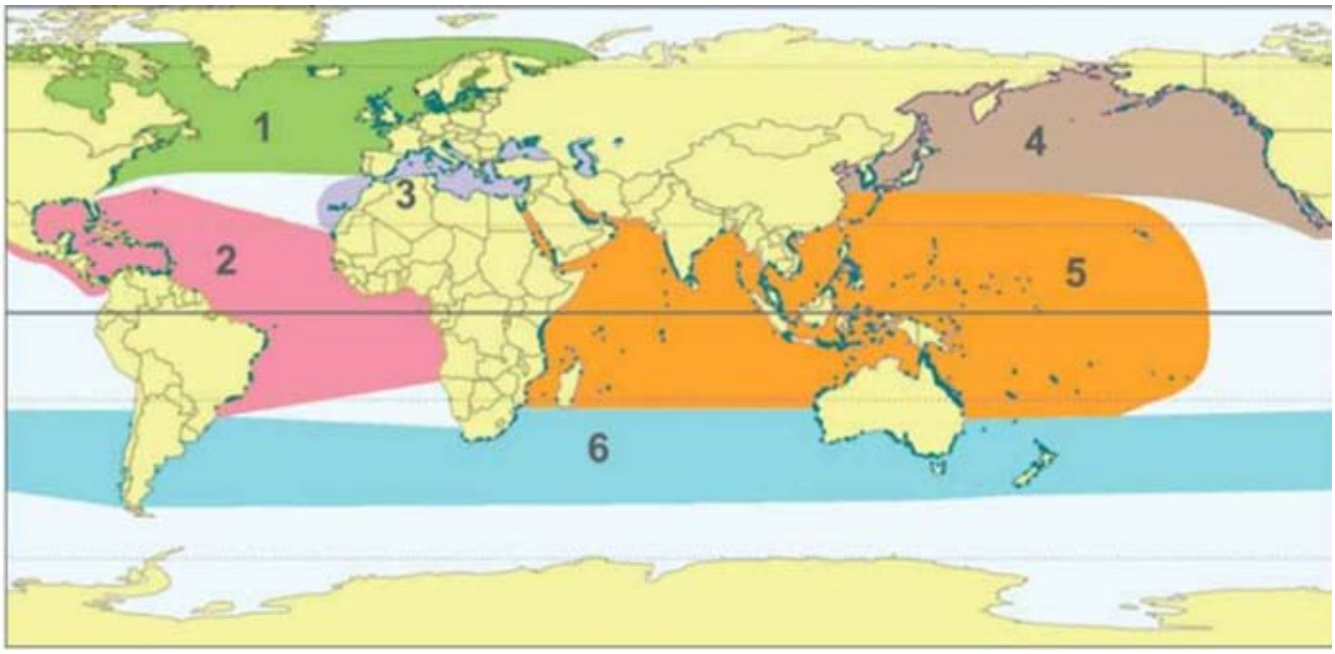


Image 4: Sea Grass Bioregions

1: Temperate North Atlantic, 2: Tropical Atlantic, 3: Mediterranean, 4: Temperate North Pacific, 5:Tropical Indo-Pacific, and 6: Temperate Southern Oceans (Short et al. 2007)

STUDY AREA

2. Study Area

A). State: Gujarat

Gujrat ranks first among India's coastal states, having a coastline of 1650 kilometers (21.9% of India's coastline), and is the only state in the country with two gulfs,Gulf of Kachchh and Gulf of Kambhat (Gulf of Cambay). The Gulf of Kachchh (referred as GoK) is home to our country's northernmost coral reef ecosystems. The coral reef present along GoK's southern side. There is other diverse coastal habitat such asmangroves, sea grass meadows, open mudflats, rocky and sandy beaches present in theGoK. This diverse habitat has provided shelter to thousands of marine biotas and helpedto maintain the ecosystem's integrity (Kamboj. et. al. 2014).

B). Region: Gulf of Kachchh

The GoK is an indentation in the Saurashtra Peninsula created by the Arabian Sea. It is situated in Gujrat's semi-arid zone. This massive body of water is bounded on the north by Kachchh district, and on the south by Jamnagar and Rajkot districts. There are two different physical habitat presences in the GoK. GoK's northern coast is characterized by mangroves and vast open mudflats with some sandy beaches while southern shore is a more of coral reef, rocky and sandy shore with numerous tiny to moderate-sized islands (Kamboj. et. al. 2014). The Gulf of Kutch contains fringing, platform and patch reefs as well as coral pinnacles with at least 37 different species of hard corals with other reports indicating 44 species of hard coral and 12 species of soft coral. These coral reefs are thousands of years old with the youngest being from 5,240 years old at Salaya although these

coral clusters grow at a rate of 1 cm/yr to 10 cm/yr (Geevan and Dixit, 2012). GoK is triangular in shape, with a surface area of roughly 7350km^2, a length of 170 km, and a width of around 75 km near the mouth. The GoK has totalcoastline is of approx. 774 km. out of which of 406 km. in the north (Kachchh district), 342km. in the south (Jamnagar district and Dwarka district), and 26 km. in Rajkot (Ravi Dutt Kamboj, M.M. Bhalodia, Dhiraj Chavada, 2014). GoK's temperature is ranges from 10°C(January) to 35°C (May-June) (Kamboj. et. al. 2014). The low annual rainfall that flows into the gulf means that there are no major rivers going into the gulf and creating run-off (Kunte et.al. 2010). Tidal conditions range with spring tide peaking around 6.2 m while the annual average is around 4 m. Moreover, the height of the tides can also vary depending on how deep into the gulf it's recorded. Ohka has been measured in a range of 3.06 m while Kandla has shown heights of 5.89 m at the same time (Waghle, 1979).

The speed of the current has been recorded between 1.5 to 2.5 knots at the entrance and3 to 5 knots within the center (Kunte et.al. 2010).

The Gulf of Kutch is a shallow water basin about 60 m deep at the mouth, slopingup to a depth of less than 20 m at the head (Biswas, 2009). Because of this range of depth there are 4 major ports and 31 jetties are located in the GoK. Some of the largest ports are Kandala and Mundra. These ports and jetty are point of transport of coal, cement, salt, crude oil, container, minerals bauxite and other items. There is also an upcoming ship breaking yard in Balachadi beach. Prescence of these ports and jetties means there is considerable ship traffic in the GoK which can intersects paths of marine mammals' movements.

A). Place: Marine National Park and Sanctuary

Marine National Park and Sanctuary (MNPS), commonly known as MNP in the scientific community and Pirotan National Park among common population, is India's first Marine National Park established in 1982. The Gujarat government designated 457.92 square kilometers of land as a Marine Sanctuary, recognizing the significance of these coastal and marine habitats. Later, a Marine National Park was established covering an additional 162.89 square kilometers. This Marine National Park and Sanctuary is classified as a Category II (Protected area managed primarily for ecosystem protection and recreation, i.e., National Park) of Marine Protected Areas by the International Union for Conservation of Nature (IUCN) (Kamboj, et.al, 2014). MNP is now one of the state's four national parks. It is located along the coasts of Jamnagar, Dev Bhumi Dwarka and Morbi districts in the southern region of the Gulf of Kachchh (GoK). The National Park and Sanctuary encompasses 42 islands and a small number of islets, some of which havesince been joined to the mainland and are no longer considered islands (Kamboj, et.al, 2014). The richness and habitats that this Marine National Park supports make it unique.Coral reefs, mangrove forests, Sea grass meadows, islands, creeks, bays, salt pans, peaceful sandy beaches, enormous mudflats, rocky shoreline, and open waters may all be found there. In the Gulf's relatively sheltered waters, these diversified ecosystems areideal for a range of coastal and marine flora and wildlife (Kamboj, et.al, 2014). GOK's coral reefs are the only ones in the Indian subcontinent that may be visited by walking across intertidal zones. Although corals have evolved to withstand extremes in environmental circumstances, certain coral species discovered in the GoK have not beenreported in living conditions elsewhere in India. The coral reefs of MNP & S are unique and equally important as major coral reef regions of India. The GOK reefs are home to 49 hard coral species and 8 soft coral species of various shapes and sizes that reflect a rainbow of colors (Kamboj. et. al. 2014). The existence of reef-associated life such as algae, sponges, annelids, mollusks, crabs, prawns, echinoderms, fishes, sea turtles, reptiles, birds, and marine mammals, as well as several other minor phyla, makes the coral reef habitat livelier (Kamboj, et.al, 2014). The GoK's coral reefs are home to 1245 species of marine and coastal biota, including 783 species of fauna, including 70 speciesof sponges, 52 species of corals, 44 species of hard corals, 10 species of soft corals, andnearly 90 species of birds (Kamboj, et.al, 2014). Because of this rich habitat there is a high diversity of reef depended animals such as from Class Coelenterates (jelly fish, Portuguese man of war, sea anemones) and Arthropodes (27 species of

prawns, 30 species of crabs, lobster, and shrimp). Class Molluscs is one of the most diverse class which include pearl oyster, sea slug. Echinoderms like starfish, sea cucumber, sea urchinand Class Pieces like puffer fish, sting rays, mudskippers, and other fish dwell these coastal waters. Class Reptilia represented by endangered sea turtles such as green seaturtles, olive Ridley turtles and 3 sea snake species. Because of the healthy habitat and presence of food marine mammals like Dugong, fine less porpoises, common dolphins, bottlenose dolphins, and IndoPacific humpback dolphins, blue whale, humpback whale etc. also can be found in GoK (Kamboj, et.al, 2014). Zoological Survey of India has reported about 766 species of marine fauna and 180 species of marine flora only from Marine National Park (Kamboj, et.al, 2014). This is not the final figure; along the Gujarat coast, several new species and distribution extensions of marine biota are reported on are gular basis.

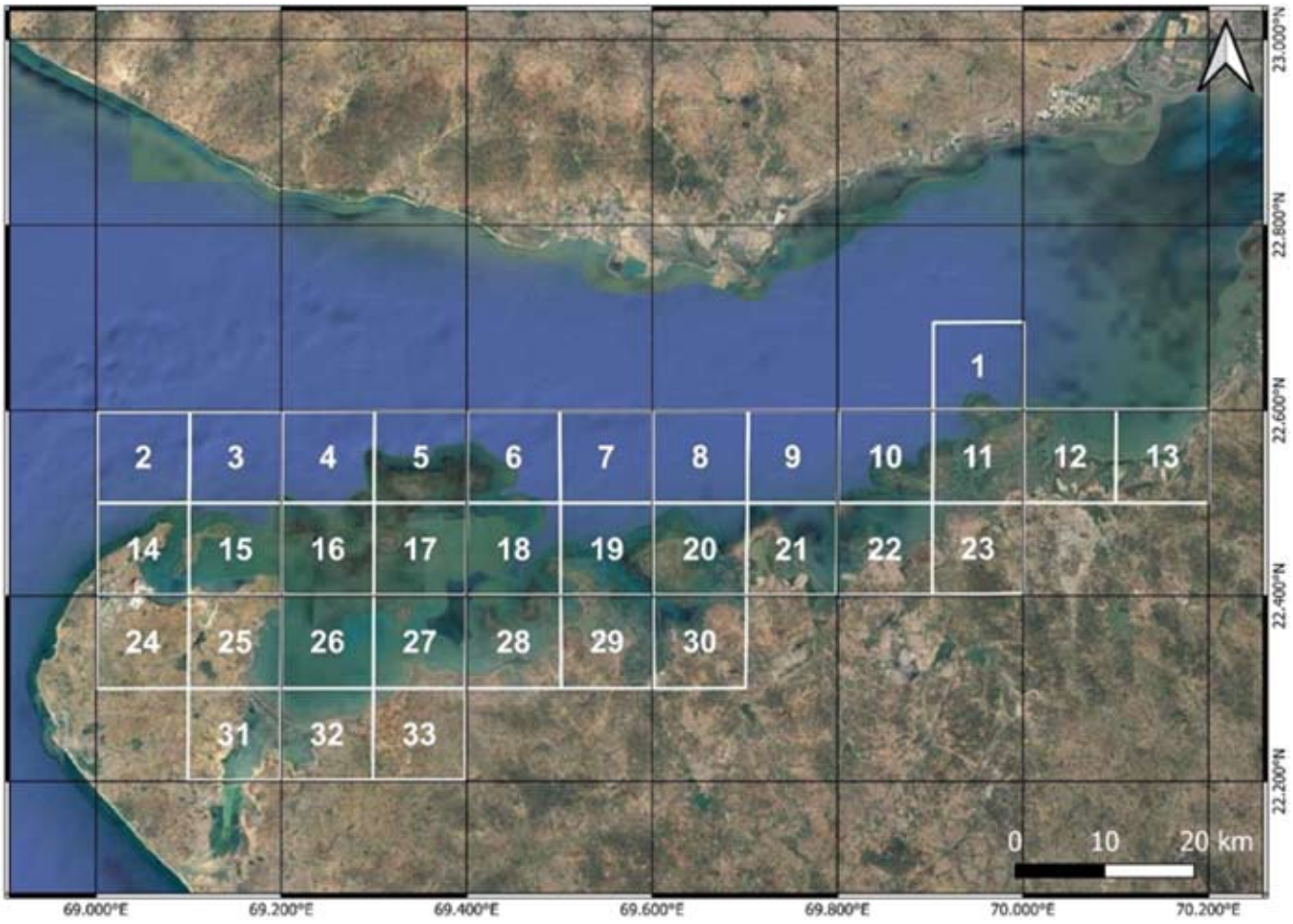
Photo 6: Seagrass patch mix with algae at Vadinar

Photo 7: Island of Gulf of Kachchh holds religious value among the locals

Photo 8: Mangrove ecosystem in Gulf of Kachchh has important role to play in Seagrassconservation

Photo 9: Gulf of Kachchh hold a unique coral reef which is believed to have more climatechange resilient

Photo 10: Gulf of Kachchh provides a good feeding ground for Migratory birds



Map 1: Grid Map of Study area (Gulf of Kachchh)

OBJECTIVE

3. Objective

1. Assessment of presence and absence and distribution of Dolphins and Dugongand their abiotic environment in the Gulf of Kachchh
2. Identification of seagrass beds and mapping its extent, species assemblage andassociated community.
3. Assessment of carbon stored in the seagrass species and the ecosystem soil.
4. Assessment of the restoration potential of the sea grass ecosystem in the studyarea.

METHODOLOGY

4. Methodology

Several marine mammal survey approaches are applicable in underdeveloped nations. Interview surveys, land/shore-based monitoring, ship/boat and airborne surveys, and carcass analysis all have methodologies, requirements, and potential outputs. The best survey procedures are determined by the survey objectives, spatial scale, location, budget and timing, and logistical support available. Interviews are the most cost-effective approach for gathering the fundamental qualitative data needed to create more technologically complex surveys. (Lemnuel, Helene, 1997).

In present study various method were followed to get some estimation about population, distribution etc. of marine mammals. The data collection from secondary and primary sources were also done during the project to get clear picture of marine mammal status. Following are the method that had been used during this project.

A). People Perception Survey

People perception surveys (PPS) can either be in person or over the telephone. Broadly speaking, a face-to-face interview in the context of survey research can be defined as a face-to-face interaction between two persons in which one person (interviewer) asks questions by means of a questionnaire and the other person (respondent) answers these questions. PPS can be further divided in to non-structured and structured interviews/questionnaires. In non-structured interview an interviewer can as random questions, with more like go with the flow line of conversation, about the subject of research to a respondent. This kind of PPS is used when the research subject is of sensitive nature and there is a chance that respondent might reject to give any information or give false information. In structured interview a researcher developed questionnaire containing question, generally close ended or multiple choice, which can be divided to different heads to a respondent. This kind of PPS is more effective and less time consuming as compare to non-structured interview, less effective and more time consuming.

People perception surveys are capable of obtaining information from large samples of the population. They are also well suited to gathering demographic data that describe the composition of the sample (McIntyre 1999). People perception surveys are inclusive in the types and number of variables that can be studied, require minimal investment to develop and administer, and are relatively easy for making generalizations (Bell, 1996). This type of surveys can also elicit information about attitudes that are otherwise difficult to measure using observational techniques (McIntyre, 1999). It is important to note, however, that surveys only provide estimates for the true population, not exact measurements (Salant & Dillman, 1994). However, Pinsonneault and Kraemer (1993) noted that surveys are generally unsuitable where an understanding of the historical context of phenomena is required. Bell (1996) observed that biases may occur, either in the lack of response from intended participants or in the nature and accuracy of the responses that are received. Other sources of error include intentional misreporting of behaviors by respondents to confound the survey results or to hide inappropriate behavior (Priscilla, 2005). Finally, respondents may have difficulty assessing their own behavior or have poor recall of the circumstances surrounding their behaviour.

During the present survey we followed structured interview method to know the people perception about presence of marine mammals in the study area. The questionnaire (Annexure 1) contains various question regarding local observation on marine mammals. We tried to achieve a balance between sex and age group to have a clear picture of people's perception. We were able to cover 9 villages (Map 2) from the study area. We also developed a pictorial photo-identification booklet containing various photos of the marine mammals for identification (Annexure 2) by the locals. We also highlight fin shape in that so that local can easily identified marine mammal which they have observed in the field. We also number of meetings with local forest staff to know their prospective on the marine mammals.

Photo 11: People Perception Survey among the fishermen

Photo 12: People perception Survey with forest official

B). Boat Survey

Systematic sightings surveys are the standard for estimating density and abundance of marine mammal populations. The most commonly used method for cetaceans and pinnipeds is line-transect surveys and aerial photography, respectively. Ship/boat survey employs observer on each side of the vessel, i.e., large commercial or research ship to a small fishing boat, to identify the species and estimate the group size of marine mammals with the naked eye and/or with the aid of binoculars. Moreover, ship or boat surveys can also be used to: investigate the spatial and temporal distribution of identified species; estimate an index of relative abundance to monitor trends over time; estimate absolute abundance using line transect techniques; collect information on habitat use and identify conservation threats. Ship or boat surveys are also often used to collect data for photoidentification studies. Generally, close-up, sharp photographs of individual dolphins or whales are taken using long lenses and the photos are then examined and individual animals are recognized using natural marks, such as fin shapes, nicks and sears on fins and flukes, body scars, and color patterns (Hammond et al, 1990).

Information on movement patterns, social organization, habitat use, and reproductive parameters can be obtained from photo-identification studies.

We used boat transect method for marine mammal's survey as Macleod et. Al. (2010) recommended that boat survey is commonly used method for systematic visual surveys of cetaceans, ie. Dolphins. We carried out boat survey in study area and tried to cover as much area as possible in transect survey. We carried out total 13 boat transect surveys in November (2 transects), December (2 transects), February (3 transects), April (3 transects) and May (3 transects). It is essential to collect the appropriate data to enable adequate data analysis and realization of the desired output metrics (e.g., abundance estimates, distribution maps). A well- designed data recording form will ensure the relevant parameters are measured and furthermore facilitate the development of a common database. For this we also took photographs whenever we sight our subject animals, record the data (time, GPS location, number of individuals). We also took GPS location every 15 minutes so that we can plot our transect on the GIS platform.

Photo 13: Getting ready for Boat Survey

C). Survey for Sea Grass and Carbon Sequestration

According to the UN's Intergovernmental Panel on Climate Change, urgent and unprecedented changes are needed to avoid a climate change catastrophe. Although efforts are already being made to reduce the production of greenhouse gasses, they are by most estimations not enough. It is therefore critical that we find ways to drastically reduce the number of pollutants in the atmosphere. Ecosystems capable of absorbing and storing large amounts of carbon dioxide known as "carbon sinks" are ideal for this. In principle, all living organisms – all animals, plants, algae and bacteria – consist of carbon and so function as a carbon sink. For example, as long as a tree lives it will absorb and store carbon. However, once chopped down and turned into firewood, the carbon in those trees will be released and emitted back into the atmosphere as CO_2. On other hand Seagrass have an excellent capacity for taking up and storing carbon in the oxygen- depleted seabed, where it decomposes much slower than on land. This oxygen-free sediment traps the carbon in the dead plant material which may then remain buried for hundreds of years.

Soil carbon is probably the most important component in soils as it affects almost all soil properties. Carbon, as soil organic matter, alters the physical, chemical, and biological properties of soils. Soil organic matter refers to all decomposed, partly decomposed and undecomposed organic materials of plant and animal origin. Soil organic carbon contributes to the cation exchange capacity of a soil. Increased soil organic carbon enhances the biomass and diversity of the soil biota. Since the soil microbial community drives many of the nutrient transformations in soil, plant nutrient availability is often enhanced with the increase in microbial biomass and microbial activity of the soil. (Walkley and Black,1934)

Quadrat sampling is the best method of sampling for sedentary life form such as Seagrass (Krebs 1986). In the Gulf of Kachchh, the available time for sampling is very less during the low tide, hence quadrats give more stability to the observations as well as to the observer. In the reefs of Gulf of Kachchh, where the data collection is carried out by walking on the reef and not by SCUBA or skin dive, the surrounding water becomes muddy (turbid) very fast and observations are hampered, hence the quadrats are the best suitable methodology to study the reef community, especially in the Gulf of Kachchh (Arthur, 2000). Hence,

quadrat sampling method is used for the present study. Quadrats of 1x1 meter size with grids are the best suited in the Gulf of Kachchh area, as the visibility remains very clear in the 1x1 meter area and the sampling area being smaller identification of seagrass and other details on various parameters like substratum and associated fauna can be obtained comprehensively (Arthur, 2000). Total 4 sites, which are having past record of feeding trails of Dugong (Map 8) named Pirotan, Narara, Kalubhar and Paga were surveyed for sea grass and sample of sea grass along with sedimentation were collected for analysis of carbon sequestration. Amount of organic carbon sequestration were carried out in the lab by following Walkley and Black (1934).

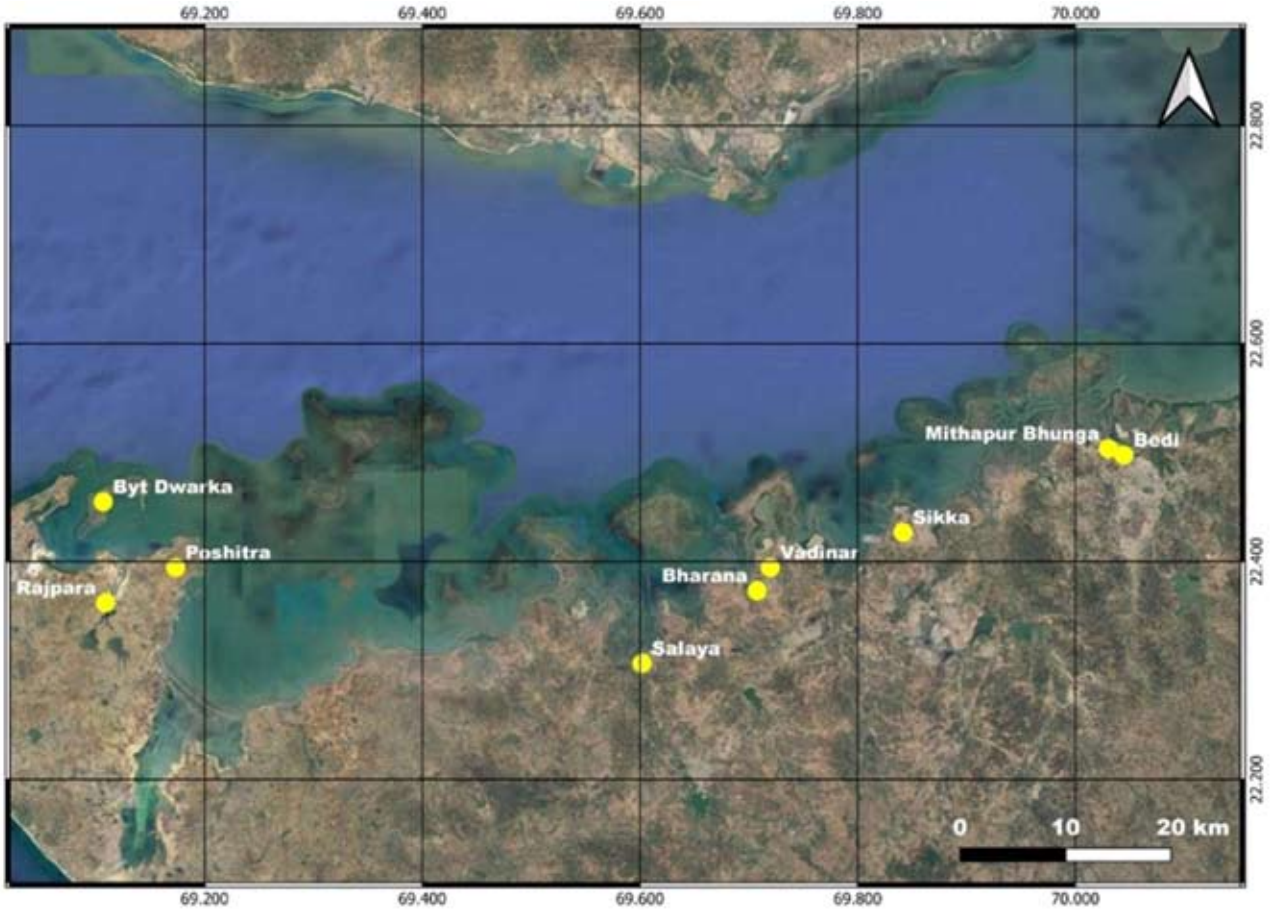
Photo 14: Collecting seagrass and substratum sample for analysis

Photo 15: Habitat survey with forest official

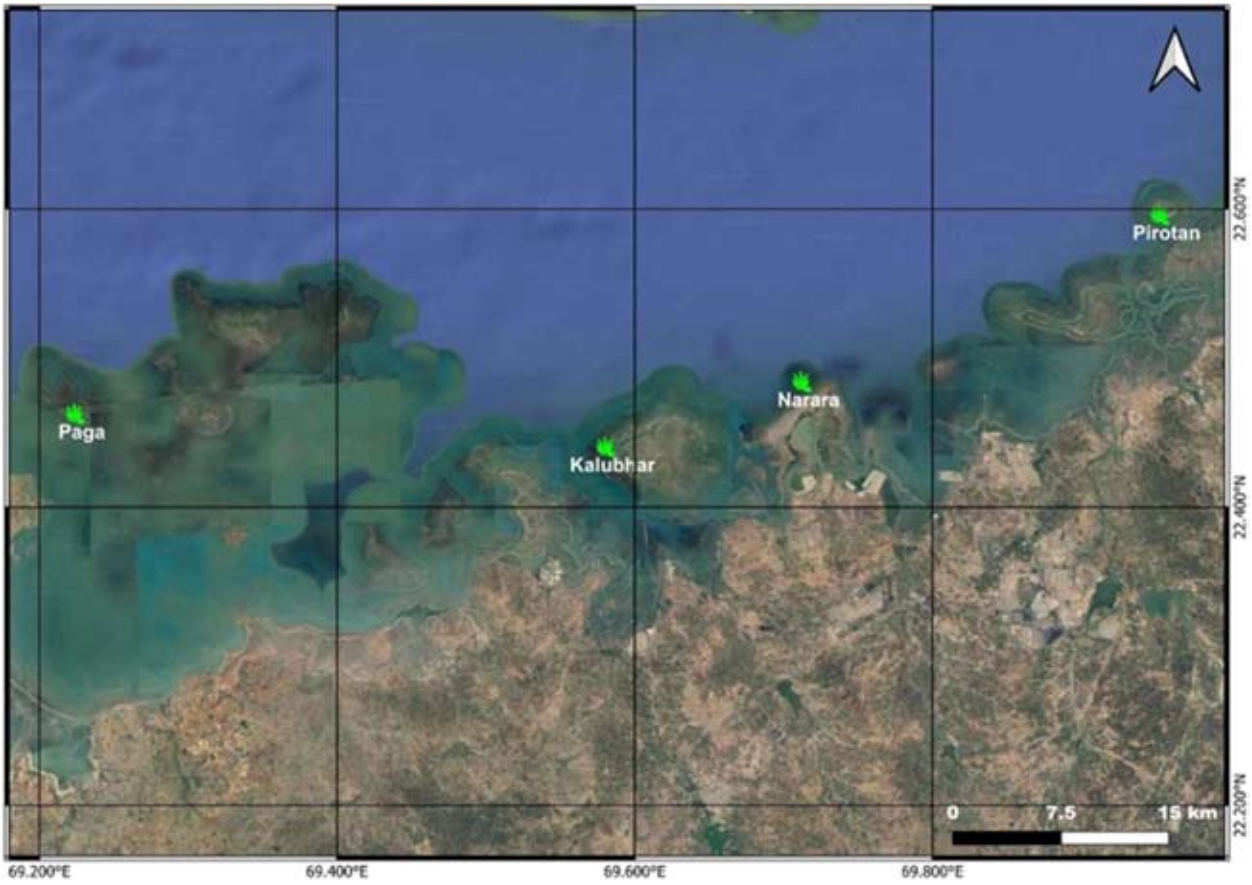
D). GIS Work

Geographic Information Systems (GIS) were 'born' on land; they are around 35 to 40 years old, but only about 15 years ago did they 'migrate' to the sea" (Valavanis 2002). GIS has become a standard technology in a number of terrestrial analyses, but is only still being introduced into marine research. The field of marine mammal science is a complex one, with habitat use continuing to be a perplexing question for marine mammal researchers. GIS has the ability to provide a simpler, more efficient way to study habitat use in marine mammals. And although GIS still has its disadvantages in a marine environment, new advances made in this technology daily will continue to make GIS an essential tool in the characterization of marine habitats. GIS is "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information" (ESRI 1990). The mystery of how marine mammals utilize their habitats and where these animals are when they are not visible has been a perplexing question for researchers for a number of years (Kenney et al. 1995; Winn et al. 1986). This information is extremely important for the conservation of marine mammal species, particularly so for the North Atlantic right whale (Eubalaena glacialis). This species is the most critically endangered large whale in the world (Kenney and Wishner 1995). Knowing where these whales are and keeping accurate records of their locations might give some insight into the reasons for their lack of recovery. While GIS has not yet become a standard technology for the monitoring of this species, it has been shown that with some adjustments, GIS may be able to greatly increase the efficiency with which we study this population (Moses 1997; Schick 2002).

In present study we used free GIS software, QGis (ver. 3.22.8) to plot our finding, such as sea grass bed, sightings of marine mammals etc., marking, of our transects, grid layout and conservation measure, in terms of future sea grass bed. We use Google Earth map plug-in as our base map and use Vector tools, such as point, polygon and line, to present our work.



Map 2: People Perception Survey Villages



Map 3: Sea grass survey reefs

RESULT

5. Result

A). Results of People Perception Survey

1. The focal area for the study was Marine National Park and Sanctuary - Jamnagar. The field visits were carried out almost on monthly basis. In total 7 field visits were executed with each visit of minimum 5 days to maximum 8 days. Initial visit focused on consultation with the MNP & S authorities for secondary information.
2. Post coordination meetings, interview surveys were carried out in 10 different fishing villages from Jamnagar and Devbhoomi Dwarka districts. Photographs of two species of Dolphins, Dugong and other marine mammal species were shown to the respondents. In addition, a grid-based map of 10 x 10 km was shown to the respondents to describe and understand the exact locations.
3. At every village location, a common place was decided, and interviews were taken. All the responders were cooperative and provided comprehensive insight regarding their sightings. Total 100 respondents were interviewed of which 8 were female of Sikka village and rests of 92 were male fishermen. The age of majority of the respondents (39%) were between 40 years to 60 years whereas 30% were above 60 years (Figure 1)
4. The questionnaire comprised of 10 different sets of questions. The respondents were fishing in the Gulf of Kachchh region for more than 20 years. At least 38% fishermen were fishing for more than 20 years whereas 32% were fishing for more than 10 years but less than 20 years. There was no specific pattern observed with reference to their respective fishing area. They fish according to the ongoing season and available resources. About 68% of the respondents confirmed that they had seen Dolphin at least once in their life span in the ocean. Those respondents, who had seen Dolphins, were showed different species photographs, from which they identified the species. About 45% identified S. plumbea as the only species seen and only 11% could identify T. aduncus as the only species observed while fishing. Majority of the observations if the respondents were in grid no 15, 16 and 17 followed 22, 26 and 27. About 64% individual respondents agreed that the population of Dolphin is reducing. The major reason for such depletion is thought to be reduction in fish resources (45%) and increase in large vessels (37%).

5. However, for Dugong the respondents were not much aware and only 18% confirmed the sighting of Dugong in the environs of Gulf of Kachchh.
6. Furthermore, 27% confirmed the sighting of two species viz. Sausa plumbea and T. aduncus, whereas 45% confirmed sighting of only S. plumbea and 11% confirmed sighting of only T. aduncus.
7. Frequency of sighting Dolphins was much higher (n=32) always sighted Dolphin whenever they go for fishing in the sea. However out of 18 respondents, 17 rarely seen Dugong.
8. Based on the average sightings were further divided into the group size for dolphins and 37 responded the average group size to be 2 to 5 dolphins in a group.
9. About 82% respondents considered Grid No. 15 and 16 to be the most promising zones for sighting Dolphins.
10. Considering the threat analysis, the respondents were asked whether the Dolphin population has decreased or increased, 64 respondents felt that the population is decreasing whereas, 12 respondents felt that the Dolphin population has increased. All Respondents were unaware about the Dugong population.
11. The factor considered for depletion in Dolphin population was depletion of fish resources and there could be a direct correlation with the same too.
12. Whereas, 37 respondents also felt that the increased vehicular traffic in terms of large vessels also affected the Dolphin and other large marine animal's population. Some respondents selected multiple factors affecting the Dolphin population.
13. Based on the questionnaire survey, the awareness for Dolphins was much higher than that of Dugong. The possible reason could be the relative abundance of Dolphins compared to Dugong. In addition, the frequency of sighting Dolphins is restricted to some areas only and is not uniform at all.

Table 2: Field Work detail

Activity	No. of observer	No. of Days	No. of hrs per day	Total human hrs
Interview survey	3	8	8	192
Boat survey	3	25	8	600

Table 3: Information of Villages covered during People Perception's Survey

District	Village Name	Male respondents	Female respondents
Jamnagar	Bedi	12	0
	MithapurBhunga	5	0
	Bharana	10	0
	Sikka	15	8
	Vadinar	10	0
	Salaya	10	0
DevbhoomiDwarka	Rajpara	10	0
	Poshitra	8	0
	BetDwarka	12	0
	Total	92	8

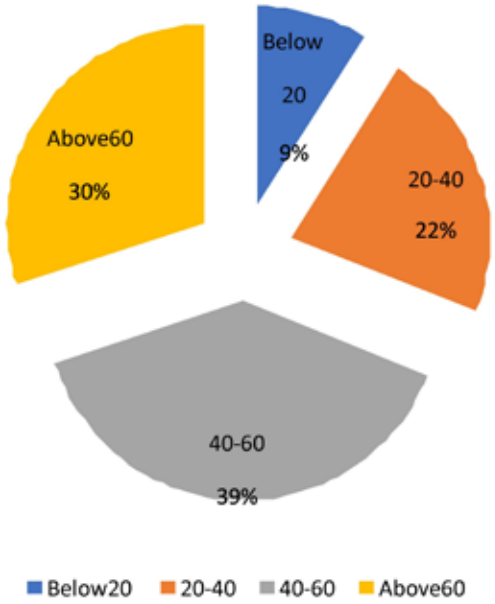


Figure 1: Age class of respondents (in Years)

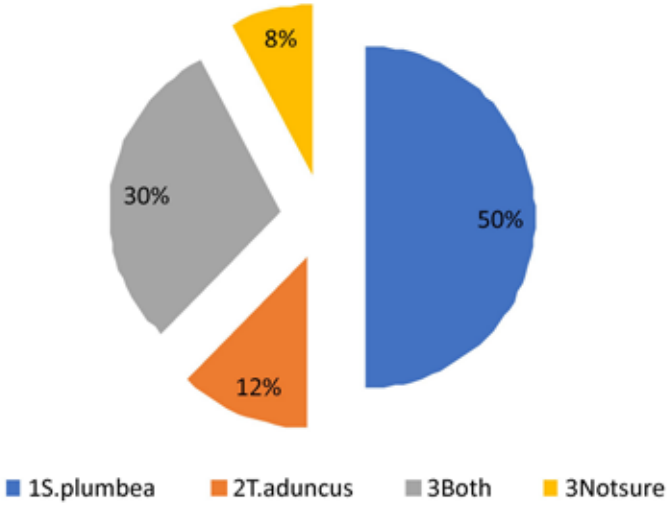


Figure 2: Sighting of two species of Dolphins (People's perception survey)

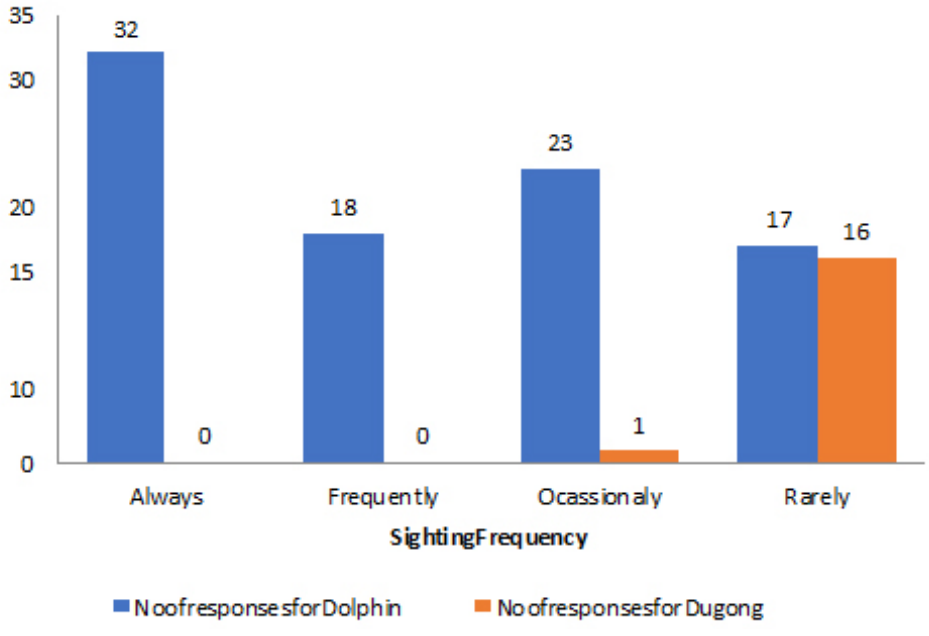


Figure 3: Frequency of Dolphins and Dugong sightings People's perception survey

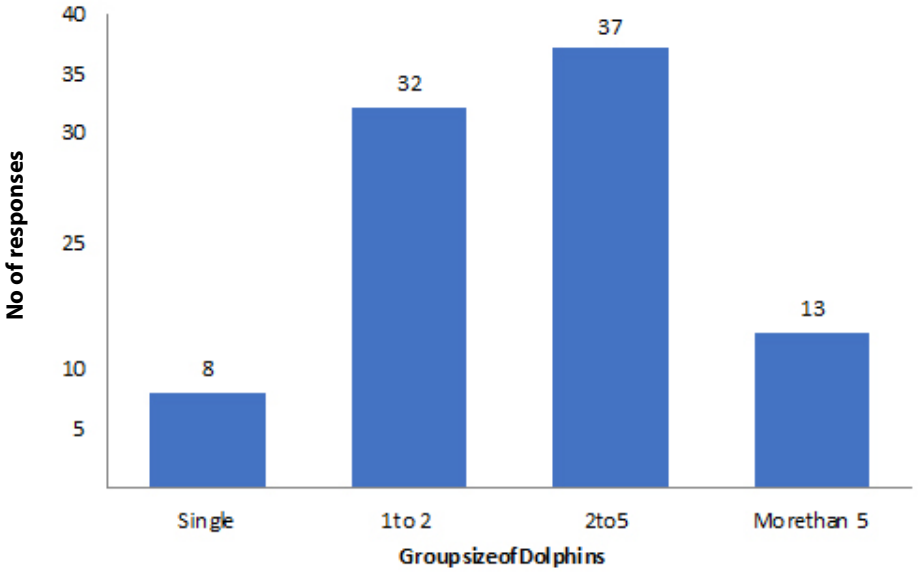


Figure 4: People's perception Survey regarding group size of Dolphins

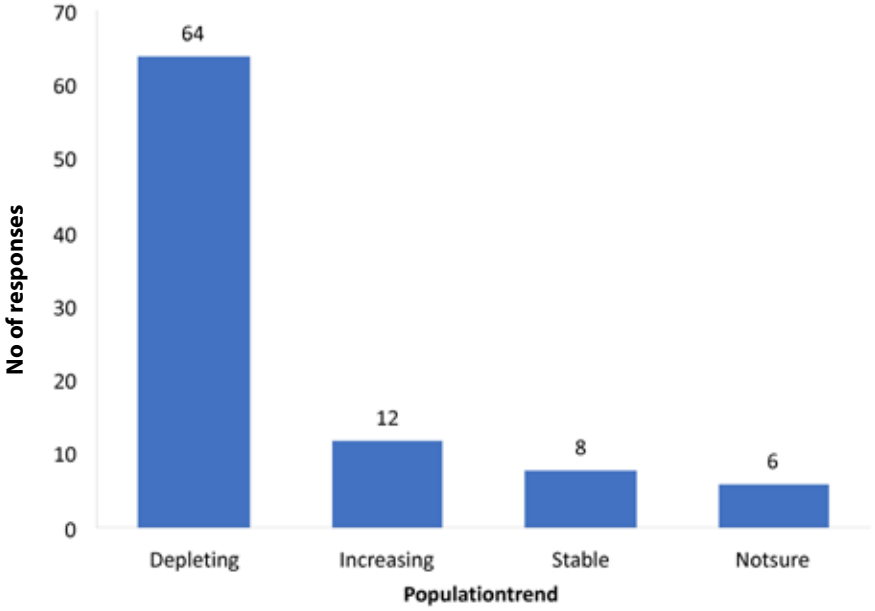


Figure 5: People's perception towards Dolphin's trend

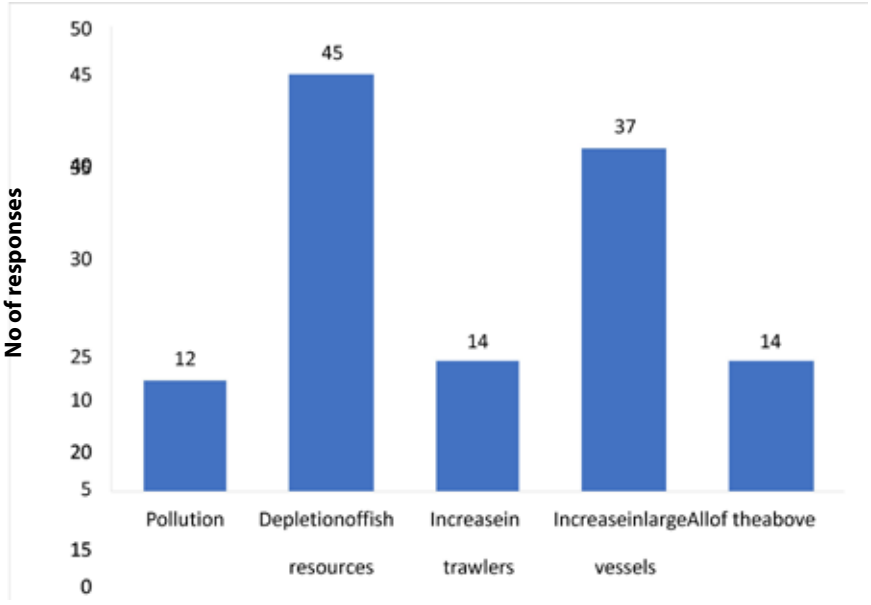
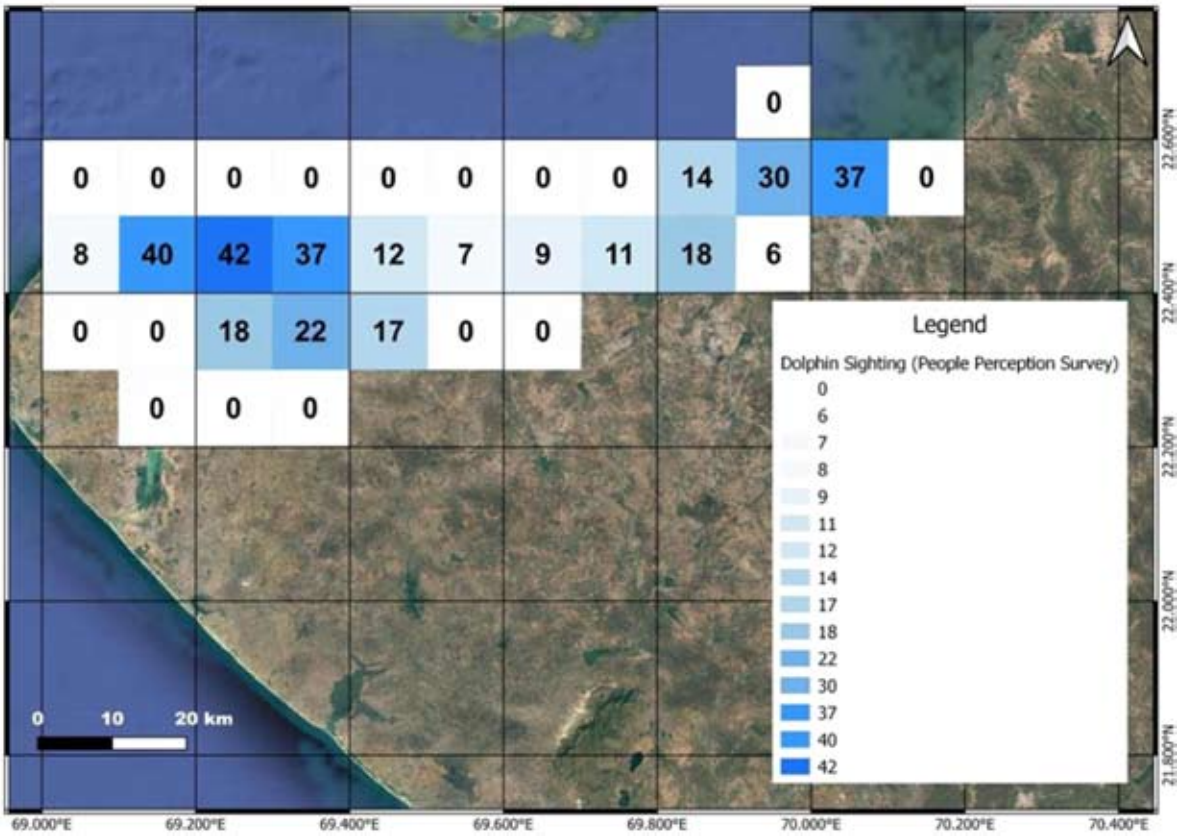


Figure 6: People's perception towards factors affecting Dolphin's population

Photo 16: Carrying out people perception survey with Identification guide and Grid Map



Map 4: People's perception survey results regarding sightings of Dolphins in various zones

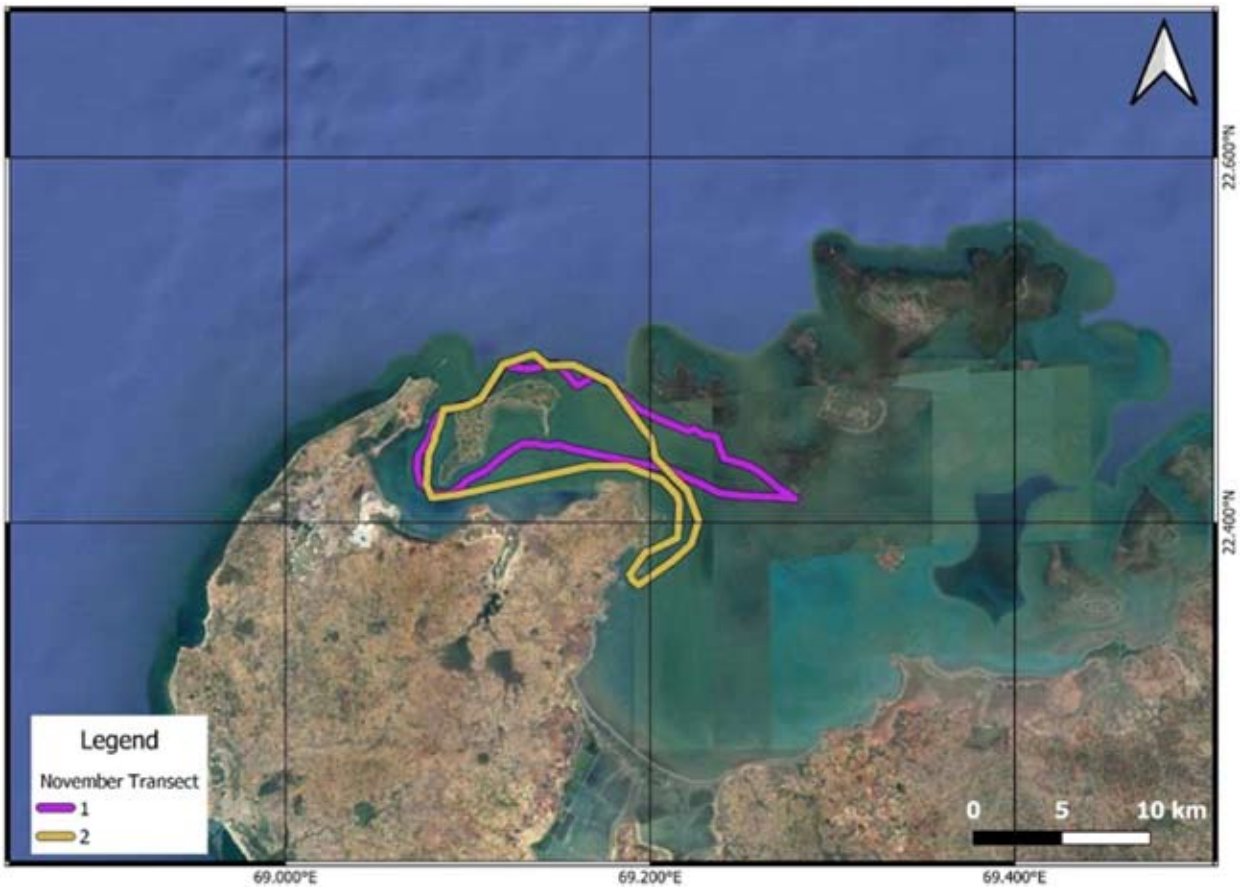
B). Results of direct sightings from Transects (Dolphins)

1. The entire study area was divided in 10 x 10 km grids. Total 33 grids covered an area of 3300 km2 of Marine National Park and Sanctuary and its adjoining areas in the Gulf of Kachchh.
2. A total of 13 transects covering 444 km were laid in 6 different field visits covering 33 grids of 10 x 10 km.

3. Considering the width of transect as 1 km (500 m on both sides) the total area surveyed is 444 km2, which is 13% and is greater than 10% of the total study area (3300 km2) and is statistically adequate sample size.
4. The maximum length of the transect was 56 km of Transect No. 1 followed by Transect No. 2 of 53 km and the shortest transect was Transect No. 4 of 11 km. The average length of transect was 34.15 km. At an average speed of 6 km per hour, total transect time was calculated as 74 hrs.
5. During this study we recorded 2 species of Dolphins in Marine National Park and Sanctuary, Gulf of Kachchh, Indian Ocean humpback dolphin (Sousa plumbea) and Indo-Pacific bottlenose dolphin (Tursiops aduncus).

Table 4: Transect length

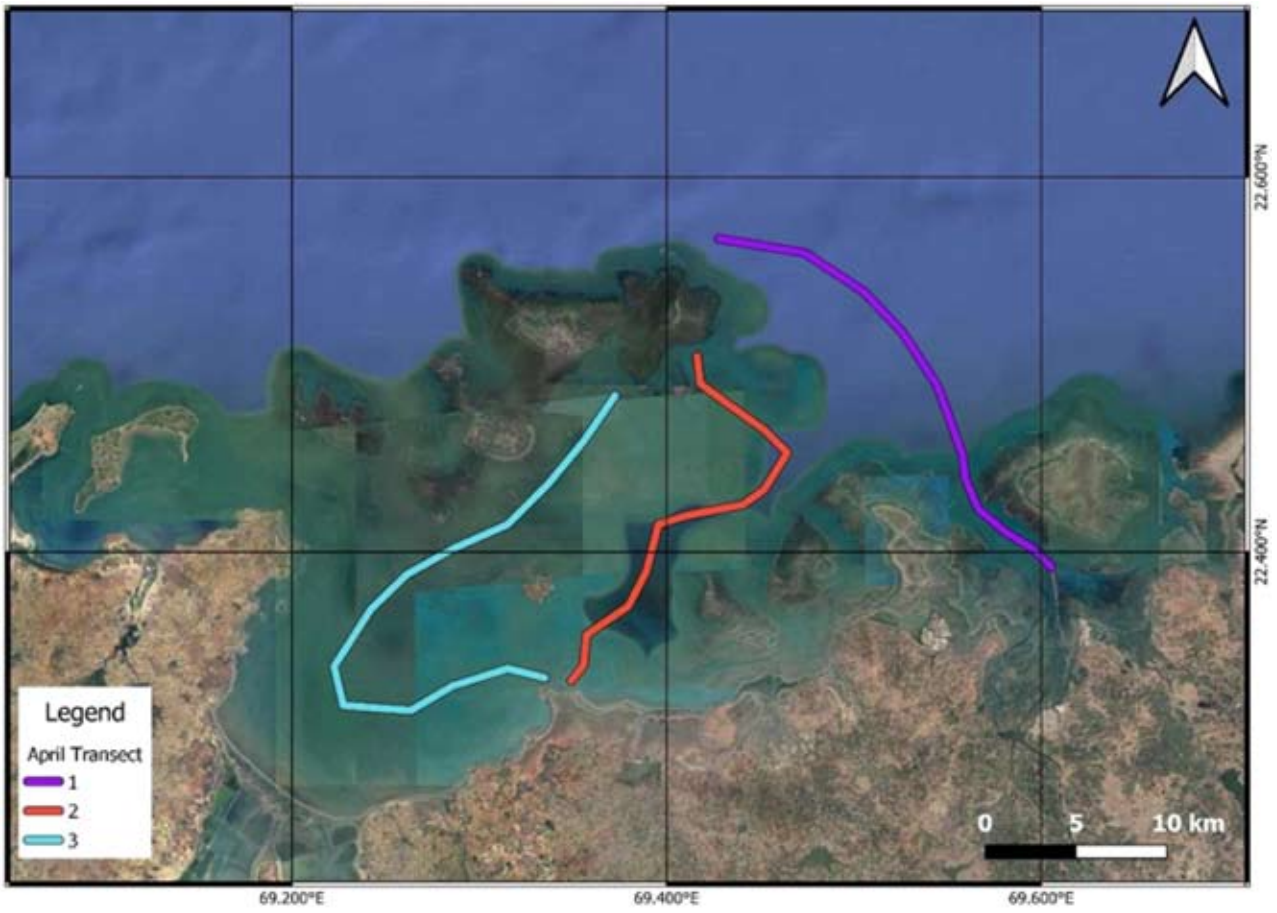
Sr. No.	Transect	length(km)
1	T1	56
2	T2	53
3	T3	18
4	T4	11
5	T5	28
6	T6	27
7	T7	19
8	T8	29
9	T9	28
10	T10	37
11	T11	48
12	T12	40
13	T13	50



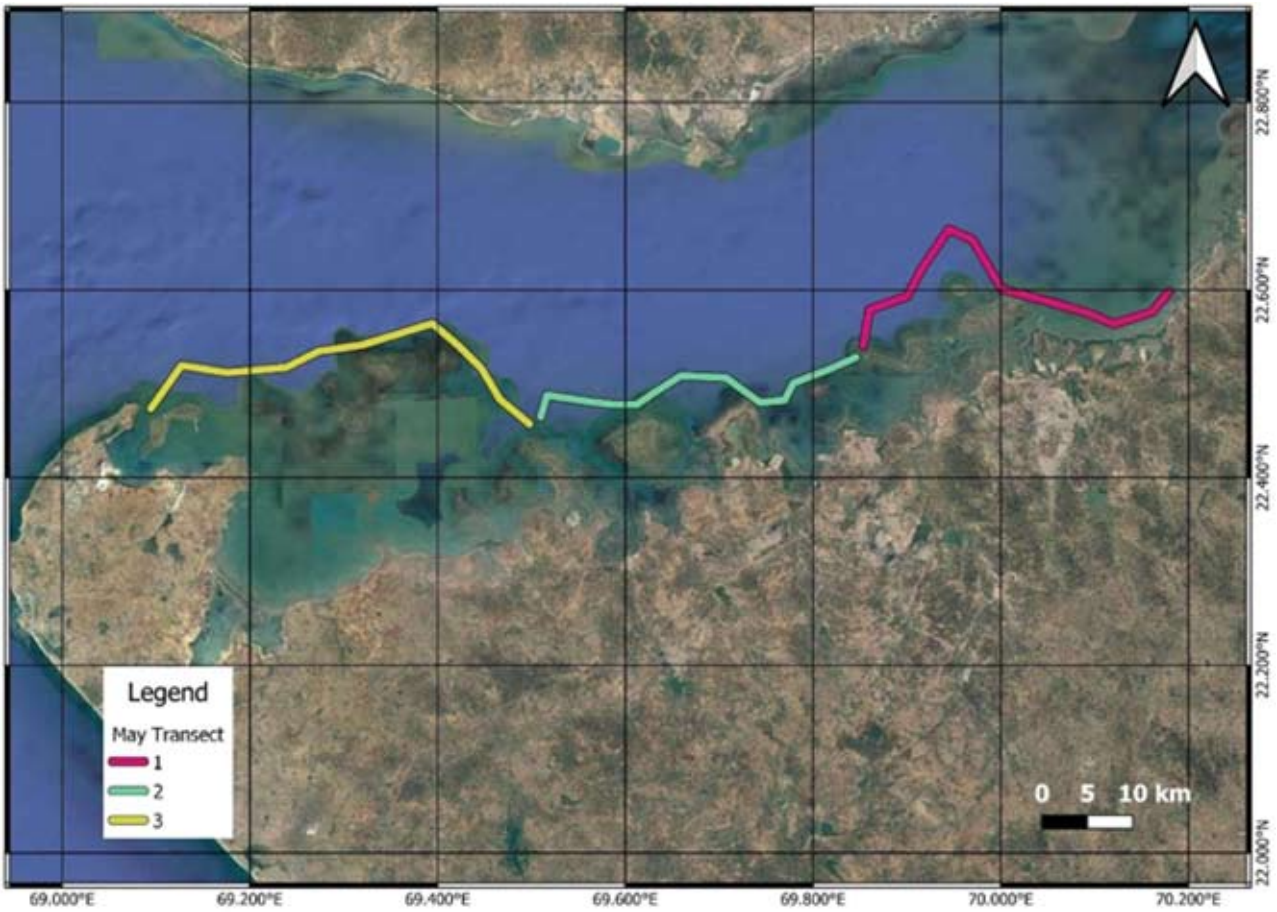
Map 5: Transects of November'21 (T1 and T2)

Map 6: Transects of December'21 (T3 and T4)

Map 7: Transects of February'22 (T5, T6 and T7)



Map 8: Transects of April'22 (T8, T9 and T10)



Map 9: Transects of May'22 (T11, T12 and T13)

C). Density of Dolphins

1. Density is defined as the number of individuals of given species that occurs within a given unit or study area. Species density refers to the number of individuals of a species in an area. It is measured in individuals per unit area. It is a useful value that can be used to determine the health of an ecosystem. In this study we took density of Dolphins and calculate it. Density formula is no. of individuals / area (Km2).
2. $Density\ (D) = No.\ of\ Dolphins\ recorded\ (n)\ area\ of\ Transect\ (km2)$
3. Total 113 individuals of S. plumbea were recorded of which one individual was a calf on Transect No.
4. Total 10 individuals of T. aduncus were recorded during the study, so in total 123 individual Dolphins were recorded from 440 km2 area with an average density of 0.27/ km2. The probability of sighting a Dolphin thus becomes, 3.6 km2 within the sampled area.
5. The maximum density was recorded on transect no. 1 followed by 4 and 7.
6. The correlation between density and length of transect was marginally positive.

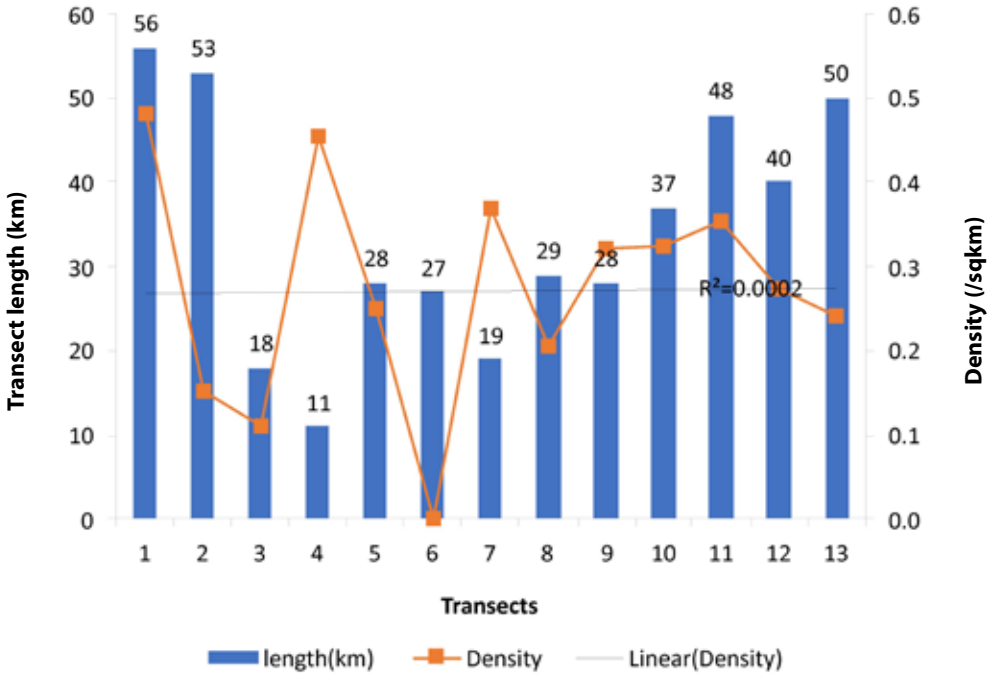


Figure 7: Density of Dolphins on various transects

D). Frequency

1. There was total 33 instances out of 296 where Dolphins were recorded. Thus, the frequency of sighting a dolphin was 11% per effort.
2. Maximum sightings were in Transect no. 1 and 11 (n=5)
3. The average distance between two sightings was 6 km

E). Encounter Rate

1. Encounter rate can be calculated as
   $Encounter\ rate\ (R) = No.\ of\ Sightings\ Total\ km\ of\ distance\ travelled$
2. Average encounter was calculated based on above equation (Gowda and Kumara 2009).
3. The number of sightings were 35 and the total length of transects was 444 km, thus the average encounter rate was calculated as 0.08.
4. Maximum encounter rate was calculated on transect no. 4 followed by transect no. 7. Whereas transect no. 6 had nil sightings.
5. However, there was moderate inverse correlation between the length of the transect and the encounter rate (Correl=-0.3).

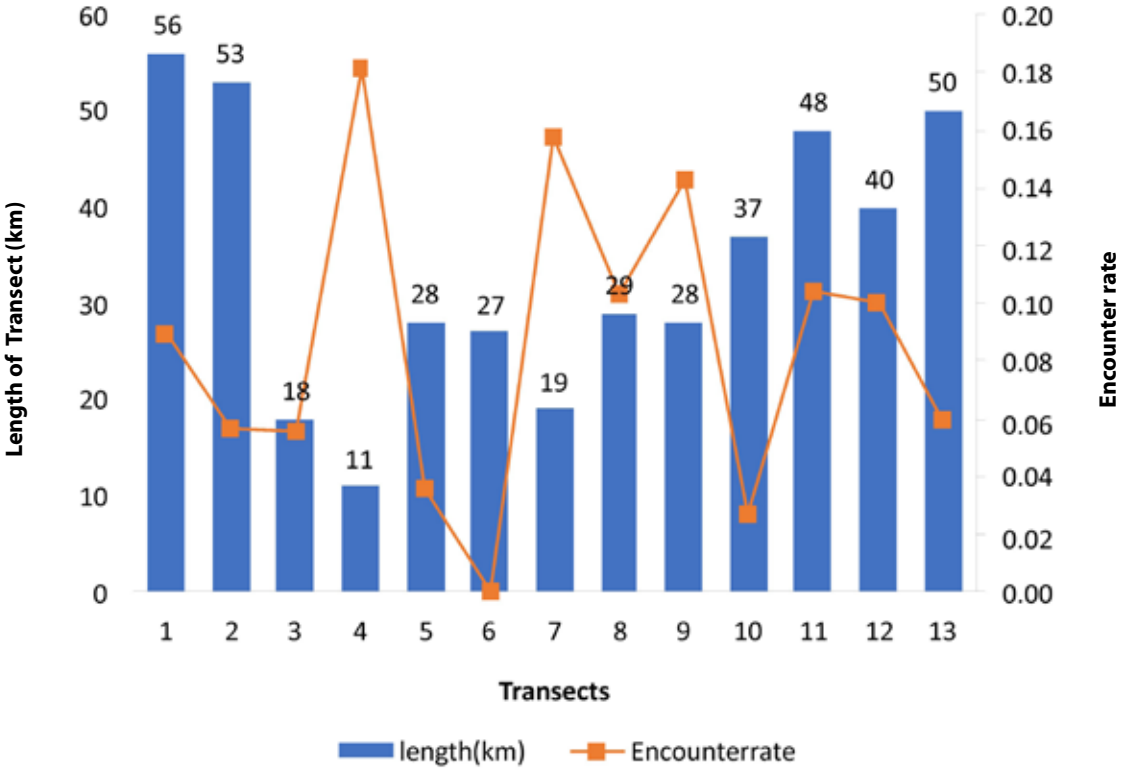


Figure 8: Encounter rate of Dolphins in MNP & S

F). Depth

1. The depth at each sighting was measured and it varied from 1to 33m. The correlation between Dolphin population and depth is positively correlated.
2. Majority of the Dolphins (61%) were sighted within the depth of 10 meters, whereas 29% were sighted between the depth of 11 m to 20 m

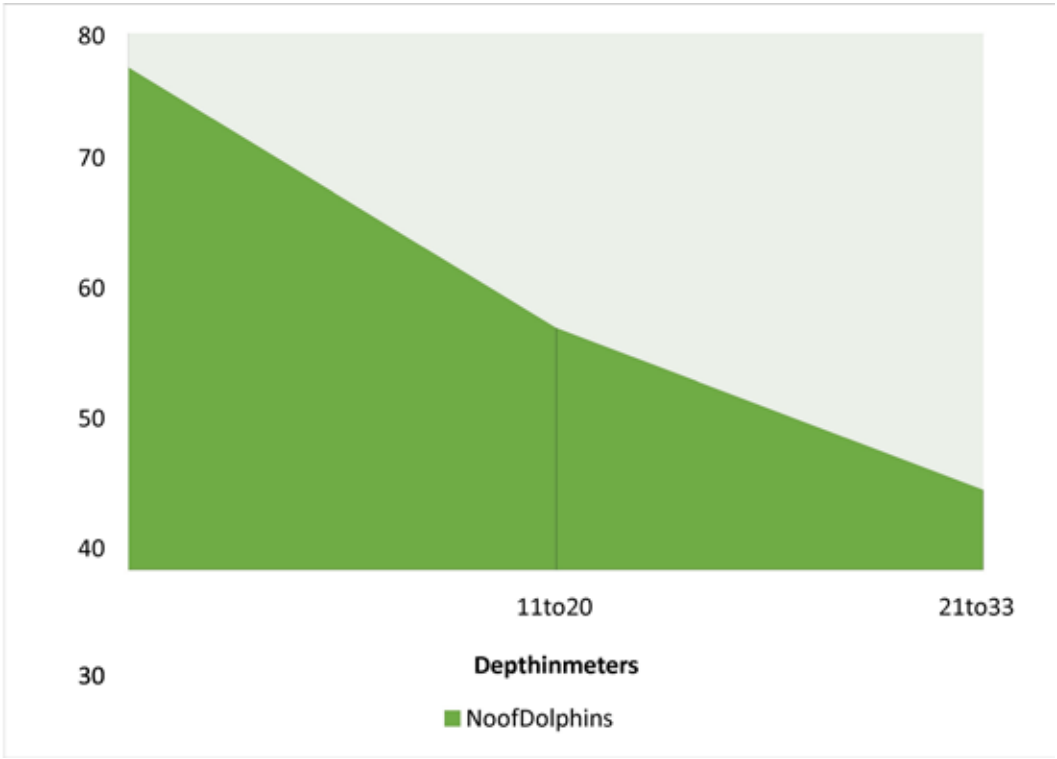


Figure 9: Dolphin sightings at Different depth

G). Evidences of Dugong presence

1. Dugong is an herbivorous marine mammal and generally nocturnal in behavior. However, for breathing it surfaces during the bright day light, which is the only probable time to sight the animal.
2. Intensive search was made around seagrass beds to assess the presence of Dugong, through direct sighting.
3. There was no direct sighting of the species during the survey.
4. During the assessment of the seagrass beds, indirect evidences such as feeding trails were recorded for understanding the Dugong presence
5. Dugong feeding trails were recorded at Paga, Chank, Bhaidar Ajad, Pirotan and Narara
6. These feeding trails were assessed to be of Dugong and the width varied from 27 cm to 11 cm.
7. The width of 27 cm recorded at Narara can be considered as large trail and can be of a full-grown adult Dugong.

Photo 17: Feeding trail on Halodule uninervis

Table 5: Dugong feeding trails

N	E	Island/Reef	Length ofthetrail(m)	Dominating Sea Grass	Average width of the trail(cm)
22.46472222	69.22027778	Paga	4	*Halophilaovalis*	14
22.52555556	69.40861111	Chank	9	*H. ovalis*	17
22.45694444	69.29666667	Bhaidar	8	*Haloduleuninervis*	19
22.4	69.325	Ajad	9	*H. ovalis*	11
22.47805556	69.73333333	Narara	4	*H. uninervis*	27
22.59527778	69.94583333	Pirotan	11	*H.ovalis*	22

H). Seagrass assessment

1. Assessment of seagrass beds was done through 1 x 1 m quadrats. These quadrats were laid in the pre-identified seagrass patches at Pirotan, Narara, Kalubhar, Ajad, Bhaidar and Paga.
2. Total 120 quadrats were laid at six locations
3. Total 4 species viz. Halophila Ovalis, Halophila stipulacea, Halodule uninervis and Halodule pinifolia.were reported belonging to two genera viz. Halophila and Halodule.
4. Average live grass cover was 26%. Maximum was recorded at Narara and Vadinar with 42% live grass cover followed by Kalubhar (28%) and Pirotan (24%).
5. Total 18 species of fauna was recorded from the Seagrass beds of which maximum diversity was recorded at Narara followed by Pirotan.

Table 6: Quadrats laid at different locations

Sr. No.	Location	Total mapped area (km^2)	No of quadrats
1	Pirotan	0.82	18
2	Narara	0.92	27
3	Kalubhar	1.68	30
4	Ajad	0.73	12
5	Bhaidar	0.21	20
6	Paga	0.96	13
	Total	5.32	120

Table 7: Live grass cover and benthic composition

Sr. No.	Location	Live Grass cover	Algae	sand/mud	Rubbles
1	Pirotan	24	45	18	13
2	Narara&Vadinar	42	39	14	5
3	Kalubhar	28	38	12	22
4	Ajad	10	27	45	18
5	Bhaidar	20	32	30	18
6	Paga	32	37	22	9
	Average	26	36.33	23.5	14.17

Table 8: List of faunal species recorded from seagrass beds

Sr. No.	Group	Species	Pirotan	Narara	Kalubhar	Ajad	Bhaidar	Paga
1	Sponge	Cinachyrellasp	+	+	+	+	+	-
2		Leucosolenia sp	+	+	+			
3		Halichondria panacea	+	+	+		+	
4	Annelida	Polychaetasp.		+	+			

Table 8: List of faunal species recorded from seagrass beds (*contd.*)

Sr. No.	Group	Species	Pirotan	Narara	Kalubhar	Ajad	Bhaidar	Paga
5	Arthropoda	Wolfcrab	+	+				
6		Portunus pelagicus	+	+	+	+	+	+
7		Spidercrab		+				
8	Gastropoda	Cerithedea1		+				+
9		Cerithedea2	+	+				
10		Turbosp1	+	+		+	+	+
11		Turbosp 2		+	+		+	
12		Joruna funnebris	+		+		+	
13		Hypselodoris infucata	+	+	+	+	+	+
14		Conussp.				+		
15	Echinodermata	Holothuriasp.		+	+			
16		Seastarsp.	+	+	+			
17		Brittlestar sp.		+			+	
18	Pisces	Groupersp	+	+		+	+	+
			11	16	10	6	9	5

Species Profile	
Common Name	Indian Ocean humpback dolphin
Class	Mammalia
Order	Artiodactyla
Infraorder	Cetacea
Family	Delphinidae
Genus	Sousa
Scientific name	*Sousaplumbea* (G.Cuvier,1829)
Information	• Humpback dolphins are found in shallow near-shore marine environment throughout their tropical and subtropical range, which includes most of Australia's, Africa's, and Asia's coastlines. • The Indo-Pacific humpback dolphin (*Sousa chinensis*), the Indian Ocean humpback dolphin (*Sousaplumbea*), the Atlantic humpback dolphin (*Sousateuszi*), and the Australian humpback dolphin (*Sousasahulensis*) are the fours pecies of humpback dolphins, with very little overlap between their ranges. • The Indian Ocean humpback dolphin (*Sousaplumbea*) occupying coastal areas ranging from Southern Africa to Western Indochina. The species (*Sousachinensis*) was formerly included within the same species, but in 2014 study revealed them to be a separate species (Jefferson,*etal.* 2014).

Species Profile (*contd.*)	
Photo	

Species Profile	
CommonName	Indo-PacificBottlenoseDolphin
Class	Mammalia
Order	Artiodactyla
Infraorder	Cetacea
Family	Delphinidae
Genus	Tursiops
Scientific name	*Tursiops aduncus*(Ehrenberg, 1832[1833])
Information	• Thecommonbottlenosedolphin(Tursiopstruncatus)andtheIndo-Pacific bottlenose dolphin (Tursiops truncatus) are thetwospecies(Tursiopsaduncus)(Charlton-Robb,K.etal. 2011).
Photo	

DISCUSSION

6. Discussion

A). Dolphins

1). **General Discussion**: Marine mammals can play important ecological roles in aquatic ecosystems, and their presence can be a key to community structure and function. Consequently, marine mammals are often considered indicators of ecosystem health and flagship species (Nelms et al. 2021, Endangered species research). The Marine National Park and Sanctuary (MNP & S) falling in Gulf of Kachchh area was highly neglected with reference to systematic ecological studies of marine mammals for a long time, except few papers (Fraizer and Mundkur 1990; Singh H. S. 2003; Sutaria and Jefferson 2004). The current study was originally planned for two years of fieldwork to understand the distribution patterns, breeding grounds and abundance with reference to their environs. However, one season data also throws light upon several aspects of marine mammals in the protected waters of MNP & S.

In total 3 species of marine mammals were identified and recorded during the study viz. Indian Ocean humpback dolphin (Sousa plumbea), Indo-Pacific Bottlenose Dolphin (Tursiops aduncus) and Dugong (Dugong dugon).

The Indian Ocean humpback dolphin (Sousa plumbea) was described as a separate species from the Indo–Pacific humpback dolphin (Sousa chinensis), based on molecular analysis, skeletal morphology, and external morphology and coloration (Jefferson & Rosenbaum, 2014; Mendez et al., 2013). There needs to be an official document to be published through the IUCN Red List, which still lists both these species as forms of S. chinensis (Reeves et al., 2008). More recently, Sousa plumbea has been assessed as an independent species by Braulik, Findlay, Cerchio, and Baldwin (2015) using IUCN Red List Criteria, based on the most recent available

data across its range. Both assessments agree that, regardless of taxonomic status, Indian Ocean humpback dolphins should be listed as 'Endangered' when considered as a separate species (Braulik et al., 2015) as well as when considered as S. chinensis (cf. plumbea form) (Reeves et al., 2008). The dolphin population of the entire west coast of India, including MNP & S falls under the recent distribution of the newly described S. plumbea however, molecular analysis of these population patches is required.

The population in the MNP & S is restricted to few patches and requires adequate attention for better conservation management policies. Considering the poor knowledge on the species movement patterns and fine scale population structures, any in−depth assessment of the species' total abundance, conservation status and management needs remains challenging.

There were two major studies published, describing the abundance of Dolphins in the MNP & S (Sutaria and Jefferson 2004 and WII press report 2019). Sutaria and Jefferson (2004) could record 78 individual in 21 groups belonging to only one species

i.e. Sousa chinensis. However, the study and the area cover were very restricted. Whereas, the Wildlife Institute of India reported about 235 individuals along the coast of Gulf of Kachchh. In the current study, a total of 123 individuals from two species viz. Indian Ocean humpback dolphin (Sousa plumbea), Indo-Pacific Bottlenose Dolphin (Tursiops aduncus) were recorded in 35 groups. Out of 123 only 10 individuals belonged to T. aduncus and thus S. plumbea was the outright dominant species. The density varied from 0.1 to 0.5 individuals / km2, which is near to the density of the study carried out in 2004 by Sutaria and Jefferson (0.27 individuals/ km2). The density in the MNP & S is relatively higher compared to its nearby population in the Northern Persian gulf (Hemami et al. 2018, Ecological Indicators).

During the entire study, only one calf was recorded in the month of February 2022, indicates low breeding population. There is a need for continuous monitoring of such groups to understand the life cycle of dolphin in the particular region. Species such as Common Dolphin (Delphinus delphis) (as reported by Singh H. S. (2003), was not recorded during the study, and looking at its geographical range, it is probably misidentified with T. aduncus.

The results of the distribution data based on the fishermen's perception surveys and the survey data coincided and showed similar distribution pattern. There are two distinct groups, one around Chusna and Beyt Dwarka islands and another group around Dedeka-Mundeka and Pirotan islands. The remaining small groups may be a part of these two distinct groups. The maximum density was observed near Khara-meetha Chusna island where a group of 16 S. plumbea was recorded in the month of November 2021. In the current study 61% dolphins were sighted within the depth of 10 meters and 29% between the depth of 11 to 20 meters. Whereas Sutaria and Jefferson (2004) had recorded that 57% sightings were within the depth of 10 meters. Thus in the MNP & S, the preferred depth for dolphins are up-to 20 meters with 10 meters as most preferred depth. Also, such subtidal depths near the reefs during low tides are ideal for these species as with the receding tides, fishes from reef also travels down to these depths, which will be utilized by dolphins as source of food.

2). **Threats to Dolphin**: From the Maritime Board jetty of Okha, regular dolphin watching shows are being arranged by local boatmen on chargeable basis. These charges may vary from INR 1,000/- per person to 15 to 20 thousand rupees for the entire boat ride of three to four hours. These shows are purely on private basis and no government department has stake in the same. This may lead to notorious, uncontrolled disturbing behaviours of tourists which affect the dolphins. Videos of such dolphin watch programs are available on social media and one can observe disturbing behaviours, including use of loudspeakers by tourists during dolphin watch. This activity needs to be intervened and shall be done under strict observations.

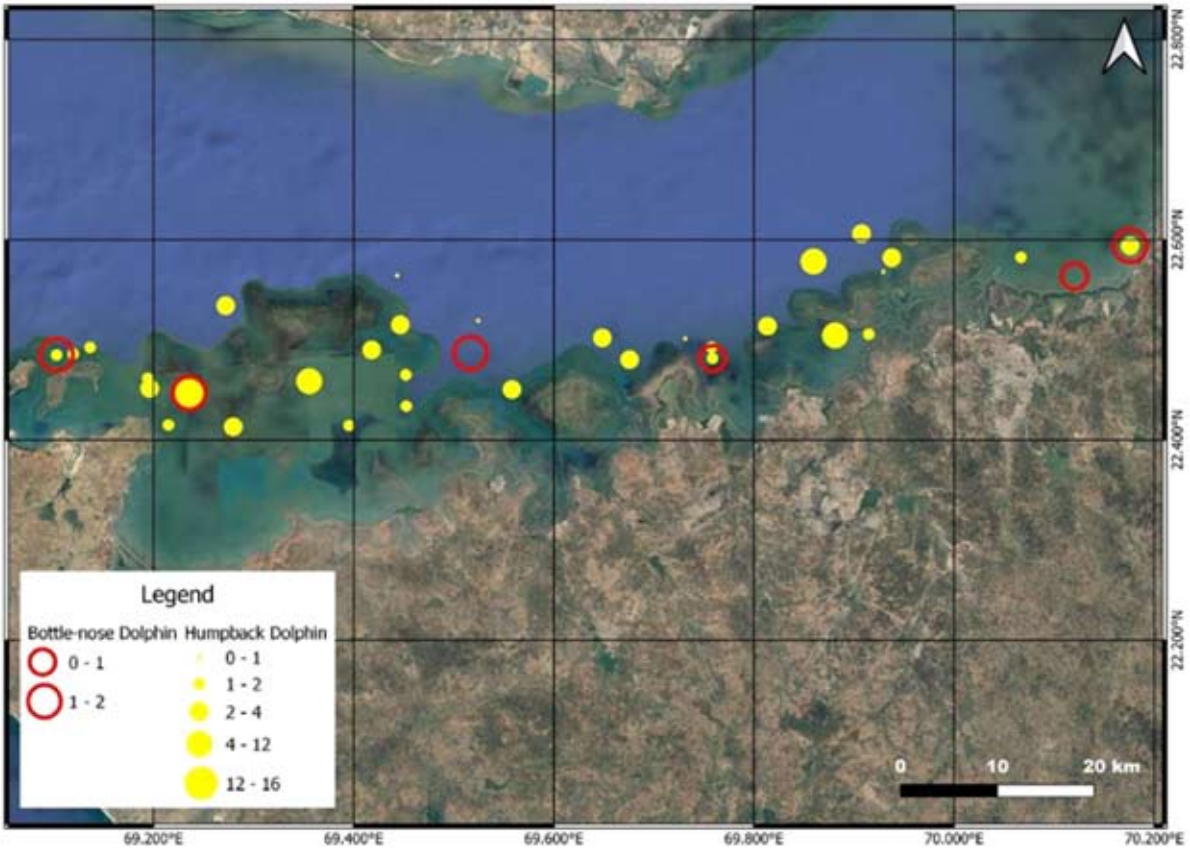
The area is also known for prawn fishing and hundreds of large trawlers are being operated in the area. These trawlers accidentally may get dolphin calves as bycatch. In addition to that, the possibilities of dolphins getting injured through propellers is also very high. Impacts of pollution, coal, petroleum wastes etc. needs

to be checked on regular basis. In case of any dead carcass of dolphin is available, proper tissue analysis for toxicity and impact of pollution shall be studied.

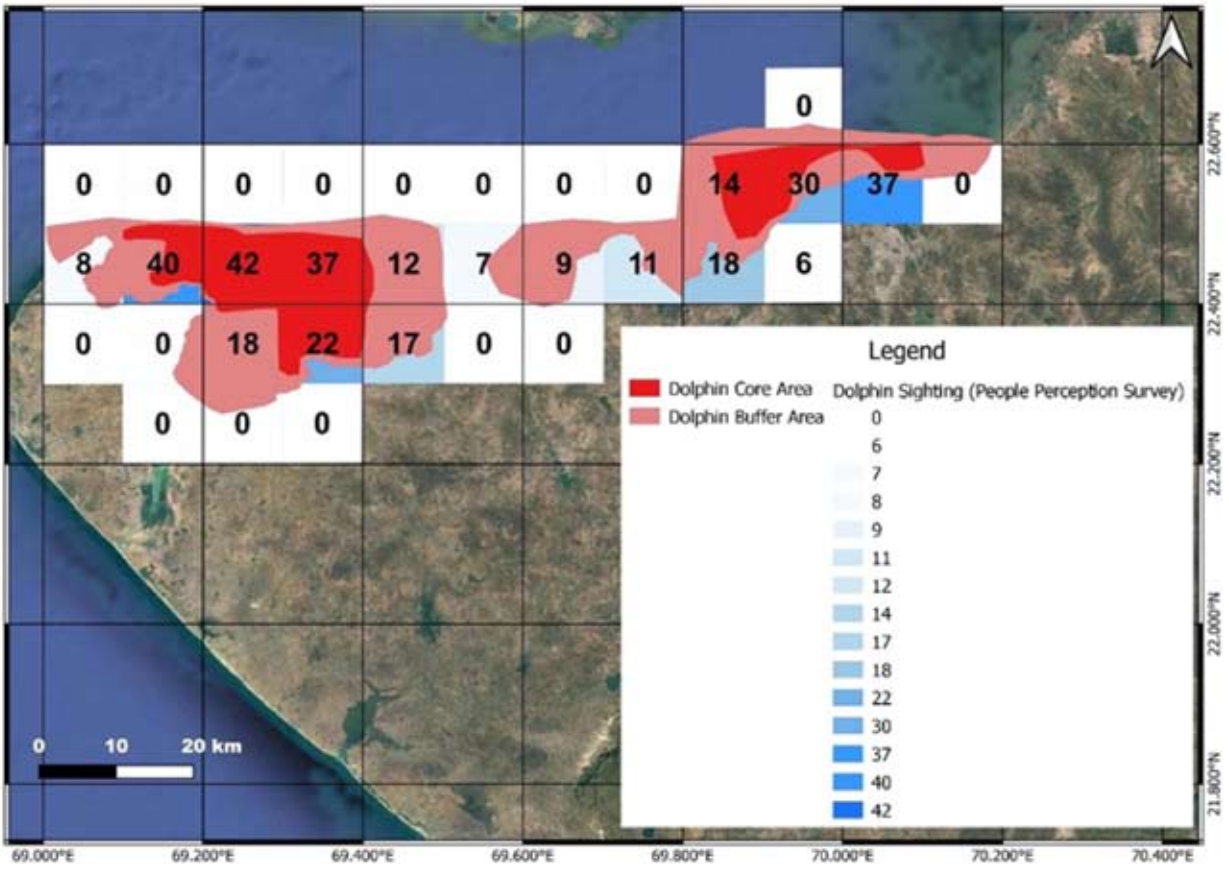
Most of the islands are isolated and many times fishermen utilize these islands to clean their nets. Some of these nets are discarded on islands itself. During the hightides these nets floats into the coastal waters and act as ghost nets. These are one of the threat which needs to be addressed through banning the net discarding in water or islands and if foud, collection of these nets should be a part of management practice.

Status of Dugong in the Marine National Park and Sanctuary

Photo 18: Boat traffic and Dolphin



Map 10: Distribution of Dolphins in MNP & S



Map 11: Distribution of dolphins based on perception survey and actual field survey

B). Dugong

1). **General Discussion**: Dugongs (Dugong dugon Müller, 1776), belonging to the family Dugongidae and order Sirenia are herbivorous marine mammals. They are distributed in the Indo-Pacific region from Gulf of Aden to Australia. They mainly feed upon seagrasses of the genera Cymodocea, Halophila, Thalassia and Halodule (Marsh et al. 2002). Developmental activities and an economic dependence of coastal populations on marine resources threaten near-shore seagrass beds, which are declining globally at a rate of 7% per year (Waycott et al. 2009; Green and Short 2003). Restricted to the inshore waters due to their dependence on seagrass beds, dugongs remain vulnerable to hunting, boat strikes and habitat disturbances . Additionally, incidental entanglement in gill nets has been identified one of the prime causes of the decline of the dugong population in all the sub-regions of its current distribution, which extends across the waters of 37 countries (Marsh et al. 2002).

The waters off Sikka and Vadinar, the inter-island area between Ajad Island, Chank Island, Bhaidar Island and Bet Dwarka, were identified as a critical dugong habitat (WII 2013). The region around Poshitra and Bet Dwarka is reported to be suitable for dugongs due to the presence of seagrass and the low anthropogenic stress due to the absence of major ports (Singh 2003).

The presence of this herbivorous mammal in the MNP & S is mostly through indirect evidences. There are two major reasons for it (i) the species itself is very shy and nocturnal in behavior (ii) The population of the species is thought to be very little and thought to be 10 to 15 (Pandey et.al, 2010) and is sparse.

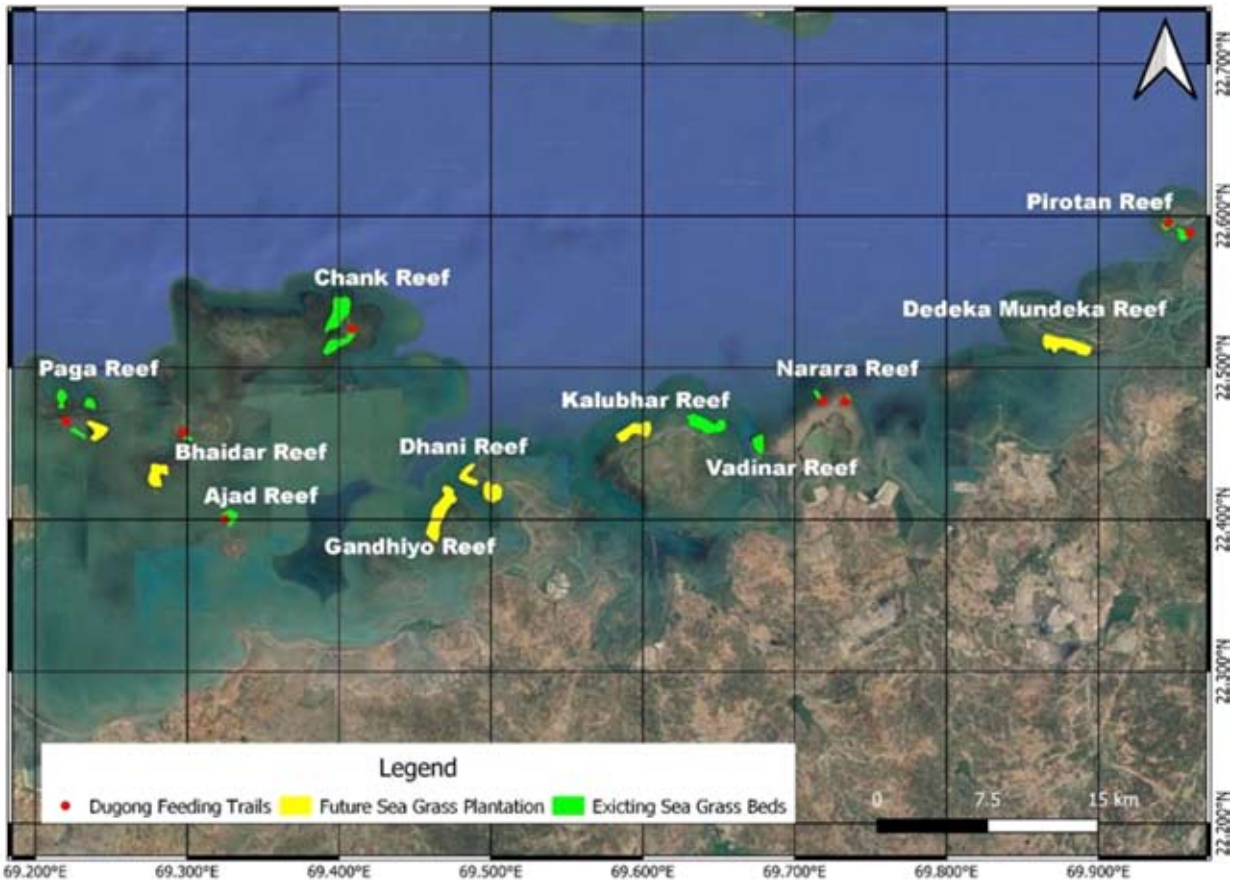
Most of the records of the species are from the western parts of the gulf and majority of the records are stranded, washed off dead animal questioning the status of the population within the GoK. Most of the observations of the species in the GoK are stranding records towards Okha, Poshitra and Bhaider i.e. opening

of the gulf, indicating the population as vagrant or non-resident to the GoK. Pandey et al. (2010) recorded the first feeding trail for Gulf of Kachchh from the seagrass meadows of Pirotan Island This is the second record of the feeding trail from the central part of the GoK. Narara is an important Dugong habitat in the Gulf of Kachchh (Sivakumar and Nair 2013). Kamboj (2014) provided status of the seagrass in the Marine National Park and Sanctuary, however the seagrass beds of Narara are not included in the same. Most of the records of Dugong, whether stranded or evidences such as feeding trails, coincide with the existing seagrass beds (table 2; Fig 2).

The dugong population in the Arabian Gulf is believed to be the second largest in the world after Australia. Akab Island (Umm al Qaywayn, UAE) is the oldest site (6000 years) where dugong remains have been discovered (Jousse 1999). The Arabian Gulf is considered to contain the most important dugong habitat in the western half of the dugong's range (Preen 1989a). The population of the Arabian gulf was estimated to be 1861 individuals in summer and 2185 in winter. (al-Ghais & Das 2001). The phenomenon of winter congregation and dispersed population in summer was also reported by Preen (1989).

During the current study, direct sightings were not reported. The presence of the species was noticed only through the feeding trails in the seagrass beds. Seagrass patches were surveyed at Pirotan, Narara, Vadinar, Kalubhar, Ajad, Chank, Bhaidar and at Paga reef and feeding trails were recorded. The observation of Dugong feeding trail in this area is important indirect evidence of the presence of the species and is of considerable importance as it indicates the presence of live animal in the central areas of the GoK indicating the presence of the species in this area further more towards the east in the Gulf of Kachchh. The width of the feeding trails normally ranges from 10 to 25 cm (approximately the width of a dugong's facial disk) and the length ranges from 30 cm to several meters (Anderson and Birtles, 1978; Aragones, 1994; Preen, 1992). Evidence of dugongs using a locality can be obtained from their feeding trails.

The size of the feeding trails varied at each location and did not show any significant correlation between any two sites. These trails ranged between 11cm to 27 cm in width and from 4 to 11m in length. The lower width suggests the presence of calf/sub adult whereas the width of 27 cm represents large or adult Dugong.



Map 12: Seagrass distribution and Dugong feeding trails

The feeding trail reported by Anand et al (2012) was in the month of May whereas, Apte et al. 2019 also reported feeding trail in month of May The presence of the species in summer give rise to two different probabilities; (a) The species is present in the area in very low number so that it is not recorded live or (b) The occurrence is accidental and result of population dispersal in Gulf of Arab during summer. However, distance between these two sites is more than 1500 km and this hypothesis needs to be assessed by satellite tagging few animals in the Arabian Gulf. Even at all the latter hypothesis is proved, it might lead to several other avenues of research for this species.

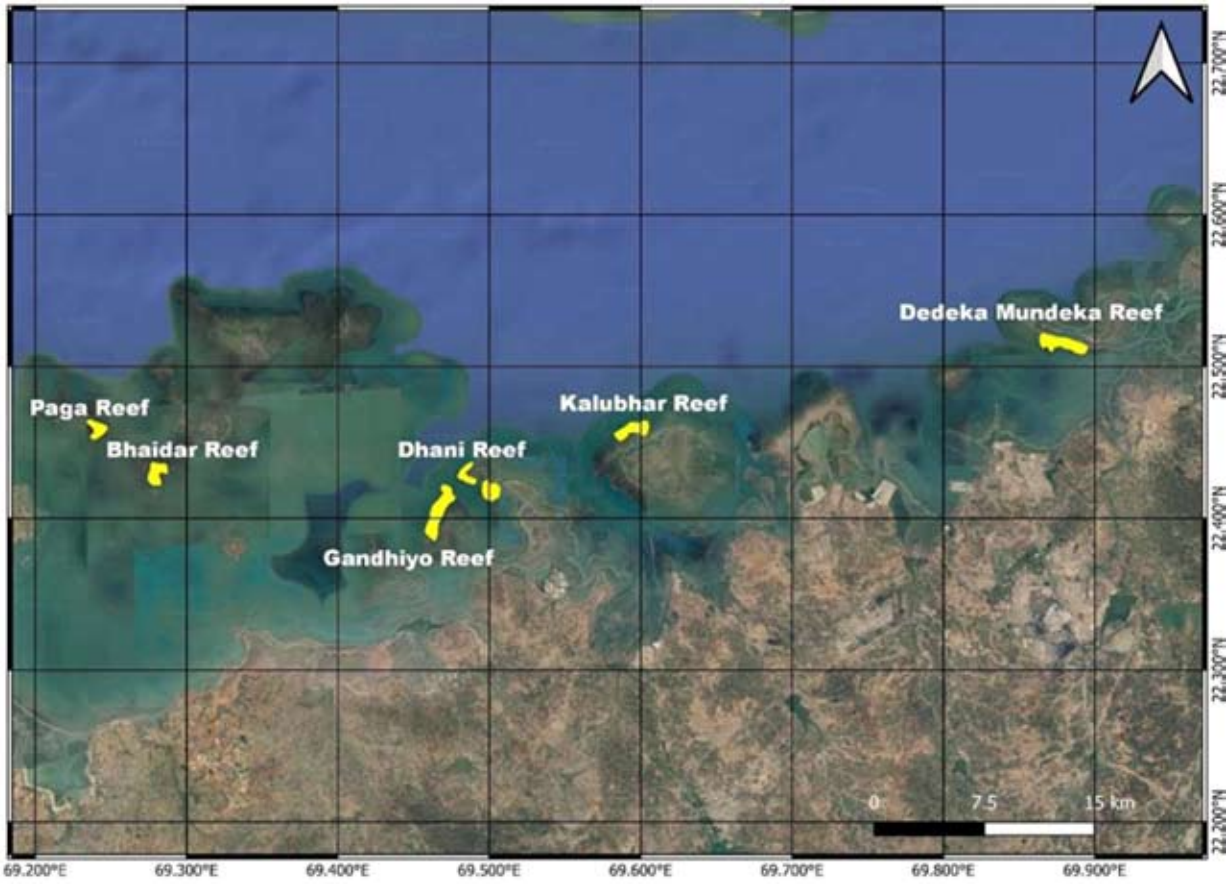
Observations and frequent monitoring of these seagrass meadows may help in understanding the presence and movements of the Dugong population in the area. This information will be valuable for the better management practice of the species in the region.

C). Sea Grass

1). **General Discussion**: Seagrass meadows constitute ecologically and economically important habitats. Many edible fish inhabit seagrass beds, which also act as nurseries for many commercial fish and shellfish species (Kamboj 2014). Six species of seagrass are reported from the region (Phillips & Menez, 1988). There are few published studies on seagrasses in the Gulf of Kachchh MNP&S, but the distribution of seagrass has been recorded by various agencies/organizations working among the mangroves, coral reefs and other habitats. Jagtap (1991) reported the occurrence of four species of seagrass from Gulf of Kachchh viz Halophila beccarii was reported to be common while Halodule uninervis, Halophila ovalis and Halophila ovata were very rare. The status of seagrass was reported to be degraded. Nair (2002) reported three species, Halodule univervis, Halophila ovate and Halophila beccari on sandy regions of Narara and Kalubhar reefs. A comprehensive study on biodiversity and management issues of the MNP&S by Singh et al. (2004) indicates the status of seagrass in different locations. Singh et al. (2004) reported only three species of seagrass from the intertidal reef areas of Gulf of Kachchh MNP&S compared with the six species reported by SAC (2010).
The current study reported four species of seagrass viz. Halophila Ovalis, Halophila stipulacea, Halodule uninervis and Halodule pinifolia. All the species were reported earlier. Through GIS, 5.32 km2 area was mapped under seagrass beds. The density of seagrass was high at Vadinar followed by Paga, Kalubhar and Pirotan. Along with seagrass, filamentous algae were the dominant flora with high cover upto 58% in several quadrats, covering the seagrass patches. Gastropods were one of the most common group amongst associated fauna with Hypselodoris infucata as common species observed throughout the all locations. In crustaceans, Portunus pelagicus was the most common species.

2). **Threats**: Seagrass beds are highly threatened due to pollution and sediment load in the area. Constant movement of trawlers, boats and cargo vessels keep churning the water which leads to deposition of sediments and pollutants on the floor of intertidal areas.
In total at 6 locations, seagrass transplantations are proposed based on the similarities of substrates, sediment compositions and presence of same or similar fauna. The total area of this proposed seagrass restoration is about 11km2. Such restorations shall be carried out on regular basis and new areas shall be explored. The seagrass beds are smaller in size in this area compared to that of east coast.

Photo 19: Flat inter tidal area is good for sea grass



Map 13: Proposed Seagrass restoration sites

Photo 20: Typical behavior of Indo-pacific Humpback Dolphin

Photo 21: Hunting behavior of Indo-pacific Humpback Dolphin

Photo 22: Pod of Indo-pacific Humpback Dolphin

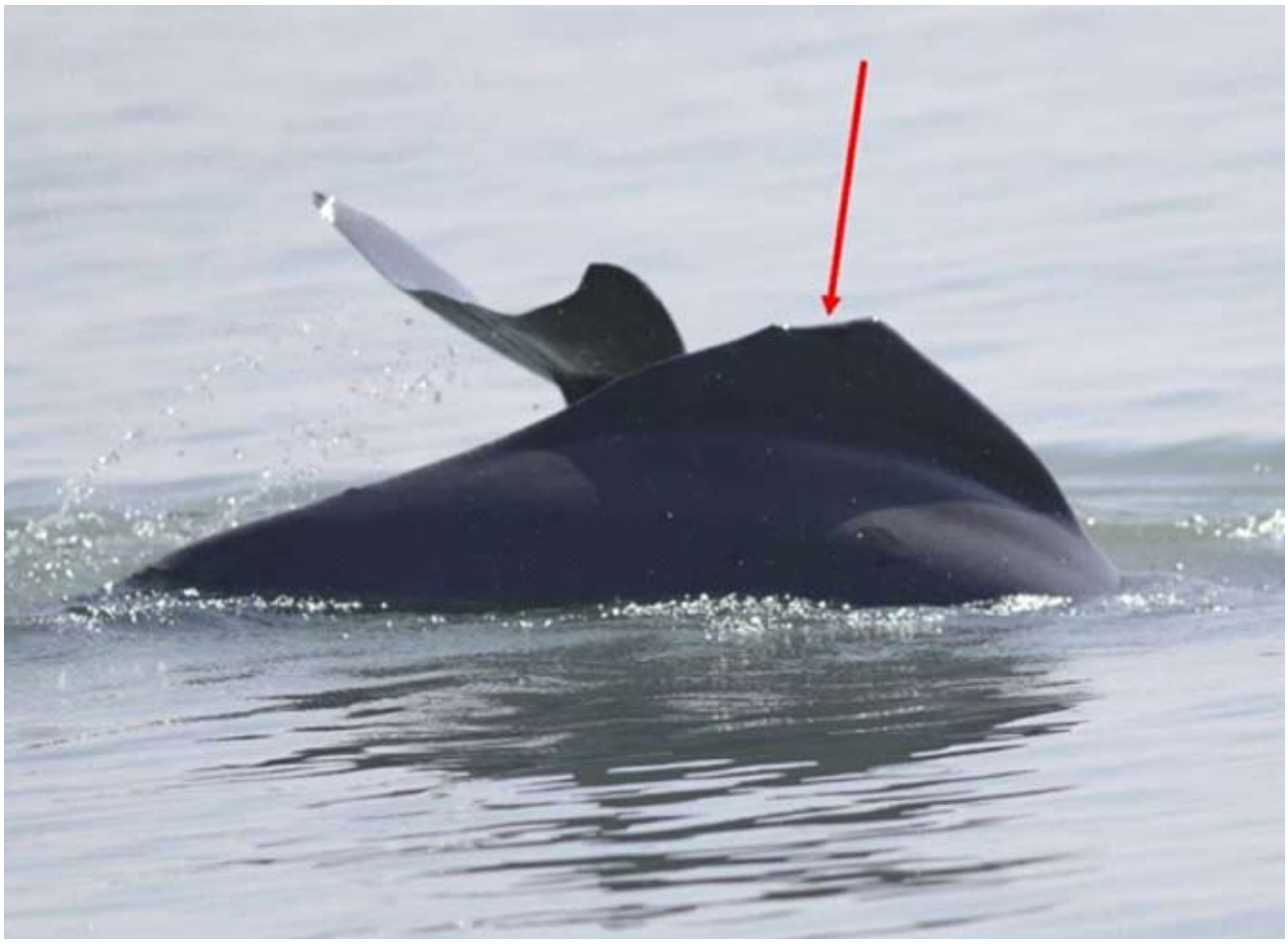


Photo 23: Damaged dorsal fin in Indo-pacific Humpback Dolphin

Photo 24: Threat from Ghost net is real (Gul sp. Trapped in Ghost net)

CONSERVATION INPUTS

7. Conservation Inputs

Marine mammals like Dolphins and Dugongs act as umbrella species for the conservation of their respective ecosystems such as coral reefs and seagrass beds. They are also part of the migratory phenomenon taking place in oceans. Marine National Park and Sanctuary situated in the Gulf of Kachchh is protecting three major coastal ecosystems viz. coral reefs, mangroves and seagrass beds. For the conservation of these ecosystems, issues related to marine mammals shall be prioritized as these species are the umbrella species of the respective ecosystems. Some of the recommendations are as follows:

Regular scientific monitoring of Dolphins shall be carried out. There can be two monitoring exercises in every year i.e. in September / October and another in February/March. In addition to this, monitoring through drones can be carried out intensively on daily or weekly basis.

The frontline staff shall be trained in the monitoring. Training should include identification, monitoring and documentation techniques etc. Documentation techniques should also include operations of cameras and drones.

Information and stranding response system can be developed for marine mammals which are sighted live or stranded by local community.

To understand the movements of these marine mammals including Dolphins and Dugong, telemetry programs can be started and long-term satellite tracking data should be generated.

To understand the genetic population, genetic analysis shall be carried out.

For the habitat restoration for Dugongs, seagrass transplantation plots can be developed. During this project, a small exercise was carried out to identify similar intertidal patches where seagrass restoration / transplantation can be done.

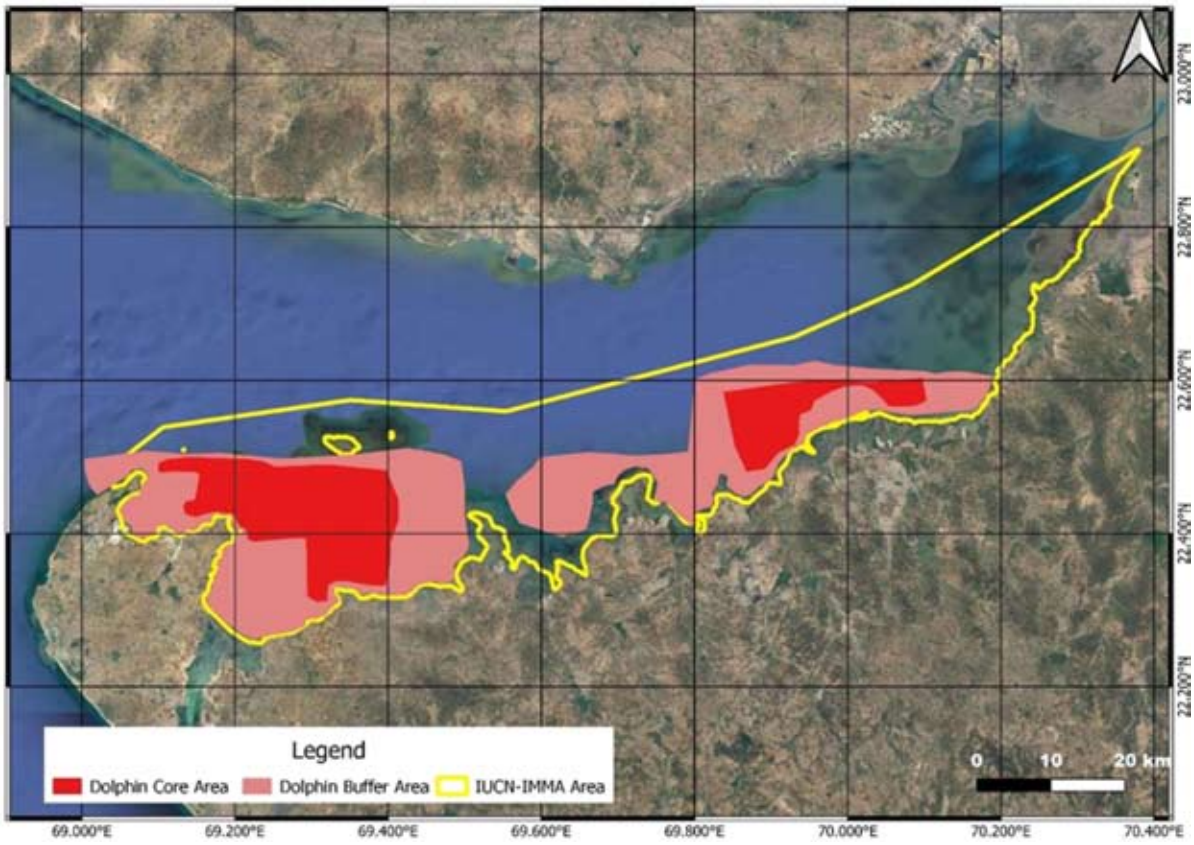
Monitoring of seagrass is essential as we may get evidences of existence of Dugong through feeding trails. Such monitoring shall be carried out in pre-identified seagrass areas and data such as length and width of trail, species of seagrass etc. shall be recorded.

There is a need to completely map the seagrass ecosystem of the MNP & S and come up with an Atlas of seagrass by competent national level agency.

Awareness material such as pamphlets, posters shall be displayed in local language at various fishing villages and ports to aware the community about the ecological importance of marine mammals.

Plastics and ghost nets are one of the key threats to the marine mammals. Various stake holders such as fishermen, Indian coast guard, Indian Navy, Industries etc. shall be involved in Plastic collection and ghost net removal drives. Awareness programs shall be arranged for these stake holders.

Important Marine Mammal Area (IMMA) is the program by Marine mammal task force, and they have identified entire Gulf of Kachchh as an IMMA. However, based on the current study, we have proposed that within the defined IMMA, two major areas are critical for marine mammal conservation and must be prioritized for conservation management. Both the areas fall within the identified IMMA of Gulf of Kachchh (Map:14)



Map 14: Critical Marine Mammal area in Gulf of Kachchh IMMA

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9. Annexure

Annexure 1: Questionnaire Survey Form

Village Name: ________________ Sex: ________________ Age: ________________

Do you do Fishing: ________________ How long you do Fishing: ________________ Where do you fish: ________________

Have you seen Dolphin: ________________ Where have you seen Dolphin (on the base of Grid Map): ________________

Which Species of Dolphin (on basses of photo card): ____

Frequency of sighting: ________________ Pod Size: ________________ What has happened to Dolphin population: _________

What is the reason behind change in Dolphin population: ____

Have you seen Dugong: ________________ Where have you seen Dugong (on the base of Grid Map): ________________

Frequency of sighting: ________________ Pod Size: ________________ What has happened to Dugong population: _________

What is the reason behind change in Dugong population: ____

Annexure2: Marine Mammals Identification Guide