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RECOVERY OF **DUGONGS** AND THEIR HABITATS IN INDIA

AN INTEGRATED
PARTICIPATORY APPROACH



Recovery of Dugongs and their habitats in India: An integrated participatory approach

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1. EXECUTIVE SUMMARY

Dugong (*Dugong dugon*), commonly known as **sea cow**, is found to occur in three states/Union Territories of India viz. Andaman & Nicobar Islands, Tamilnadu (Gulf of Mannar, Palk Bay) and Gujarat (Gulf of Kutch). Being primarily herbivorous, these marine mammals depend on underwater seagrass habitats for forage and require large areas to breed along near shore waters of these sites. Dugongs are assessed as vulnerable to extinction in the IUCN red list and are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendix II of the Convention on Migratory Species (CMS). Their population along the Indian coast has declined considerably mostly due to human-mediated threats such as fishnet entanglement, hunting for meat, seagrass habitat loss and degradation, coastal pollution apart from natural threats such as climate change.

With substantial funding from National CAMPA Authority under the aegis of Endangered Species Recovery Program, Dugong Recovery Program was initiated with major objectives to a) Assess dugong population status through advanced census techniques and determine its abundance and distribution, identify critical habitats, classify threats and develop site-specific monitoring plan to reduce poaching and incidental entanglements, b) Characterize the critical dugong habitats, reduce direct and indirect threats, c) Raise awareness on the species and encourage the participation of the local communities; and d) Enhance the capacity of the State Forest Department staff and develop/implement smart patrolling tools to improve protection enforcement; train forest staff and local communities in underwater surveys for long-term habitat monitoring. In the last three years of its implementation, an **integrated participatory approach** was adopted to ensure recovery of dugong populations and conservation of seagrass their habitat in India. Some key achievements of this program have been listed below:

1. Habitat assessment of Critical Dugong Habitats conducted at Gulf of Kutch, Palk Bay and Andaman Islands have revealed new foraging grounds for dugongs at these sites helping delineation of critical dugong habitats. At Gulf of Kutch, several new meadows, homogenous as well as patchy, were mapped at Pagar (Hadkiwala and Betiwala reefs), Chusna (Chepri reef) Nakya reef, Bhaidar, and Noru (Tam reef). Seagrass surveys in Gulf of Kutch revealed new dugong foraging trails in Pashu islands' reef and Chepri reef. Hydrocharitaceae family members like *Halophila ovalis*, *Halophila decipiens*, *Halophila beccarii* etc are the most commonly found seagrasses in the GoK. These seagrasses along with the turf grass *Halodule uninervis* are considered to be the most resilient seagrasses with high colonisation ability, seed stock, and extreme tolerance to fluctuating salinity and light. Paga intertidal fringing reef, has the most contiguously growing yet topographically different meadows in its western and eastern parts. These meadows are protected from tidal currents and waves by a peripheral fringing coral reef. This gives seagrasses a unique opportunity to colonize sheltered areas of the reef. This meadow, although patchy, experiences a high seagrass abundance during summers with an average wet-weight of 10.4 grams per 20 Cm² SD- ±19.7 in Paga west and an average wet-weight of 20 grams SD± 11.02 in Paga east. The difference in wet-weights is because the eastern part of the Paga reef is more sheltered from tidal disturbances than the western region. East of Paga reef, being more stable, makes conditions for seagrasses to colonize available. Epiphytes were observed to be seasonal and their cover may reach a peak

of around 55-65 % of the whole leaf area during the dry summer season. Epiphytes majorly are composed of brown or green microalgae on the Hankiwala reef and Bhaidar islands. On Betiwala reef epiphytes on *Halodule uninervis* were crustose coralline algae. The less common of the epiphytes were polychaetes which were observed on mid-intertidal *Halodule uninervis*. Paga reef, our representative site for monitoring epiphytic variations, experienced a gradual decline in microalgal-epiphytic cover during winters of 2020 when temperatures drop by 10°C. Temperature loggers placed in the seagrass meadows provided new information on temperature fluctuations experienced by meadows in Gulf of Kutch.

2. Spatial distribution of seagrasses was assessed at 27 sites of Palk Bay, Tamilnadu using SCUBA diving and snorkelling. Surveys have been focussed mainly in Palk Bay due to high fishing pressure and the lack of any legal protection to the waters of this area. Seagrass meadows were surveyed for characteristics like abundance, the composition of seagrass species, species-specific shoot densities of seagrass, and algal cover. Central Palk Bay (segment B: 83.37% and segment C: 81.86%) showed a maximum cover of seagrass. North Palk Bay (Segment A: 58.82%) and South Palk Bay (Segment D: 54.8%) showed the comparatively lower cover of seagrass due to the presence of other coastal habitats like the mangroves in North and corals in South Palk Bay. *Halodule uninervis* and *Halophila ovalis*, the abundant seagrasses in this area are found to grow even in very shallow areas (<1m). Some of these areas are exposed during low tides. However, conforming to field observations, *Enhalus acoroides* grows in subtidal areas. Growth of *Halophila ovalis* is hampered by varying depths (at least till a maximum of 5-metre depth). Water enough to permanently submerge seagrasses (Sub-tidal areas; ~1.5m and above) is needed for the growth of other species like *Cymodocea* sp., and *Syringodium isoetifolium*. At Ammanichathram and Puduthuru, *H. uninervis* grew in monospecific meadows, thereby allowing for its lush growth. Minimum and maximum depth surveyed was at ~2 to 3m, respectively. Except at Gopalapattinam, where the depth was <1m, all other sites show a relatively uniform distribution of seagrass species.

At Andaman Islands, intertidal and sub tidal meadow surveys across 12 Islands reported 11 species belonging to six genera viz; *Halophila beccarii*, *H. decipiens*, *H. ovalis*, *H. minor*, *Halodule uninervis*, *Halodule pinifolia*, *Enhalus acoroides*, *Syringodium isoetifolium*, *Cymodocea serrulata*, *Cymodocea rotundata* and *Thalassia hemprichii*. The seagrass meadows reported were either monospecific beds of *Halophila ovalis* (Interview, Chester and Twins), *Halodule pinifolia* (Inglis) or of mixed species meadows of two (John Lawrence, Sir Hugh Ross, Tarmugli, Boat) or more species up to five being the highest. Six of the 11 species were intertidal in distribution recorded from a depth of 2m, while the genus *Halodule* sp. was restricted to shallow waters (up to 7m). The genus *Halophila* sp. showed a diverse depth wise distribution pattern, as *Halophila beccarii* was recorded from intertidal region (2m) whereas *Halophila decipiens* from around 16m. Highest total percentage seagrass cover was 56.1 ± 36.6 (%) recorded for a mixed species meadow at Henry Lawrence in RJMNP whereas the lowest cover was recorded from Chester in MGMNP, from a monospecific meadow of *Halophila ovalis* (1.5 ± 2.7 %). Seagrass cover was found to be high in shallow waters and decreased towards deeper regimes. Shoot density (870.6 ± 131.9 / m²) and total biomass (28.2 ± 7.3 gm/ m²) was highest for unprotected island; Swaraj dweep while lowest shoot density was recorded from Interview Island in the North Andaman (150 ± 10.4 / m²). Canopy height was the highest at Inglis island of *Halodule pinifolia* (7.9 ± 1.5 cm) whereas it was the lowest at John Lawrence (1.4 ± 0.5 cm) for *Halophila* sp. Algal cover was the highest at John Lawrence in RA (77.8 ± 33.6 %). It highlights the importance of unprotected seagrass

meadows of tourism hotspots like Swaraj dweep and Shaheed dweep which harbour mixed species dense meadows, but are presently under anthropogenic pressure through coastal development, pollution and boat anchorage. Further, the importance of seagrass meadows as important dugong habitats is highlighted with strong frequency of dugongs sighted from Shaheed dweep and Swaraj dweep.

3. Pollutant analysis of sediment and seagrass samples collected from Gulf of Kutch were analysed for residues of 12 Polychlorinated biphenyls (PCB) congeners. Σ PCBs concentration in the sites ranged from 3.105-57.175 ng/g dw @ 1% TOC in sediments were found to be higher than the threshold limit (29 ng/g dw @ 1% TOC) set by the standard guidelines in coastal sediment. Four species of seagrasses were analysed across the seven islands. The concentration of total PCB in seagrasses were found to be between 6.568251.751 ng/g dw in *Halophila ovalis* species, 8.608-23.232 ng/g dw in *Halodule uninervis*, 12.002 ng g/1 dw in *Halophila decipiens* and 48.744 ng/g dw in *Halophila beccarii*, which is higher than permissible threshold (same as sediment). Of all the PCBs congeners detected, PCB52 was found to be in the highest concentration followed by PCB28, PCB77, PCB101, PCB153, PCB138, PCB187, PCB126, PCB180, PCB118, PCB44 and PCB105. Since the dugongs mostly feed on seagrass, the higher levels of PCB congeners in seagrass species, especially higher accumulation capacity of PCBs in *Halophila ovalis* species is a matter of concern. It is likely that PCBs may be moving up the food chain and accumulating in dugongs and thus may pose a threat to the health and population of this species.

4. Ecological surveys for seagrass-associated benthic macrofauna in the Gulf of Kutch from Paga Reef, Tam reef, Chepri Island, Hadkiwala reef and Dunny point-Beyt Dwarka revealed 14 faunal groups viz Gastropods, Pelecypod, Crustaceans such as Tanaidceans, Cumceans, Polychaetes, Amphipods, Isopods, Foraminiferans, Holothuroideas, Echinoids, Ophiuroideas, Crinoids, Scaphopoda and Polyplacophora. The highest wet weight biomass and higher number of groups were found at Hadkiwala. Average biomass varied from 0.5 – 35.4gm/m² wet weight), average biomass varied from 34.1- 167.7 nos/m². Surveys in seagrass meadows of Andaman Islands reported 7 macrofaunal groups viz. Gastropod(GS), Bivalve(BV), Polychaete(PL), Nematodes(NM), Amphipod(AP) and Foraminifera(FM). The overall biomass of organisms varied from 0.0025- 69.32 gm/m² and number of individual vary from 1750-25 no./m². The highest biomass was recorded from Twin island whereas abundance was highest in Tarmugli Island.

5. Ecological surveys for seagrass-associated fish species were quantified using SCUBA-diving at Andaman Islands. Fish from 28 genera belonging to 14 families by belt transects and 27 genera belonging 17 families were recorded using underwater point counts. Diversity indices did not indicate any difference between the two sampling methods. It was observed that density of coral/ anemone associated fish was the highest (239.15±429.07 Ind/ha) as compared to other habitat guilds. The densities of omnivorous fishes were found to be highest (338.44±568.47 Ind/ha) as compared to other feeding guilds. A significant positive effect of live coral cover, rubble cover, sand cover and seagrass shoot density while the significant negative effect of algal cover and seagrass cover was observed. In 2020, we found 54 species of fish belonging to 18 families. The fish density was highest at Henry Lawrence Island (0.019 ±0.012 Ind/m²). Observed fish densities were found to be higher at meadows consisting of multiple seagrass species (fish density= 0.018±0.011 Ind/m²) and meadows with higher shoot length (fish density= 0.033±0.02 Ind/m²). According to the surveys conducted in both the seasons, it can be concluded that the complexity of the habitat played a major role in

determining the diversity and density of fishes, may it be presence of corals/ anemones in the meadows or the seagrass characters like multiple species and higher shoot length. In Tamilnadu, fish market survey at fish landing centre in Mandapam and Vedalai in Palk Bay and Gulf of Mannar region recorded 26 commercial species. Point counts in Gulf of Mannar at Kurusadai, Shingle, Muyal, Manoli, Valai and Mulli islands recorded 51 species of seagrass-associated fishes. A pilot study of gut content analysis for two seagrass associated fishes, *Gerres erythronus* and *Psammoperca waigensis* was done at Palk Bay. We found Polychaetes, shells, fish scales, algal filaments, and seagrass in the gut of *Gerres erythronus* and crabs, shrimps and amphipods in *Psammoperca waigensis*.

6. Threats mapping of 'Critical Dugong Habitats' in the Andaman Islands was carried out in the Ritchie's Archipelago including Rani Jhansi Marine National Park (RJMNP). And in Wandoor region in and around the Mahatma Gandhi Marine National Park (MGMNP). The overall boat traffic for the Ritchie's archipelago was low with only one grid of each sampling season, showing high boat density (7 boats/ km² in 2019 and 18 boats/km² in 2020), while one grid had moderate boat traffic (1.5 boats/ km²) in March 2020. Boat traffic was majorly contributed by fishing vessels (81.67%) followed by recreational boats (15%) and defence vessels (3.33%). It was observed that food wrappers/ boxes formed the most frequently found (43.27%) floating litter across all the three sites, followed by plastic bottles and cans (29.81%). Through the present study, for the first time, threats to dugong population have been quantified, which not just spatially helps us to understand threats to dugongs and their habitats, but provides the intensity of these threats and in turn, highlights areas with strong need of management as well. Few of the habitats frequented by dugongs, happen to be popular tourist destinations in Ritchie's Archipelago. Recreational activities like operation of speed boats is a major concern as it poses the risk of collision with dugongs, not to mention the disturbance caused due to noise pollution. Such activities need to be regulated by the management authorities at the identified locations to avoid such incidences, which our study has successfully highlighted.

7. Aerial surveys for dugong population monitoring were conducted across five sites in the South Andaman Islands which were earlier identified as Critical Dugong Habitats (CDH) by Sivakumar and Nair (2013). Two important CDH's were selected for the pilot studies viz; the Rani Jhansi Marine National Park (RJMNP) in the Ritchie's archipelago (RA) and the Mahatma Gandhi Marine National Park (MGMNP) in Wandoor. Besides these primary protected sites, few other unprotected sites around RA and Wandoor were chosen randomly namely Swaraj Dweep, Shaheed Dweep and Chidiyatapu. A total of 31 flights were undertaken using the UAV- DJI Mavic 2 Pro with a total flight time of 570 minutes and average flight time of about 18 minutes. Total 11 flights were undertaken inside both the Marine National Parks (MNP's), out of which five flights were in RJMNP and six in MGMNP, with a total flight time of 211 mins. Another 20 flights were undertaken in different forest areas of South Andaman including Chidiyatapu, Swaraj Dweep and Shaheed Dweep islands with a total flight time of 359 mins. Encounter rate based on total flight time of dugongs was calculated as one dugong detection per 142.5 mins of aerial survey effort. Dugong detection within the limits of the protected areas of marine national park was one detection per 52.75 mins as all encounters were within the marine national park.

Total four times, dugongs were detected throughout the study period, all within the protected areas of MGMNP (n=1) and RJMNP (n=3), out of which once mother and calf pairs were

sighted in each of the MNP's. No dugongs were detected outside the marine national parks but the UAV was successful in detecting a wide range of species like eagle rays, squids, sea turtles, needle fish, zebra shark, sting rays, and shoals of fish. Threats to dugong populations like marine litter, floating buoys, fishing boats and boats used for recreational activities like scuba diving and game fishing were recorded during the survey effort.

At Gulf of Kutch, drone surveys were conducted at Beyt Dwarka based on the findings of our social surveys and previous sighting and stranding records. We conducted UAV based aerial surveys in Beyt Dwarka only north part of Hanuman Dandi beach which falls under the Marine National Park boundary. We were able to successfully carry out fixed-width aerial transects in dugong habitats. Turtles, birds, fishing boats fishing nets were detected in the survey effort. A total area of 4.5 sq. km surveyed in the effort. No dugongs were detected during the surveys but feeding trails of dugongs were observed confirming the presence of dugongs. For next season, the spatial coverage will be increased to estimate the dugong population in the region.

8. Citizen science approach was adopted targeting several stakeholders to supplement dugong sightings through the Islands. Total 340 regular seafarers including fisherfolk (n=90), forest department frontline staff (n=12), Indian Coast Guard and Indian Navy (n=109), school children of fisherfolk (n=110), and tourism sector viz; SCUBA divers (n=9), glass bottom boat operators (n=4), Life guards (n=4) and informants from 'other' category (n=2) which included sailors/ locals, were involved in the Dugong Monitoring Network. Since February 2017 to May 2020, eight different stakeholder groups were engaged in the Dugong Monitoring Network including fishers, tourism-allied operators, patrolling agencies and school children. Total 238 dugong sightings were received throughout the Andaman Islands and three dugong individuals were photo- identified, one in the year 2017 and two individuals in 2018. In the last one year, >10 mother-calf sightings were received which highlights the importance of habitats in the islands for dugong conservation as it supports a breeding population. Few sightings (n=4) shared by Indian Navy and Indian Coast Guard are from the coastline of Jarawa tribal reserve, an area not accessible to researchers due to its tribal protection status, thus, identifying new dugong habitats.

9. Interview based surveys targeting fishers were conducted at Andaman Islands and Palk Bay to document the change in the dynamics of fisheries and assess its impacts on dugong populations. We surveyed 45 fishing villages throughout the Andaman Islands including North (n=18), Middle (n=8) and South (n=19) Andaman Islands. The duration of a fishing trip is dependent on factors like target fisheries, availability and accessibility of fishing grounds, market for the catch, and gear & crafts used. Long duration trips were undertaken only by fishers of North and South Andaman, as open sea is available at both the sites while middle Andaman fishers restricted their trips to smaller duration. Further, most of the fishers in North and South Andaman are involved in export fishing, which requires long trips till the pre-decided catch capacity is full. Short trips in these regions are generally done where the catch has local available market. Type of crafts and gears used is an important aspect in dugong conservation, as it influences both, the sighting probability and threats to dugongs. Hallee boat users in the North and Middle Andaman, with limited movement have seen dugongs rarely, while motorised/ mechanised boat users who travel larger distances, have frequently sighted dugongs either while fishing or in transit, because of the overlap in their fishing ranges and dugong distribution. Further, these pose threats to dugongs in terms of destructive trawl/gill nets being used or boat strike. The major outcome of our study was

successful understanding of this spatial overlap and updated 'dugong trouble spots' with latest information on hunting and net entanglement pressures. On the other hand, the level of awareness and importance which fishers had about dugongs was not reflected for seagrass habitats, highlighting a strong need to carry out integrated species-habitat sensitization programs amongst these communities.

At Palk Bay, fisherfolk from 40 villages were interviewed to understand the perception and awareness of the community towards the sea, its resources and the dugong. Out of 822 respondents, 370 people reported their last sighting of a dugong in the past 2 decades. There is an increase in the dugong sightings as reported by the fisherfolk (from 3 sightings in 1999 to 72 in 2019). High numbers of dugongs have been reported in recent years (165 sightings from 2017-19). This response is considered to be positive as it indicates the higher frequency of dugong sightings in North Palk Bay waters. Majority of respondents (n=798) were of 21 to 60 years in age. On average, the respondents had 22.65 (SE=0.41) years of fishing experience, ranging from 2 months to 60 years of experience.

10. Mass boat surveys were conducted in Mandapam, Ammapattinam, and in North Palk Bay. Each boat was led by a researcher from our team, a forest guard, a boatman, and one or 2 others from the fishing community to help in an efficient sighting of marine megafauna and plastic.

11. Dugong Scholarship Programme, initiated as a unique participatory program to engage local fisherfolk communities at the grass-root level. This program targets school-going children of local communities (most of them are fisherfolk) and provides them with a scholarship of Rs. 500 / month for two years to support their education. A total of 153 students were selected under this program in the Phase-I starting from July 2017. Out of these, 57 from Andaman & Nicobar Islands, 53 from Tamil Nadu, and 40 students were selected from Gujarat field sites. Under the phase-II, 100 more students from Tamil Nadu and 46 students from Andaman & Nicobar Islands and 22 students from Gujrat have been selected as Dugong Ambassadors in 2019. So far, 558 students have received scholarship under this unique conservation outreach program.

In Gujarat, we have completed three years of this program from July 2017 to July 2020. Till now 142 students have been awarded this scholarship and the students selected under this program are identified as Dugong ambassadors. In Tamil Nadu, we have completed three years of the dugong scholarship program from July 2017 to July 2020. Till now, a total of 306 students have been awarded the dugong scholarship and the students selected under this program are identified as Dugong ambassadors. In Andaman Islands, Dugong Scholarship Program was started in July 2017 and 7 schools across the Andaman Islands were targeted. As of August 2020, 110 students have been awarded this scholarship and the students selected under this program are identified as Dugong ambassadors.

This multi-pronged strategy involves school children in Dugong conservation awareness activities. It integrates their families as part of the broader network of forest department frontline staff, divers, tourist boat operators, and coastal village communities. This network provides us with information on dugong sightings/stranding as well as participates in outreach events for generating awareness in the areas of Dugong occurrence. With continuous streaming of data on dugong distribution or stranding, the field team and forest department are enabled to respond swiftly and initiate necessary action on the ground. Outcomes of this programme include the volunteer release of entangled dugongs into the sea, reporting of

dugong sightings from the sea, reporting of dugong stranding by fishermen, reduction in the poaching incidents of dugongs, reporting of poaching by fishermen, reduction in the illegal collection of other protected marine animals, etc. Thanks for all three State Forest, Fisheries and Education Departments especially the frontline officers at Gulf of Kutch NP, Gulf of Mannar BR, Palk Bay, Andaman and Nicobar Islands that helped the WII Team to successfully implement this programme.

12. Outreach and awareness programs consisting of a variety of tools including community workshop, presentations, street plays, rallies, beach clean-up activities, exhibitions, TV shows, radio programs, etc. So far, we have conducted over 275 outreach programs at all three field sites targeting over 20,000 stakeholders.

At Gulf of Kutch, a total of 98 outreach and awareness activities were conducted to aware people about the species, its importance and major project activities to the school students, teachers, locals and fishermen. Out of 98 events, 25 events were conducted for awareness and scholarship and 66 meetings were conducted with different stakeholders like forest department, marine police and head of various schools to involve them in the conservation activity, as the involvement of local people is very crucial for any species conservation.

A total of 35 outreach and awareness activities were conducted at Tamil Nadu field site, to aware people about dugongs, their importance and major project activities to the school students, teachers, locals and fishermen. Out of 35 events, 17 events were conducted for awareness and scholarship, 11 meetings were conducted with fishermen for questionnaire surveys and 882 questionnaire surveys were conducted, 5 meetings were conducted with others stakeholders like education officers and forest officials. Most of the awareness efforts were published and highlighted in the local Newspapers and News channels. National Science Day, World Environment Day, World Turtle Day, Dugong Day, World Wildlife Day was celebrated creating awareness regarding wildlife and Environment conservation among the school students.

13. Dugong awareness at CMS CoP 2020: The 13th Meeting of the Conference of the Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS COP13) showcased the efforts of Wildlife Institute of India towards conservation of endangered species. A large amount of awareness material of Dugong project was distributed on a global platform and the meeting helped the project to get recognition and a platform to interact with the researchers and delegates from all around the world.

14. Dugong Day Celebration on 28th May 2020: This was the first time a day was dedicated for dugong conservation awareness anywhere in the world. The significance of the day comes from signing of the CMS-UNEP MoU by India on 28th May 2008 for the conservation and management of dugongs and their habitats . Due to the ongoing COVID-19 pandemic and restrictions on travel and organizing gatherings, this day was commemorated as Dugong Day with online events conducted over a period of ten days. It included a social media campaign from 19th- 28th May 2020 with the theme '**Save Dugong and Save Livelihood**'. The campaign was organized in collaboration with ENVIS resource partner "Wildlife and Protected Area" (<http://www.wiienvis.nic.in>), and was channelized through social media platforms like Facebook, Twitter and Instagram.

The campaign included daily posting of one infographic poster on dugongs on social media platforms and online painting, slogan and quiz competitions. The painting competition was

organized under the age categories, 6 -13 years, 14-18 years and, 19 years and above to engage people from all age groups. Slogan competition was for all age groups in English as well as four Indian languages of Hindi, Tamil, Gujarati and Bengali. The quiz competition consisted of 30 questions related to dugongs and marine conservation topics was open for everyone to participate. The campaign saw an active participation of >10000 people from across the country making it one of the biggest event so far on dugong conservation in the country. A total of 2659 people (50.7% male, 49.2% female) participated in the quiz competition and were awarded the quiz participation certificate. More than two hundred entries each were received for slogan (210) and painting (227) competition.

15. Capacity building programs were conducted to provide orientation to State Forest Departments of Andaman & Nicobar Islands, Gujarat and Tamilnadu for dugong conservation. In addition, key partnerships with Indian Navy, Indian Coast Guard, Marine Police, Coastal Security Group, State Fisheries Departments and State Education Departments were included in these programs. It was done by conducting a series of sensitization, orientation and training workshops on marine biodiversity conservation, marine mammal stranding response, SCUBA-diving for underwater marine biodiversity monitoring etc. So far, over 1000 personnel from these departments have been trained and sensitized for dugong conservation in the country. These trainings have helped us get aerial footages of dugongs from Indian Navy and Indian Coast Guard, helped us to identify priority sites for dugongs, reduce mortalities due to poaching by increased in active patrolling and enhance the capacity of these frontline stakeholders in conservation of marine biodiversity in the country. Similar integrated approach was adopted to include school children, local universities, Non-Governmental Organisations, tourism operators and staff for marine biodiversity monitoring and management. These trainings were given to fisherfolk, boat operators, divers, local NGOs, college and school students and multiple conservation activities were conducted to increase their direct participation. These trainings were given through unique community workshops conducted periodically at all sites.

So far, about 40 training programs have been conducted on illegal Trade in Wildlife and role of Wildlife Forensics in Dealing with Wildlife Crime and SCUBA diving and underwater marine biodiversity monitoring, Orientation workshop on importance, and conservation implications of marine life in the Islands, Dugong ambassador Refresher Course, Orientation workshop for handling marine mammal stranding. The training mainly involves an introduction to tools and techniques (snorkelling, boat survey methods, and handling equipment and seagrass mapping by random quadrat method, forest management practices in protected marine areas and identifying living organisms in the sea), used to carry out research and monitoring in the coastal environment. The effective capacity building benefits both the partners and local stakeholders by generating inclusive processes that strengthen trust and build commitment and good relationships. With continuous streaming of information on dugong distribution and stranding, the WII field team and forest department have been enabled to respond swiftly and initiate necessary action on the ground.

16. Dugong monitoring logbooks have been developed in six languages for involving state forest department, Indian Coast Guard, Indian Navy, State Fisheries Department, Marine Police, fisherfolks to generate ground information on marine megafauna in and around critical Dugong habitats.

17. Dugong comic book, My friend Dugong written by Shri. Chanchal Singha Roy, a school teacher in the Andaman & Nicobar Islands, has been published in six languages i.e. Tamil, Telegu, Bengali, Gujarati, Hindi and English. It shares a heart-warming story of the friendship between a boy Lingaraju and a Dugong from the Andaman Islands. These books will be distributed in every school library of the three dugong field sites.

18. Seagrass field guide for easy identification of seagrass species in India has been developed. This guide will provide key information on seagrasses of India, and its associated faunal species.

19. Rescue and release of dugongs: Our continuous efforts to sensitize fisher communities has helped rescue 11 dugongs and released back into sea at the three field sites. This has been done in close association with frontline forest department staff, marine police and fisher communities.

20. Marine Mammal Stranding Response: Marine animals like cetaceans, dugongs, sea turtles, etc. are found stranded regularly across the coastline of India. Understanding their health status, causes of stranding/mortality, genetics and pollutant load is required to formulate strategies for their population management. A dedicated stranding programme is thus required for systematic collection of marine species data along the Indian coastline. CAMPA-Dugong Recovery Program has formed Friends of Dugong network at all the dugong range states. With inputs from the network members, our team responds to each marine species stranding event and collects data on species, number, location, causes of mortality (wherever necropsies are conducted in presence of a veterinarian). Through this rapid response action on ground, invaluable data on dugongs and co-occurring species has been collected to fill up the gaps related to their biological parameters (age, health, diet, pollutant load, genetic structure etc.). The Project aims to continue this participatory monitoring over a sustained period and utilize this data in formulating surgical interventions to minimize the threats and causative agents of marine vertebrate species mortality. Several standings have been reported in time by various stakeholder groups and proper response was subsequently initiated by the field teams on the ground. Marine mammal stranding protocol manual is being developed.

21. Nutrients in the sediments and seagrasses were assessed at all field sites as important parameters in influencing growth, reproduction and metabolic activities of biotic components. The concentration of nutrients is based on the season, tidal conditions and flow of fresh water from the land. Distribution of nutrients is also mainly based on these season, tidal conditions and freshwater flow from land. The concentration of nutrients in the sediments among the study sites varied significantly. All the parameters were observed to be maximum in the site Gujarat, except for phosphorus the concentration of which was observed to be higher in Andaman and Nicobar Island. The concentration of nutrients in the seagrass samples also varied significantly among the study sites (Figure 5.9). N, P, K, Na and ash content was observed to be more in the seagrasses of Tamil Nadu. Whereas, Total Organic Carbon (TOC) and Total Organic Matter (TOM) in Andaman and Nicobar Island.

22. First comprehensive assessment of genetic status of Indian dugongs: We provided the most exhaustive description of genetic groups of dugongs at a global scale till date, and first in-depth investigation of genetic diversity and structure of Indian dugong populations. Our findings show that the Indian samples are part of a single genetic cluster, comprising South Asia, northwest Indian Ocean and southwest Indian Ocean populations with low genetic

differentiation. This pattern of genetic clustering is in accordance with earlier studies by Blair et al. (2013). However, these results show a slightly different pattern from Plon et al., (2019), where Madagascar/Comoros formed a unique lineage within the western Indian region. It is also noteworthy to point out that such patterns could also be driven by the use of poor quality sequence data from historical samples. We feel that the addition of critical dugong samples from India helped in getting a clear picture of genetic groups within this region. Overall, the global data showed a very structured phylogeographic pattern with very limited sharing of haplotypes among the identified regions. While such pattern could arise from incomplete sampling effort across the dugong range, it could also indicate potential loss of gene flow among these regions due to fragmentation of contiguous dugong habitats (Marsh, O'shea & Reynolds III, 2011). Our study elucidates divergent mtDNA lineages of South Asian dugongs within the western Indian Ocean populations. Indian dugong population genetically grouped within the South Asia region, although not genetically unique, consists of unique mtDNA haplotypes. Addition of novel mtDNA haplotypes from Indian dugong samples points towards high genetic diversity within South Asia. Two of the previously reported haplotypes from Sri Lanka (Plon, Thakur, Parr & Lavery, 2019) were found to be shared with the southern part of dugong distribution in India at Gulf of Mannar, whereas one haplotype sampled from Andaman & Nicobar Islands was observed within Southeast Asian lineage. This indicates potential genetic connectivity between these populations in the recent past, and future work should focus on further fine-scale sampling for in-depth investigation. With local extinctions from Mauritius and Maldives and a highly imperilled dugong population in Sri Lanka (Marsh, Penrose, Eros & Hugues, 2002; Marsh & Soltzick 2015), India holds the largest and potentially the last viable dugong populations within the south-Asia region thereby requiring immediate conservation attention.

Within India, we identified novel haplotypes from each sampling site i.e. Gulf of Mannar, Palk Bay, Gulf of Kachchh and Andaman & Nicobar Islands. Overall haplotype and nucleotide diversity for dugong populations in India were comparable to Australia (McDonald, 1997; Blair et al., 2014; Seddon et al., 2014) and Thailand (Palmer, 2004; Bushell, 2013) dugong populations. Gulf of Mannar population showed higher haplotype diversity within the Indian regions. Presence of shared haplotypes across Gulf of Mannar, Palk Bay and Gulf of Kachchh suggests potential genetic connectivity among these populations. We found a new haplotype with longer sequences generated in this study ($n=789$ bp) when compared with earlier studies from Australia (McDonald, 1997; Blair et al., 2014; Seddon et al., 2014) and Thailand (Palmer, 2004; Bushell, 2013), suggesting that longer sequence data is required to assess genetic variation at regional/global scale. Finally, it is important to point out that our Indian dugong data show contrasting patterns of population differentiation, where we found shared haplotypes among the sampled areas but high F_{ST} values. Further, the AMOVA analyses indicated signatures of within-population structures. We feel that these contrasting patterns probably arise from a low sample size from each area and short sequences (less polymorphic sites) leading to the effects of genetic drift. Further efforts through intensive sampling and more genetic data would clarify these genetic patterns in Indian dugong populations.

23. Identification of round worms from stranded dugong in Tamil Nadu: Gut content samples of two stranded Dugongs were collected from the field sites of Tamil Nadu and Gujarat. Two dead dugongs, measuring 290-299 cm long and respectively, were reported washed ashore in Vembar and Thondi village in Tamil Nadu on 17 February 2018 and 20 June 2018 respectively. The worm samples were collected from the stomach, foregut and hindgut of dugong and preserved in 90% ethanol for further study. The specimens were examined in the laboratory at Wildlife Institute of India, Dehradun and Zoological Survey of India, Kolkata.

The morphological observation was carried out using a stereomicroscope (Olympus SZX16) and photographed using the computer camera (model Olympus U-TV1X-2 Tokyo Japan). All specimens were identified as *Paradujardinia halicoris*. Out of 9 individual 7 were female and 2 were male.

24. Geospatial analysis of seagrass meadows of Ritchie's archipelago was done using satellite imageries to attempt the detection of submerged seagrass meadows along the coast of islands of Ritchie's archipelago. Machine learning algorithms such as Random Forest, Support Vector Machine and Nearest Neighbour was incorporated for seagrass detection and mapping. This work was carried out in collaboration with Centre for Space Science and Technology Education in Asia and the Pacific (affiliated to United Nation) at Indian Institute of Remote Sensing, Dehradun as part of dissertation work. This work was eventually published as a research communication article in *Current Science* journal on 25th April 2020.

25. Assisting Marine Protected Area management: Management plan prepared for Gulf of Mannar Marine National Park is under implementation by the Tamilnadu State Forest Department. A draft management plan has been submitted for Rani Jhansi Marine National Park to the Andaman & Nicobar Department of Environment and Forest.

26. Management Recommendations: At Gulf of Kutch, we recommend enhancing patrolling around Bhaidar island, Pashu island and Taam reef as these are 'Critical Dugong Habitats'. These sites must be regarded as slow speed zones wherein it should be made mandatory for operational fishing vessels to sail at an 'idle speed' to avoid harmful collisions. We recommend increased threat monitoring efforts during seagrass growing phase; August-December. Overall, seagrass meadows of Gulf of Kutch have a high turnover rate which gives it the resilience needed to re-colonise post-monsoon, after shedding period in monsoon. Dugong sighting and monitoring efforts needs to be increased in 'Critical Dugong habitats' like Chepri and Taam reef. The connecting habitats between foraging meadows needs to be established and monitored regularly using drone and boat-based surveys. At Tamilnadu, patrolling should be upscaled in north Palk Bay especially from Adhirampattinam to Ammapattinam area. More surveys are required to generate data to demarcate critical dugong habitats in the region. The frontline staff needs to be trained in conducting seasonal seagrass monitoring surveys and marine mammal monitoring surveys. We plan to organise such trainings in the upcoming season for state forest department personnel and other key stakeholders at all the sites. At Andaman & Nicobar Islands, we recommend imparting structured training to frontline forest staff in data collection and documentation, dugong stranding response and sample collection from dead dugongs, using standard protocols is strongly recommended, as this stakeholder group is the first responder to marine mammal strandings. More frontline forest staff to be trained in certified SCUBA courses, and involved in long term seagrass and coral monitoring in the islands. Rigorous patrolling is recommended jointly by forest department, Indian Coast Guard in 16 sites identified as 'dugong trouble spots. Engaging crucial stakeholders like tourism department, directorate of shipping services, chamber of commerce, SCUBA diving associations and other tourism allied sectors, to help minimize direct or indirect impacts caused by tourism activities on dugongs.

27. Future plan of action: Project could successfully minimize the illegal intake of dugongs and degradation of their habitat through participatory approach and various awareness programs. Further, the dugongs genetic study revealed that the dugong population in India was observed with high genetic heterogeneity and the population is seems to be genetically

stable. Identification of critical dugong habitat in Palk Bay as 'Conservation Reserve' for community-based management was another milestone of the project and the project will assist Tamil Nadu Forest Department to declare this site as Conservation Reserve. Drone surveys will be conducted at all the sites to determine dugong population at all sites. It is planned to establish and build capacity for mobile 'Dugong Rescue and Rehabilitation Facilities' in three regions. Seeking supports of fishers in the conservation of dugongs in India will continue. It is planned to further enhance the network of 'Dugong Ambassadors' and 'Friends of Dugongs.' After the drone surveys get underway, there are plans to tag with telemetry at least 10 Dugongs so that they will be closely monitored.

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GULF OF KUTCH, GUJARAT

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2.1 Research and Monitoring

2.1.1 Seagrass surveys and ground truthing of intertidal zones in Gulf of Kutch, Gujarat

Methods

Seagrass and sediment samples were collected using a 50x50 Cm quadrat which was placed randomly. For each quadrat ecological parameters like shoot density, seagrass cover, algal cover, epiphytic cover, canopy height, sediment type, depth, temperature and light intensity. Seagrasses collected were washed to remove debris and epiphytes. Wet weight was noted, after which each sample was analyzed for morphometry and dried. Seagrass samples were further analyzed for Carbon (C), Nitrogen (N), Phosphorus (P), Pottassium (K), and organic matter content.

Sediment samples taken from both seagrass present and absent areas were air-dried and stored in plastic zip-lock bags and sent for further lab-based analysis. Sediment texture/grain size and nutrient content were studied.

Result

This season permanent plots for the seasonal study were characterized and studied. During the winter season, foraging trails were hard to spot on a patchy meadow with sparse seagrasses, however in Pashu islands reef (Figure 2.2-a) where the meadow was continuous, several fresh trails were found. Winters in Beyt-Dwarka island brought a massive algal bloom of green filamentous *Ulva flexuosa* over the *Halophila decipiens* meadow (Figure 2.2-f). Whether the shading effect of the large thallus of the macroalgae has any detrimental effect on the meadow remains to be studied.



Figure 2.1: *Halophila decipiens* meadow shaded by *Ulva flexuosa*. Also note sponge of *Haliclona* sp. growing as seagrass associated fauna. (Right) Field researcher ground truthing seagrass meadow in sub-tidal zone of Beyt-Dwarka holds *Ulva flexuosa* thalli



Figure 2.2 : Old dugong foraging trails found at Chepri reef of Gulf of Kutch, Gujarat

Old dugong foraging trails found at Chepri reef, the thallus of macroalgae *Ulva prolifera* blooms on reef tops Chepri reef. Algae persist till late March. Channels intersecting a heterogeneous *Halophila beccarii* meadow in Bida reef of Bhaidar island.

2.1.2 Understanding seasonal changes in seagrass meadows of the Gulf of Kutch, Gujarat

Methods

The random quadrat method was employed at each station to study seagrass characteristics. Permanent survey sites were identified and shall be revisited fortnightly in forthcoming seasons to understand the following ecological and phenotypic parameters: sediment type, percentage seagrass cover, percentage algal cover, seagrass canopy height, seagrass shoot density, percentage seagrass epiphytic cover, biomass, nutrients, depth, and temperature. Like their terrestrial counterparts, seagrass undergoes drastic changes in their morphology and reproductive biology. Hydrocharitaceae family members like *Halophila ovalis*, *Halophila decipiens*, *Halophila beccarii*, etc are the most commonly found seagrasses in the Gulf of Kutch. These seagrasses along with the turf grass *Halodule uninervis* are considered to be the most resilient seagrasses with high colonization ability, seed stock, and extreme

tolerance to fluctuating salinity and light. There are several topographically unique meadows composed of more or less the same species but experiencing the seasonal changes differently.

Seasonal seagrass survey efforts were made for the Paga reef, Bhaidar islands and Tam reef. With the consultation and permission of the Gujarat forest department, HOB0 pendant loggers were carefully set near meadows on each site.

The peak growth period for seagrasses is winters, from November- March. During monsoons seagrass abscise their leaves which drastically reduces the wet-weight. Depending upon the species and topography, a meadow shall take at least three months to recolonise. The growth period can extend well into March. Further, wet-weight increases in the peak summer months of April-May as seagrasses reach the climax of their growth period.

Thus, a contrast in wet-weight is seen in all the meadows during the summer and winter periods (Figure 2.3). The high and low standard deviations values reflect the patchiness and homogeneity in the meadows respectively.

Seagrass meadow in Taam reef are subject to drastic disturbances from surrounding channels. Note that the morphologically smaller *Halophila* sp. which dominates the meadow is responsible for the seemingly low seagrass abundance in Taam reef (in wet-weight) in all the seasons.

A meadow can be patchy and still have high biomass during the peak summer. The implication of monitoring seasonal changes in seagrasses has an important value in the conservation of dugongs. Dugongs, being a strategic forager, may have a foraging pattern which relates to the seasonal patterns in seagrasses. This may further reveal the movement patterns of dugongs across these meadows.

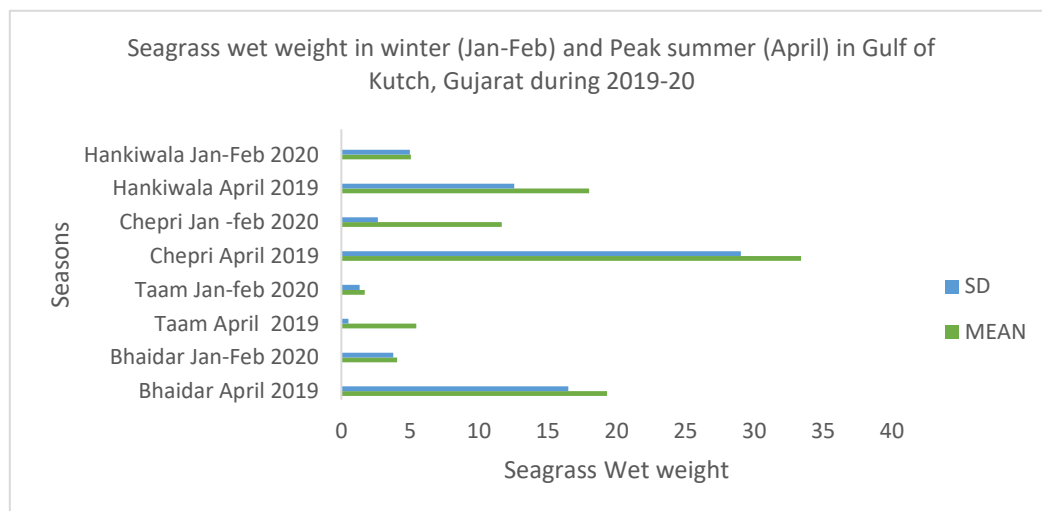


Figure 2.3: Biomass (wet weight) changes in seagrasses in colder months of January and February and hot-dry month of April 2019-2020 at Gulf of Kutch, Gujarat

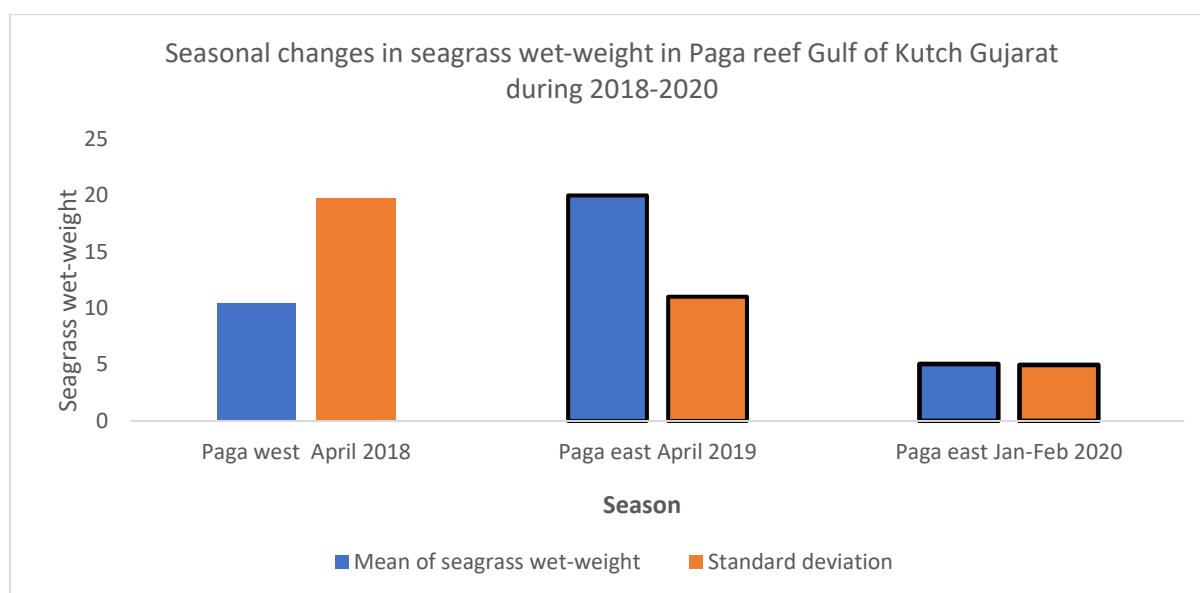


Figure 2.4: Seasonal changes in seagrass wet-weight in Paga-reef, 2018-2020. Bordered bars represent seasonal variations from the same meadow east of Paga reef at Gulf of Kutch, Gujarat

Paga intertidal fringing reef has the most contiguously growing yet topographically different meadows in its western and eastern parts. These meadows are protected from tidal currents and waves by a peripheral fringing coral reef. This gives seagrasses a unique opportunity to colonize sheltered areas of the reef. This meadow, although patchy, experiences a high seagrass abundance during summers with an average wet-weight of 5.2 ± 19.7 kg/m² in Paga west and 10 ± 11.02 kg/m² in Paga east. The difference in wet-weights is because the eastern part of the Paga reef is more sheltered from tidal disturbances than the western region. East of Paga reef, being more stable, makes conditions for seagrasses to colonize available. The high and low standard deviations values reflect the patchiness and homogeneity in the meadows respectively.

Moreover, bordered bars in Figure 2.4 represent seasonal variations from the same meadow east of Paga reef during the hot dry month of April 2019 and subsequent winter of 2020. As mentioned before, during the winter period seagrass meadows have low abundance as they still are in the recovery/growing phase after the monsoon leaf abscission period.

Clonal reproduction and shoot density variations in seagrasses of Gulf of Kutch, Gujarat

Seagrass are marine flowering plants that reproduce by both sexually and asexually. The more common asexual method is through clonal shoots. The primary rhizome can produce secondary and tertiary off-shoots. The intricate branching system is unique to seagrasses and their occurrence is limited to a seasonal cue. In most elevated meadows such as Chepri reef, Paga reef, Bhaidar island (west), meadows are at their lowest shoot densities after the monsoon. This is a cumulative result of strong monsoon currents and the deciduous phase of seagrasses.

The average shoot density from post-monsoon to winters (December-January) can be around 80-150/m². The peak growth period for seagrasses is winters, from November- March. The table below shows average leaf length and internodal length for *Halodule uninervis* colonizing the exposed reef areas of Chepri reef, Patthiwadi reef of Bhaidar island and Hankiwala reef of Paga. This grass was observed to have an extraordinary capacity to colonize through clonal shoots.

Table 2.1: Average leaf lengths and inter-nodal lengths of *Halodule uninervis* for elevated reef at Gulf of Kutch, Gujarat

	Average Leaf Length (in mms)	Average Internodal length (in mms)
Chepri	68.6±20.4	21.8±4.24
Pathiwadi reef	75±16.12	21±5.47
Hankiwala reef	55±30.14	18±6.34

Reproductive ecology of seagrasses of the Gulf of Kutch, Gujarat

Studying the reproductive biology of seagrasses is an essential key to understand reproductive demography. Members of the *Halophila* genera of the Hydrocharitaceae family in Gulf of Kutch do not reproduce all year round with the same flowering intensity. Sex ratios, flowering frequencies are all elemental facets to layout the genetic structure of seagrasses of the Gulf of Kutch. This, in turn, shall help re-establishing the declining meadows and in undertaking appropriate management decisions. *Halophila ovalis* and *Halophila beccarii* are dioecious with different plants bearing female and male flowers. *Halophila decipiens* or Paddle grass, a recent record from the Gulf of Kutch (in review Sameeha et.al), is a bisexual plant with a different reproductive strategy. Although, more sampling efforts are needed to factualize this, Paddle grass in Gulf of Kutch seems to be protandrous in nature. Mature male flowers were noticed before female flowers. A meadow might maintain its genetic heterogeneity by avoiding self-fertilization through this strategy.

No flowers were found on *Halodule uninervis*. This seagrass rarely produces any flowers and reproduce using clonal shoots.



Figure 2.5: 1. Female plant of *Halophila ovalis*, 2. Male plant of *Halophila ovalis*, 3 and 4 Male and female flowers of *Halophila ovalis*, 5. Ramet of Tiger grass *Halophila beccarii*, 6. Male flower of Tiger grass, 7. Ramet of *Halodule uninervis*, 8. Ramet of *Halophila decipiens*, 9. Flower of *H. decipiens*

Epiphytes

Epiphytic algae provide habitat and food for snails (gastropods), crabs, shrimps, amphipods (shrimp-like crustaceans) and worms. Epiphytes are an important component of a productive estuarine ecosystems as they provide biomass and oxygen. As seagrass has roots and algae do not, a seagrass blade offers a point of attachment for algae not usually able to settle in sandy or muddy areas. In a healthy ecosystem, algae epiphytes are kept to a minimum by the continual shedding of leaves by seagrass, and by gastropods and crustaceans actively grazing the algae. Experiments have indicated that the presence of these grazers significantly increases seagrass growth by reducing the amount of epiphytic algae smothering the seagrass plant.

As seagrasses and epiphytic algae are competing for the same light and nutrients, seagrasses engage in partial chemical warfare with the algae. Seagrass plants release from their leaves dissolved compounds that interfere with epiphyte growth. Unchecked epiphytic algae absorb most of the light and nutrients before they reach the seagrass, reducing seagrass photosynthesis and hence growth.

Epiphytes were observed to be seasonal and their cover may reach a peak of around 55-65 % of the whole leaf area during the dry summer season. Epiphytes majorly are composed of brown or green microalgae on the Hankiwala reef and Bhaidar islands. On Betiwala reef epiphytes on *Halodule uninervis* were crustose coralline algae or the CCA. Epiphytes start growing from the apex of the leaf and progress towards the base. Also, epiphytes initially were observed to only cover the edge of the leaf and later filled the rest of the lamina. The less common of the epiphytes were polychaetes which were observed on mid-intertidal *Halodule uninervis*. Epiphytes are at a healthy cover percentage, not only can summon herbivorous gastropods, crustaceans and fishes, they also increase the total biomass of a seagrass meadow. It should also be noted that morphologically smaller seagrass species like *Halophila beccarii* (Tiger grass) does not get heavily bio-fouled by epiphytes. This might be for the fact that Tiger grass grows on smooth and loose mud in high exposure areas. Further study is warranted for this.

Paga reef, our representative site for monitoring epiphytic variations, experienced a gradual decline in microalgal-epiphytic cover during winters of 2020 when temperatures drop by 10°C as shown by the dotted line in Figure 2.7. Epiphytes increase the overall photosynthetic biomass of a meadow, making healthier pastures for herbivores.



Figure 2.6 : Top panel – Brown microalgal biofouling leaves of *Halodule uninervis* (left) and *Halophila ovalis* (right)

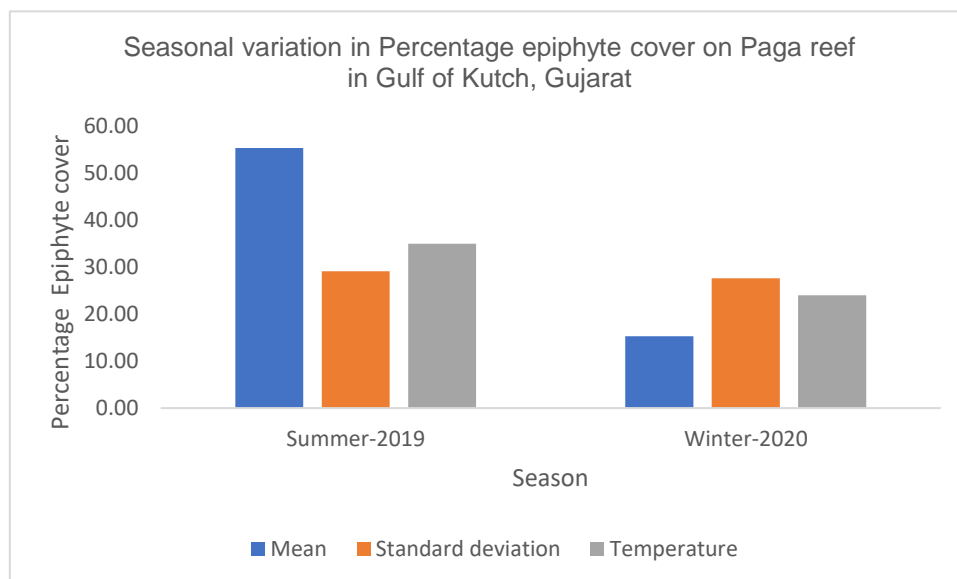


Figure 2.7: Seasonal variation in percentage epiphyte cover on Paga reef during 2019-2020 in Gulf of Kutch, Gujarat

2.1.3 Understanding temperature and light intensity trend in Bhaidar island's seagrass meadow in Gulf of Kutch, Gujarat

Temperature

Temperature affects the seagrass distribution through effects on flowering (de Cock 1981, McMillan 1982, Durako and Moffler 1987) and seed germination (Harrison 1982, Phillips *et al.* 1983a).

Temperature and light intensity plays a critical role in the eulittoral zone in deciding the distribution of seagrasses and macroalgae. The multiple loggers were placed carefully only after understanding the hydrodynamics and tidal depth of a meadow. The aim was to depict a general temperature and light profile for a representative meadow ie Bhaidar. The values are of temperature and light are of the meadow conditions above the sediment line. The device was set to take readings according to the mixed semidiurnal diel tidal cycle, a characteristic of Gulf of Kutch.

The representative temperature and light intensity values of approximately a fortnight during 26.01.2020 to 02.02.2020 (Figure 2.8) are presented to report the fluctuations experienced by a typical seagrass meadow in Gulf of Kutch, Gujarat. Although the average temperature remains stable at 20.5 °C the values seem to fluctuate throughout a day due to the semi-diurnal tidal regime of the region. This causes some seagrass meadows to be exposed at least twice a day. The maximum temperature during winters was 24°C and the minimum temperature that the meadow endured was 18°C. As mentioned above, these species are hardy in nature and can tolerate a range of temperatures in their habitat.

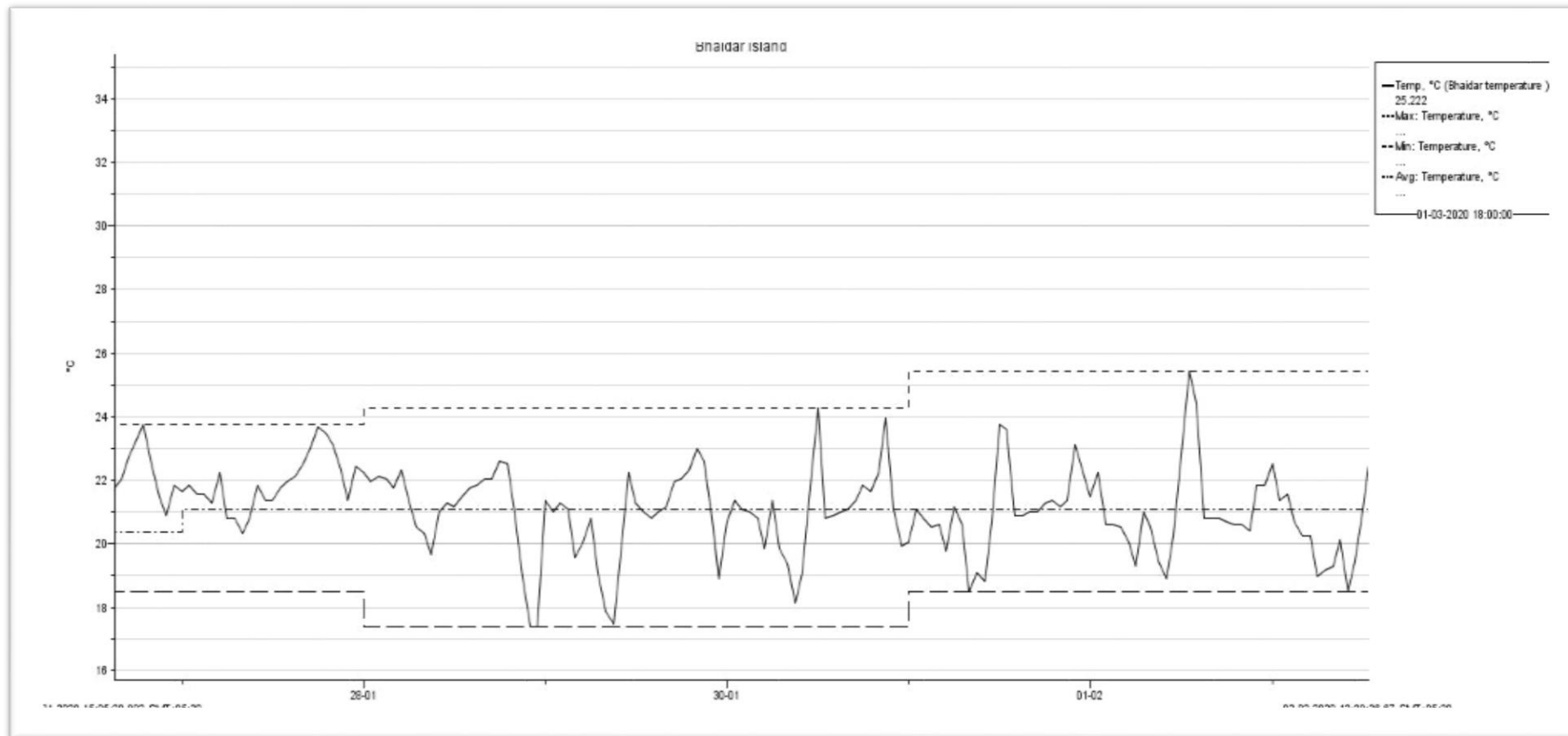


Figure 2.8 : Representative temperature profile of a typical seagrass meadow of the Gulf of Kutch,Gujarat

Light

In shallow waters and intertidal, seagrass photosynthesis and production are inhibited by exposure to high light conditions (Hanelt 1992, Masini *et al.* 1995). Such photoinhibition can prevent the proliferation of some species and result in a distribution that favors more high light tolerant species.

Light plays a fundamental role in deciding which seagrass species colonizes at what depth or elevation. Short-term changes in light availability driven by a large tidal range have an impact upon seagrass survival. Figure 2.9 shows light intensity values in lux for a typical seagrass meadow in Gulf of Kutch. Since the sensor measure light from direct sunlight in the water column, a calibration factor of 0.0185 was used to convert lux values to $\mu\text{mol m}^{-2} \text{s}^{-1}$. The average maximum light intensity for the winter period of about a month was $359.421 \mu\text{mol m}^{-2} \text{s}^{-1}$. Note that the full sunlight is $2000 \mu\text{mol m}^{-2} \text{s}^{-1}$. The average Light intensity was $27.12 \mu\text{mol m}^{-2} \text{s}^{-1}$. These values fall within the acceptable light intensity values for a seagrass meadow composed of such resilient species. Values shown in the figure 2.9 are lux values for light intensity. $1 \text{ lux} = 0.0185 \text{ Photons } (\mu\text{mol m}^{-2} \text{s}^{-1})$.

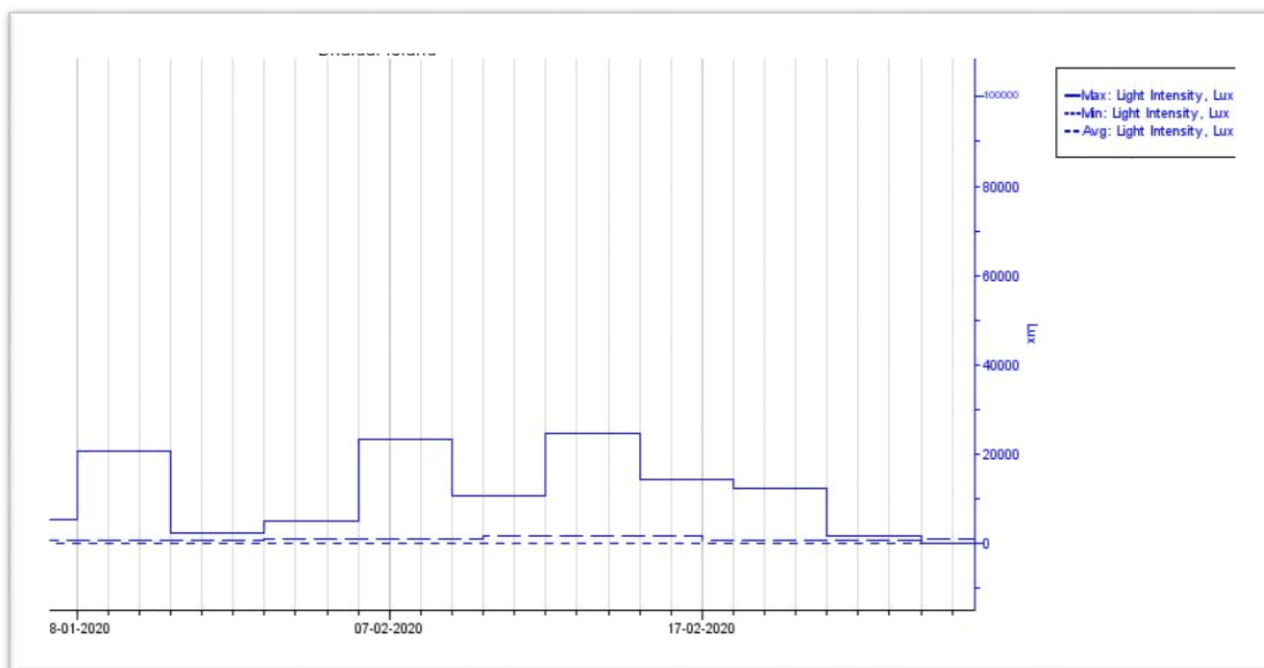


Figure 2.9: Light intensity profile of Bhaidar island's seagrass meadow of Gulf of Kutch, Gujarat

2.1.4 Sediment profile of seagrass meadows in the south-western Gulf of Kutch during 2019

Soil texture was determined by the international pipette method and water holding capacity (WHC) determined by methods of Keen box. Piper C.S. (1966) Soil and Plant Analysis. Hans Publisher, Bombay.

To understand the spatial ecology of seagrasses in a region as topographically heterogeneous as the reefs of the Gulf of Kutch, sediment on which the grasses colonizes needs to be studied too. Seagrasses colonize benthic habitat with the varying softness that is imparted by the ratio of mud/silt in a meadow.

Since seagrasses are rooted plants, they have an obvious dependence on the nature of their sedimentary environment (Thangaradjou and Kannan, 2005). We report that the general configuration of seagrass species distribution on a particular reef depends not only upon the exposure of a meadow to waves, tidal currents but also the sediment texture. The hydrodynamics of a region and sediment texture are not independent variables in a natural system. Moreover, seagrasses, based on species and shoot density can change the sediment structure by reducing the canopy and within meadow water movement and enabling sedimentation.

This has been observed in places like the Paga reef. Soft and loose sediment dominates the sheltered part of an island. This creates an opportunity for smaller sized seagrasses like *Halophila ovalis* and *Halophila beccarii* (HB) to colonize. Although *Halophila ovalis* (HO) and *Halodule uninervis* (HU) can also grow on a variety of sediment types ranging from fine to coarse sand as is observed in the Chepri reef, Hankiwala and Patthiwadi reef of Bhaidar island. Tam reefs sediment is composed of the highest percentage of fine sand. Reefs like Chepri, Hankiwala, Betiwala, and Bhaidar islands reef are all high elevation reefs experience high-velocity surface currents during the high tide periods which makes the general sediment profile skewed towards the larger grain-sized sediment particles (Figure 2.10) and are low in fine sand and clay.

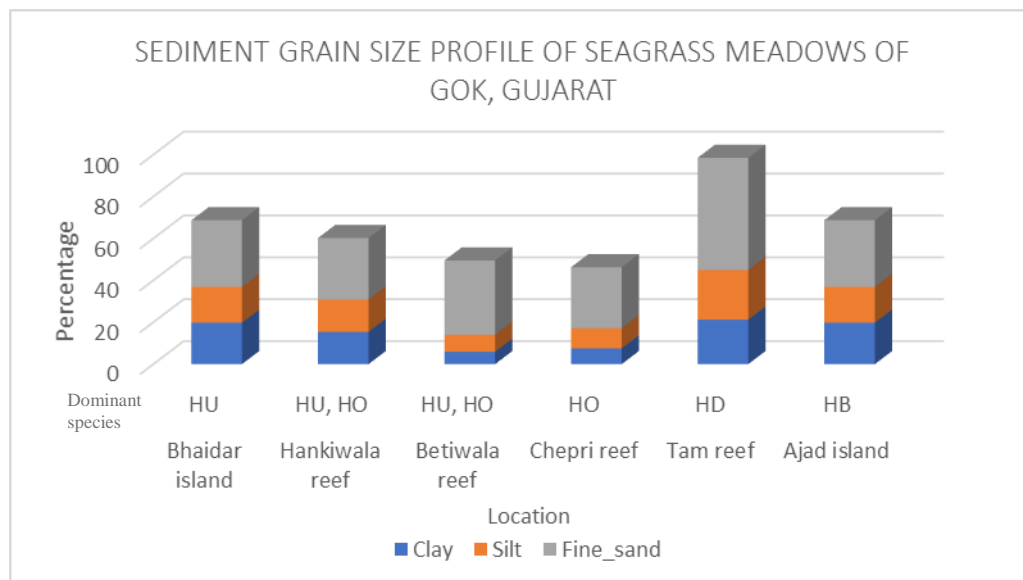


Figure 2.10: Sediment grain size profile of seagrass meadows of Gulf of Kutch, Gujarat (HU- *Halodule uninervis*, HO- *Halophila ovalis*, HB- *Halophila beccarii*, HD- *Halophila decipiens*)

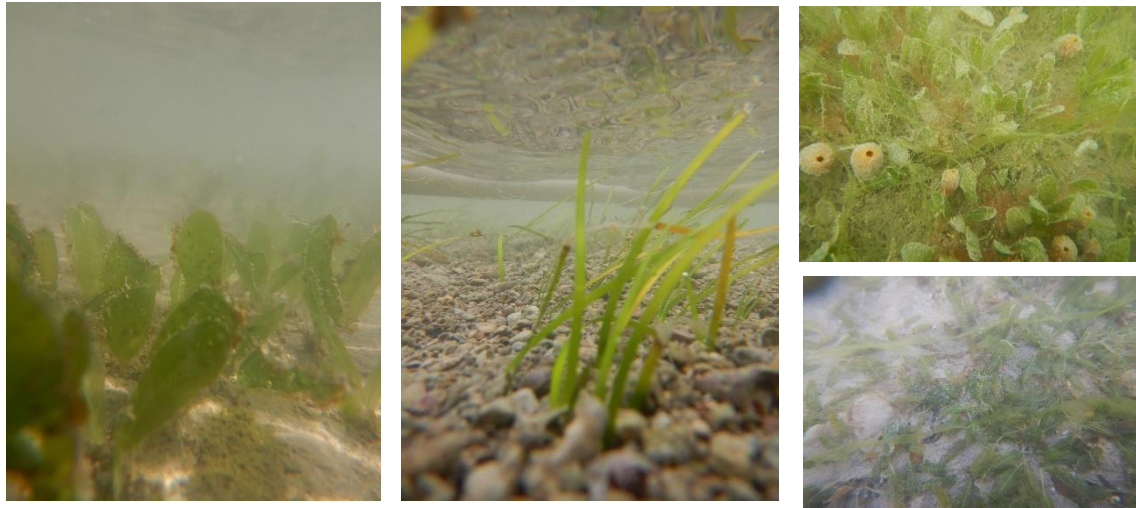


Figure 2.11: Clockwise *Halophila ovalis* colonising fine sand sediment on Chepri reef, *Halodule uninervis* on coarse sand and gravel on Paga reef, *Halophila decipiens* on muddy substrate in Beyt-Dwarka island, *Halophila beccarii* occupies the soft clayey sediment

2.1.5 Subtidal seagrass surveys in Gulf of Kutch, Gujarat

Understanding the distribution of seagrasses in the deeper waters is integral to studying the movement patterns and foraging range of dugongs in the Gulf of Kutch, Gujarat. These meadows are also home to various benthic fauna that Seagrasses grow along the contour lines of the depth gradient. A GPX fix was taken for every sampling effort. Physical parameter like turbidity was estimated using Sacchi disk. Depth, temperature and salinity were also noted.

Dive attempt to map subtidal seagrass in the Bhaidar Island cove was conducted. Although a new bed of *H. decipiens* was discovered at a depth of 6-8 meters, it was realized that mapping the subtidal zones by using the diving method is not possible a very extremely risky feat too. This is due to the very low visibility and high current speed of the water. The team resorted to the use of Van Veen grab for subtidal mapping of seagrasses using the presence-absence method. However, it became difficult to use the grab during high surface currents.

Coves of Dunny point, Paga reef and Bhaidar islands shelter subtidal areas that need to be surveyed more for mapping the spread of paddle grass.

Table 2.2: Updated list of seagrass meadows: location, sediment type, seagrass composition and surveyed area in south-western Gulf of Kutch, Gujarat

SN	Site	Location	Meadow type(s)	Dominant sediment type	Seagrass species composition	Study year	Meadow area (in kms)
1	Ajad island	22°23'7.50"N 69°19'32.77"E	Intertidal mud-flat	Mud	Hb, Ho	2018	2.57
2	Bhaidar island- West	22°29'11.54"N 69°17'0.82"E	Intertidal sandy	Coarse sand	Hu, Ho, Hb, Hd	2018	2.61
3	Bhaidar island- SW cove	22°27'20.80"N 69°16'31.52"E	Subtidal	Mud	Hd	2019	2.35
4	Bhaidar island-East	22°26'43.70"N 69°19'19.76"E	Intertidal mud-flat	Mud	Hb	2020	2.58
5	Chepri reef	22°26'50.37"N 69°15'47.42"E	Intertidal reef-flat	Coarse sand	Ho, Hu, Hd	2019	4.36
6	Paga-West	22°28'4.24"N 69°12'39.59"E	Intertidal reef-flat	Coarse sand	Hu, Ho	2017	3.09
7	Paga-Central	22°27'34.25"N 69°13'53.30"E	Intertidal reef-flat	Coarse sand-mud-silt	Hu, Ho	2018	4.83
8	Paga-cove	22°29'4.60"N 69°12'26.73"E	Subtidal	Silt-mud	Hd	2020	1.62
9	Paga-North	22°28'18.55"N 69°14'8.46"E	Intertidal reef-flat	Coarse sand-mud	Hu, Ho	2019	1.97
10	Beyt-Dwarka	22°27'7.44"N 69° 6'50.93"E	Mid-intertidal mud-flat	Mud-silt	Ho, Hd	2018	4.82
11	Dunny point	22°27'14.38"N 69° 8'56.14"E	Subtidal	Mud	Hd	2020	3.37
12	Taam reef	22°32'23.68"N 69°17'46.53"E	Mid-intertidal	Silt-mud	Ho, Hd, Hb	2019	4.82
Note: Hu: <i>Halodule uninervis</i> ,Ho: <i>Halophila ovalis</i> , <i>Halophila beccarii</i> , Hd: <i>Halophila decipiens</i>							

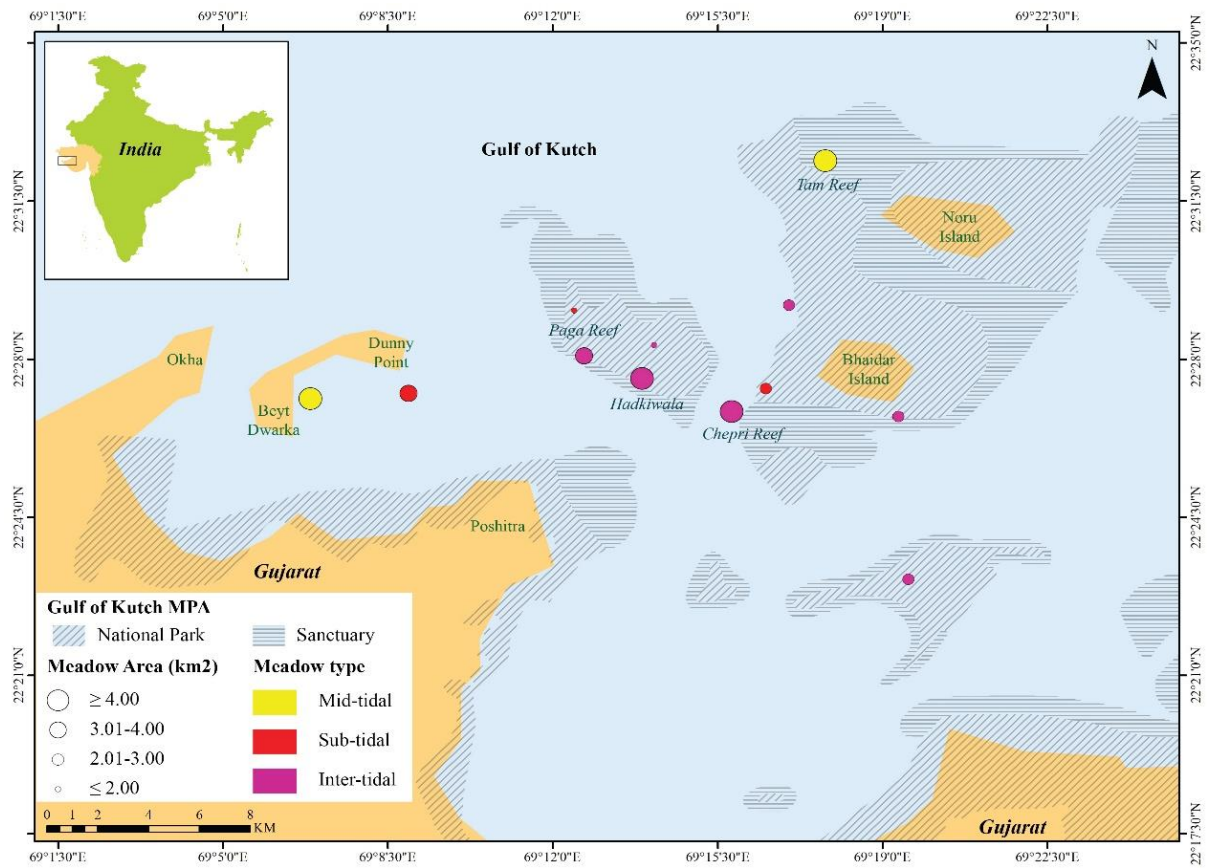


Figure 2.12: Seagrass meadows surveyed area in south-western Gulf of Kutch, Gujarat

Table 2.3: Subtidal seagrass meadows seagrass composition with environment parameters in Gulf of Kutch, Gujarat

SN	Location	Date	Type of collection	Quadrat	Seagrass	Seagrass composition	Seagrass cover	Seagrass shoot density/m ²	Depth (in ft)	Temperature (in celsius)	Salinity ppm
1	Paga reef	26-02-2020	Subtidal	PG1	Present	HD	NA	1	9	24.6	34
2	Paga reef	26-02-2020	Subtidal	PG2	Absent	NA	NA	0	11.5	24.6	35
3	Paga reef	26-02-2020	Subtidal	PG3	Absent	NA	NA	0	11.8	22.6	35
4	Paga reef	26-02-2020	Subtidal	PG4	Present	HD	NA	6	8.2	23.2	35
5	Paga reef	26-02-2020	Subtidal	PG5	Present	HD	NA	9	9.5	26.5	35
6	Paga reef	26-02-2020	Subtidal	PG6	Absent	NA	NA	0	11.9	23.3	35
7	Paga reef	26-02-2020	Subtidal	PG7	Absent	NA	NA	0	12.8	24	35
8	Paga reef	26-02-2020	Subtidal	PG8	Present	HD	NA	11	6.4	24.04	35
9	Paga reef	26-02-2020	Subtidal	PG9	Absent	NA	NA	0	5.42	NA	35
10	Paga reef	26-02-2020	Subtidal	PG10	Absent	NA	NA	0	NA	24.2	35
11	Paga reef	26-02-2020	Subtidal	PG11	Present	HD	NA	4	12.1	24.9	35
12	Dunny Point	26-02-2020	Subtidal	DU1	Present	HD	NA	10	9.6	24.9	35
13	Dunny Point	26-02-2020	Subtidal	DU2	Present	HD	NA	4	8.3	25	35
14	Dunny Point	26-02-2020	Subtidal	DU3	Present	HD	NA	14	10.9	24.6	35
15	Dunny Point	26-02-2020	Subtidal	DU4	Present	HD	NA	9	10.8	24.8	35
16	Dunny Point	26-02-2020	Subtidal	DU5	Present	HD	NA	23	10.6	24.9	35

Note : HD: *Halophila decipiens*



Figure 2.13: Left- Subtidal seagrass mapping attempt near Bhaidar islands, Right- *Halophila decipiens* at the depth of 7 meters in Gulf of Kutch, Gujarat

2.1.6 Ecological surveys of the abundance and diversity of benthic macrofauna associated with seagrass meadows in the Gulf of Kutch, Gujarat

Benthos is a crucial component of biotic life found in shallow water estuarine and coastal marine ecosystems. Macrobenthos are the bottom-dwelling organisms found in all the aquatic ecosystems of the world and which differ from ecosystem to ecosystem. Benthos plays a major link between primary producers, decomposers, and higher trophic levels. Benthos are classified into three types based on body size. macrofaunal animals (body size greater or equal to 0.5 mm); meiofaunal animals (smaller than 0.5 mm but greater than 0.1 mm) and microfaunal animals (less than 0.1 mm in size) (Levinton, 1995).

A rich community of infaunal organisms directly or indirectly contribute to the success of seagrasses. Bioturbation by mobile infauna can aid in nutrient cycling and seed burial. Different mixtures of seagrass species alter environmental conditions and food availability within the sediment through a range of processes (ranging from sediment trapping to interspecific differences in photosynthate production) which in turn affect differences in nematode community structure directly or through indirect pathways (Somerfield et al., 2002).

The abundance and biomass patterns of macrofaunal assemblages associated with seagrass habitat were investigated in the Gulf of Kutch from February 2020 to March 2020.

Study area

Paga reef is located between 22°28.8' to 22°30.0'N latitude and 69°11.6' to 69°15.0'E longitude covering an area of 1472.4 ha which remains submerged during high tide and gets exposed only during low tides. Paga=A foot (An island having foot-shape).

Beyt Dwarka is an inhabited island at the mouth of the Gulf of Kutch situated 3 km off the coast of Okha.

Hadkiwala reef is a seagrass habitat that harbors dense stands of seagrasses of both Cymodoceaceae and Hydrocharitaceae family. The seagrass meadow here grows in a lagoon-like an area might be the oldest seagrass meadow in the area. Fossil coral reef flats act as a physical wave-breaker as they form a rim around the meadow. These coral reef flats are mainly composed of *Montipora*, *Goniopora* etc. The meadow experiences mixed-semidiurnal tides, i.e. two high and low tides with different sizes each lunar day.

Chepri reef is a fringing reef flat which is an extension of the island Chusna. Large extensions of sandy/muddy substrate are lined by coral reef flats along the seaward side. The site is tide prone and the meadow experiences mixed-semidiurnal tides, i.e. two high and low tides with different sizes each lunar day. But owing to its slight elevation, the meadow remains exposed for a relatively long time.

Seagrass habitat type-young stands of seagrass of two genera *Halophila* and *Halodule* grow in vast mixed meadows, making it an important dugong foraging area.

Tam reef is situated on the outer rim of the western part of the reef making it closer to the off-shore open sea of the gulf. The fossilized coral reef acts as a barrier between the meadow and the high energy currents as they cover a significant area of the very reef itself. Seagrass meadows are located towards the inner sheltered part of the reef.

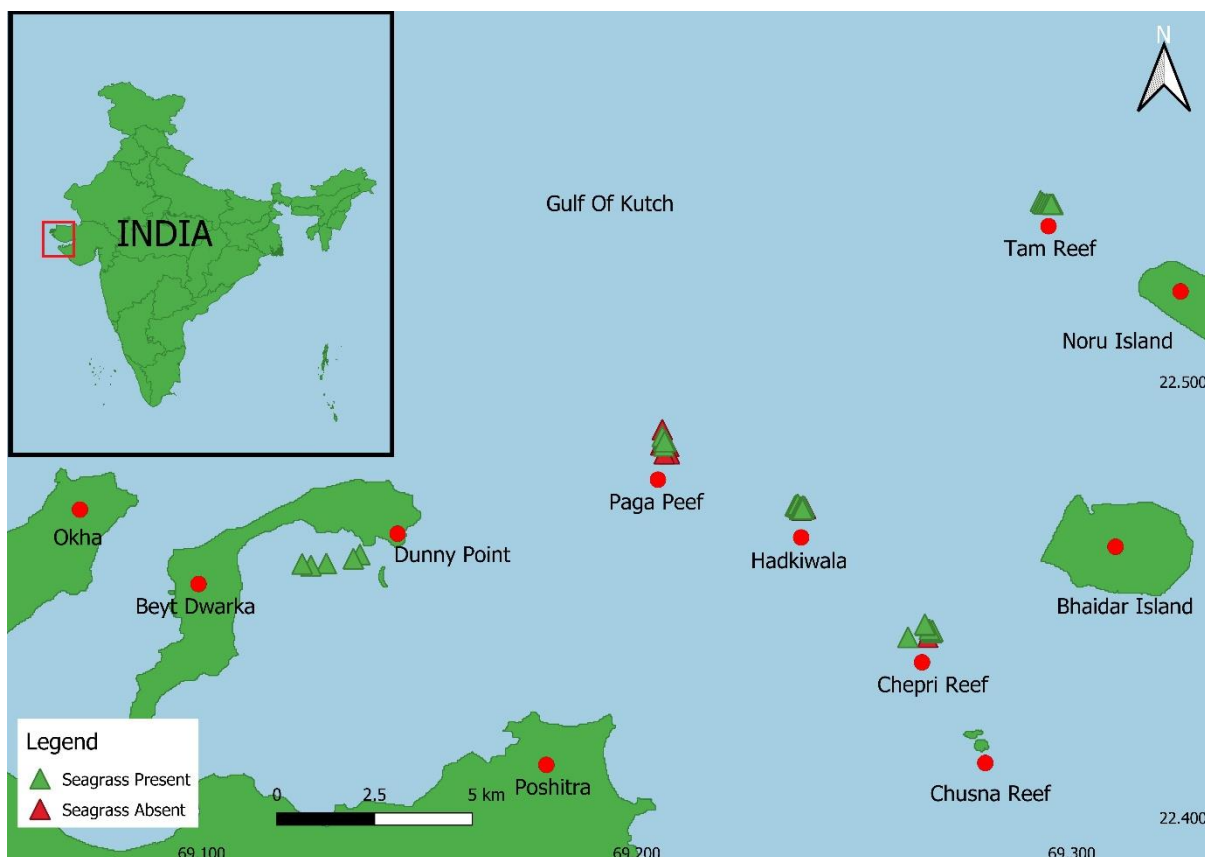


Figure 2.14: Sampling locations for seagrass associated macrobenthic fauna at Gulf of Kutch, Gujarat

Methods

For Intertidal Benthic Faunal Sample Collection

Seagrass associated invertebrates were collected during the low tide in the pre-monsoon season during February 2020- March 2020. A PVC pipe frame of 50 x 50cm Quadrat was placed over the area covered by seagrass. In all stations, sampling was carried out at low tide in the lower, middle zone, and high zone part of the intertidal area, which will be 100 meters spaced apart exposed during low tide. The quadrat was positioned so that the lower right corner of the quadrat is on the random distance mark when the person placing the quadrat is facing the shore. A photograph of the quadrat was taken. The photograph from an angle as vertical as possible, which includes the entire quadrat frame, the quadrat label. The seagrass species present in the quadrat was identified and was entered in the datasheet % cover and % cover of each species in the quadrat was estimated using the "Seagrass percentage cover photo guide" in the back of the SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat, Worldwide edition (Short et al., 2006).

Seagrass biomass core to 10 Cm depth outside each quadrat by selecting an area approximately 0.5m landward of the quadrat in an area of the same seagrass species and the cover as the quadrat. Plant parts were rinsed in freshwater, was air-dried for 24hr, and were weighed to calculate Biomass (g wet wt m²). Sediment characteristics such, Salinity, Sediment quality size (% gravel/sand/silt+clay), organic content (% loss on ignition) will be carried out in the laboratory. For this study period, water parameters such as Salinity were measured on the field with the help of Generic 0-28 Percent Salinity Refractometer Concentration Detection Salinometer Salinity Meter which was calibrated before use. Water temperature was measured with the help of an MCP Digital thermometer, model no TP3001(Black). Photographs on the field were taken with help of waterproof NIKON COOLPIX camera W300.

Natural Geography in Nearshore areas (NaGISA): The Nearshore component of the Census of Marine Life Protocol was followed for this macrobenthic fauna in intertidal seagrass meadows. At each study site, a stratified random sampling strategy was employed, with strata representing vertical heights above and below low water datum. That is, for each site, five random replicate samples will be taken at the high, mid, and low intertidal position. Ideally, five replicates will be taken from each quadrat of 20x20 Cm to a depth of 5-10 Cm adjacent to seagrass. Samples were preserved in 5%, formalin, and stained with Rose-Bengal. The benthos in the sediment sample were recorded after sieving through the Brass metal sieve of 500 microns mesh size sieve. In the laboratory, sediment type, % seagrass cover, % algal cover, seagrass canopy height, seagrass shoot density, % seagrass epiphytic cover, Biomass, nutrients, depth, salinity, and temperature. The total population was estimated as the number of animals in 1 meter and biomass on a wet weight basis.



Figure 2.15: Researcher conducting benthic sample processing on board at Gulf of Kutch, Gujarat

Subtidal faunal collection

Devices used to sample soft-bottom macrobenthos comprise grabs, dredges, box-corers and hand nets. Grabs and corers are suitable for quantitative studies, i.e. when the collection of a defined amount of sediment is required. Van Veen grabs with area 0.04m^2 was used to collect subtidal benthic samples. The Van Veen grab is easily operated by a rope and, therefore, it is suitable for relatively deep waters but has the disadvantage that it takes an uneven mouth-shaped bite of the sediment.

Samples were sieved to remove fine sediments and any other extraneous material. Once on the boat, the grab was opened above a plastic bucket and the sample was gently removed. Depth was measured onboard using DEPTHTRAX 1H handheld depth finder with the inbuilt temperature sensor. Seagrass cover could not be estimated due to turbidity. Seagrass composition and shoot density were estimated in the lab.

When clay sediments were present, the sediment was broken up inside the bucket by adding filtered seawater and stirring gently. Filtered water was used to avoid the introduction of unrelated small organisms. The sample was then sieved; water was sprinkled directly onto the sample with a low-pressure nozzle to prevent any damage to animals. The samples were kept in watertight plastic bags. The delicate process of sieving was performed very carefully to avoid any damage to the fragile organisms and to ensure that all animals present in the sample is collected. To separate macrofauna, a sieve of 0.5 mm mesh was used. The samples were preserved in 5% formalin and stained with Rose Bengal.



Figure 2.16: Grab sampling on board for subtidal seagrass meadows in Beyt Dwarka in Gulf of Kutch, Gujarat

Sample processing

Upon receipt in the laboratory, samples were already preserved in 5% formalin fixative and will be washed and transferred to a preservative after 2 weeks. Organisms were sorted according to their taxonomic groups, counted, and will be identified to the lowest possible taxonomic level using relevant identification guides. Sorting is the process by which organisms in a benthic sample that were alive at the time of collection are removed from the organic and inorganic residues (debris) that compose the sample and sorted into broad taxonomic categories for subsequent taxonomic analysis. Biomass was obtained by weighing wet weight using calibrated TECHway High Precision Table Top Digital Weighing Scale, (Capacity:600 g Accuracy:0.01 g (10 mg))lab weighing scale and was documented. Benthic samples were sorted with the help of Accumax stereomicroscope Model No BPM-3TCPC for photo documentation and the voucher specimen was photographed. After sorting the samples were stored in sterile Tarson sample containers of PP/HDPE material of 100 ml capacity. After weighing the samples were stored in 70% Ethanol and were sealed with Parafilm to avoid evaporation.



Figure 2.17: Sample sorting with Stereomicroscope at Fishery Research Station, Okha

Results

Total 53 samples were collected from Paga Reef, Tam reef, Chepri Island, Hadkiwala reef and Dunny point-Beyt Dwarka during premonsoon period of February- March 2020. Total 14 groups viz Gastropods, Pelecypod, Crustaceans such as Tanaidceans, Cumceans, Polychaetes, Amphipods, Isopods, Foraminiferans, Holothuroideas, Echinoids, Ophiuroideas, Crinoids, Scaphopoda, Polyplacophora. For further taxonomic level identification samples will be sent to another research institute. More replicates need to be taken for the conclusion for the assemblage in seagrass meadows and seagrass absent areas for comparison.

The highest wet weight biomass population and groups were found at Hadkiwala since the sampling efforts were more. Average biomass varied from 0.5 – 35.4gm/m² wet weight), average biomass varied 34.1- 167.7 nos/m²) and average no of groups 3-8.

For baseline only one sample was taken from each quadrat while sampling. In next survey more replicates will be taken.

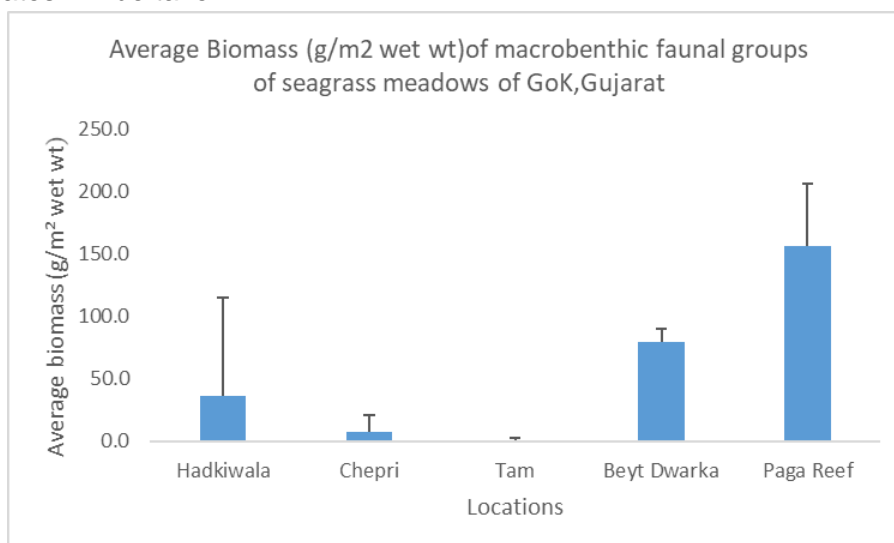


Figure 2. 18: Average biomass (g/m²) of macrobenthos associated with seagrass during February -March 2020 of Gulf of Kutch, Gujarat

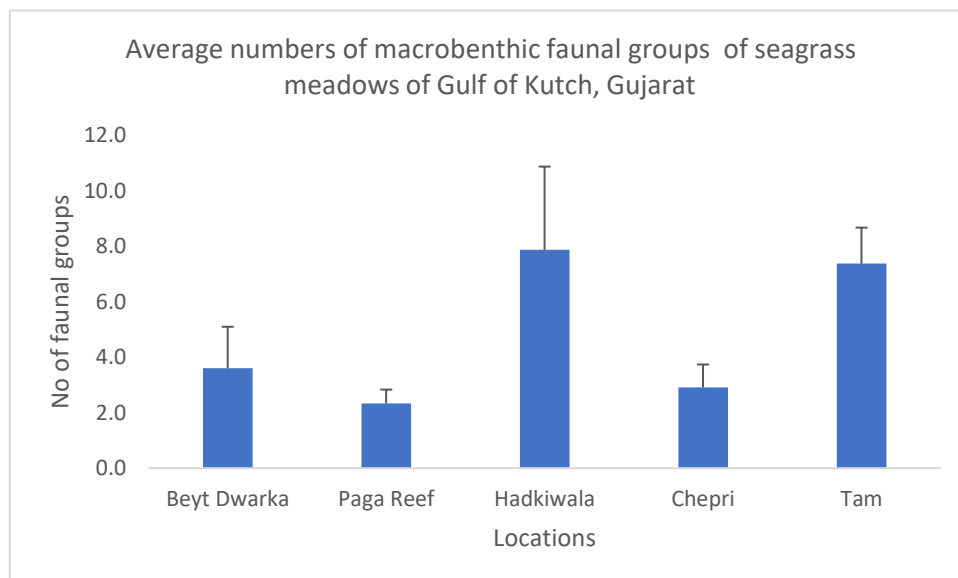


Figure 2.19: Average number of faunal groups of macrobenthos during February- March 2020 of Gulf of Kutch,Gujarat

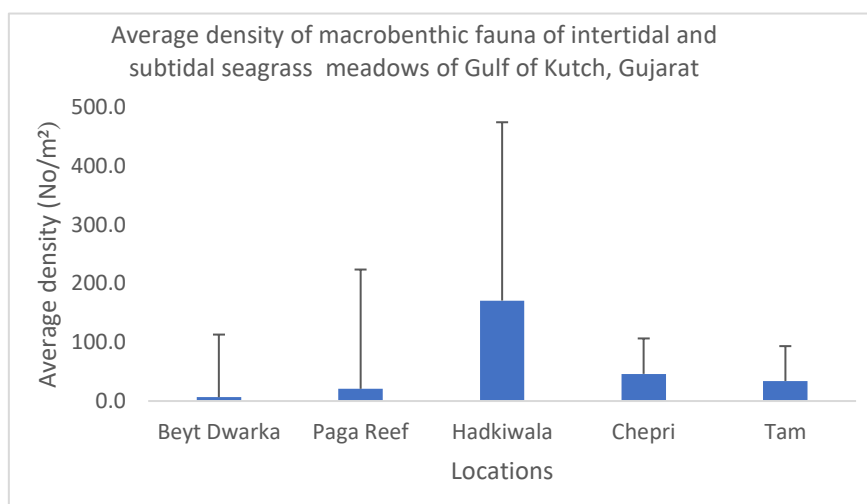


Figure 2.20: Average density of faunal groups of macrobenthos during February- March 2020 of Gulf of Kutch,Gujarat

Hadkiwala Reef

Two seagrass species viz *Halophila ovalis* and *Halodule uninervis* were observed at Hadkiwala reef. The population density of macrobenthic fauna associated in intertidal seagrass meadows of Hadkiwala in February (4-556; avg 71; SD± 155.42 no/m²), biomass (0-200 g/m²; avg 15.8; SD± 43.44) and faunal groups 1- 7, avg 5 SD± 1.79). Population density varied widely (Table 2.4) during the monitoring period in February 2020. Gastropod (76.41%), Polychaetes (7.6%), Amphipods(6.0%) and isopod (3.8%) The salinity didn't vary at site 35 ‰ The typical seawater has a salinity of 35 ppt or 35‰.The surface water temperature showed a slight variation 21°-22.3°C avg 9°C SD±10.74.

Table 2.4: Seagrass associated macrobenthos composition of Hadkiwala reef during February 2020 of Gulf of Kutch,Gujarat

Location Hadkiwala	Date Of Collection	Type of Collection	Seagrass	Groups	Biomass(g/m ² wet wt)	Density (no/m ²)	No of groups
HQ1	13/02/2020	Intertidal	Present	Gastropod	15.08	40	1
HQ2	13/02/2020	Intertidal	Absent	Gastropod	56.1	188	7
	13/02/2020	Intertidal		Tanaidaceans	0.0	8	
	13/02/2020	Intertidal		Pelecypod	4	4	
	13/02/2020	Intertidal		Isopods	8	8	
	13/02/2020	Intertidal		Echinoids	4	4	
	13/02/2020	Intertidal		Polychates	0.0	24	
	13/02/2020	Intertidal		Amphipods	0.0	8	
HQ3	13/02/2020	Intertidal	Present	Gastropod	200	732	5
	13/02/2020	Intertidal		Echinoids	0.0	4	
	13/02/2020	Intertidal		Polychates	0.0	32	
	13/02/2020	Intertidal		Isopods	1.4	48	
	13/02/2020	Intertidal		Amphipods	0.5	20	
	13/02/2020	Intertidal		Gastropod	158.8	544	
	13/02/2020	Intertidal		Isopods	2	64	
	13/02/2020	Intertidal		Amphipods	0.8	52	
	13/02/2020	Intertidal		Holothuroids	0.0	28	
	13/02/2020	Intertidal		Polyplacophora	0.0	4	
	13/02/2020	Intertidal		Tanaidaceans	0.0	4	
HQ4	13/02/2020	Intertidal	Present	Gastropod	158.8	544	6
	13/02/2020	Intertidal		Isopods	2	64	
	13/02/2020	Intertidal		Amphipods	0.8	52	
	13/02/2020	Intertidal		Holothuroids	0.0	28	
	13/02/2020	Intertidal		Polyplacophora	0.0	4	
	13/02/2020	Intertidal		Tanaidaceans	0.0	4	

Location Hadkiwala	Date Of Collection	Type of Collection	Seagrass	Groups	Biomass(g/m ² wet wt)	Density (no/m ²)	No of groups
HQ5	13/02/2020	Intertidal	Absent	Amphipods	0.0	48	6
	13/02/2020	Intertidal		Isopods	0.0	4	
	13/02/2020	Intertidal		Polychates	0.56	128	
	13/02/2020	Intertidal		Echinoids	0.0	4	
	13/02/2020	Intertidal		Gastropod	27.7	116	
	13/02/2020	Intertidal		Tanaidaceans	0.0	4	
HQ6	13/02/2020	Intertidal	Present	Echinoids	0.0	4	4
	13/02/2020	Intertidal		Gastropod	53.04	308	
	13/02/2020	Intertidal		Amphipods	0.0	28	
	13/02/2020	Intertidal		Polychates	0.0	20	
HQ7	13/02/2020	Intertidal	Present	Amphipods	0.0	20	6
	13/02/2020	Intertidal		Tanaidaceans	0.0	8	
	13/02/2020	Intertidal		Polycheates	0.0	8	
	13/02/2020	Intertidal		Holothuroids	0.0	32	
	13/02/2020	Intertidal		Gastropod	0.0	32	
	13/02/2020	Intertidal		Isopods	0.0	8	
HQ8	13/02/2020	Intertidal	Absent	Isopods	0.0	44	6
	13/02/2020	Intertidal		Gastropod	24.24	108	
	13/02/2020	Intertidal		Amphipods	0.0	36	
	13/02/2020	Intertidal		Echinoids	0.0	12	
	13/02/2020	Intertidal		Tanaidaceans	0.0	16	
	13/02/2020	Intertidal		Polycheates	0.0	12	
HQ9	13/02/2020	Intertidal	Present	Gastropod	149.48	556	4
	13/02/2020	Intertidal		Echinoids	0.0	16	
	13/02/2020	Intertidal		Amphipods	0.0	20	
	13/02/2020	Intertidal		Polycheates	0.9	52	
HQ10	13/02/2020	Intertidal	Present	Gastropod	91.12	416	6
	13/02/2020	Intertidal		Amphipods	0.0	4	

Location Hadkiwala	Date Of Collection	Type of Collection	Seagrass	Groups	Biomass(g/m ² wet wt)	Density (no/m ²)	No of groups
	13/02/2020	Intertidal		Isopods	0.28	16	
	13/02/2020	Intertidal		Polychaetes	0.0	24	
	13/02/2020	Intertidal		Echinoids	0.0	4	
	13/02/2020	Intertidal		Tanaidaceans	0.0	4	
HU: <i>Halodule uninervis</i> ; HO: <i>Halophila ovalis</i>				Average	15.8	71	5

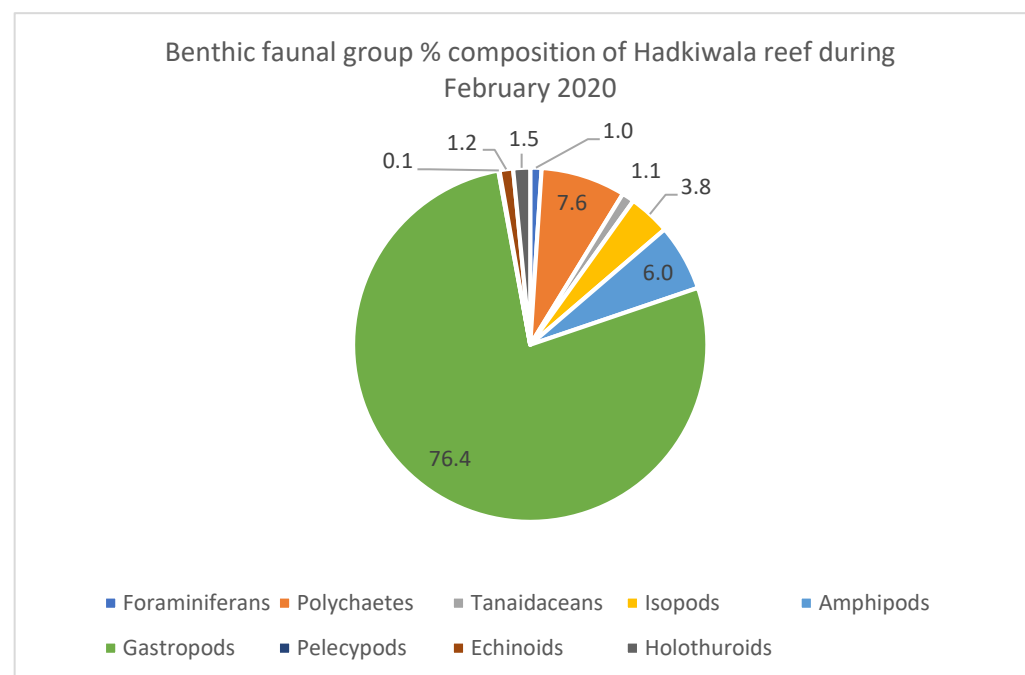


Figure 2.21: Benthic faunal percentage composition at Hadkiwala reef during February 2020

Chepri reef

Total 10 quadrats were laid. The seagrass composition in the area is *Halophila ovalis*, *Halodule uninervis*. The sediment texture is sandy silt. The intertidal seagrass associated macrofaunal standing stock in terms of population density at Chepri (4-184, SD_{\pm} 60.27 avg 46.1 no/m²), biomass (0-62.12 /m²; SD_{\pm} 13.55 avg 6.96 g/m² wet wt) and faunal groups (2-4, SD_{\pm} 0.8 avg 3 no). the population is dominated by Gastropods (88.3%), Pelecypods (8.7%), Isopods (1.7%). The environmental parameters were not documented at this site.

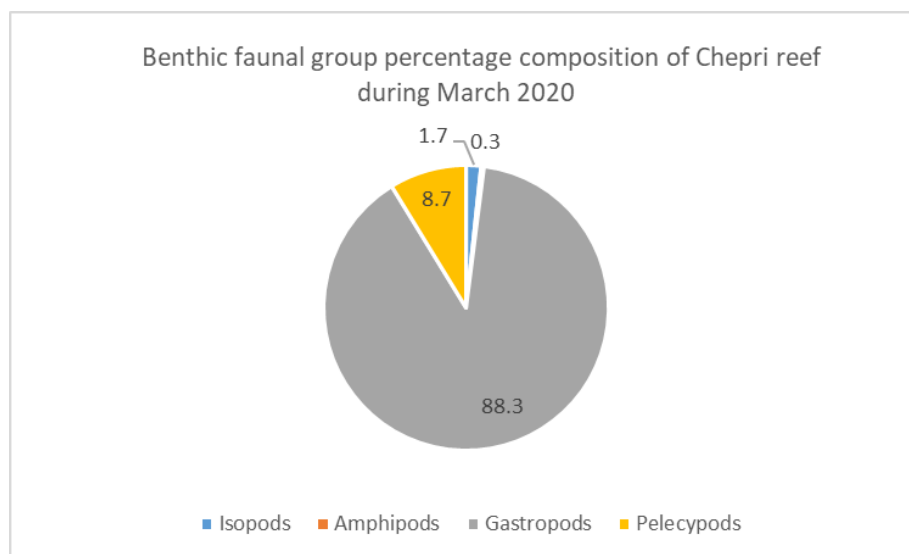


Figure 2.22: Benthic faunal percentage composition of Chepri reef during March 2020

Table 2.5: Seagrass associated macrobenthos composition of Chepri reef during March 2020

Location Chepri	Date of Collection	Type of collection	Seagrass	Groups	Biomass (g/m ² wet wt)	Density (No/m ²)	No of groups
CP1	02/03/20	Intertidal	Present	Pelecypod	1.6	4	2
				Gastropod	7.64	100	
CP2	02/03/20	Intertidal	Absent	Gastropod	10.76	112	3
				Isopod	0.0	4	
				Pelecypod	0.64	8	
CP3	02/03/20	Intertidal	Present	Gastropod	62.12	184	4
				Amphipod	0.0	4	
				Isopod	0.0	4	
				Pelecypod	0.0	16	
CP4	02/03/20	Intertidal	Present	Gastropod	12.8	116	4
				Isopod	0.0	8	
				Polycheate	0.0	8	
CP5	02/03/20	Intertidal	Present	Gastropod	8.8	16	2
				Pelecypod	0.0	4	
CP6	02/03/20	Intertidal	Present	Gastropod	16.92	116	3
				Pelecypod	0.48	16	
				Polycheate	0.0	4	
CP7	02/03/20	Intertidal	Present	Gastropod	7.84	72	2
				Pelecypod	0.0	8	
CP8	02/03/20	Intertidal	Present	Gastropod	25.52	132	2
				Polycheate	0.0	32	
CP9	02/03/20	Intertidal	Present	Isopod	0.0	4	3
				Pelecypod	0.0	16	
				Gastropod	31.16	212	
CP10	02/03/20	Intertidal	Present	Gastropod	8.68	64	4
				Polycheate	0.0	4	
				Amphipod	0.0	8	
				Pelecypod	0.0	16	
				Average	6.96	46.14	3

Hadkiwala

Total of 8 quadrats were laid. Only two seagrass species were documented here viz *Halodule uninervis* and *Halophila ovalis*. The sediment texture is coarse sand and silt. The intertidal seagrass associated macrofaunal standing stock in terms of population density at Hadkiwala (4-532, SD \pm 147.8 avg 99.8. no/m²), biomass (0-129.68 g/m²; SD \pm 35.14 avg 20.5 g/m² wet wt) and faunal groups (1-5, SD \pm 1.2 avg 3 no). The population is dominated by Gastropods (90.5%), Polychaetes (7.5%) during March 2020. The salinity varied from 33-35 SD \pm 0.7Avg 34.6. The surface water temperature varied from 22.5- 24.5 SD \pm 0.8 avg 23.6.

Table 2.6: Seagrass associated macrobenthos composition of Hadkiwala reef during March 2020

Location Hadkiwala	Date of Collection	Type of collection	Seagrass	Groups	Biomass (g/m ² wet wt)	Density (No/m ²)	No of groups
HQ1	12/03/20	Intertidal	Present	Gastropod	30.32	104	2
				Amphipod	0.0	8	
HQ2	12/03/20	Intertidal	Present	Gastropod	30.2	132	3
				Polychaetes	0.28	8	
				Polyplacophora	0.0	4	
HQ3	12/03/20	Intertidal	Present	Gastropod	90.44	308	3
				Polychaetes	0.88	80	
HQ4	12/03/20	Intertidal	Present	Gastropod	65.04	532	3
				Polychaetes	0.0	4	
				Amphipod	0.0	8	
HQ5	12/03/20	Intertidal	Present	Gastropod	129.68	416	2
				Polychaetes	0.0	4	
HQ6	12/03/20	Intertidal	Present	Isopod	0.0	4	4
				Gastropod	46.32	220	
				Polychaetes	0.0	20	
				Pelecypod	0.0	4	
HQ7	12/03/20	Intertidal	Present	Gastropod	16.72	92	5
				Isopod	0.0	12	
				Polyplacophora	0.0	4	
				Polychaetes	0.0	48	
				Ophiroides	0.0	4	
HQ8	12/03/20	Intertidal	Present	Gastropod	41.24	180	1
				Average	20.5	99.8	3

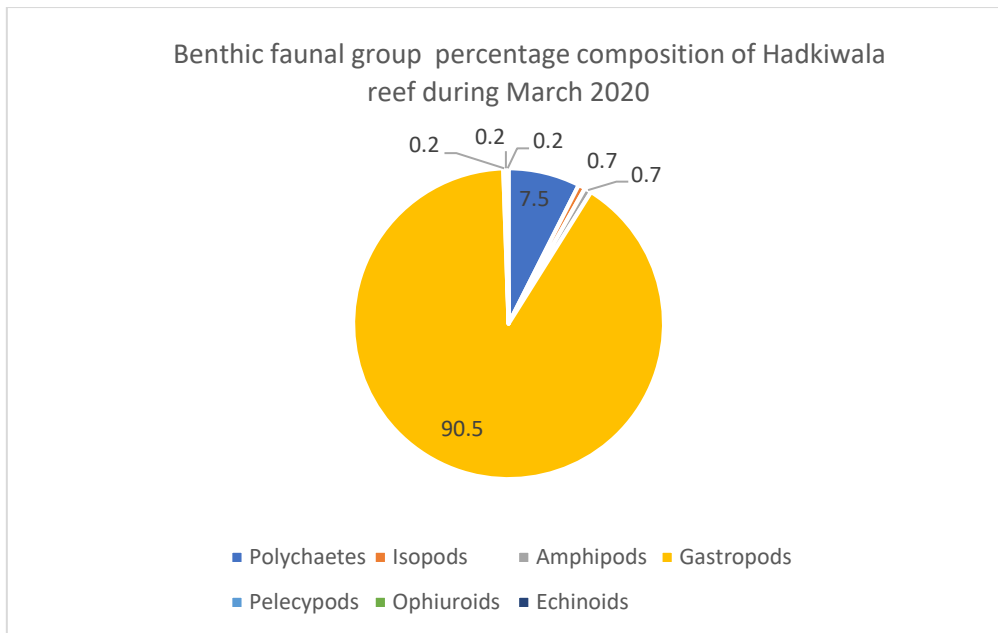


Figure 2.23: Benthic faunal percentage composition of Hadkiwala reef during March 2020

Tam Reef

A total 8 quadrats were laid and *Halodule decipiens* were observed in all quadrats. The sediment composition is mainly fine sand and silt. The intertidal seagrass associated macrofaunal standing stock in terms of population density at Tam reef (4-336, SD± 59.23 avg 34.11 no/m²), biomass (0-18.08 g/m²; SD ± 2.54 avg 0.53 g/m² wet wt) and faunal groups (1-8, SD ± 1.30 avg 7 no). the population dominated by Gastropods (43.1%), Pelecypods (26.1%), Tanaidaceans(12.1%), Polychaetes (6.5%), Foraminiferans (4.9%), Amphipods (4.2%) and Cumaceans (1.8%). The surface temperature varied from 24.6- 28.3°C SD ±1.25 Avg 26.43. Salinity was constant at 35 ppm.

Table 2.7: Seagrass associated macrobenthos composition of Tam reef during March 2020

Location ID	Date of collection	Type of collection	Seagrass	Groups	Biomass (g/m ² wet wt)	Density (No/m ²)	No of groups
TM1	14/03/20	Intertidal	Present	Polychaetes	0.0	24	8
				Amphipod	0.0	20	
				Gastropod	18.08	224	
				Pelecypod	0.32	104	
				Cumacean	0.0	4	
				Tanaidacean	0.0	4	
				Ophiroides	0.0	8	
				Foraminiferan	0.0	4	
TM2	14/03/20	Intertidal	Present	Polychaetes	0.0	24	6
				Tanaidacean	0.0	36	
				Gastropod	4.56	336	
				Pelecypod	0.0	160	
				Amphipod	0.0	12	
				Foraminiferan	0.0	8	
TM3	14/03/20	Intertidal	Present	Polychaetes	0.24	16	7
				Ophiroides	0.0	4	
				Tanaidacean	0.0	48	
				Amphipod	0.0	16	
				Gastropod	0.9	44	
				Pelecypod	0.5	48	
				Foraminiferan	0.0	16	
TM4	14/03/20	Intertidal	Present	Polychaetes	0.0	16	7
				Pelecypod	0.0	32	
				Amphipod	0.0	8	
				Tanaidacean	0.0	12	
				Gastropod	0.0	84	

Location ID	Date of collection	Type of collection	Seagrass	Groups	Biomass (g/m ² wet wt)	Density (No/m ²)	No of groups
				Cumacean	0.0	8	
				Ophiroides	0.0	4	
TM5	14/03/20	Intertidal	Present	Polychaetes	0.0	12	6
				Cumacean	0.0	16	
				Pelecypod	0.6	64	
				Tanaidacean	0.0	104	
				Gastropod	0.0	20	
				Amphipod	0.0	4	
TM6	14/03/20	Intertidal	Present	Polychaetes	0.0	4	7
				Cumacean	0.0	4	
				Tanaidacean	0.0	4	
				Amphipod	0.0	4	
				Gastropod	1.0	4	
				Pelecypod	0.4	4	
				Foraminiferan	0.0	4	
TM7	14/03/20	Intertidal	Present	Polychaetes	0.0	4	4
				Gastropod	0.48	4	
				Tanaidacean	0.0	8	
				Pelecypod	0.0	52	
TM8	14/03/20	Intertidal	Absent	Polychaetes	0.48	16	8
				Gastropod	0.0	56	
				Pelecypod	0.0	4	
				Amphipod	0.0	12	
				Holothuroid	0.0	8	
				Foraminiferan	0.0	56	
				Cumacean	0.0	12	
Tanaidacean	0.0	4					
				Average	0.53	34.11	6.50

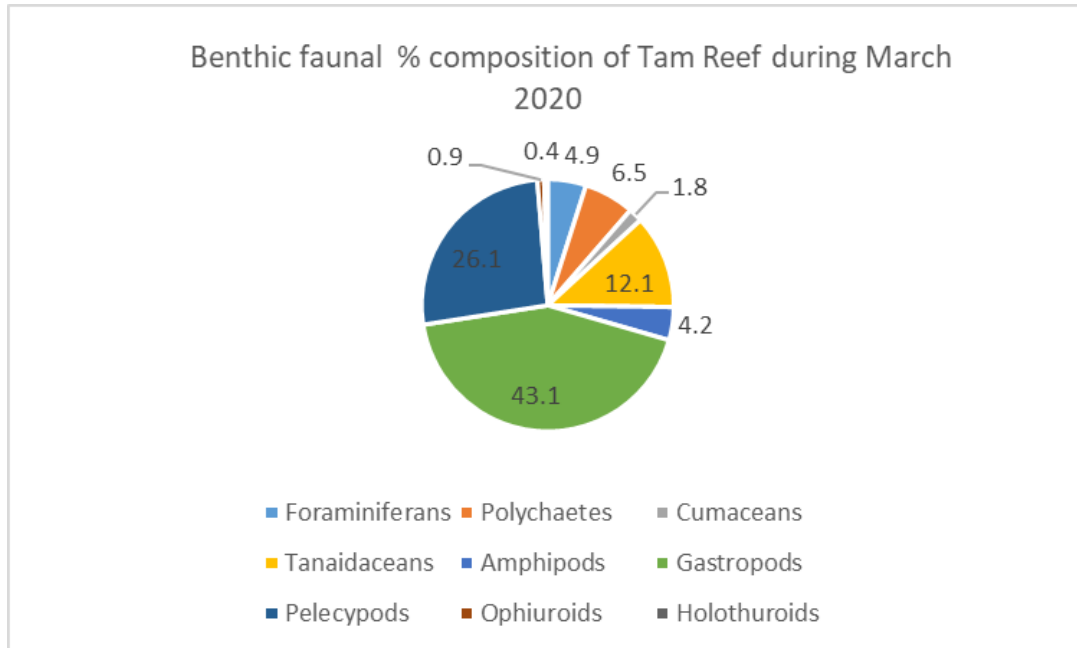


Figure 2.24: Benthic faunal percentage composition of Tam reef during March 2020

Species richness and relative abundance are the two factors that are considered when measuring species diversity. Species richness refers to the number of species in an area. Species abundance refers to the number of individuals per species. Since the species level identification will take a longer time. Macro-benthic samples were identified till the group level.

The Hadikiwala site shows the highest abundance compare to other sites and site Tam Reef shows the lowest abundance, as shown in (Figure 2.24). Whereas Tam reef showed the highest faunal richness as shown in Figure 2.25.

The subtidal macrofaunal standing stock in terms of population density at Beyt Dwarka Dunny point (4-425, avg 80 no/m²), biomass (0-35.75g/m²; avg 6.48 g/m² wet wt) and faunal groups (2-5, avg 4 no). the population dominated by Pelecypods (59.7%), Gastropods (27.4%), Polychaetes (4.8%), Tanaidaceans(1.6%), Amphipods(1.6%), Crinoids(1.6%), Holothuroids (1.6%).The depth varied from 8.3- 10.9 feet. The temperature didn't vary much in range 24.6°C-25°C The salinity remains constant 35 ppm or ‰ throughout the sampling stations.

Table 2.8: Seagrass associated macrobenthos composition of Beyt Dwarka (Dunny Point) during February 2020

Location Beyt Dwarka Dunny Point	Date of collection	Type of collection	Seagrass	Groups	Biomass (g/m ² wet wt)	Population (No/m ²)	No of groups
DN1	26/02/20	Subtidal	Present	Gastropod	0.0	25	2
				Pelecypod	35.75	425	
DN2	26/02/20	Subtidal	Present	Gastropod	18	250	5
				Pelecypod	15	50	
				Amphiopod	0.0	25	
				Polycheates	0.0	25	
				Crinoides	0.0	25	
DN3	26/02/20	Subtidal	Present	Gastropod	1.25	25	5
				Pelecypod	12.5	100	
				Polycheates	8.25	25	
				Tanaidaceans	0.0	25	
				Echinoides	0.0	25	
DN4	26/02/20	Subtidal	Present	Pelecypod	21.25	250	4
				Gastropod	0.0	50	
				Polycheates	0.0	25	
				Holothuroides	0.0	25	
DN5	26/02/20	Subtidal	Present	Gastropod	7.75	75	2
				Pelecypod	9.75	100	
				Average	6.48	80	4

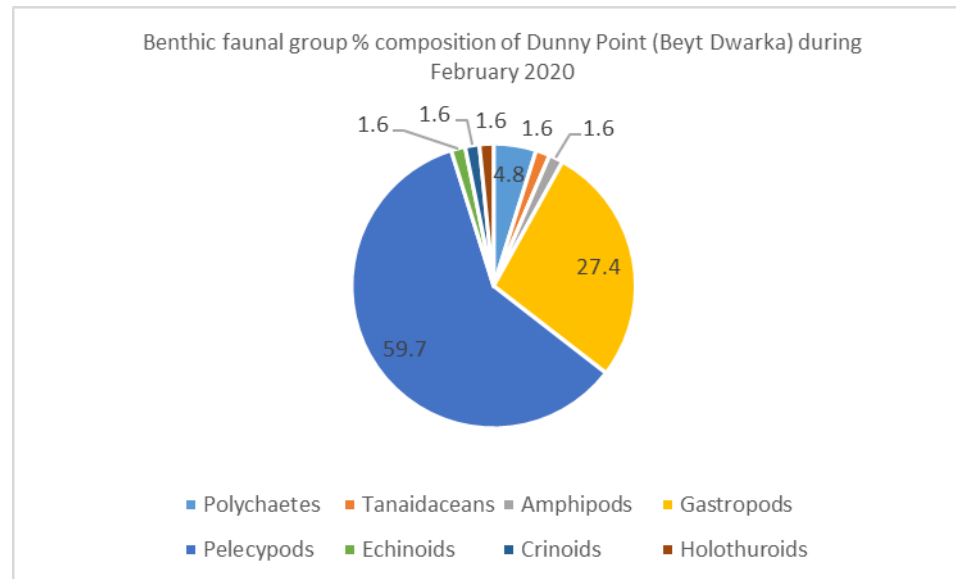


Figure 2.27: Benthic faunal percentage composition of Dunny Point Beyt Dwarka during February 2020

Paga Reef

The subtidal macrofaunal standing stock in terms of population density at Paga reef (25-575, avg 156.5 no/m²), biomass (0-44.32 g/m²; avg 20.7 g/m² wet wt) and faunal groups (2-3, avg 2 no). The population dominated by Gastropods (90.3%), Polychaetes (4.8%). Pelecypods(3.2%), Scaphalopod (1.6%).The depth at the sampling sites varied 6.4feet - 12.1feet SD ± 3.8, avg 9.8 Feet. The salinity remained constant almost 34-35‰. The temperature range was between 22.6- 26.5°C SD ± 7.36 avg 24.19°C.

Table 2.9: Macrobenthos composition of Paga reef during February 2020

Location ID	Date of collection	Type of collection	Seagrass	Groups	Biomass (g/m ² wet wt)	Population (No/m ²)	No of groups
PG1(1)	26/02/20	Subtidal	Present	Gastropods	5.25	50	2
PG1(1)				Pelecypods	24	100	
PG1(2)				Gastropods	265	350	
PG1(2)				Pelecypods	2	25	
PG1(2)				Gastropods	6.25	100	
PG2(1)	26/02/20	Subtidal	Absent	Pelecypods	24	75	3
PG2(2)				Gastropods	11.75	175	
PG2(2)				Pelecypods	9.25	250	
PG2(2)				Scaphaphopod	6.5	25	
PG3(1)	26/02/20	Subtidal	Absent	Gastropods	5	50	3
PG3(1)				Pelecypods	3.75	100	
PG3(2)				Gastropods	8.25	75	
PG3(2)				Pelecypods	9	225	
PG3(2)				Polychaete	7.75	75	
PG4(1)	26/02/20	Subtidal	Present	Gastropods	8.25	75	3
PG4(1)				Pelecypods	9	225	
PG4(1)				Scaphaphopod	1.25	25	
PG5(1)	26/02/20	Subtidal	Present	Gastropods	0.75	125	2
PG5(1)				Pelecypods	0.5	50	
PG6(1)	26/02/20	Subtidal	Absent	Gastropods	11.75	975	2
PG6(1)				Pelecypods	16.25	575	
PG7(1)	26/02/20	Subtidal	Absent	Gastropods	10	50	2
PG7(1)				Pelecypods	12.5	75	
PG8(1)	26/02/20	Subtidal	Present	Gastropods	17.5	100	2
PG8(1)				Pelecypods	17.5	75	
PG11(1)	26/02/20	Subtidal	Present	Gastropods	64.5	175	2
PG11(1)				Pelecypods	2.5	25	
				Average	20.7	156.5	2

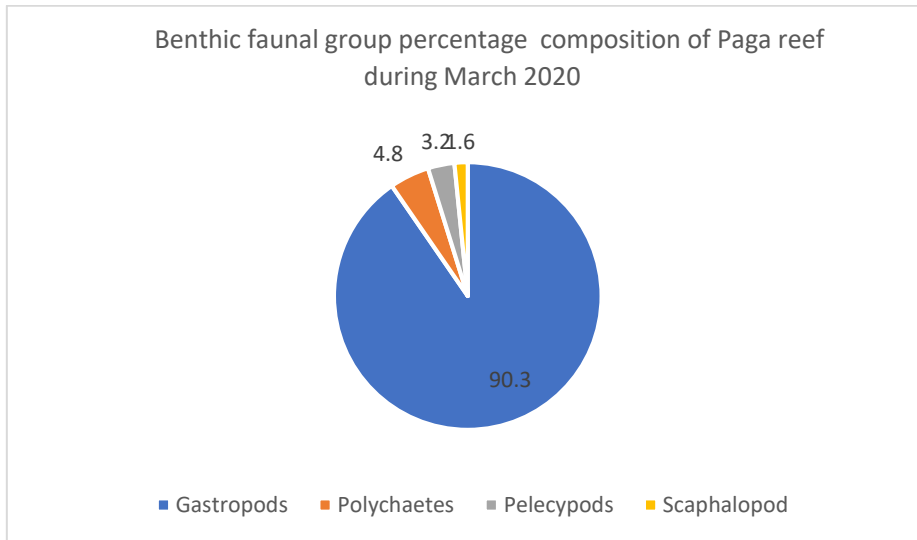


Figure 2.28: Benthic faunal percentage composition of Paga reef during February 2020

The Paga reef, site shows highest abundance and lowest richness as shown in (Figure 2.29-2.30).

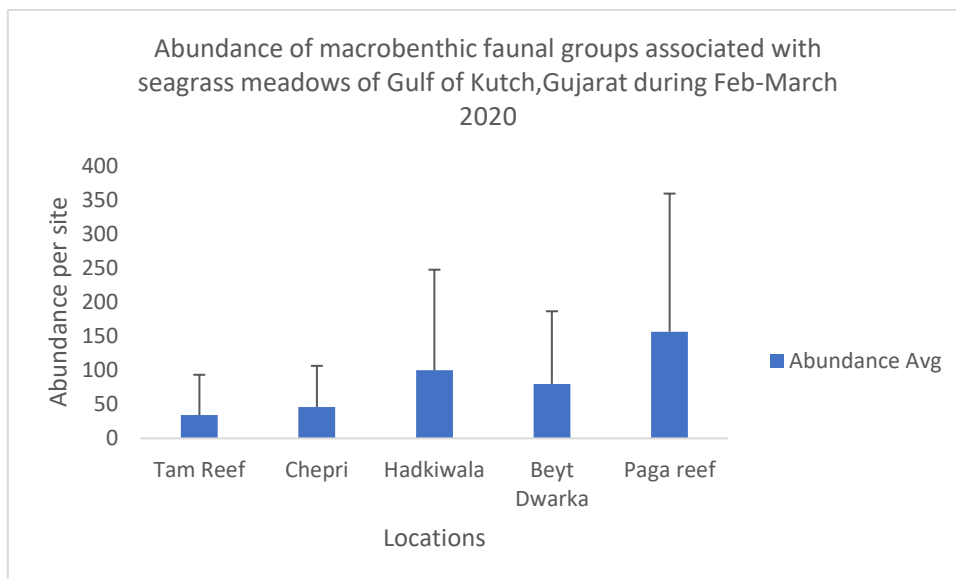


Figure 2.29: Abundance of macrobenthic faunal groups associated with seagrass of Gulf of Kutch, Gujarat during February -March 2020

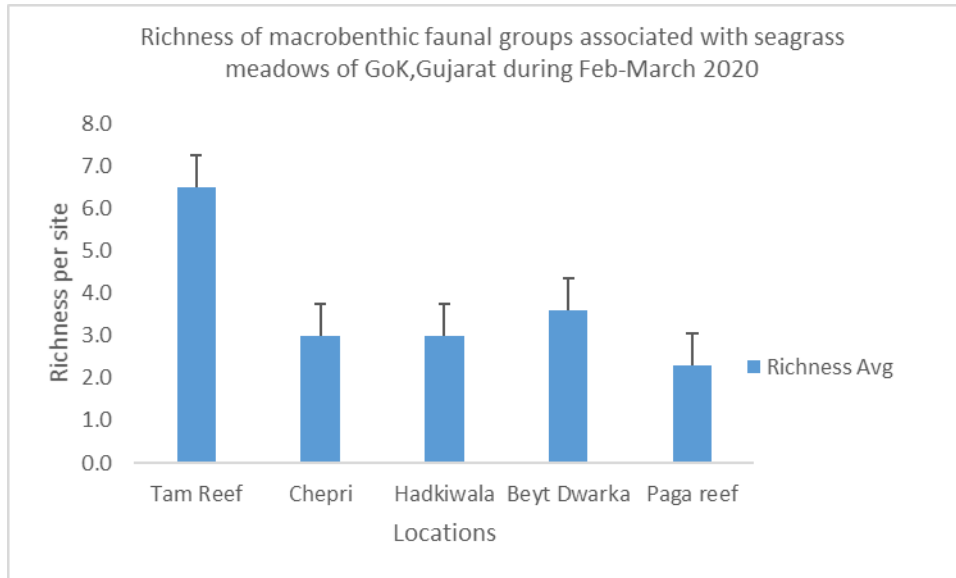


Figure 2.30: Richness of macrobenthic faunal groups associated with seagrass of Gulf of Kutch, Gujarat during February -March 2020

Table 2.10: Diversity of macrobenthic faunal group associated with seagrass meadows in Gulf of Kutch, Gujarat during February-March 2020

SN	Faunal Groups	Hadikiwala	Chepri	Tam Reef	Paga Reef	Beyt Dwarka
1	Amphipods	+	+	+	-	+
2	Cumaceans	-	-	+	-	-
3	Crinoides	-	-	-	-	+
4	Foraminiferans	-	-	+	-	-
5	Gastropods	+	+	+	+	+
6	Holothuroids	+	-	+	-	-
7	Ophiuroids	+	-	+	-	-
8	Pelecypods	+	+	+	+	+
9	Polychaetes	+	+	+	+	+
10	Tanaidaceans	+	-	+	-	-
11	Scaphalopod	-	-	-	+	-
12	Isopod	+	+	-	-	-
13	Echinoids	+	-	-	-	+
14	Polyplacoplacophora	+	-	-	-	-

Note: + : Present , -: Absent

Ecological Importance

Like Amphipoda, cumaceans are an important food source for many fishes. Therefore, they are an important part of the marine food chain. They act as a bioindicator of different environmental conditions.

Polychaetes play a major role in Environment Impact Assessment studies as stress indicators (Sivadas et al., 2010). Some polychaetes play a similar ecological role in the ocean as earthworms do on land by burrowing and ingesting sediment. Polychaetes modify geochemical gradients, redistribute organic matter and change the hydrodynamics above the sediment layer. Because of their abundance, polychaetes are important in assessing the ecological state of marine environments (Victoria and Donald 2009).

Benthic foraminifera play an important role in the carbon cycle in algal sediments. The living-total ratios of Foraminifera can be a measure of the rate of sediment deposition which has indicated little modern deposition in many continental shelf areas (Phelger, 1964).

Diet composition analysis indicated that seagrass leaves were the main food source for most gastropod species examined in Singapur seagrass meadows while epiphytes were important for microsnail (shell size <5 mm) species (Fong *et al.*, 2018).

Echinoids sea cucumbers burrow into the sand, providing more oxygen at greater depths of the sea floor. This allows more organisms to live there. Also, starfish prevent the growth of algae on coral reefs.

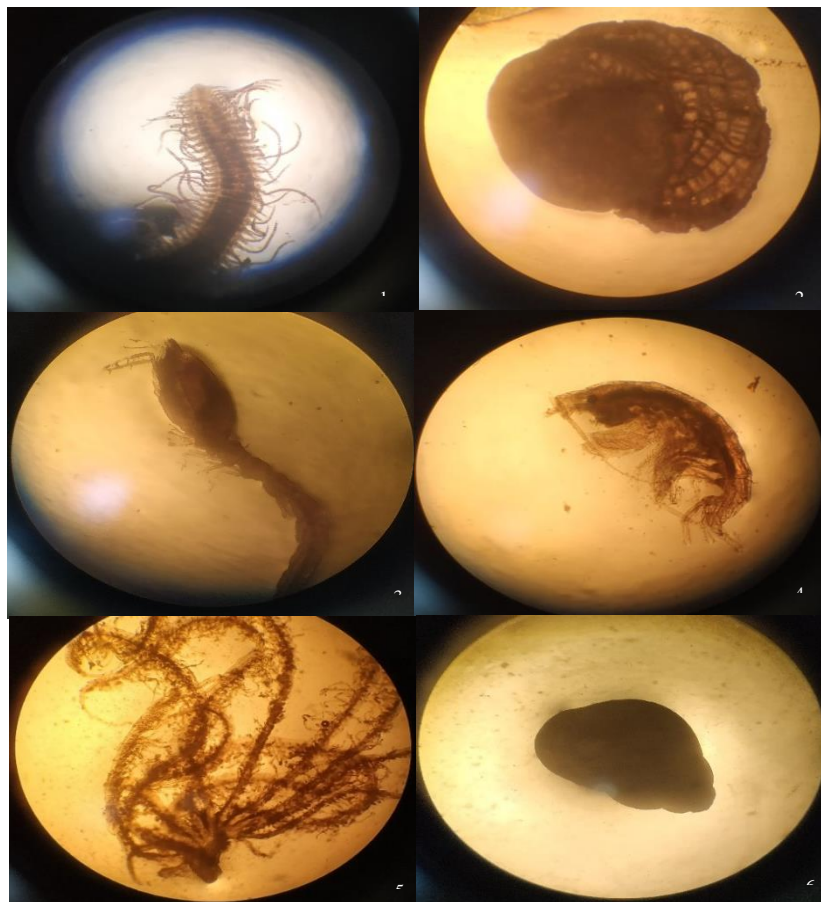


Figure 2:31. Macrobenthic groups found during survey in Gulf of Kutch,Gujarat
1. Polychaete 2. Foraminiferan 3. Cumacean 4. Amphipoda 5. Crinoidean
6. Gastropod

2.1.7 Pilot Aerial Transect surveys at Beyt Dwarka, Gulf Of Kutch, Gujarat

Aerial Surveys are an efficient way to detect marine mammals and have been extensively used to study the populations of marine mammals. Drone surveys have been widely used throughout dugong distribution ranges, to estimate populations (Marsh and Sinclair 1989a, b, Marsh 1995, Miller *et al.*, 1998) or understand distribution trends and habitat use patterns (Anderson, 1985). But a similar approach is lacking in Indian waters, due to cost associated with such surveys and logistics. In accordance, the objective of species conservation and management, assessing population status, distribution and threats and with long term monitoring in perspective, the fixed-width aerial surveys were carried out in Beyt Dwarka. Beyt Dwarka was selected for surveys based on the findings of our social surveys and previous sighting and stranding records. We conducted UAV based aerial surveys in Beyt Dwarka only north part of Hanuman Dandi beach falls us under the Marine National Park boundary, using fixed-width aerial transects from 29th December to 31st December 2019.

Study Site: Beyt Dwarka, Gulf of Kutch Gujarat

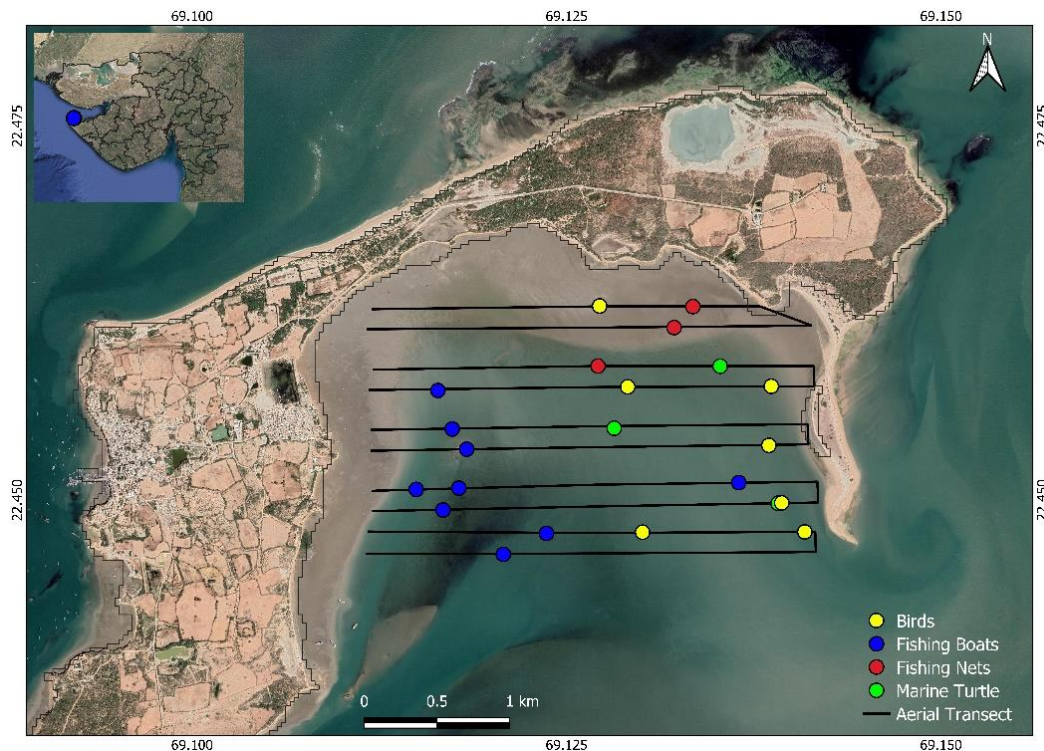


Figure 2.32: Drone transect conducted at Balapur during December 2019 in Gulf of Kutch, Gujarat

Methodology: For detecting dugongs in the shallow coastal habitats of Beyt Dwarka Island, the UAV DJI Mavic 2 Pro was used. The altitude was fixed at 100m with the camera gimbal fixed at an angle of -90° at a constant speed of 30 kmph. The length of the transect was fixed at 3km and the transect width was 150m. Videos were recorded for further analysis to record detection. A total of 10 transects were undertaken using the fixed-width aerial transect methods. Detections of animals and threats were recorded.

Table 2.11: Summary of detections during aerial surveys of Balapur, Gulf of Kutch Gujarat

SN	Date	Time	Sighting	Number
1	29/12/2019	14:45	Bird	3
2	29/12/2019	14:48	Fishing net	1
3	29/12/2019	14:52	Fishing net	1
4	29/12/2019	14:55	Fishing boat	7
5	30/12/2019	15:47	Fishing net	1
6	30/12/2019	15:49	Sea Turtle	1
7	30/12/2019	15:51	Bird	18
8	30/12/2019	15:53	Bird	2
9	30/12/2019	15:56	Fishing boat	5
10	30/12/2019	16:34	Fishing boat	2
11	30/12/2019	16:36	Sea Turtle	1
12	30/12/2019	16:40	Bird	3
13	30/12/2019	16:42	Fishing boat	6
14	30/12/2019	17:31	Fishing boat	5
15	30/12/2019	17:31	Fishing boat	3
16	30/12/2019	17:35	Fishing boat	2
17	30/12/2019	17:38	Fishing boat	1
18	30/12/2019	17:39	Fishing boat	6
19	31/12/2019	13:38	Fishing boat	6
20	31/12/2019	13:43	Bird	2
21	31/12/2019	13:49	Fishing boat	4

Results:

We were able to successfully carry out fixed-width aerial transects in dugong habitats. Turtles, birds, fishing boats fishing nets were detected in the survey effort. A total area of 4.5 sq. km surveyed in the effort. No dugongs were detected during the surveys but feeding trails of dugongs were observed confirming the presence of dugongs. The pilot surveys were successfully carried out and for the next season, the spatial coverage will be increased to cover the maximum area possible to detect dugongs and estimate the dugong population.



Figure 2.33: Aerial photograph of Beyt Dwarka in Gulf of Kutch, Gujarat



Figure 2.34: Sea turtle sighting during pilot drone survey in Beyt Dwarka, Gulf of Kutch, Gujarat



Figure 2.35: Dugong Feeding trails observed during drone survey in Beyt Dwarka, Gulf of Kutch, Gujarat

2.2 Records of marine animal stranding off Gujarat coast (2019-20)

2.2.1 Green Sea turtle stranded at Okha beach

One subadult Green sea turtle (*Chelonia mydas*) was stranded on Okha beach on 18.12.2019. Information was given to the local forest department. Morphometric measurements and tissue samples were collected for further examination. The carapace was covered with barnacles. Moreover, pieces of plastic were found in its mouth.



Figure 2.36: Green sea turtle stranding at Okha beach on 18th December 2019

2.2.2 Marine mammal stranding information

One Finless porpoise (*Neophocaena phocaenoides*) was stranded on the Saurashtra coastline on 19.05.2020 the information was provided by Forest Department Dwarka.

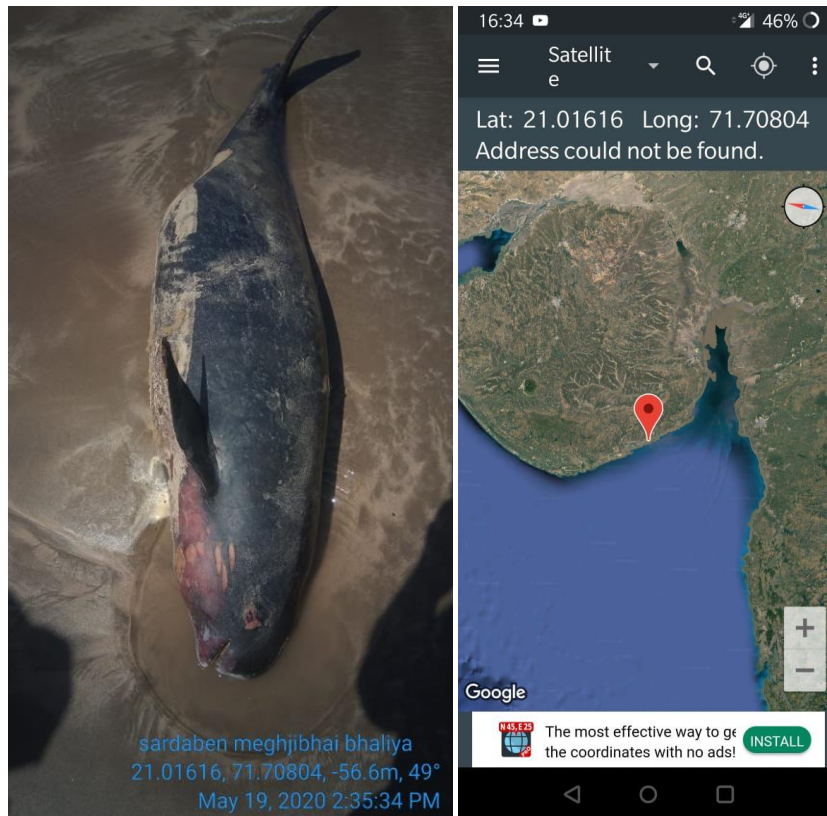


Figure 2.37: One finless porpoise stranded on Saurashtra beach 19th May 2020

2.3 Future research priorities and actions in Gulf of Kutch, Gujarat

2.3.1. Herbivory exclusion experiment to assess the impact of marine megafauna herbivory in Gulf of Kutch, Gujarat

As primary consumers, megaherbivores like green sea turtles and dugongs are very important for seagrass ecosystems and may have a considerable impact on seagrasses depending upon the area. Also, herbivory exclusion devices were made and mounted on each site. Cages were designed to exclude mega-herbivores like dugongs and green sea turtles from the sheltered area. Before mounting the cage, the seagrass and macroalgal parameters were noted for each site. The idea was to understand the effects of herbivore exclusion on the ecology of seagrasses. Readings were to be taken every month. Unfortunately, despite our best efforts to protect the cage, they were stolen by unknown vandals. This resulted in the discontinuation of the experiment. A new fitting experimental technique needs to be tried for the execution of this study.



Figure 2.38: Researcher and field assistant setting up cage for experiment in seagrass meadow in Paga reef in Gulf of Kutch, Gujarat

2.3.2. Estimating seagrass recovery rate from dugong grazing

To understand the grazing effect these animals, have on seagrasses, we created troughs to simulate the effect of feeding trails. The experimental troughs made to simulate dugong feeding trails were made to understand the seagrass recovery rate in the meadow.

This study and the rest of the survey period for seagrass mapping and phenology was discontinued as a result of CoVID-19 lockdown.

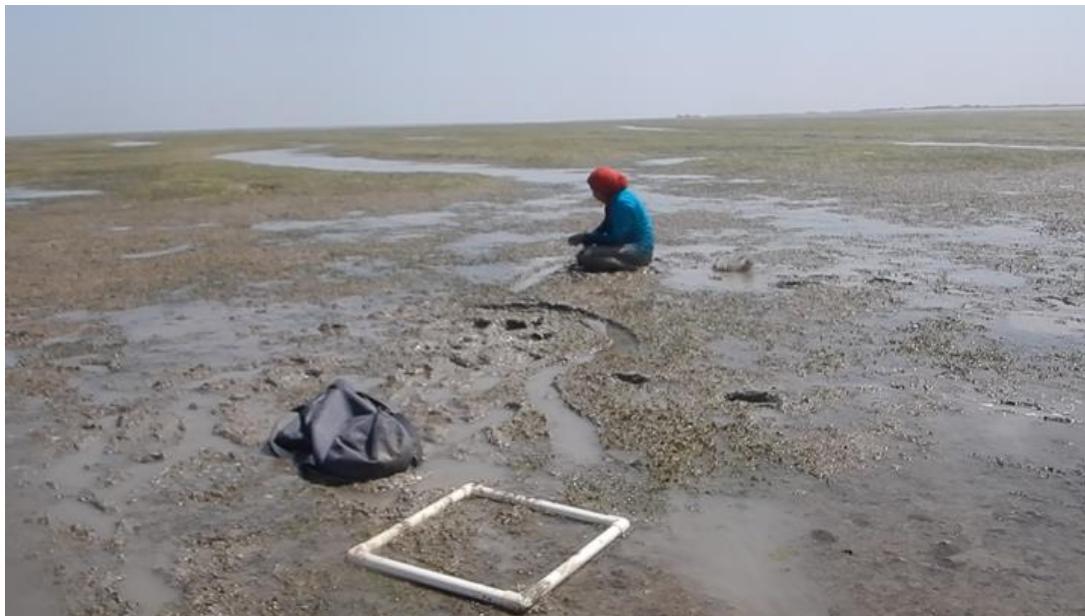


Figure 2.39: Field researcher excavating seagrasses to simulate the dugong feeding trail to check seagrass recovery rate in Bhaidar reef in Gulf of Kutch, Gujarat

2.3.3. Dependence of fisher community on Beyt-Dwarka meadow in Gulf of Kutch

The Fisher community of Beyt-Dwarka island depends greatly on the commercially valuable crustacean catch like lobster and crabs which has a market value of at least 100-120/Kg and 1120-180/Kg respectively. The sustenance of this community depends upon the meadow reared full-grown crabs and lobsters. Fisher-folks have been complaining about the decreasing trend of their catch with the decreasing meadow size. The detrimental effect on the meadow is pointed towards the alleged anchoring activity of trawlers which illegally dock near the island.



Figure 2.40: Fisherman manoeuvring his boat across the Beyt- Dwarka bay in Gulf of Kutch, Gujarat

2.4 Outreach and Awareness Activities in Gulf of Kutch, Gujarat

In the field season 2019-2020, a total of 98 outreach and awareness activities were conducted to aware people about the species, its importance and major project activities to the school students, teachers, locals and fishermen. Out of 98 events, 25 events were conducted for awareness and scholarship and 66 meetings were conducted with different stakeholders like forest department, marine police and head of various schools to involve them in the conservation activity, as the involvement of local people is very crucial for any species conservation.

The purpose of outreach activities was to sensitize our important stakeholders about the importance of marine biodiversity (flora and fauna), the role and importance of seagrass and Dugong habitats in the marine ecosystem. The major threats to the biodiversity were also addressed to the people. Dugong comic book and pamphlets were distributed in the schools where awareness events and scholarship program were conducted, as pictorial guides are a helpful and effective measure to convey an important message to common people.

Table 2.12 : Details of outreach and awareness activities conducted in different areas of Gujarat in the year 2019-20

SN	Location	Date	Name of the event	Type of Stakeholders	Total no. of people attended the event
1	Okha	10-Jan-20	Awareness Program for college students	College Students, Professors	72
2	Vasai	17-Jan-20	Awareness Program RMSA Govt school	School Students, Teachers	73
3	Vasai	17-Jan-20	Awareness Program Varvala wadi school	School Students, Teachers	14
4	Varvala	21-Jan-20	Awareness Program at Karmayog school	School Students, Teachers	144
5	Beyt Dwarka	21-Jan-20	Awareness Program for swaminaryan school	School Students	65
6	Dwarka	22-Jan-20	Awareness Program at PVM School	School Students	97
7	Okha	25-Jan-20	Awareness Program Okha gram panchyat school	School Students	174
8	Okha	29-Jan-20	Awareness Program coastguard	Coastguards	38
9	Okha	30-Jan-20	Awareness Program Marine police	Marine Police	28
10	Okha	7-Feb-20	Awareness Program scout guard	School Students	49
11	Gandhinagar	15 to 20 Feb 2020	CMS COP Meeting	Researchers, Scientists, Forest officials, Ministry people, govt. and non-govt. Institute and organizations	Approx. 7000
12	Okha	17-Feb-20	Awareness Program School	School Students, Teachers	126
13	Gandhinagar	19-Feb-20	Side event	Researchers, Forest	200

SN	Location	Date	Name of the event	Type of Stakeholders	Total no. of people attended the event
				officials, Govt and non-govt institute, organizations	
14	Varvala	24-Feb-20	Awareness program at Varvala school	School Students, Teachers	154
15	Varvala	25-Feb-20	Sovnior distribution	School Students	25
16	Rupen Bundar	28-Feb-20	Awareness Programmes in Schools	School Students	156
17	Dwarka	28-Feb-20	Awareness Programmes in Schools	School Students	35
18	Dwarka	28-Feb-20	Sovnior distribution	School Students	15
19	Vasai	1-Mar-20	Sovnior distribution	School Students	10
20	Okha	3-Mar-20	World Wildlife Day	School Students, Teachers and locals	122
21	Varvala	6-Mar-20	Sovnior distribution	School Students	10
22	Okha	23-May-20	Turtle Day	School Students, Teachers	40
23	Okha	26-May-20	Dugong Day	School Students, Teachers	16
24	Okha	27-May-20	Dugong Day	School Students, Teachers	13
25	Okha	28-May-20	Dugong Day	School Students, Teachers	43

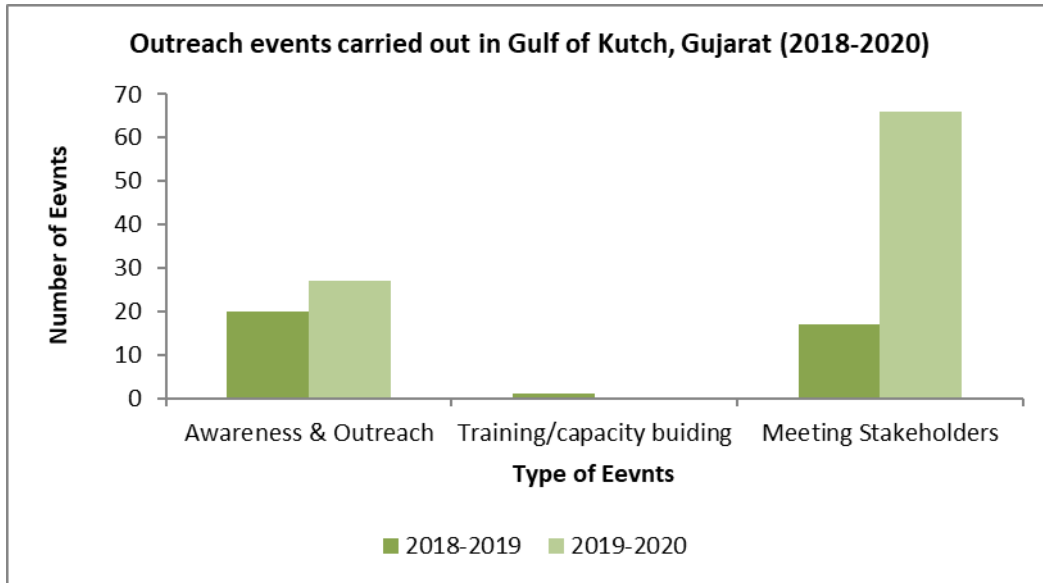


Figure 2.41 : Details of various outreach events conducted in Gulf of Kutch, Gujarat in the year 2018-19 and 2019-20

In this field season 2019-20, 73.31 percent of school and college students were targeted as the children in the learning phase and understanding phase are our supreme stakeholders, the involvement of children is beneficial to save the species in a longer run. The second highest targeted stakeholders were fishermen and locals 21.15 per cent as the knowledge and experience of fishermen and locals is important to conserve the species on the ground. Figure 2.42 shows a percentage of stakeholders targeted in the last two field seasons.

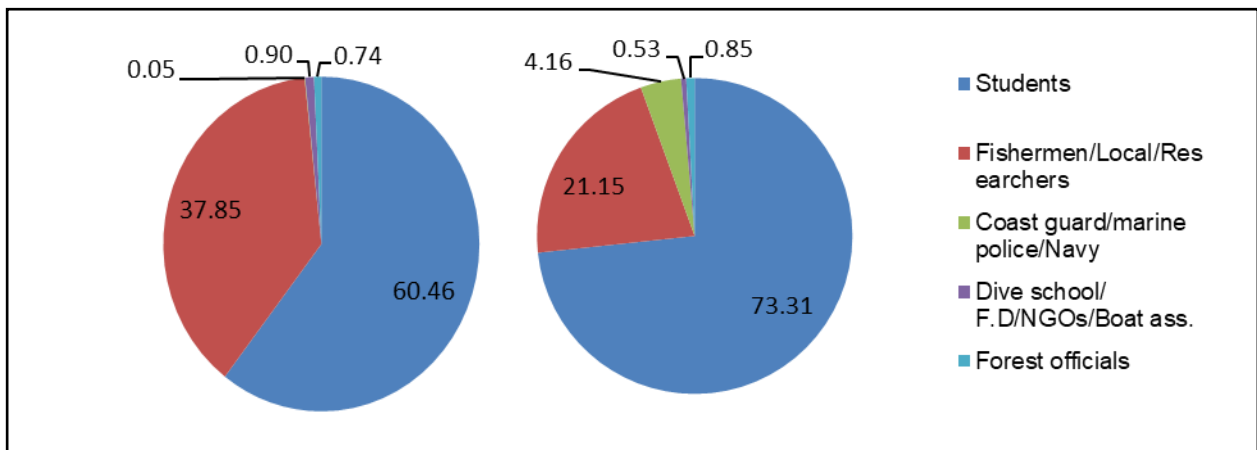


Figure 2.42: Percentage of stakeholders targeted in Gulf of Kutch, Gujarat the year 2019-20

2.4.1. Dugong Scholarship Programme

A unique participatory program, the **Dugong Scholarship Scheme** was initiated to engage local fisherfolk communities at the grass-root level. This program targets school-going children of local fisherfolk communities and provides them with a scholarship of Rs. 500 / month for two years to support their education. The motive behind the Dugong Scholarship program is to encourage the fisherfolk students to study and financially help them. This scheme has helped us to build a strong network of the informant. The beneficiaries are selected through

the competitive written examination followed by several participatory programs conducted at schools to raise awareness about Dugong and seagrass conservation. In Gujarat, we have completed three years of this program from July 2017 to July 2020. Till now 142 students have been awarded this scholarship and the students selected under this program are identified as **Dugong ambassadors**. The list of Dugong ambassador is attached as annexure.

Table 2.13: Details of Dugong scholarship programs in Gulf of Gulf of Kutch, Gujarat

SN	School Name	Village/ Town	District	Students Phase 1 2017-2018	Students Phase 2 2018-2019	Students Phase 3 2019-2020
1	Mithapur High school and Higher Secondary School	Mithapur	Devbhumi Dwarka	3	5	4
2	Swaminarayan Highschool	Beyt Dwarka	Devbhumi Dwarka	0	8	7
3	OkhaGrampanchayat High School and Higher Secondary School	Okha	Devbhumi Dwarka	6	7	10
4	PVM Girls Highschool High School and Higher Secondary School	Dwarka	Devbhumi Dwarka	8	2	8
5	NDH School	Dwarka	Devbhumi Dwarka	1	0	0
6	Government High School- Vasai	Vasai	Devbhumi Dwarka	9	0	0
7	Government High School- Bharana	Bharana	Devbhumi Dwarka	13	0	0
8	Shri Karmayog Madhyamik Shala	Varvala	Devbhumi Dwarka	0	0	5
9	Shree Dwarka Taluka School 1	Dwarka	Devbhumi Dwarka	0	0	1
10	Shree Varvala Wadi Primary School	Varvala	Devbhumi Dwarka	0	0	11
11	RMSA Government Highschool Vasai	Vasai	Devbhumi Dwarka	0	0	3
12	Nagar PalikaSanchalit Okha Primary School	Okha	Devbhumi Dwarka	0	0	13
13	Shree Varvala Primary School	Varvala	Devbhumi Dwarka	0	0	7
14	Shree Rupen Bandar Primary School	Varvala	Devbhumi Dwarka	0	0	11
	Total			40	22	80

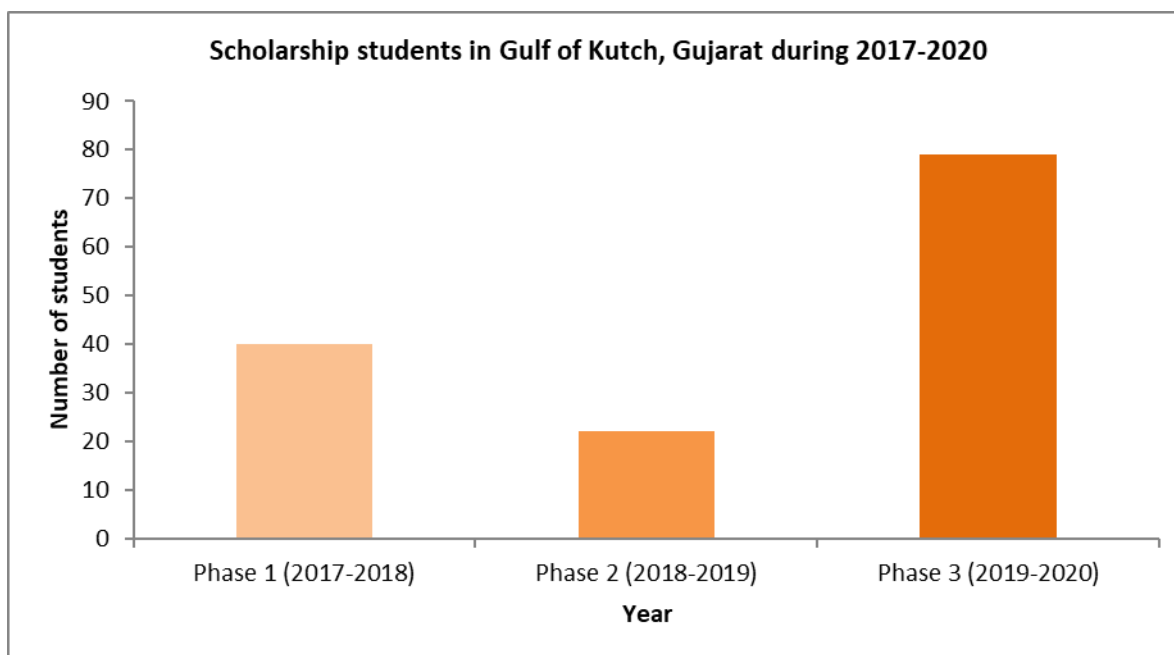


Figure 2.43: Number of scholarship students over three years in Gulf of Kutch, Gujarat

2.5 Outputs and accomplishments

2.5.1 Research and Monitoring

Pilot Aerial Transect surveys were conducted at Beyt Dwarka, Gulf Of Kutch. A total area of 4.5 sq. km was surveyed. No dugongs were detected during the surveys but turtles, birds, fishing boats and fishing nets were detected and identified in the survey.

First baseline ecological survey of the abundance and diversity of benthic macrofauna associated with seagrass meadows in the Gulf of Kutch was conducted from February to March 2020. Natural Geography in Nearshore areas (NaGISA) protocol was followed for intertidal collection and Van veen grab was used for subtidal collection. Total 53 samples were collected from Paga Reef, Tam reef, Chepri Island, Hadkiwala reef and Dunny point-Beyt Dwarka during February- March 2020. Total 14 groups viz Gastropods, Pelecypod, Crustaceans such as Tanaidceans, Cumceans, Polychaetes, Amphipods, Isopods, Foraminiferans, Holothuroideas, Echinoids, Ophiuroideas, Crinoids, Scaphopoda, Polyplacophora. For further taxonomic level identification samples will be sent to another research institute. More replicates needs to be taken for conclusion for the assemblage in seagrass meadows and seagrass absent areas for comparison.

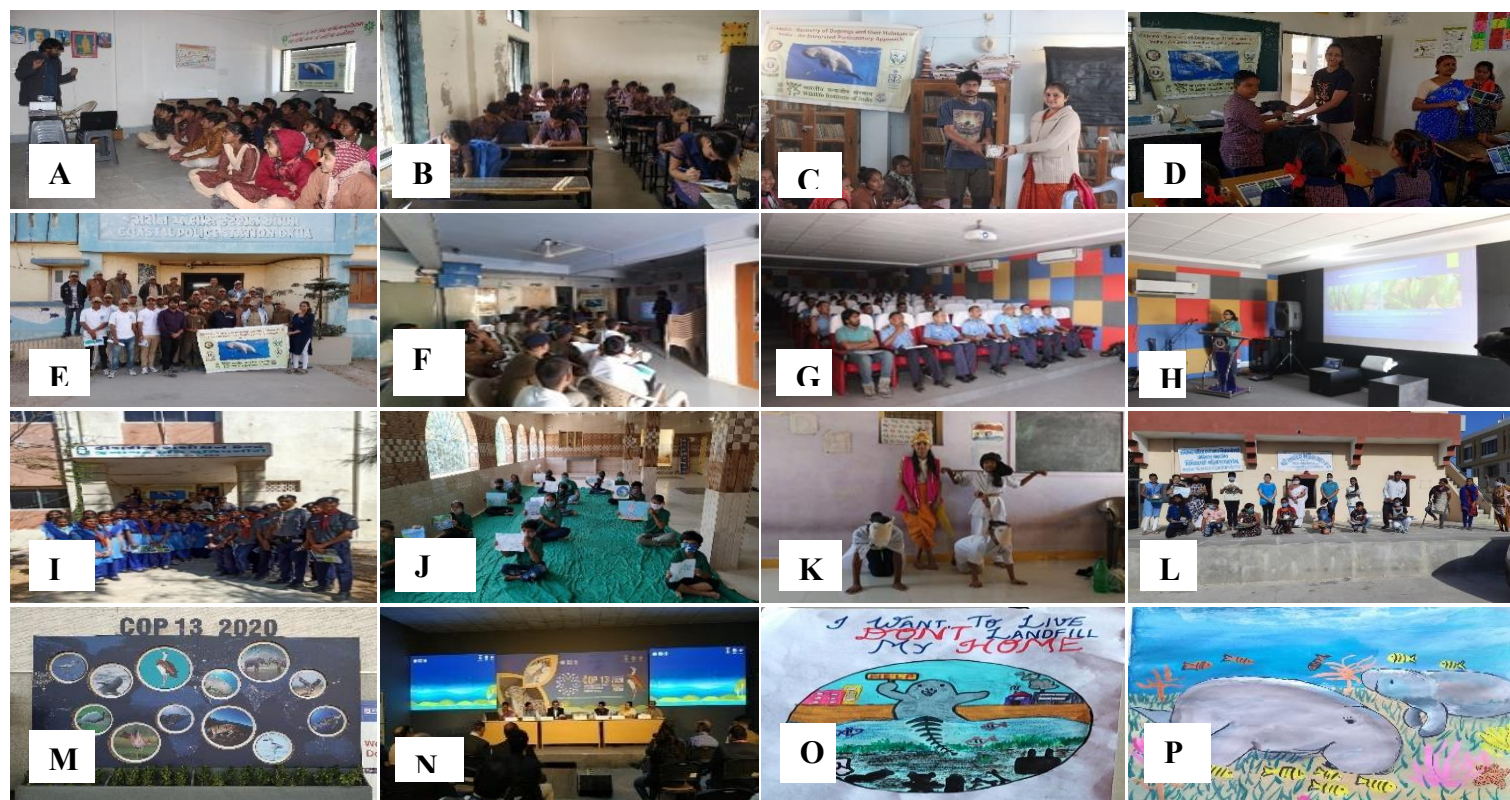


Figure 2.44: Depicting the outreach events carried out in Gulf of Kutch, Gujarat during year 2019-2020
A-D: Awareness programs and scholarship program, E-H: Awareness program for stakeholders, I-L: Dugong Day celebration,
M-P: CMS meeting and Dugong day paintings by Dugong volunteers

2.5.2 Awareness and outreach

Total 23 outreach programs were conducted which majorly covered school and college students, along with major stakeholders viz Marine Police and Indian Coast guard. We reached out to 1500 people through outreach and awareness campaigns this field season. Most of the awareness efforts were published and highlighted in the local Newspapers and News channels.

National Science Day, World Environment Day, World Turtle Day, Dugong Day, World Wildlife Day was celebrated creating awareness regarding wildlife and Environment conservation among the school students.

The 13th Meeting of the Conference of the Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS COP13) showcased the efforts of Wildlife Institute of India towards conservation of endangered species. A large amount of awareness material of Dugong project was distributed on a global platform and the meeting helped the project to get recognition and a platform to interact with the researchers and delegates from all around the world.

On the occasion of Dugong Day, a regional essay writing and quiz competition were organized for local students in Okha. An online drawing and quiz competition was organized throughout the country by the headquarter team and a drama competition was organized by Tamil Nadu team. Ten local students from Okha took part in the drama competition and prepared a drama on the theme 'Threats to dugongs due to plastic pollution'.

Awareness programs were conducted for our major stakeholders like the Indian Coast Guard and Marine Police during January 2020. All 66 participants were informed about the project activities, marine mammals, identification clues, threats and how their support can help us to locate Dugongs in Gulf of Kutch. The datasheets have been distributed to all the officers for recording the sightings.

Eighty new students from classes IV and X from ten different schools in district Devbhoomi Dwarka were enrolled in the third phase (2020-21) of Dugong Scholarship Programme.

2.6 Management recommendations

We recommend enhancing patrolling around Bhaidar island, Pashu island and Taam reef as these are 'Critical Dugong Habitats'. Forked channels intersect these areas and are used by fishing vessels for navigation purposes. These sites must be regarded as slow speed zones wherein it should be made mandatory for operational fishing vessels to sail at an 'idle speed' to avoid harmful collisions. However, for Gulf of Kutch, commonly used small gill-netters which can efficiently sail in water as shallow as 2 mts should be mandated to sail at a speed of at least 4 km/hr. The wisdom behind slow-speed zones is to give fisherfolk a good chance to spot a passing animal and to avoid harmful or fatal collisions.

We recommend increased threat monitoring efforts during seagrass growing phase; August-December. Overall, seagrass meadows of Gulf of Kutch have a high turnover rate which gives it the resilience needed to re-colonise post-monsoon, after shedding period in monsoon. Detrimental activities like sedimentation and subsequent seagrass burial due to trawling and illegal docking in '*seagrass-priority area*' like North Beyt-Dwarka should be stopped and measures should be taken to forestall it.

Trawler docking in Beyt-Dwarka also causes sediment resuspension which could increase the turbidity of associated coral outcrops in the Balapur cove and North Beyt- Dwarka. Such docking also uproots seagrasses and has been heavily criticised by the native community which depends on seagrass meadows for small scale crab fishing.

Some areas falling under the Marine National Park, Paga reef and Bhaidar island, needs to be monitored for infiltrating activities like illegal poison fishing and beach seining. Although, these activities may be minimal in number but have the potential to leave a long-lasting effect on corals and seagrass meadows. We report the use of mangrove branches used as stakes for building a seine.

Dugong sighting and monitoring efforts needs to be increased in 'Critical Dugong habitats' like Chepri and Taam reef. The connecting habitats between foraging meadows needs to be established and monitored regularly using drone and boat-based surveys.

The frontline staff of GFD needs to be trained in conducting seasonal seagrass monitoring surveys and marine mammal monitoring surveys. We plan to organise such trainings in the upcoming season for state forest department personnel and other key stakeholders.

The frontline staff of GFD should also be provided with training sessions and workshops for the ecology and identification of seagrass species in Gulf of Kutch.

We recommend a series of strategized awareness programmes be conducted with the local fishing community to manage plastic and other solid waste. Some of the waste types encountered during our surveys are:

Plastic on-board: Milk bags, water pouches, disposable plastic bottles etc. Their use should be discouraged especially along the MNP area.

Ghost-net: Ghost nets are fishing nets that have been left or lost in the seawater by fishermen. We suggest Incentivising gill-netters and small-scale fishers, who venture in the gulf for fishing, to bring back disused/discarded and abandoned fishing nets, ropes and other plastic waste to the dock. Ghost-net has been a leading cause for entanglement of marine mammal, sea turtles, whale shark. Moreover, microplastics that breaks down from a weathered ghost-net becomes bio-available to a variety of marine organism consequently leading to diseases and death. Regular ghost net removal should be conducted (at least once in a fortnight) and sensitization programs to be conducted for fisherfolk informing the dangers of discarding nets.

Plastic for tourists: Beyt-Dwarka is a tourism hot-spot, as a result of which tonnes of plastic is also drawn in. Poor waste management on the island has resulted in settlement of tourism caused garbage patches in the subtidal areas of Bey-Dwarka cove. This area has a commercially important mid-intertidal and subtidal seagrass meadow which is used by the locals for subsistence fishing. Local NGOs of Gujarat active in the waste management should step in with awareness programs in the region.

2.7 Media reports and Coverage

<https://www.downtoearth.org.in/news/wildlife-biodiversity/world-dugong-day-2020-marine-mammal-fighting-for-survival-in-indian-waters-71413>

<https://www.facebook.com/103515107969704/posts/140281020959779/>

<https://www.youtube.com/watch?v=wxdqKKowN1Q&feature=youtu.be> May 27 2020

Devbhumi Gujarat News

<https://www.youtube.com/watch?v=87ZoPUPkGw&feature=youtu.be> Okha Today News channel 28 May 2020

<https://www.youtube.com/watch?v=GSP2jfVFosk&feature=youtu.be>

Loksamnanews Channel 28 May 2020

<https://www.youtube.com/watch?v=S14-jdQ6ZQ4&feature=youtu.be> City News 27th May 2020

<https://www.facebook.com/332291960529888/posts/903073796785032/> Dwarka Today 27th May 2020

<https://www.saamana.com/dugong-day-celebration-wild-life-institute-india/?fbclid=IwAR0ujV5Gsnux2pfoBONytFKsDPKteYEsoFyk5Ghl2xjENAvhXVRp-1MjDmQ> Samana News paper 22nd May 2020

<https://twitter.com/mymahanagar/status/1265918419632656385> My Mahanagar 28th May 2020

<https://youtu.be/7qt5R301Cis> Okha Today News channel 6th June 2020



MUMBAI-BORIVALI--Mo.743680661, 9737200656

HARESH M. GOKANI-MUMBAI

CITY NEWS **અખતક** **સાંજ સમાચાર**

DUGONG DAY | 28TH MAY, 2020

ONLINE PAINTING, SLOGAN & QUIZ COMPETITION

પર્યાવરણ સંરક્ષણ સંસ્થા દ્વારા COVID-19 સંક્રમણને નયના કરી રાખી ગુણી દિવસ

MANATEES OF THE WORLD

પર્યાવરણ સંરક્ષણ સંસ્થા દ્વારા COVID-19 સંક્રમણને નયના કરી રાખી ગુણી દિવસ

યાદ દસ દિવસીય લંબે જાગરકતા કાર્યક્રમ

dugong

the sea cow

ઓખામાં 'દરિયાઈ ગાય' દિવસની ઉજવણી



અખતક, હરેશ ગોકાણી, ઓખા

ઓખામાં દેહરાદુન સ્થિત ભારતીય વન્ય જીવ સંસ્થાન છેલ્લા ચાર વર્ષથી ગુજરાતમાં દરિયાઈ ગાય અભ્યાસ અભિયાન ચલાવી રહી છે. આ અભિયાન અંતર્ગત ગઈકાલે દરિયાઈ ગાય દિવસ ઉજવવાનો હતો. જેમાં શિક્ષણ ક્ષેત્રે હમેશા અગ્રેસર રહેતા ચાંદનીબેન દ્વારા પર્યાવરણ અભ્યાસ દરિયાઈ જીવસૃષ્ટીનું જનકરોનો સંદેશ આપતું નાટક રજૂ કર્યું હતું.

આ સાથે રાજ્યના દરિયાઈનું વિષે પ્રાણી દરિયાઈ સ્વર્ણ અને વિજ્ઞ સ્વર્ણોનું આયોજન પણ કરેલ. અહીં રજુવંશી બાળકોએ ખુબજ ઉત્સાહ ભરે ભાગ લીધો હતો.

તમામ સ્પર્ધકોને ભારતીય વન્ય જીવ સંસ્થાન દ્વારા ટીશર્ટ અને કેપ આપવામાં આવી હતી. અને પ્રથમ, બીજા અને ત્રીજા ક્રમમાં આવુલ ને ઈનામો આપી પ્રોત્સાહીત કરાયા હતા.

હરેશ એમ ગોકાણી મુબઈ ૭૪૩૬૮૦૬૬૧ તા. ૨૧-૦૫-૨૦૨૦ કોવિડ-૧૯ લોકડાઉનમાં ભારતીય વન્યજીવ સંસ્થાન દ્વારા આયોજીત "દરિયાઈ ગાય દિવસ-૨૦૨૦"

(તા. ૧૯ મે થી તા. ૨૮ મી મે ૧૦ દિવસ ઓનલાઈન ઉજવાશે)

દરિયાઈ ગાય "ડુગોંગ" જે ગુજરાત રાજ્યનું વિશેષ દરિયાઈ સસ્તન પ્રાણી છે. જેના વિશે લોકો પ્રત્યે સંવેદના લાવવાની નવીન પહેલમાં ભારતીય વન્યજીવ સંસ્થાન વાર્ષિક લાઈફ ઈન્સ્ટિટ્યુટ ઓફ ઈન્ડિયા WII દ્વારા "ડુગોંગ ડે-૨૦૨૦" નામનો સોશીયલ મીડિયા કાર્યક્રમ તા. ૧૯ મે થી તા. ૨૮ મે સુધી રાખેલ છે.

આ દસ દિવસીય સંવેદનાનો કાર્યક્રમ જુદા જુદા સોશીયલ મીડિયા પોસ્ટ કરી ડુગોંગ દરિયાઈ ગાય ના મહત્વ, તેમના અસ્તિત્વ સામેના જોખમો અને તેમને બચાવવાની રીતીયાત વિશે જાગૃતતા વેલાવવાનો છે.

દેહરાદુન સ્થિત ભારતીય વન્યજીવ સંસ્થાન એ પર્યાવરણ વન અને આબોહવા પરિવર્ત મંત્રાલય દ્વારા વર્ષ-૨૦૧૯ થી ગુજરાતમાં CAMPA એ ડુગોંગ પ્રોજેક્ટ ચલાવી રહી છે. ઓખા મંડળના દરિયા કીનારાઓનો સર્વે પછ આ સસ્તા દ્વારા વર્ષ ૨૦૨૦ છે. અહીં વનવિભાગ, કોસગાંડ, મરીન પોલીસ, મત્સ્ય વિભાગ, સરકારીશાળા ઓ અને માચ્છીમારી સમુદાય સહયોગથી દરિયાય ગાય વિષે જાગૃત કરાય છે.

કોવીડ-૧૯ લોકડાઉન વચ્ચે સોશીયલ મીડિયાની શક્તીના ઉપયોગથી આ લુપ્ત થતી દરિયાઈ ગાયની વસ્તી વીશે ભારતના લોકોને મોટી સખ્યામાં જાણકારી આપવાની એક શરી તક છે. તો સર્વે લોકોએ આ કાર્યક્રમનો લાભ લેવા ભારતીય વન્યજીવ સંસ્થાનો અનુરોધ છે.

ઓખામાં દેહરાદુન સ્થિત ભારતીય વન્ય જીવ સંસ્થાન

Dugong Conservation and Awareness Programme Gujarat

REPORTER-HARESH GOKANI-MUMBAI

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દિવ્ય ભાસ્કર

કચ્છના અખાતમાં જોવા મળતી દરિયાઈ ગાય અને દરિયાઈ ઘાસ અંગે જાગૃતિ કાર્યક્રમ યોજાયો



જામનગર | તા. ૩૦ના જે. જી. સોલંકીની ઉપસ્થિતિમાં વાર્ષિક લાઈફ ઈન્સ્ટિટ્યુટ ઓફ ઈન્ડિયા, દેહરાદુનના કેમ્પા ડુગોંગ રિકવરી પ્રોગ્રામ અંતર્ગત ગુજરાતમાં કામ કરતા સંશોધકોએ ઓખા, મીઠાપુર મરીન પોલીસ સ્ટાફને કચ્છના અખાતમાં જોવા મળતી દરિયાઈ ગાય, દરિયાઈ ઘાસના મેદાનો, પર્યાવરણમાં મહત્વ વિશેની માહિતી આપી હતી. ઈન્ટરનેશનલ યુનિયન ફોર કન્ઝર્વેશન ઓફ નેચર દ્વારા વલ્નરેબલ જાહેર કરાયેલી એટલે કે, પર્યાવરણમાં અસ્તિત્વ ટકાવી રાખવા માટે જોખમમાં હોય એવી દરિયાઈ ગાયો અને તેમના વાસવાટોની જાળવણી માટે મરીન પોલીસ સ્ટાફનો સારો પ્રતિસાદ રહ્યો હતો.

ખાં વાર્ષિક લાઈફ ઈન્સ્ટિટ્યુટ ઓફ ઈન્ડિયાના ઘડો દ્વારા ડુગોંગ પ્રજાતિ અપેરેનેસ કાર્યક્રમ યોજાયો



ખાં મી. વાર્ષિક ઈન્સ્ટિટ્યુટ ઈન્ડિયા, ખાના કેમ્પા (દરિયાઈ રિકવરી અંતર્ગત) ખાં તા. મેની ટીમ રોખા અને મરીન ગા સ્ટાફને અખાતમાં ખાંતી દરિયાઈ ગાય (ડુગોંગ) અને એટલે કે પર્યાવરણમાં અસ્તિત્વ ટકાવી વસવાટ એવા દરિયાઈ ઘાસના રાખવા માટે જોખમમાં હોય એવી દરિયાઈ તથા તેમના પર્યાવરણમાં મહત્વ વિશેની માહિતી આપવામાં આવી હતી. ઈન્ટરનેશનલ યુનિયન ફોર કન્ઝર્વેશન ઓફ નેચર દ્વારા વલ્નરેબલ જાહેર કરાયેલ પી.એસ.આઈ. જે.જી. સોલંકી તથા મરીન પોલીસના સ્ટાફ ઉપસ્થિત રહ્યા હતા.

ઓખામાં 'દરિયાઈ ગાય અભ્યાસ' અભિયાનમાં જોડાયેલા વિદ્યાર્થીઓનું સન્માન કરાયું

અખતક

હરેશ ગોકાણી, ઓખા

ભારતીય વન્ય જીવ સંસ્થાન દ્વારા વર્ષોથી ચલાવેલ અભ્યાસ ઓખામાં વિવિધ પુસ્તકો અને તમામ પ્રાણીઓની અભ્યાસ મહેનતથી તૈયાર મહાસમૃદ્ધ પ્રક્રમ ડો. પુષ્પાબેનના પ્રોત્સાહનથી અખાતમાં ડુગોંગ અભ્યાસની પોલીસની સાથે આ મહેનતી ડેવરના હોને અને ઓનલાઈન વિજ્ઞ સ્વર્ણ, નિયમિત સ્વર્ણ અને પ્રખ્યાતની સ્વર્ણ રાખેલી હતી. અને વન્યજીવ સંસ્થાન દ્વારા વિદ્યાર્થીઓને ઈનામ આપવામાં આવેલ હતો.

જેમાં વિદ્યાર્થીઓને ઉત્સાહભરે કાર્યક્રમમાં રહે છે. પરિવેશ માસાગરમાં પુષ્પિ આકારની આરોગ્યવિધાના યમ્મી વિસ્તારમાં જોવા મળે છે. ખાસ કરીને દરિયાઈ ગાય વન્યજીવોને અખાત અને અખાતની ખાંતીમાં જોવા મળે છે. દરિયાઈ ગાય ક્રમમાં અખાત જીવન ઉત્સાહમાં છે, જેની પ્રજાતિ બચાવવા અને અભ્યાસ કરી છે, વન્યજીવ સંસ્થાન દ્વારા વિદ્યાર્થીઓમાં આ વિશે ઉત્સાહ જગાવ્યો હતો.

જાગૃતી વેબસાઈટ છે ત્યારે, અને દરિયાઈ ગાય દિવસની વિશિષ્ટ ટીમ ઉજવણી કરી. દરિયાઈ ગાય અખાતની અખાત દરિયાઈ જીવ છે. તે ઉપરાંત ઉપરખા કાર્યક્રમમાં રહે છે. પરિવેશ માસાગરમાં પુષ્પિ આકારની આરોગ્યવિધાના યમ્મી વિસ્તારમાં જોવા મળે છે. ખાસ કરીને દરિયાઈ ગાય વન્યજીવોને અખાત અને અખાતની ખાંતીમાં જોવા મળે છે. દરિયાઈ ગાય ક્રમમાં અખાત જીવન ઉત્સાહમાં છે, જેની પ્રજાતિ બચાવવા અને અભ્યાસ કરી છે, વન્યજીવ સંસ્થાન દ્વારા વિદ્યાર્થીઓમાં આ વિશે ઉત્સાહ જગાવ્યો હતો.

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GULF OF MANNAR & PALK BAY, TAMILNADU

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3.1 Research and Monitoring

Project work was carried out along the Palk Bay and Gulf of Mannar Marine National Park region covering about 400 kilometres of Tamil Nadu's coastline. It covered the coastal villages and waters of Southern Thanjavur, Pudukottai, Ramanathapuram and Tuticorin districts.

3.1.1 Spatial monitoring of dugong habitats in Palk Bay

To understand spatial distribution of seagrasses, 27 sites have been surveyed using Line-Intersect-Transsect with Quadrant method. SCUBA diving and snorkelling were used as tools for the same. Surveys have been focussed mainly in Palk Bay due to high fishing pressure and the lack of any legal protection to the waters of this area. However, some surveys have been conducted off the islands of Gulf of Mannar Marine National Park as well.

Seagrass meadows were surveyed for characteristics like abundance, composition of seagrass species, species-specific shoot densities of seagrass, and algal cover.

The area has been divided into 9 segments spatially to ease the planning of the surveys.

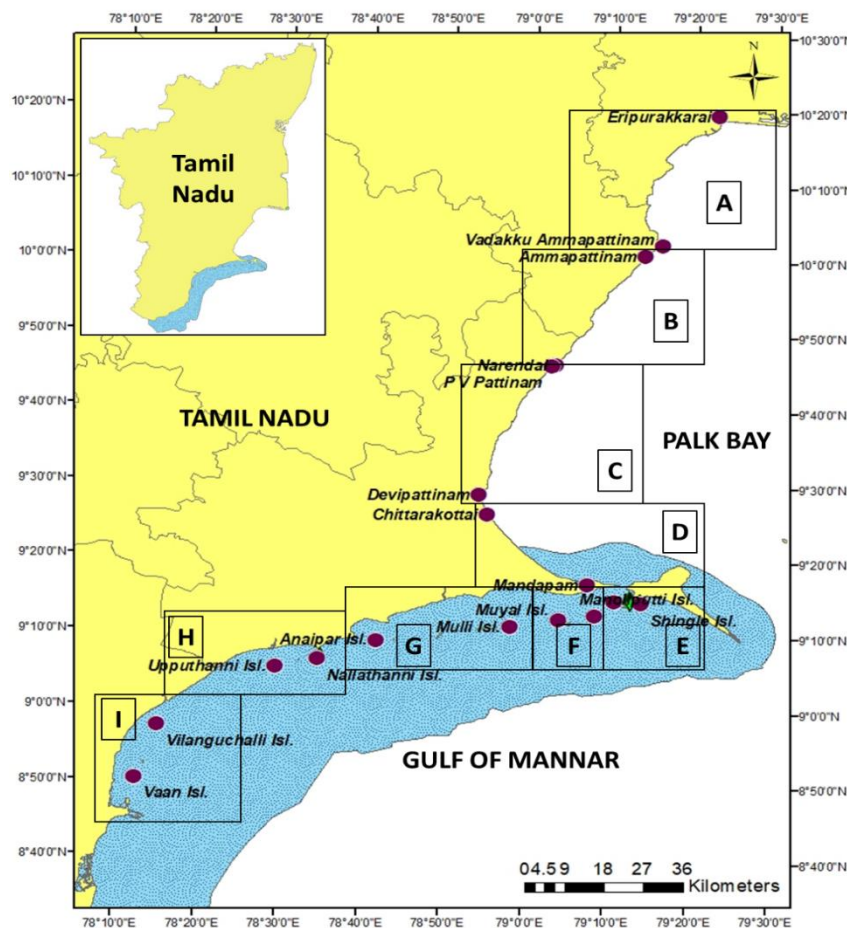


Figure 3.1: Division of study area into nine segments in Tamil Nadu

Palk Bay (Segments A, B, C and D)

The area is characterised by large, homogenous, near-shore seagrass beds that are dominated by *Cymodocea* sp. and *Syringodium* sp. Segments B and C have been considered as one unit (Central Palk Bay), owing to the homogeneity of seagrass beds in this area.

Table 3.1: Sampling locations in 4 Segments of Palk Bay- Tamil Nadu

S.No.	Segment	Region	No. of Sites	No. of transects	No. of points	Remarks
1	A	North Palk Bay	9	33	132	This area exhibits an overlap between mangrove and seagrass ecosystems.
2	B	Central Palk Bay	6	42	168	The coastal habitat predominantly consists of seagrass meadows.
3	C	Central Palk Bay	7	27	108	The coastal habitat predominantly consists of seagrass meadows.
4	D	South Palk Bay	5	30	120	The area shows an overlap between coral and seagrass coastal ecosystems.

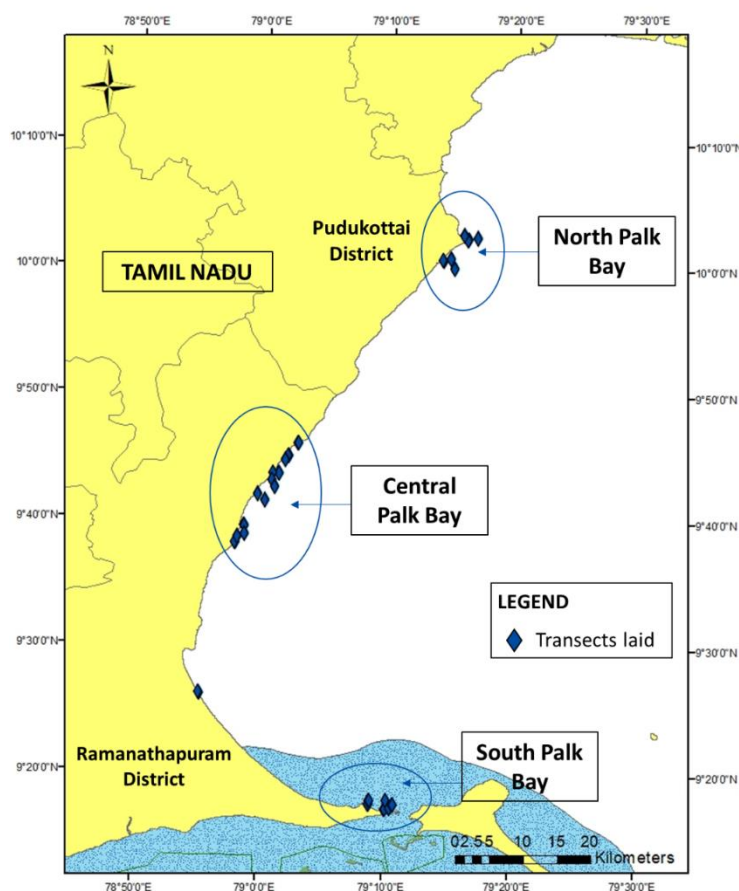


Figure 3.2: Locations of transects laid for seagrass surveys at Palk Bay, Tamil Nadu

Results

Seagrass Cover in Palk Bay

Central Palk Bay (segment B: 83.37% and segment C: 81.86%) showed maximum cover of seagrass. North Palk Bay (Segment A: 58.82%) and South Palk Bay (Segment D: 54.8%) showed comparatively lower cover of seagrass due to the presence of other coastal habitats like the mangroves in North and corals in South Palk Bay.

North Palk Bay (Segment A): *Halodule uninervis* (33.16% of total seagrass) and *Halophila ovalis* (24.36% of total seagrass) are found to make up most of the seagrass found here. This is possibly due to the muddy sediment from the mangroves of the region. This makes the area a healthy feeding ground for Dugongs, which is further confirmed by the many sightings of dugongs by local fishermen in the area.

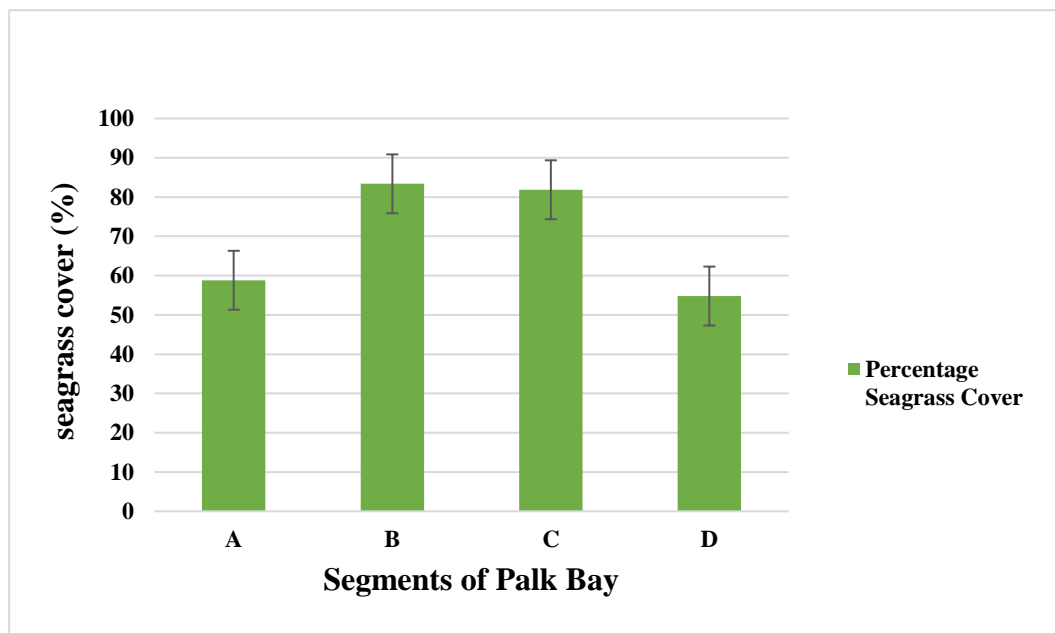


Figure 3.3: Percentage seagrass cover in Palk Bay, Tamil Nadu

Central Palk Bay (Segment B): The area is dominated by seagrasses of *Cymodocea* spp, which make up 58.12% of total seagrass in the area. This is followed by *Syringodium isoetifolium*, which contributes 22.58% of seagrasses in the area. *Thalassia hemprichii* and *Enhalus acoroides* are found very rarely. No *Thalassia hemprichii* and *Enhalus acoroides* were recorded during our surveys in the region.

Central Palk Bay (Segment C): The composition of seagrass species in Segment C resembles that of Segment B. *Cymodocea serrulata* (33.87%), *Syringodium isoetifolium* (30.88%) and *Cymodocea rotundata* (21.79%) make up the majority of seagrasses in the

region. There were some records of *Enhalus acoroides* during the survey. However, *Thalassia hemprichii* was not found in the region.

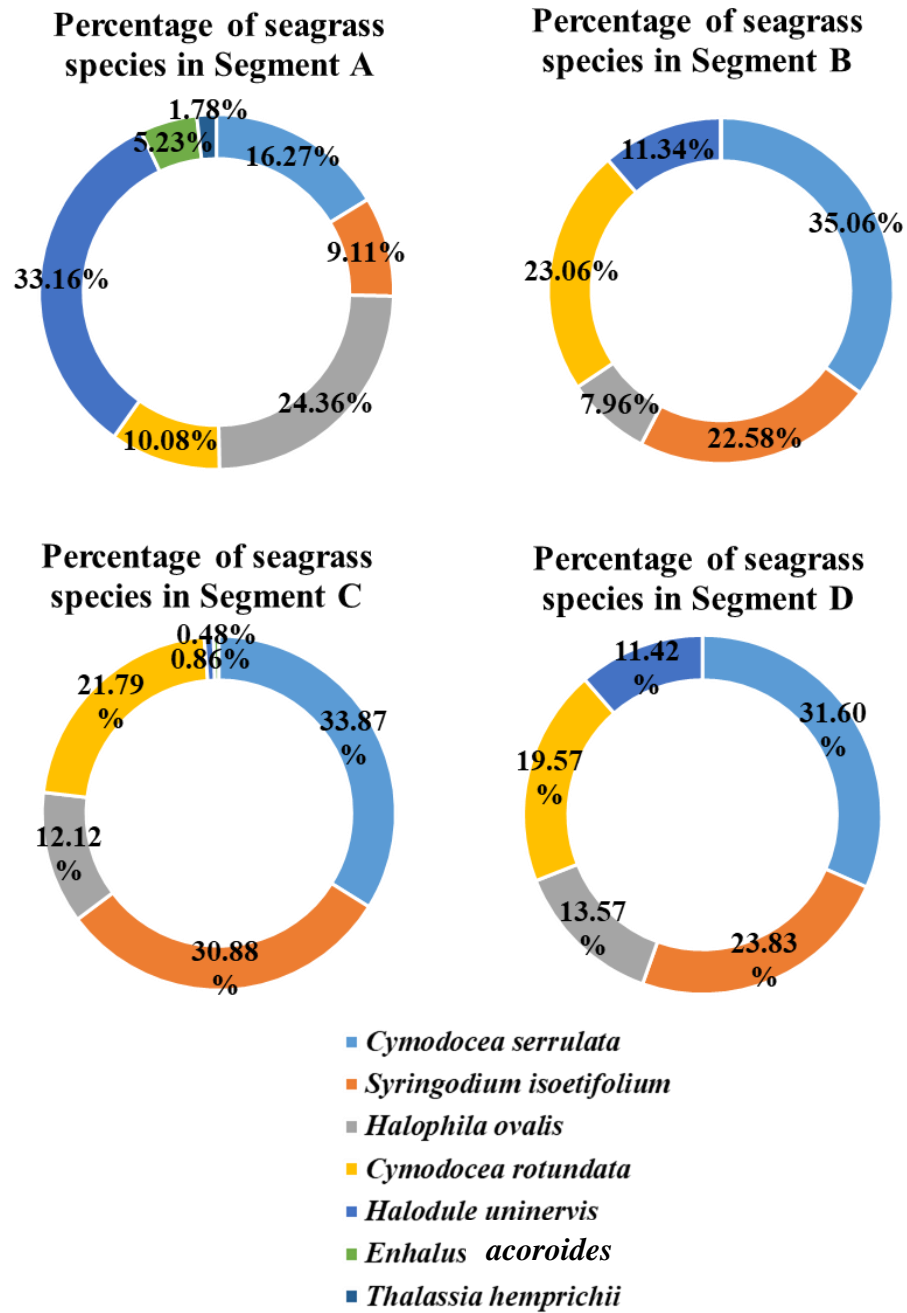


Figure 3.4: Percentage composition of seagrass species in Palk Bay, Tamil Nadu

South Palk Bay (Segment D): Other than areas of coral habitat overlap, the species composition is similar to that of Central Palk Bay.

3) Shoot densities of seagrasses of Palk Bay

Shoot Density Variation with Depth Gradient

Seagrass shoot density was compared with depth gradient in 4 study segments of Palk Bay

1) Segment A

Halodule uninervis and *Halophila ovalis*, the abundant seagrasses in this area are found to grow even in very shallow areas (<1m). Some of these areas are exposed during low tides. However, conforming to field observations, *Enhalus acoroides* grows in subtidal areas. Growth of *Halophila ovalis* is hampered by varying depths (at least till a maximum of 5 metre depth). Water enough to permanently submerge seagrasses (Sub-tidal areas; ~1.5m and above) is needed for the growth of other species like *Cymodocea* sp., and *Syringodium isoetifolium*. At Ammanichathram and Pudutheru, *H. uninervis* grew in monospecific meadows, thereby allowing for its lush growth.

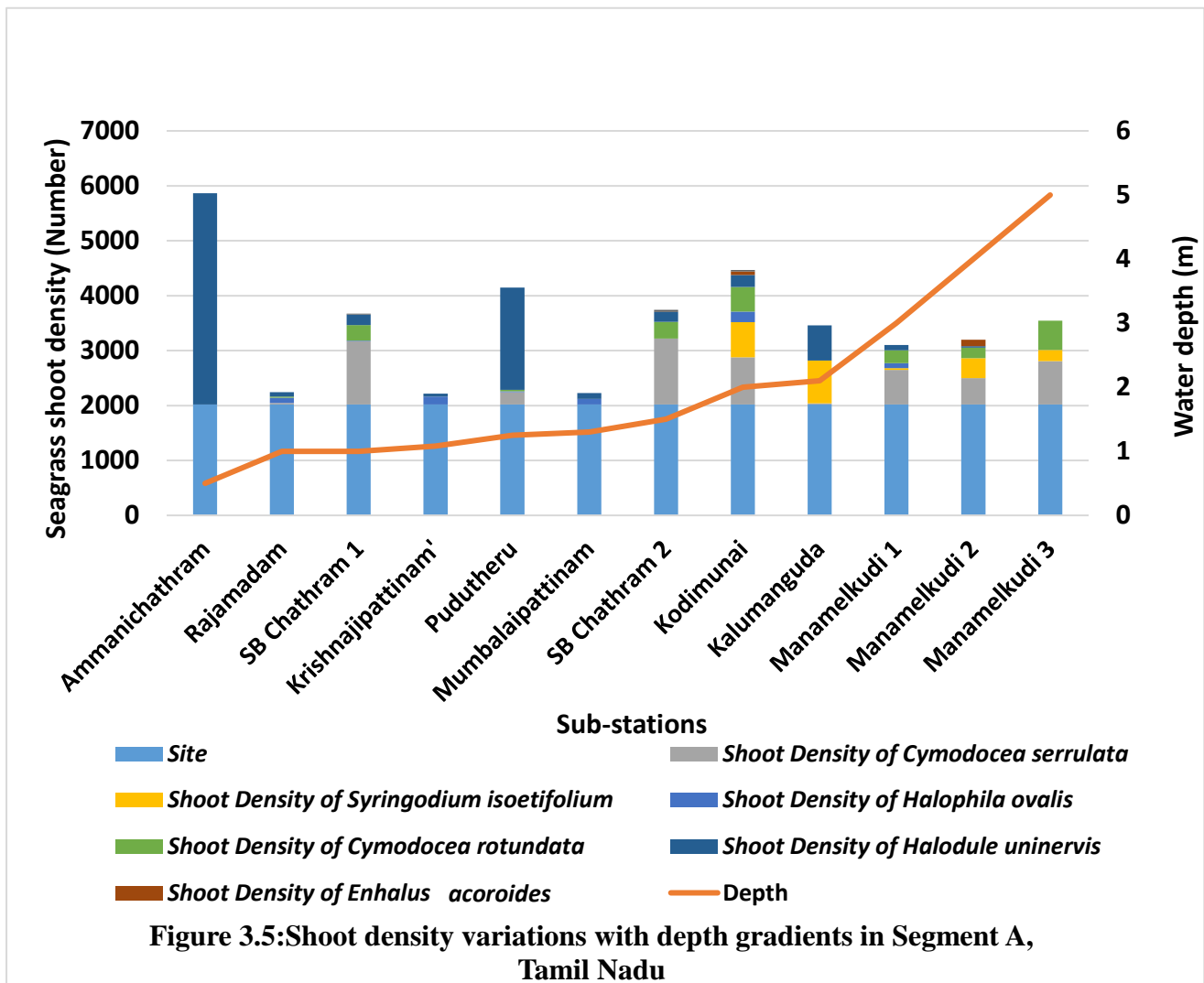


Figure 3.5: Shoot density variations with depth gradients in Segment A, Tamil Nadu

2) Segment B

Minimum and maximum depth surveyed was at ~2 to 3m, respectively. Except at Gopalapattinam, where the depth was <1m, all other sites show a relatively uniform distribution of seagrass species. As the depth is more, *Cymodocea* sp. grows better than the other seagrass species. Multispecific meadows of later seral seagrass species either shaded or stopped the growth of *Halophila ovalis*.

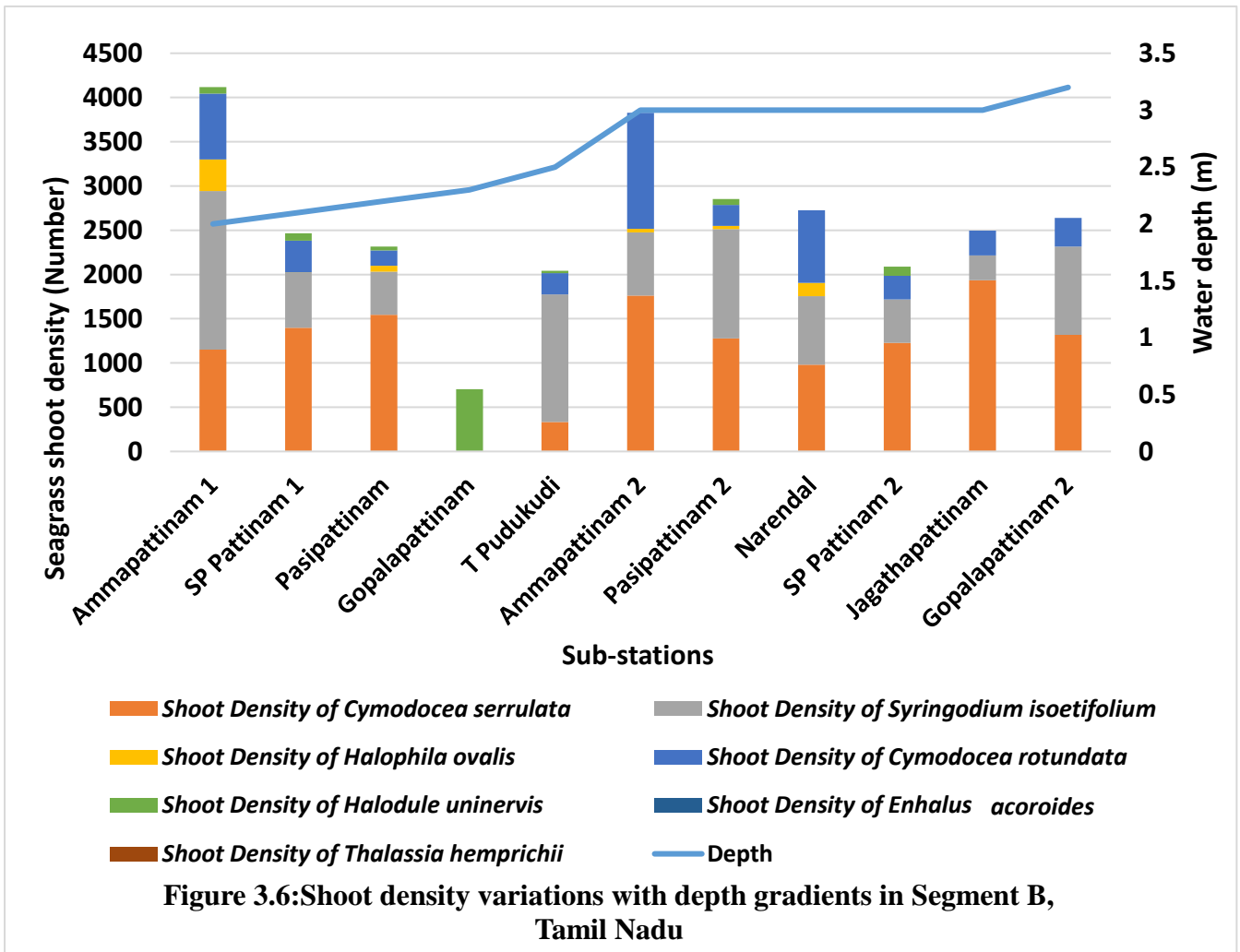


Figure 3.6: Shoot density variations with depth gradients in Segment B, Tamil Nadu

3) Segment C - Similar to Segment B, this area shows a homogenous distribution of seagrasses growing in regions of depth variations ranging from ~1 to 3m. Shoot density of *Cymodocea serrulata* and *Cymodocea rotundata* was found to be highest. *Halophila ovalis* and *Halodule uninervis* growth was also seen as the water was not deep enough to allow taller seagrasses to shade it. *Syringodium isoetifolium* grew densely. Its slender shoots grew close to each other and abundantly in the area.

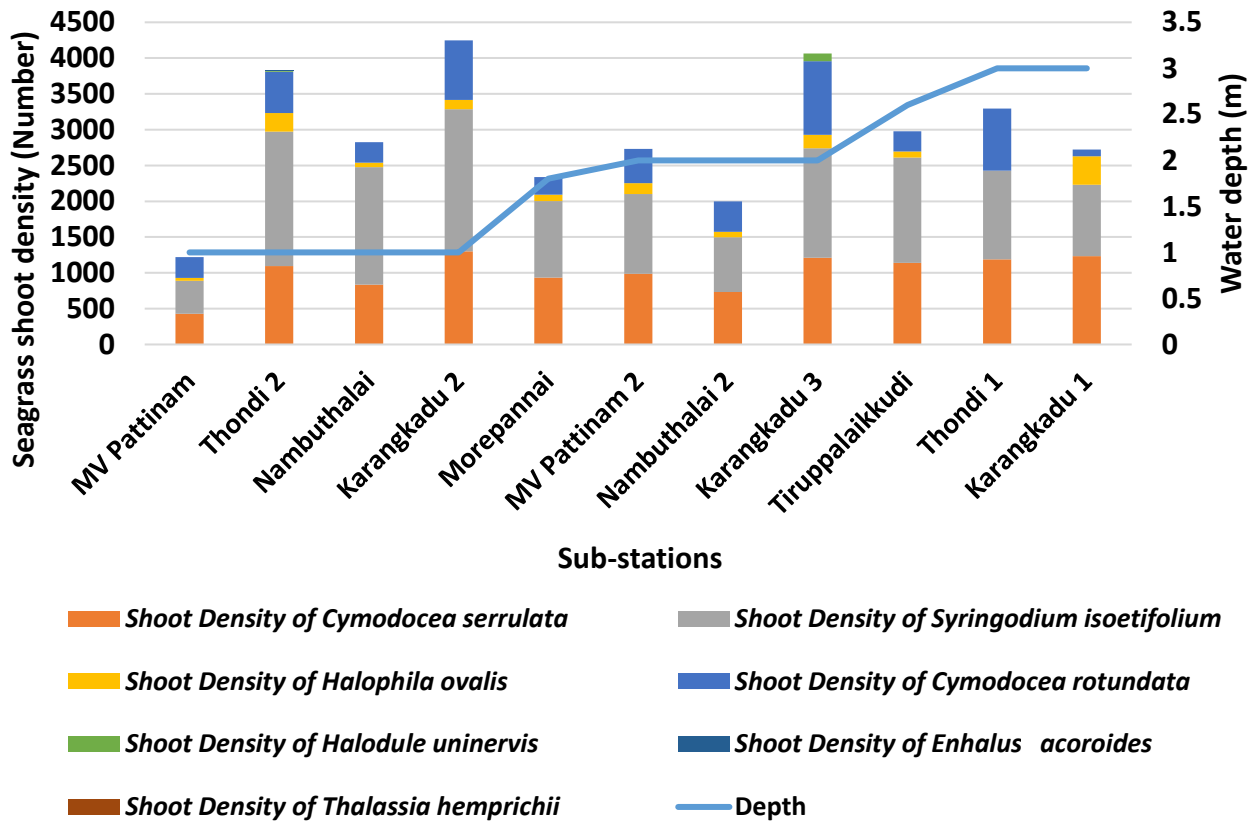


Figure 3.7: Shoot density variations with depth gradients in Segment C, Tamil Nadu

4) Segment D

This area varied in depth from 1 to 3m. The shallow intertidal waters of Devipattinam allowed for lush growth of *Halodule uninervis*. *Cymodocea rotundata*, *Cymodocea serrulata* and *Syringodium isoetifolium* showed lesser abundance compared to other segments of Palk Bay. All seagrass species grew sparsely, compared to other sites, owing to the coarse sand in this part of Palk Bay.

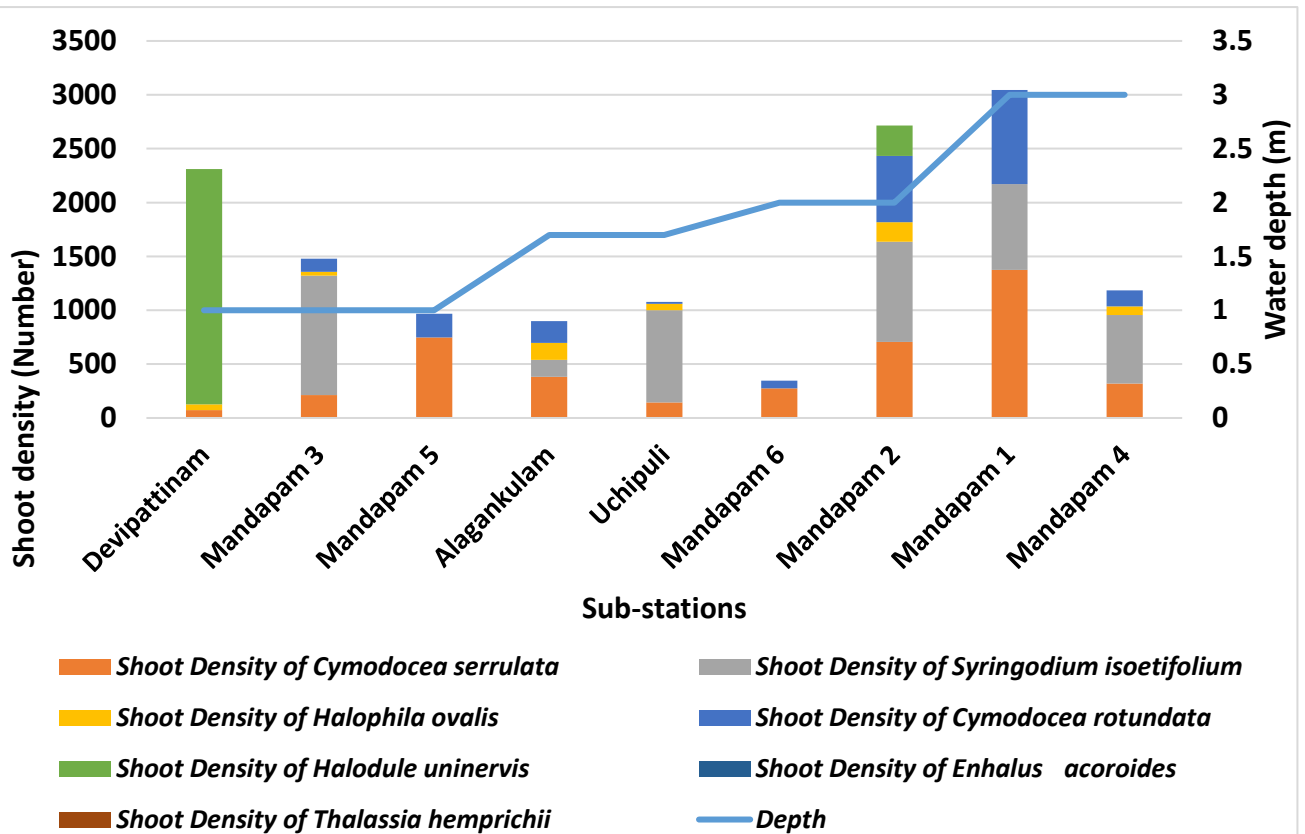


Figure 3.8: Shoot density variations with depth gradients in Segment D, Tamil Nadu

3.1.2 Dugong population monitoring through socio-economic surveys

Fisher-folk from 40 villages were interviewed to understand the perception and awareness of the community towards the sea, its resources and the dugong. Out of 822 respondents, 370 people reported their last sighting of a dugong in the past 2 decades.

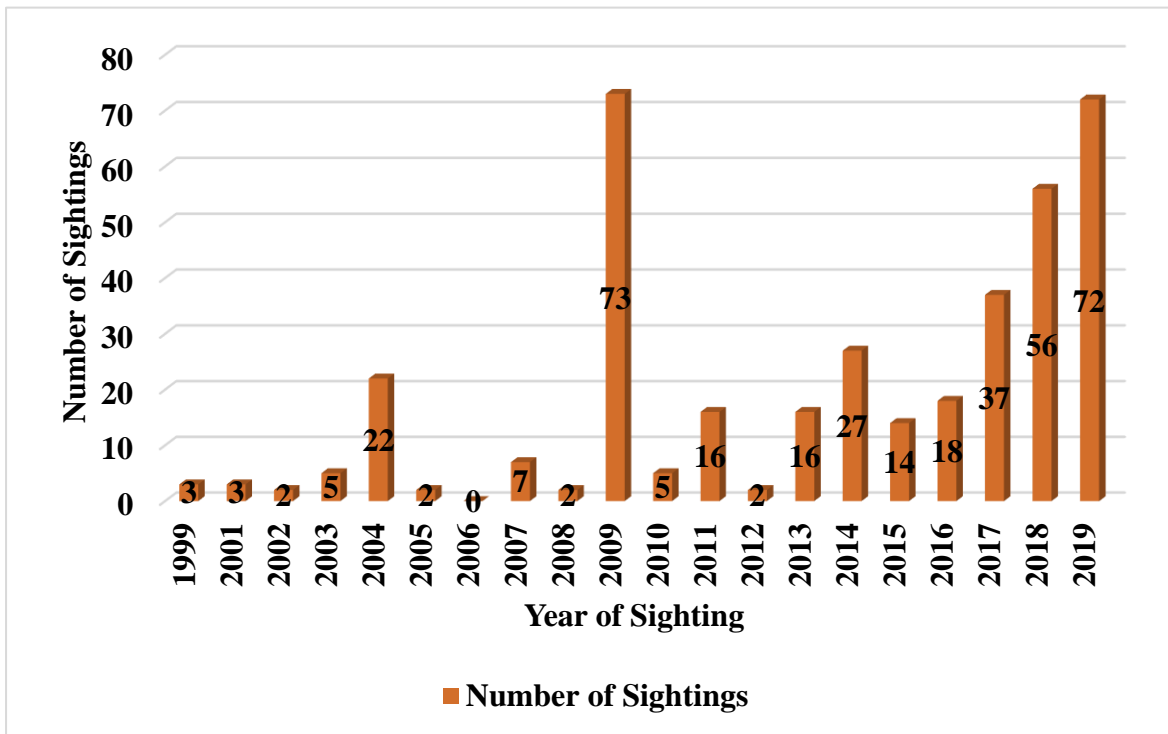


Figure 3.9: Dugong sightings reported by fisher-folk, Tamil Nadu

There is an increase in the dugong sightings as reported by the fisherfolk (from 3 sightings in 1999 to 72 in 2019). High numbers of dugongs have been reported in recent years (165 sightings from 2017-19). Although this may be due to the better recollection capacity of the respondents or increased survey effort in the area, this response is considered to be positive as it indicates the presence of dugongs in North Palk Bay waters.

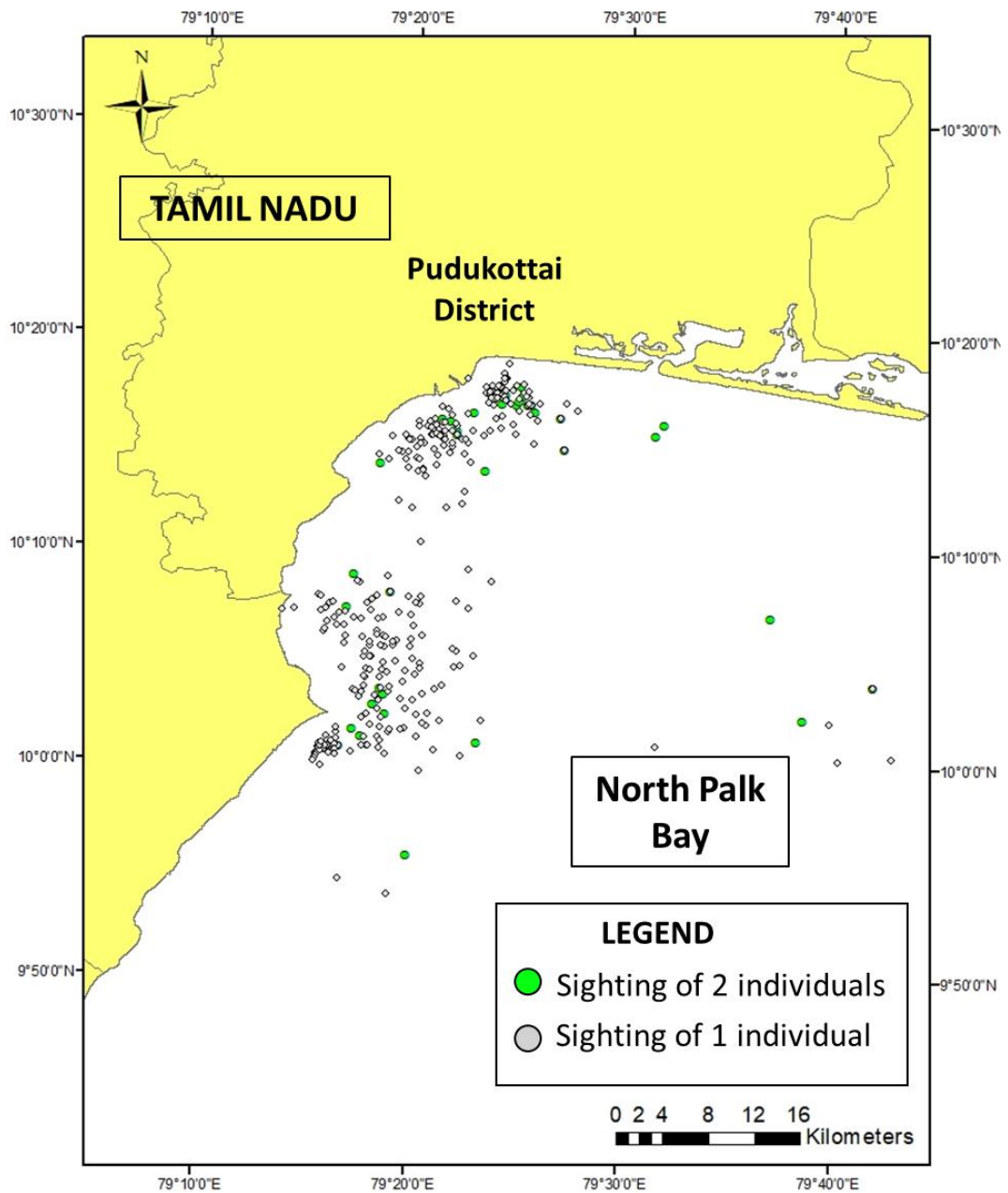


Figure 3.10: Dugong sightings by fisherfolk of North Palk Bay, Tamil Nadu

3.1.3 Socio-economic surveys in coastal villages of Palk Bay

A semi-structured questionnaire survey was conducted in 40 villages in North Palk Bay from 2018-19. 882 interviews were conducted to understand the perception of local communities towards conservation and the level of awareness about dugongs and the marine ecosystem. We also collected details about fishing methods, gears and vessels used. The surveys were started in the area proposed to be a conservation reserve- the North Palk Bay region, from

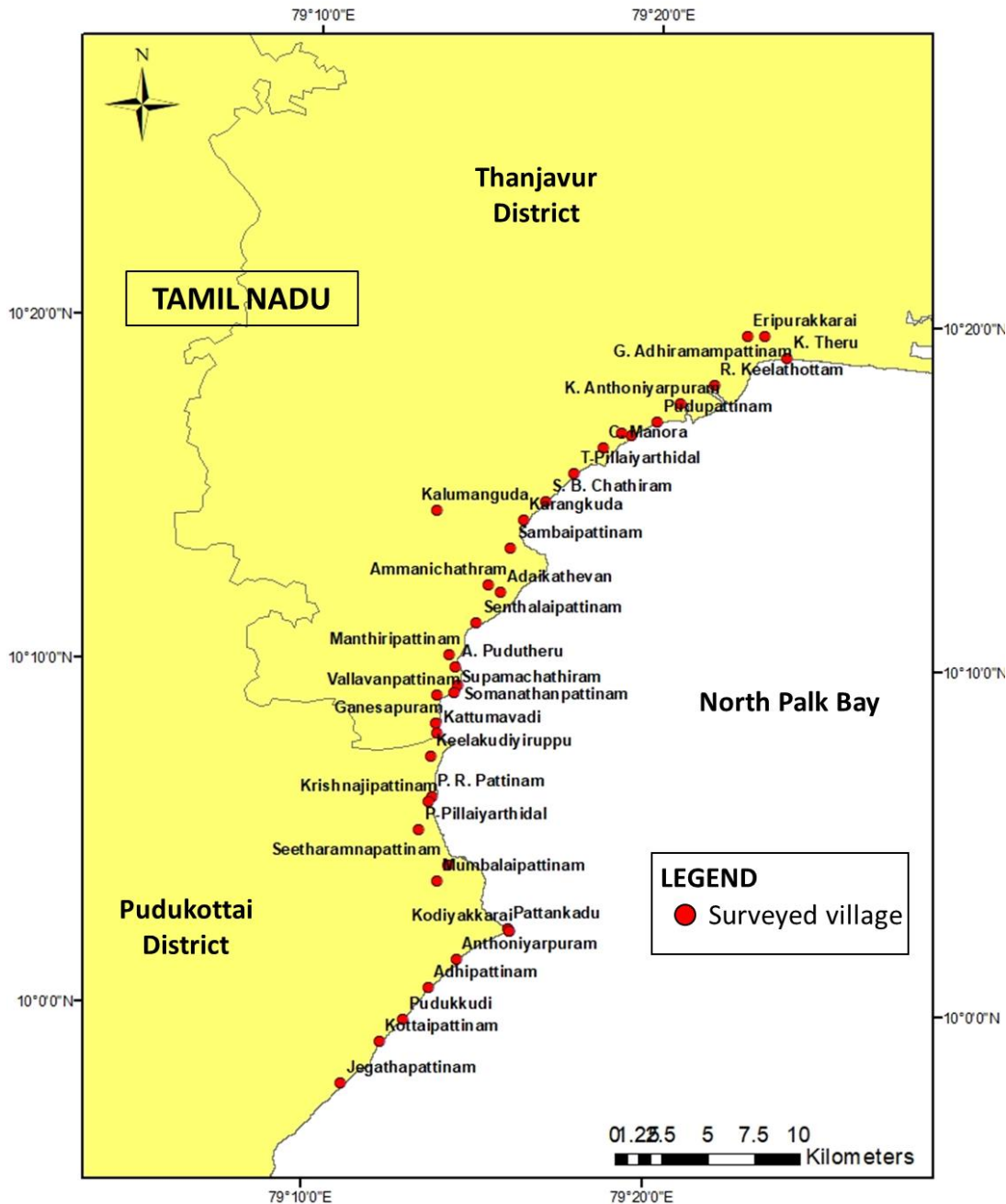


Figure 3.11: Coastal villages of North Palk Bay where interview surveys were conducted

Eripurakkarai in Thanjavur District to Therukku Pudukkudi in Pudukottai District. All interviewees were from the fishing community. Majority of respondents (n=798) were of 21 to 60 years in age. On an average, the respondents had 22.65 (SE=0.41) years of fishing

experience, ranging from 2 months to 60 years of experience. 823 respondents had 2 months-40 years of experience in fishing.

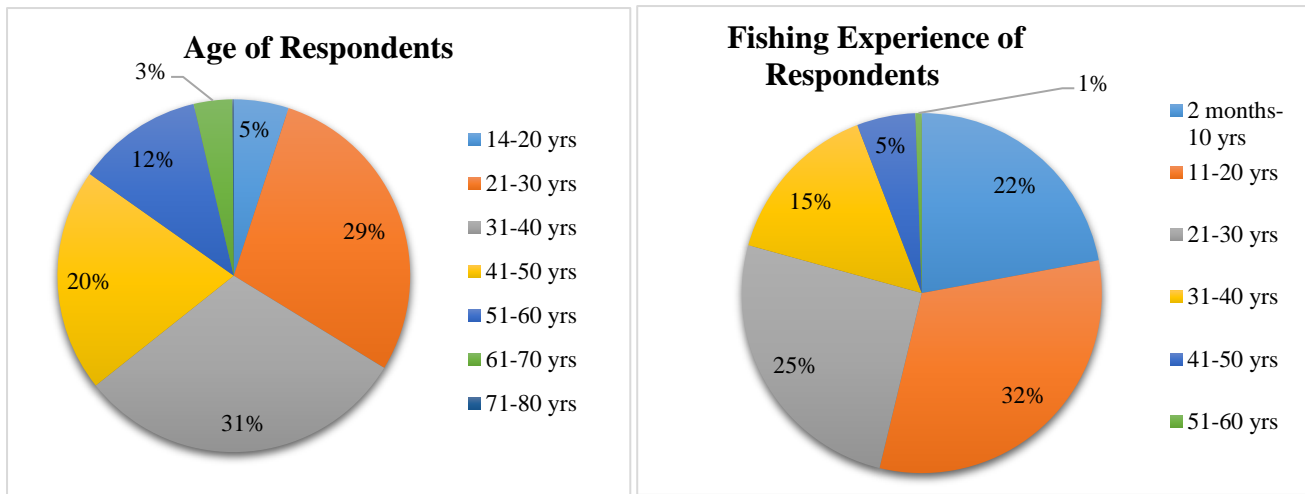


Figure 3.12: (a) Age of respondents (b) Fishing experience of respondents from social survey of villages from North Palk Bay

In the proposed conservation reserve area, majority of the crafts used are mechanized (n=735), operated using outboard engines. There are also a significant number of motorized crafts (dominated by trawl boats) (n=138) used in the region. Very few traditional boats are used (n=1).

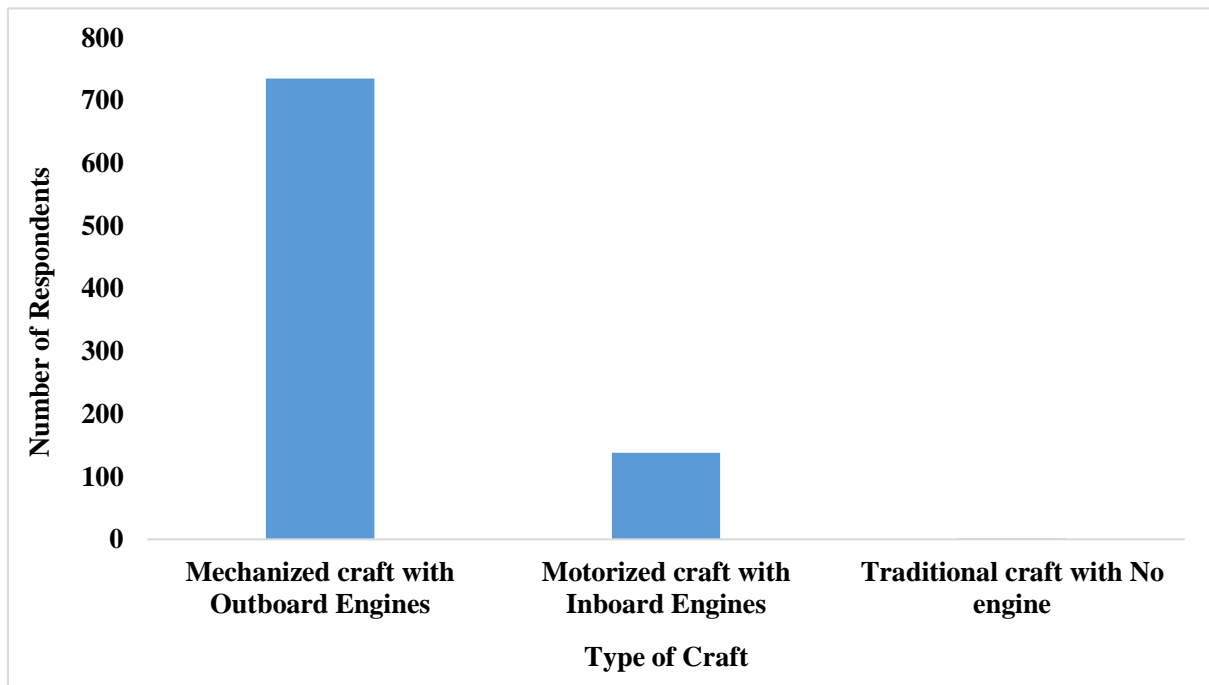


Figure 3.13: Types of craft used in the proposed conservation reserve area of North Palk Bay



**Figure 3.14: Motorized craft with inboard engine (top); Mechanized craft with outboard engine (bottom left); Traditional or Non-mechanized craft with no engine (bottom right)
Tamil Nadu**

Of those interviewed, most of the primary nets used by the respondents are set nets. This means that nets are left for a period of 2 hours to days at sea, before capturing the catch. The Drag nets are mainly used by trawlers. The trawl boats and boats that use drag nets usually have demersal resources like shrimps and lobsters as their target species.

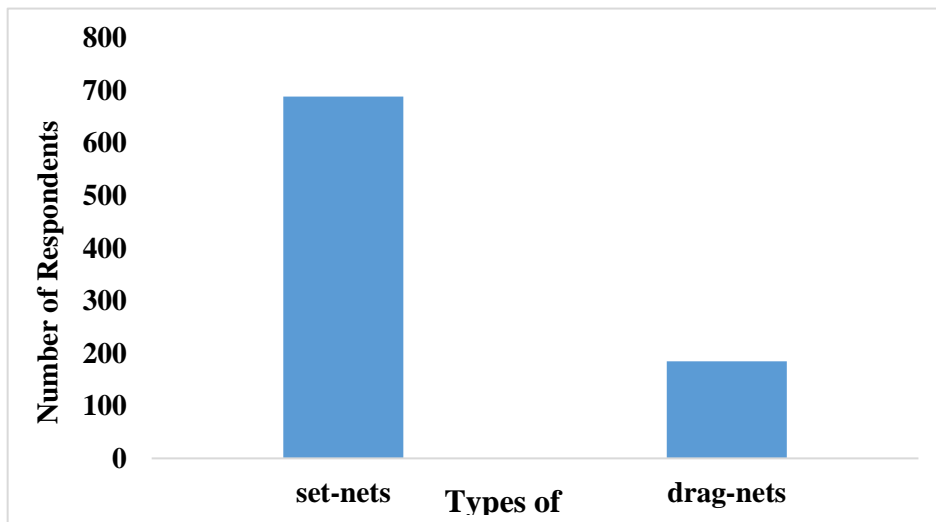


Figure 3.15: Types of fishing nets used by respondents in Palk Bay, Tamil Nadu

99.54% of the gill nets used are made of nylon; the remaining of cotton. This is not eco-friendly and makes it difficult for bycatch to escape from it. Mesh sizes of nets that make it impossible for entangled megafauna (including dugongs) are used by several fishermen here.

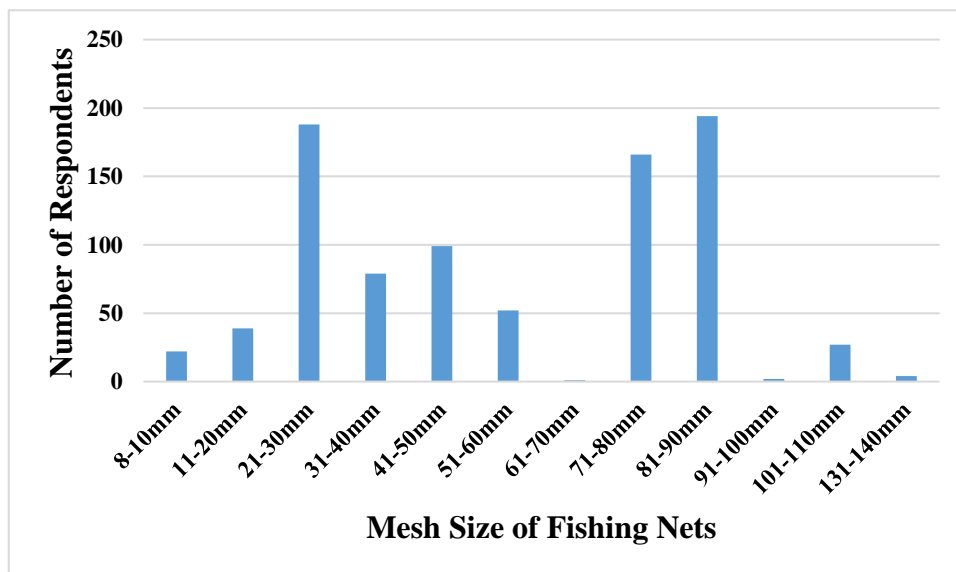


Figure 3.16: Mesh sizes of fishing nets used by respondents in Palk Bay, Tamil Nadu



Figure 3.17: Team members conducting socio-economic surveys by interviewing local fishermen in coastal villages of North Palk Bay area of Tamil Nadu

3.1.4 Temporal assessment of seagrass meadows in Palk Bay

The margins of the vast seagrass beds of Palk Bay and Gulf of Mannar are quite dynamic. Trials and pilot surveys have been carried out to enable monitoring of seasonal variations in seagrass beds of Palk Bay (segments A to D) once every 4 months. Eastward transects spaced 5 km away from each other were chosen. Point data is to be obtained at ½ km intervals along each transect till 9 km offshore. Data of seagrass species distribution, cover, canopy height, sediment texture, and water quality parameters are to be obtained at each point. As the area is vast and time is limited, effective methods like drop-down cameras and grabs were trialled and the time required to complete the surveys was reduced from 45-75 minutes per point to about 15-25 minutes per point.

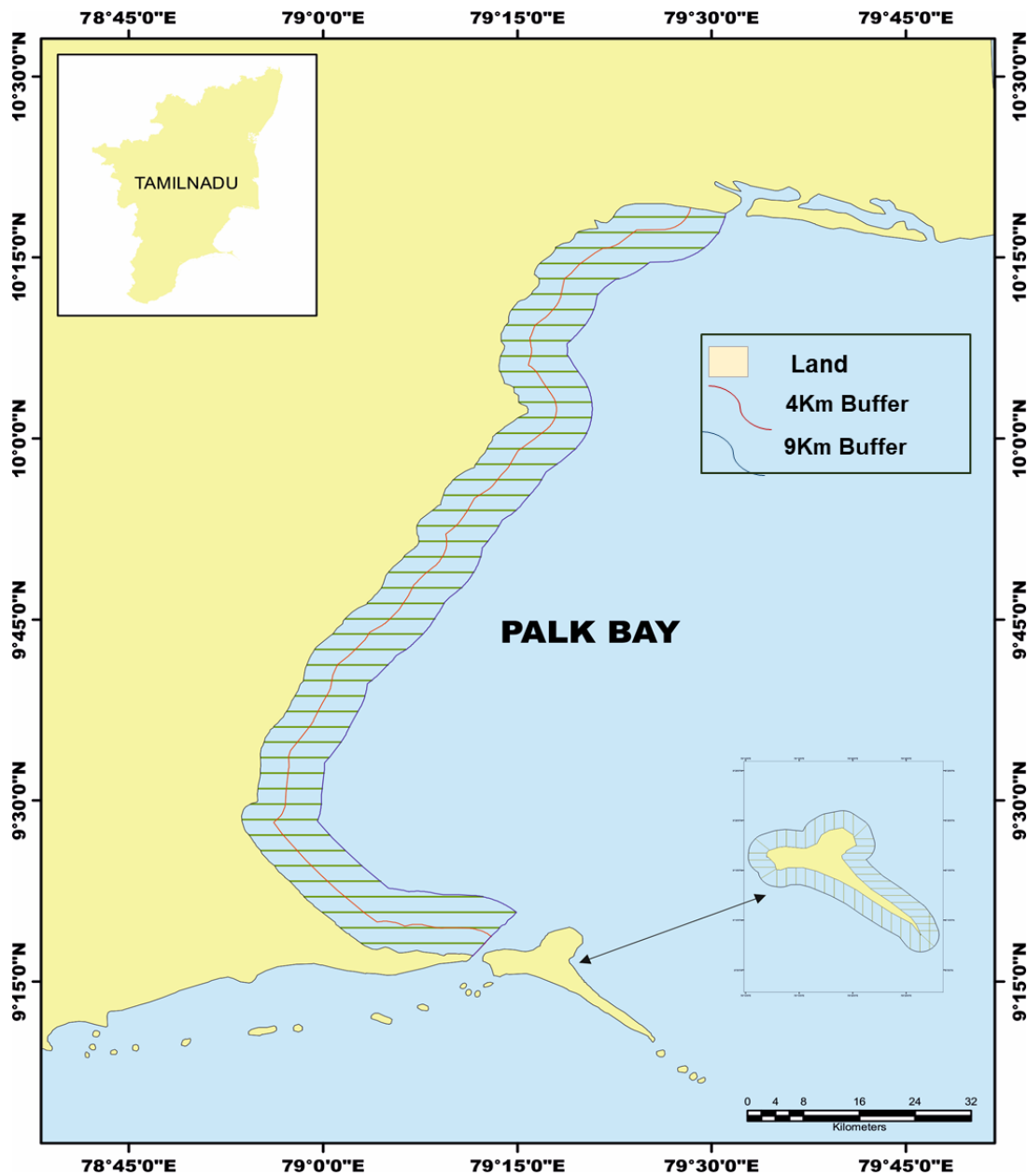


Figure 3.18: Pattern of surveys to be conducted in Palk Bay, Tamil Nadu

1) Drop-Down Camera Trials for rapid quadrant-based monitoring

To complete surveys faster, a 50 X 50cm PVC quadrat fitted with GoPro cameras to take photographs and videos of the sea-floor was designed. Challenges that were overcome by using this method were:

This apparatus can be used in places where the nature of the seafloor is unknown.

It can be used when SCUBA diving is unsafe (egs.: areas of unknown current patterns, rough seas)

It can be used from any type of boat.

Trials have been carried out and this method proves to be effective in obtaining quadrat data.



Figure 3.19: Checking the images and videos captured by the drop-down camera at Mandapam, Tamil Nadu



Figure 3.20: Deploying a drop-down camera at Mandapam, Tamil Nadu.

2) Pilot Survey

Initially pilot surveys were conducted using conventional methods such as SCUBA Diving and snorkelling. However, this method proved to be much more time consuming. It was then agreed upon to use:

drop-down cameras to obtain basic seagrass data like seagrass presence, cover and canopy height;

grabs for sample collection of seagrass and sediments; and,

SCUBA diving/snorkelling, only if required.



Figure 3.21: Grab trial off Ariyaman beach, Tamil Nadu



Figure 3.22: Pilot surveys conducted at Nambuthalai and Mandapam, Palk Bay, using trawl and small fishing boats. Collection of data and seagrass and sediment samples were carried out.

3.1.5 Seagrass growth monitoring using permanent quadrats in Palk Bay and Gulf of Mannar

To measure the growth rate of certain important seagrasses, such as *Cymodocea* spp., *Syringodium* spp., *Halophila* spp., and *Halodule* spp., sites were selected along the Palk Bay coast where it is suitable to install permanent quadrats that can be monitored on a long-term basis.

For the same, two trials have been carried out and all flaws have been rectified. Over 20 locations have been surveyed for suitability to install these quadrats on a long-term basis. The necessary factors that were to be considered to choose sites were:

Low fishing pressure

Less boat traffics

Sheltered, calm waters

Healthy seagrass meadows with less epiphyte cover

Not too dense seagrass meadows

Based on the above criteria, 3 sites (Mandapam, MR Pattinam and Thondi) were chosen to install the 3-4 quadrat each. The quadrat was of 50 X 50cm size, made of PVC pipes and held down in place using iron rods.



Figure 3.23: Installation of growth monitoring quadrats at Mandapam, Palk Bay



Figure 3.24: Installation of growth monitoring quadrats at M R Pattinam, Palk Bay

Installation included the clearing of all shoots above the sediment layer. The roots and rhizomes were left intact and not disturbed. All shoots collected were weighed and species diversity and abundance are studied.

Assessment of these quadrats were to be carried out fortnightly., assessing the plots for presence of new shoots and new plants. However, due to the Covid-19 pandemic, inter-district travel was restricted. This hampered assessment of the quadrats. The pilot surveys were successful and this forms a major part of next year's surveys.

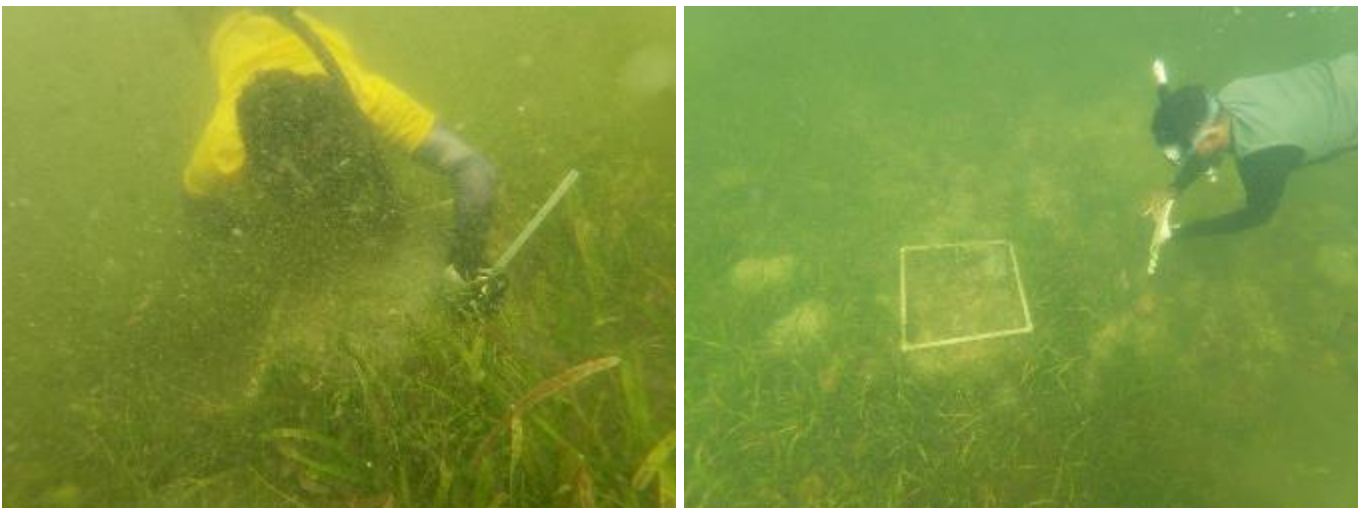


Figure 3.25: First assessment of growth monitoring quadrats at M R Pattinam, Palk Bay



Figure 3.26: First assessment of growth monitoring quadrats at Mandapam, Palk Bay

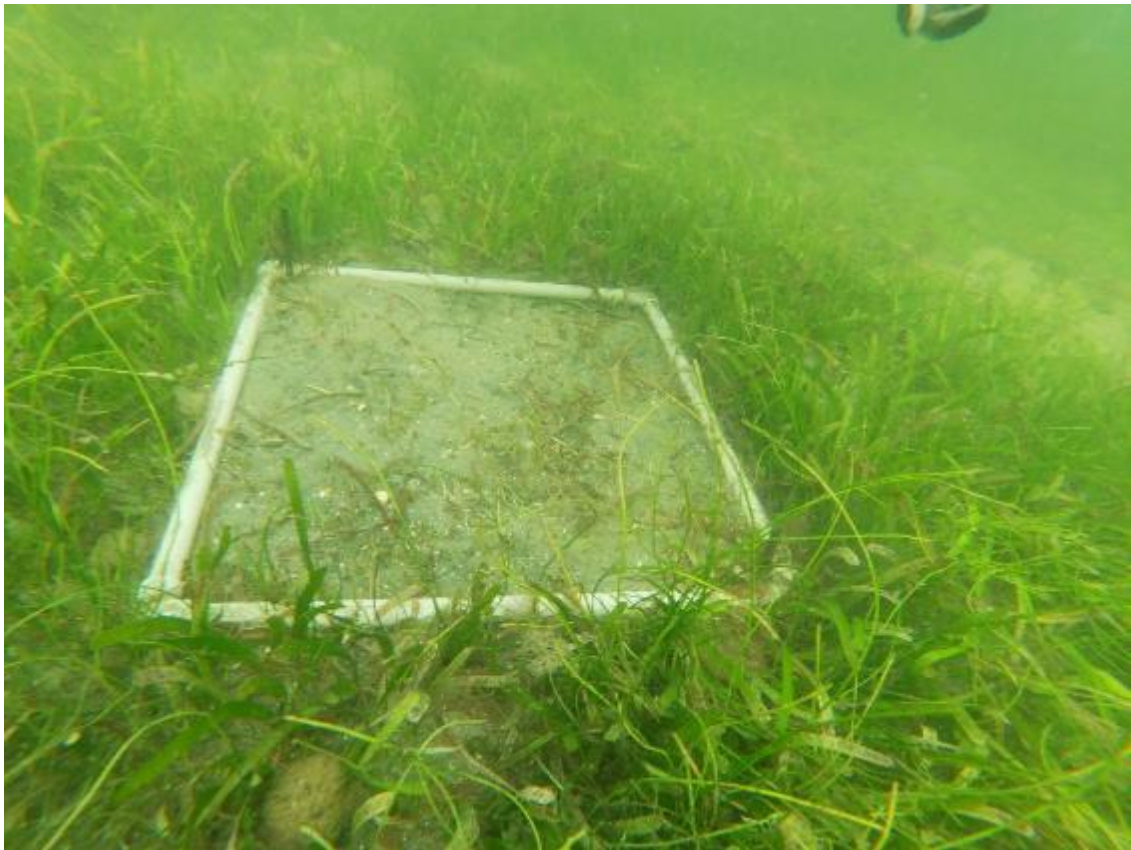


Figure 3.27: A cleared out plot ready for long-term growth monitoring, Palk Bay

3.1.6 Short-term summer projects carried out at CAMPA-dugong Tamil Nadu site

Two students worked with the CAMPA-Dugong Recovery programme at the Tamil Nadu field site for their summer internships:

1) Mr. Gagan Vaishya Shettappanavar, pursuing a BS-MS (Biology Major), from Indian Institute of Science Education and Research, Trivandrum, Kerala; and,

2) Ms. Sasmitha Swain, pursuing her M.Sc. in Oceanography, from Alagappa University, Karaikudi, Tamil Nadu.

Mr. Gagan interned for one month (May, 2019) and Ms. Sasmita, for two months (May and June, 2019).

They worked on the estimation of protein, lipid, total carbohydrate, fiber ash and chlorophyll content in seagrasses collected from 3 sites in Palk Bay.

Step 1: Literature review to finalize protocols used to estimate requires seagrass components.

Step 2: Collection of samples. During this process, the interns were given field training. They were introduced to using snorkelling as a tool to collect subtidal seagrass samples. Samples were collected from 3 sites-Mandapam, (in South Palk Bay), M. R. Pattinam (Central Palk Bay) and Manora (in North Palk Bay).

Step 3: Preparation of samples for estimation. The samples were dried and powdered and each sample was labelled separately for analyses.

In addition to this, the students also actively participated in the project's outreach work. They attended community meetings, helped with questionnaire surveys and helped prepare awareness material.



Figure 3.28: Interns at work at Tamil Nadu field site.



Figure 3.29: Interns participating in questionnaire survey at Tamil Nadu field site



Figure 3.30: Interns participating in stakeholder meeting at Tamil Nadu field site

3.1.7 Dugong stranding records in Tamil Nadu (July, 2019- June, 2020)

Since the inception of the project, 36 individual dugongs have been found stranded on the Gulf of Mannar and Palk Bay coast of Tamil Nadu.

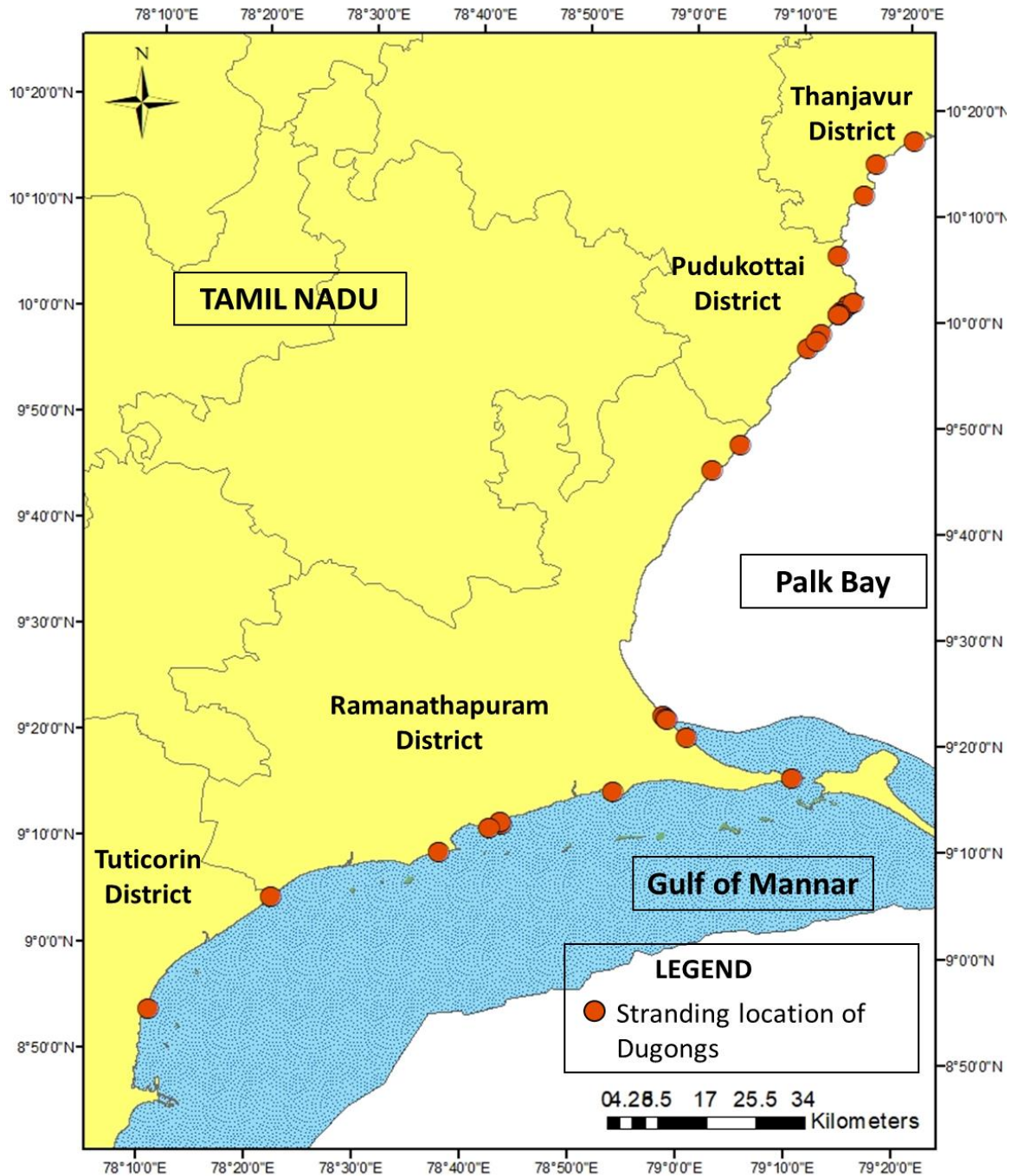


Figure 3.31: Locations of dugong stranding in Palk Bay and Gulf of Mannar

In the past one year, 12 dead dugong carcasses were found stranded on the beaches of Gulf of Mannar and Palk Bay coasts of Tamil Nadu. Till date, we have recorded highest dugong mortality in the months of March, April, January, February, June and December.

Table 3.2: A list of stranded dugongs from August 2019 to June 2020

S. No	Date	Species	Number	Sex	Age Class	Place			Location	
						Village	District	State	Latitude	Longitude
1	24-08-2019	<i>Dugong dugon</i>	1	Uk	A	Tharavaikulam	Tuticorin	Tamil Nadu	-	-
2	04-10-2019	<i>Dugong dugon</i>	1	F	SA	Kottaipattinam	Pudukottai	Tamil Nadu	9.980407	79.20231
3	05-11-2019	<i>Dugong dugon</i>	1	Uk	SA	Alagankulam	Ramanathapuram	Tamil Nadu	9.373621	78.96926
4	01-12-2019	<i>Dugong dugon</i>	1	M	SA	Valinokkam	Ramanathapuram	Tamil Nadu	9.153754	78.62576
5	17-12-2019	<i>Dugong dugon</i>	1	M	A	Alagankulam	Ramanathapuram	Tamil Nadu	9.3707	78.97251
6	02-01-2020	<i>Dugong dugon</i>	1	M	A	Alagankulam	Ramanathapuram	Tamil Nadu	9.368777	78.97436
7	07-01-2020	<i>Dugong dugon</i>	1	M	A	P. R. Pattinam	Pudukottai	Tamil Nadu	10.104863	79.22626
8	17-01-2020	<i>Dugong dugon</i>	1	M	A	Kottaipattinam	Pudukottai	Tamil Nadu	9.969391	79.19449
9	16-02-2020	<i>Dugong dugon</i>	1	F	A	S. B. Chathram	Thanjavur	Tamil Nadu	10.249753	79.28385
10	19-02-2020	<i>Dugong dugon</i>	1	M	A	Pasipattinam	Ramanathapuram	Tamil Nadu	9.803309	79.07912
11	20-05-2020	<i>Dugong dugon</i>	1	F	A	Sethukarai	Ramanathapuram	Tamil Nadu	9.248103	78.843474
12	06-06-2020	<i>Dugong dugon</i>	1	Uk	A	Sayalkudi	Ramanathapuram	Tamil Nadu	9.128187	79.468247

(Note: F= Female; M=Male; Uk= Unknown; A= Adult; and, SA= Sub-adult)

From the start of a year till the 15th of April (commencement of the annual fishing ban in Tamil Nadu) is a peak season for trawl boats to operate in the region. Several dugongs that beach during this time are wounded and possibly killed due to accidental collision with large trawl boats. This mortality rate is seen also in the month of June, when the annual fishing ban is lifted. High mechanized boat traffic is a potential threat to dugongs during this time of the year.

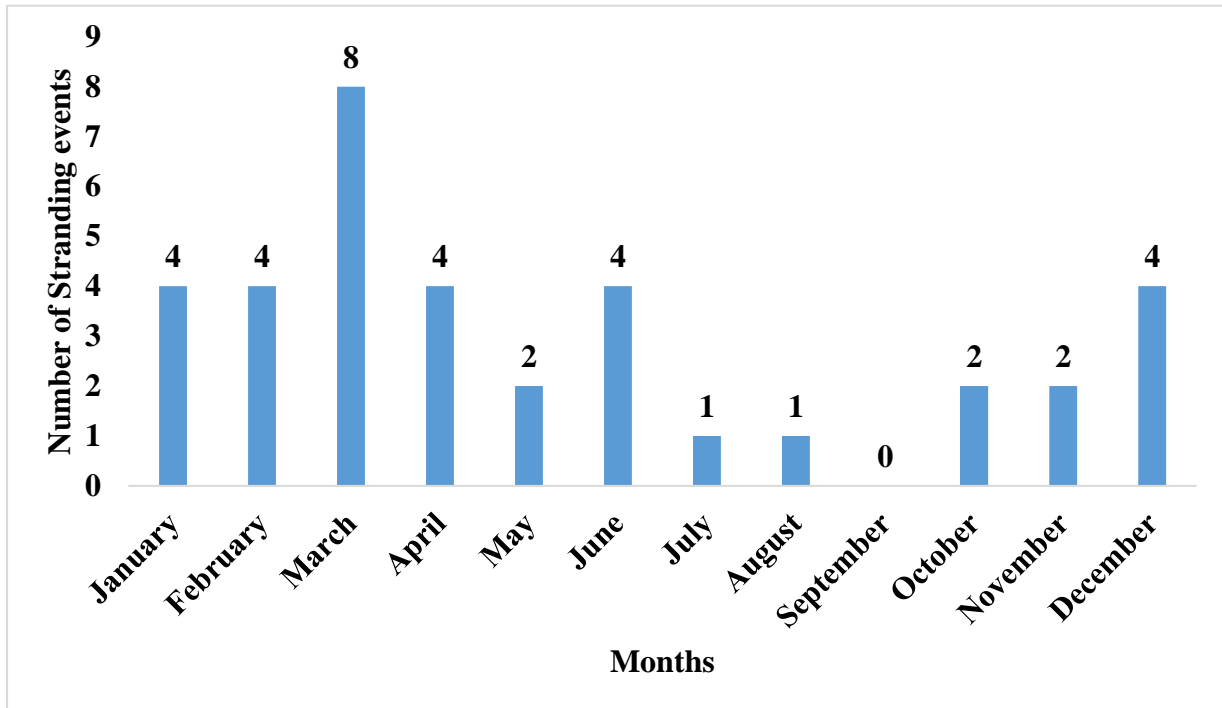


Figure 3.32: Seasonal patterns in dugong mortalities along Gulf of Mannar and Palk Bay

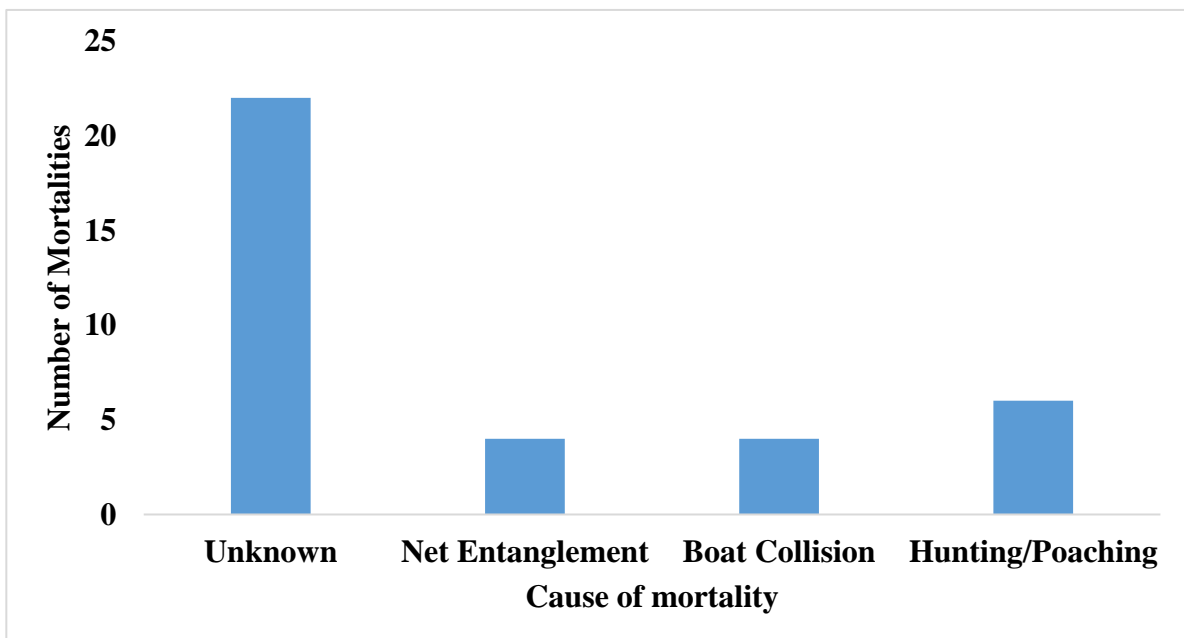


Figure 3.33: Causes of dugong mortalities along Gulf of Mannar and Palk Bay

However, the year 2020 has shown a differing pattern in dugong deaths. No dugong deaths were recorded in March and April; and only 2 were found dead in May and June. This could be due to the less boat traffic as a result of the lockdown due to COVID-19.

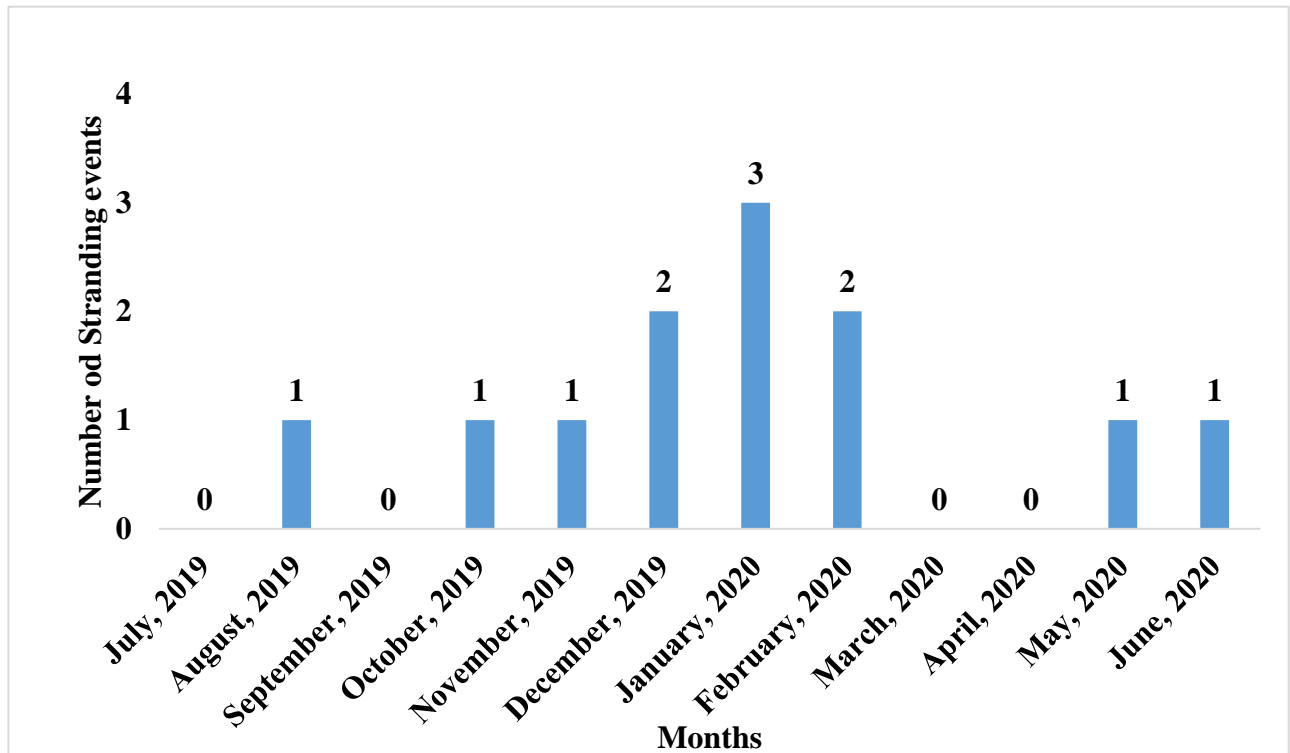


Figure 3.34: Seasonal patterns in dugong mortalities along Gulf of Mannar and Palk Bay from July, 2019- June, 2020 (1 year)

Table 3.3: Morphometric measurements of stranded dugongs at Tamil Nadu field site

S. No.	Date	Species	Total Length (cm)	Standard Length (cm)	Flipper Length (cm)	Flipper width (cm)	Muzzle Length (cm)	Muzzle Width (cm)	Fluke Length (cm)	Fluke Width (cm)	Neck Girth (cm)	Axillary Girth (cm)	Maximum Girth (cm)	Girth at Tail Peduncle (cm)	Weight (kg)
1	04-10-2019	<i>Dugong dugon</i>	270	240	47	18	-	-	30	80	90	-	-	-	300
2	01-12-2019	<i>Dugong dugon</i>	230	200	32	17	13	21	30	70	86	-	155	-	200-250
3	02-01-2020	<i>Dugong dugon</i>	253	225	48	17	16.5	27	28	74	-	151	-	-	400
4	07-01-2020	<i>Dugong dugon</i>	282	238	52.5	22.7	20.5	26	42	92	104	148	286	61	450-500



Figure 3.35: Dugong stranding along Tamil Nadu coast (2019-2020)

3.1.8 Other marine megafauna stranding recordings in Tamil Nadu (2019-20)

Table 3.4: Marine megafauna stranding recorded (2019-20)

S. No.	Marine Mammal	Date	Place	District	State
1	Dolphin	14-01-2020	Uppur	Ramanathapuram	Tamil Nadu
2	Dolphin	12-03-2020	P. R. Pattinam	Thanjavur	Tamil Nadu
3	Dolphin	23-03-2020	Eripurakkarai	Thanjavur	Tamil Nadu
4	Dolphin	23-05-2020	Jagathapattinam	Pudukottai	Tamil Nadu
5	Dolphin	06-06-2020	Athankarai	Ramanathapuram	Tamil Nadu



Figure 3.36: Stranded dolphin carcass at along Palk Bay coast

3.1.9 Seagrass associated fishes of Palk Bay and Gulf of Mannar

Introduction

Gulf of Mannar and Palk Bay in Tamil Nadu are key seagrass ecosystems among Indian Ocean. Among important seagrass ecosystems in India, Gulf of Mannar is protected as Marine National Park but Palk Bay region is not well protected by law. Like global seagrass dependent fishery, both subsistence and commercial fishery are practiced in these key seagrass ecosystems of India. Harboring abundant diversity, many villages nearby these seagrass ecosystems in these regions of Tamil Nadu are largely dependent upon fishery practices as source of income. Therefore, it is important to study interactions between seagrass ecosystems and various fish species associated with them. This study aims to understand and collect data about interactions between seagrass ecosystems and various fish species associated with them.

1) A pilot study of gut content of two seagrass associated fish species from Palk Bay

Methodology: A pilot study of gut content analysis for two seagrass associated fish, *Gerres erythronus* and *Psammoperca waigensis*, was done (n=10 each) by occurrence method. All samples were collected in June 2019 from Thondi Fish Market in Middle Palk Bay.

Result: We found Polychaetes, shells, fish scales, algal filaments, and seagrass in the gut of *Gerres erythronus* (Figure 3.37). As *Psammoperca waigensis* is a carnivorous fish, we found crabs, shrimps and amphipods in its gut (Figure 3.38).

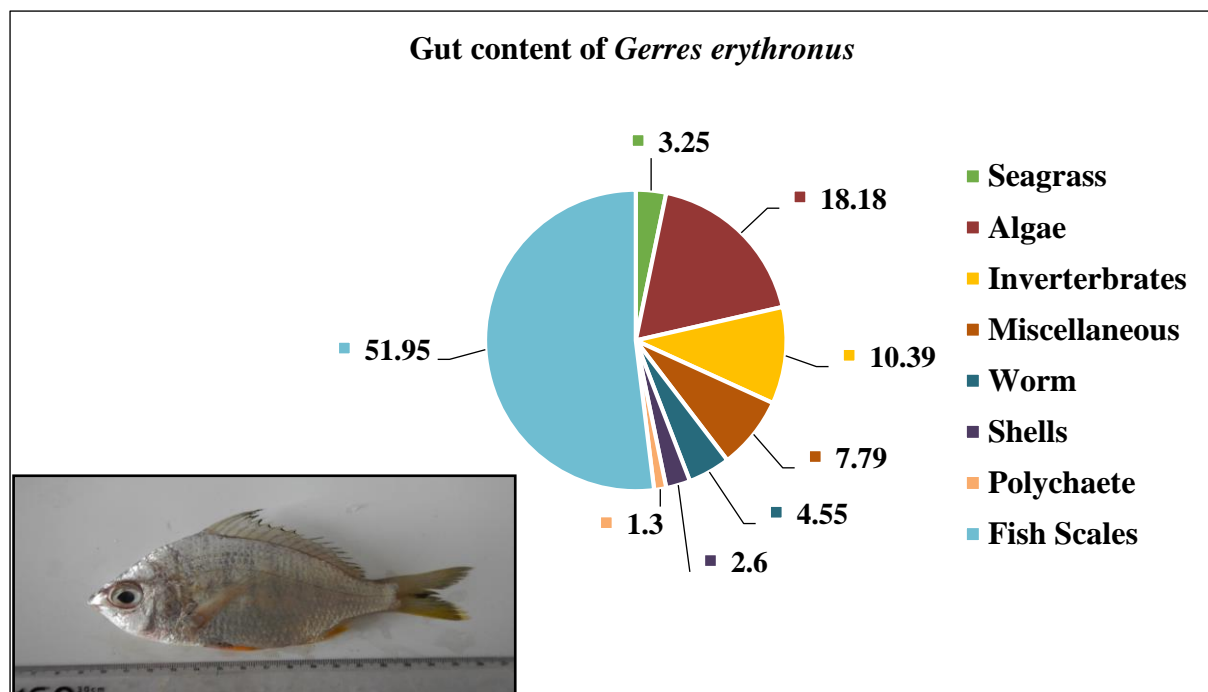


Figure 3.37: Gut content analysis of *Gerres erythronus* in Gulf of Mannar

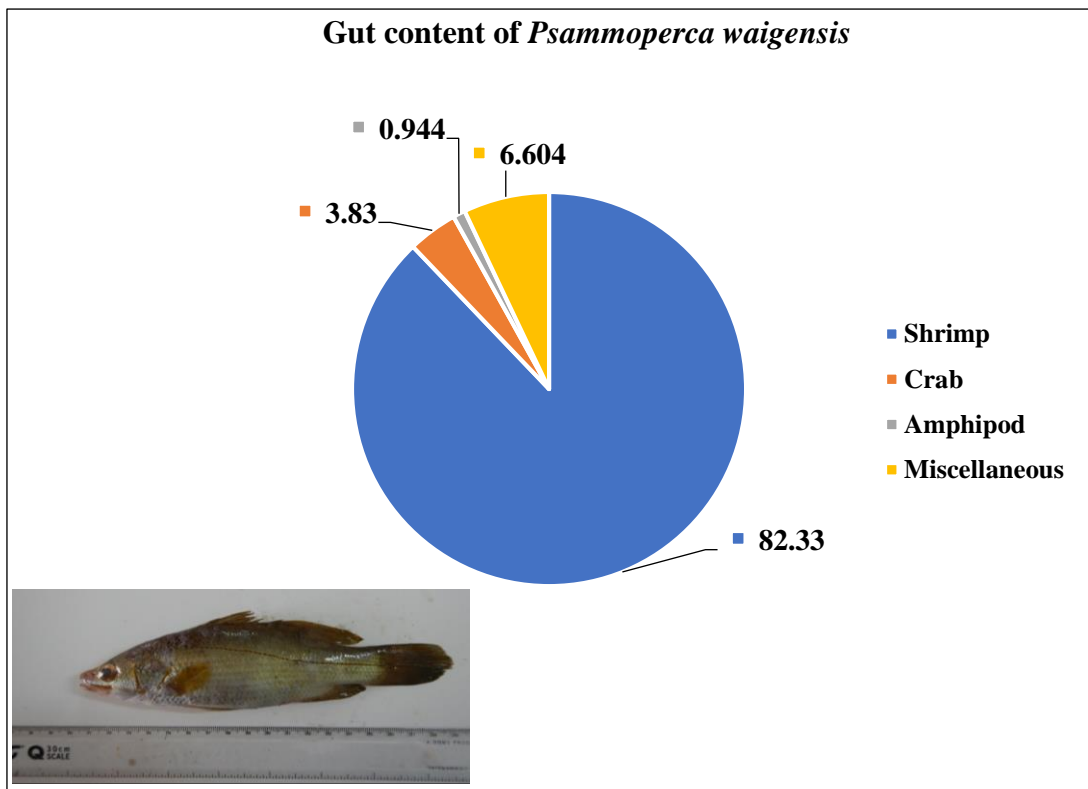


Figure 3.38: Gut content analysis of *Psammoperca waigensis*



Figure 3.39: a) Shrimp b) Amphipod c) Crab d) Fish in gut content of *Psammoperca waigensis*

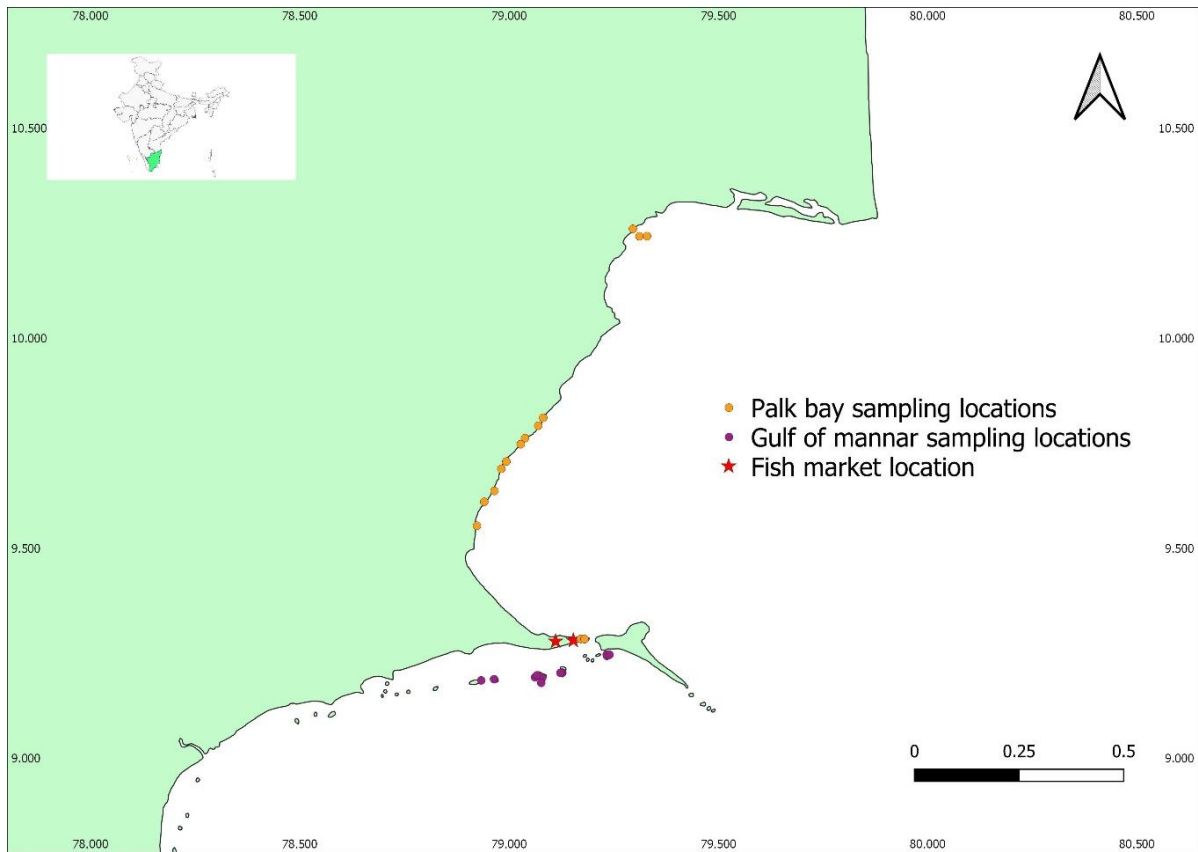


Figure 3.40: Sampling Locations for seagrass associated fish along Palk Bay and Gulf of Mannar, Tamil Nadu

2) Fish market survey in Palk Bay and Gulf of Mannar

Methodology: Fish diversity at the landing centre was recorded by recording fish species available at each vendor. Photographs were taken of individual species for identification.

Result: Fish market survey was done from January to March 2020 at fish landing centre in Mandapam and Vedalai in Palk Bay and Gulf of Mannar region (n=4).

Table 3.5: Checklist of fish species(n=26) observed in fish market at Tamil Nadu site

S. no.	Species	Common name	Family	Location
1	<i>Atule mate</i>	Yellow tailed scad	Carangidae	Both
2	<i>Chanos chanos</i>	Milkfish	Chanidae	Both
3	<i>Chirocentrus nudus</i>	White fin wolf Herring	Chirocentridae	Both
4	<i>Hilsa Keele</i>	Hilsa	Clupeidae	Both
5	<i>Ilisha megaloptera</i>	Bigeye ilisha	Pristigasteridae	Both
6	<i>Ilisha melastoma</i>	Indian ilisha	Pristigasteridae	Both
7	<i>Planiliza macrolepis</i>	Large scale mullet	Mugilidae	Both
8	<i>Lutjanus ehrenbergii</i>	Blackspot snapper	Lutjanidae	Gulf of Mannar
9	<i>Plotosus lineatus</i>	Striped eel catfish	Plotosidae	Gulf of Mannar
10	<i>Psammoperca waigiensis</i>	Sand Bass	Latidae	Gulf of Mannar
11	<i>Siganus canaliculatus</i>	White spotted Rabbit Fish	Siganidae	Gulf of Mannar
12	<i>Siganus lineatus</i>	Lined Rabbitfish	Siganidae	Palk Bay
13	<i>Arius sp.</i>	Catfish	Ariidae	Palk Bay
14	<i>Carangoides sp.</i>	Jack	Carangidae	Palk Bay
15	<i>Telatrygon zugei</i>	Pale eyed Sting ray	Dasyatidae	Palk Bay
16	<i>Ellochelon vaigiensis</i>	Square tailed Mullet	Mugilidae	Palk Bay
17	<i>Hemiramphus lutkei</i>	Halfbeak	Hemiramphidae	Palk Bay
18	<i>Ilisha sp.</i>	-	Clupeidae	Palk Bay
19	<i>Chelon parsia</i>	Goldspot mullet	Mugilidae	Palk Bay
20	<i>Mugil cephalus</i>	Flat head Mullet	Mugilidae	Palk Bay
21	<i>Parupeneus indicus</i>	Indian Goatfish	Mullidae	Palk Bay
22	<i>Stolephorus indicus</i>	Indian anchovy	Engraulidae	Palk Bay
23	<i>Strongylura incisa</i>	Reef Needle	Belonidae	Palk Bay
24	<i>Upeneus trangula</i>	Freckled Goatfish	Mullidae	Palk Bay
25	<i>Epinephalus bleekeri</i>	Dusky tail Grouper	Serranidae/Epinephelinae	Unkown
26	<i>Gerres erythronus</i>	Deep bodied mojarra	Gerridae	Unkown



Sphyraena obtusata



Chirocentrus nudus



Siganus lineatus



Atule mate



Fish vendor at Vedalai



Vedalai Fish Market

Figure 3.41: Fish Market survey at Tamil Nadu field-site

3) Study of length weight relationship of selected seagrass associated fishes in Gulf of Mannar

The study was conducted from January to February 2020 as a dissertation work of Ms. Sasmita Swain for Masters of Science in Oceanography and Coastal area studies, Alagappa University, Karaikudi, Tamil Nadu. This study attempted to understand health of selected seagrass associated fish in Gulf of Mannar.

Methodology: Based on secondary literature, 14 seagrass associated fish species found in Gulf of Mannar were selected for this study. Health assessment of these fish was done by length-weight relation study of 30 individuals of each species. The individuals were collected from Pamban and Mandapam Fish markets of Gulf of Mannar region. Length measurement was taken by measuring tape and 30 cm scale, and weight measurement was taken by weight balancing machine of 0.01 gm precision. Length-weight relationship was studied by the standard formula:

$$\log W = \log a + b \log L$$

where,

- W = weight of fish in gms,
- a = intercept
- L = total length of fish in cms,
- b = slope

The estimation of the a and b parameters were carried out by linear regression analysis by log transformation. Typically, the growth is considered positively isometric if $b > 3$ and negatively isometric if $b < 3$.

Result: Length-weight relation of 14 selected seagrass associated fish were as follows; The r^2 value ranged from 0.19 for *Hilsa keele* to 0.99 for *Lutjanus fulvus*. The exponent b ranged from 1.401 for *Hilsa keele* to 3.628 for *Arius maculatus*. Positive isometric growth was found in only 2 fishes (*Arius maculatus*, *Lutjanus russellii*), whereas the normal isometric growth found in only one fish (*Tricanthus biaculeatus*). Negative isometric growth was found in 11 fishes. Further study is required to comment on the health status of these 14 fish species.

Table 3.6: Growth pattern of selected seagrass associated fishes of Gulf of Mannar

Species Name	a(factor)	b (exponent)	r ² (regression coefficient)	G (kind of growth with isometry)
<i>Arius maculatus</i>	0.0010	3.628	0.79	Positive
<i>Arothron immaculatus</i>	0.4845	1.960	0.65	Negative
<i>Hilsa keele</i>	0.5669	1.401	0.19	Negative
<i>Lutjanus fulvus</i>	0.0271	2.851	0.99	Negative
<i>Lutjanus russelii</i>	0.0111	3.116	0.90	Positive
<i>Parupeneus indicus</i>	0.0161	2.859	0.79	Negative
<i>Siganus canaliculatus</i>	0.0219	2.869	0.90	Negative
<i>Siganus lineatus</i>	0.0405	2.717	0.91	Negative
<i>Sphyraena barracuda</i>	0.0547	2.297	0.84	Negative
<i>Sphyraena jello</i>	0.0067	2.858	0.93	Negative
<i>Sphyraena obtuse</i>	0.0327	2.408	0.75	Negative
<i>Terapon puta</i>	0.0962	2.203	0.79	Negative
<i>Tricanthus biaculeatus</i>	0.0086	3.043	0.90	Isometry
<i>Upeneus trangula</i>	0.0922	2.267	0.63	Negative

4) Point counts for assessing seagrass associated fishes in Gulf of Mannar

Methodology: To understand diversity and usage of seagrass meadows by fish, random point counts were conducted at Gulf of Mannar. Sampling was done near 6 islands named Kurusadai, Shingle, Muyal, Manoli, Valai and Mulli from January to March 2020. These sampling locations are part of Gulf of Mannar Marine National park. These areas exhibit a variety of habitats including rocks, corals and seagrasses.

Variable radius point counts (n=36) were performed by noting down each fish sighting in the point count. Observer hovered not more than 2m above centre of the point for 10 minutes. The dominant activity within every minute of every fish species individual or shoal was noted along with seagrass characteristics. Their numbers were specified according to size classes with reference to the tape. Position of fish individual/ shoal in seagrass column were also noted. Selection of next point was done by swimming in random direction. Distance between two points is kept minimum 20 m. Number of point counts were minimum 3 to maximum 5.

Point counts were also performed by underwater mounted cameras in the same area. The camera was deployed for continuous video recording of 40-50 minutes at a point. Analysis for these camera point counts is yet to be carried out.

This data collected from Gulf of Mannar in January to March 2020 (n=36) was compared with the data from Palk Bay in January to June 2019 (n=49).

Results

Table 3.7: Checklist of fish species observed (n=51) in Gulf of Mannar Marine National Park

Sr. no.	Species	Common name	Family
1	<i>Terapon puta</i>	Small scaled terapon	Terapontidae
2	<i>Pelates quadrilineatus</i>	Four lined terapon	Terapontidae
3	<i>Lutjanus lemniscatus</i>	Darktail snapper	Lutjanidae
4	<i>Lutjanus fulvus</i>	Blacktail snapper	Lutjanidae
5	<i>Lutjanus sp.</i>	Snapper	Lutjanidae
6	<i>Lutjanus vitta</i>	Brown-stripe snapper	Lutjanidae
7	<i>Lutjanus ehrenbergii</i>	Blackspot snapper	Lutjanidae
8	<i>Upeneus tragula</i>	Freckled goatfish	Mullidae
9	<i>Parupeneus sp.</i>	Goatfish	Mullidae
10	<i>Parupeneus indicus</i>	Indian goatfish	Mullidae
11	<i>Mulloidichthys sp.</i>	Yellow-stripe goatfish	Mullidae
12	<i>Cheilinus oxycephalus</i>	Snooty Wrasse	Labridae
13	<i>Coris dorsomacula</i>	Pale barred coris	Labridae
14	<i>Cheilinus chlorourus</i>	Floral wrasse	Labridae
15	<i>Hologymnosus annulatus</i>	Ring wrasse	Labridae
16	<i>Stethojulis interrupta</i>	Cutribbon wrasse	Labridae
17	<i>Thalassoma lunare</i>	Crescent wrasse	Labridae
18	<i>Gerres sp.</i>	Silverbiddy	Gerreidae
19	<i>Neopomacentrus azysron</i>	Yellowtail damsel	Pomacentridae
20	<i>Amphiprion sebae</i>	Sebae anemonefish	Pomacentridae
21	<i>Abudefduf saxatilis</i>	Sergeant major	Pomacentridae
22	<i>Pomacentrus simsiang</i>	Blueback damsel	Pomacentridae
23	<i>Scarus sp.</i>	Parrotfish	Scaridae
24	<i>Chlorosus sp.</i>	Parrotfish	Scaridae

25	<i>Scarus hypselopterus</i>	East indies parrotfish	Scaridae
26	<i>Cheaeodon collare</i>	White collar Butterfly fish	Chaetodontidae
27	<i>Cryptocentrus fasciatus</i>	Barred shrimpgoby	Gobidae
28	<i>Cryptocentrus sp</i>	Shrimp goby	Gobidae
29	<i>Amblyeleotris sp</i>	Shrimp goby	Gobidae
30	<i>Oplopomus oplopomus</i>	spinecheek goby	Gobidae
31	<i>Scolopsis sp</i>	Bream	Nemipteridae
32	<i>Synodus dermatogenys</i>	Clearfin lizardfish	Synodontidae
33	<i>Siganus sutor</i>	African white spotted rabbitfish	Siganidae
34	<i>Siganus sp</i>	Rabbitfish	Siganidae
35	<i>Monodactylus argenteus</i>	Silver mono	Monodactylidae
36	<i>Sphyaena obtusa</i>	Obtuse barracuda	Sphyaenidae
37	<i>Lethrinus nebulosus</i>	Spangled emperor	Lethrinidae
38	<i>Lethrinus orantus</i>	Ornate emperor	Lethrinidae
39	<i>Scolopsis taenioptera</i>	Slender emperor	Lethrinidae
40	<i>Lethrinus sp</i>	Emperor	Lethrinidae
41	<i>Lethrinus harak</i>	Thumbprint emperor	Lethrinidae
42	<i>Pseudalutarius nasicornis</i>	Rhino filefish	Monacanthidae
43	<i>Epinephelus coioids</i>	Orange spotted grouper	Serranidae/Epinephelinae
44	<i>Epinephelus bleekeri</i>	Duskytail Grouper	Serranidae/Epinephelinae
45	<i>Caesio sp</i>	Fusilier	Caesionidae
46	<i>Zoramia perlita</i>	Pearly Cardinalfish	Apogonidae
47	<i>Pempheris sp</i>	Sweeper	Pempheridae
48	<i>Karalla daura</i>	Gold stripe pony fish	Leiognathidae
49	<i>Echeneis naucrates</i>	Sharksucker	Leiognathidae
50	<i>Diagramma picta</i>	Silver sweetlips	Haemulidae
51	<i>Lutjanus fulviflamma</i>	Longspot snapper	Lutjanidae

According to α diversity indices, the diversity in fish communities observed in Gulf of Mannar is more than that of Palk Bay.

Table 3.8: α -Diversity indices for fish communities of Gulf of Mannar and Palk Bay

	No. of Families	Simpson's Index	Shannon index
Gulf of Mannar	23	0.7769	1.907
Palk Bay	17	0.4581	1.026

β -diversity indices for fish communities in Gulf of Mannar and Palk Bay revealed that 55% of Fish families were unique to each of these areas.

Table 3.9: β -Diversity indices for fish communities of Gulf of Mannar and Palk Bay

Beta diversity indices	
Whittaker	0.55
Harrison	0.55

Family wise average fish densities were calculated for sampled area. It revealed that Family Apogonidae (Cardinalfish) has the highest density in the sampled area as these fish are found in huge shoals. Families Serranidae (Groupers), Echeineidae (Sharksucker) and Monocanthidae (Filefish) were observed in lowest density (Figure 3.42). Figure 3.43 denotes comparison of observed fish densities in Palk Bay and Gulf of Mannar in 2019-2020.

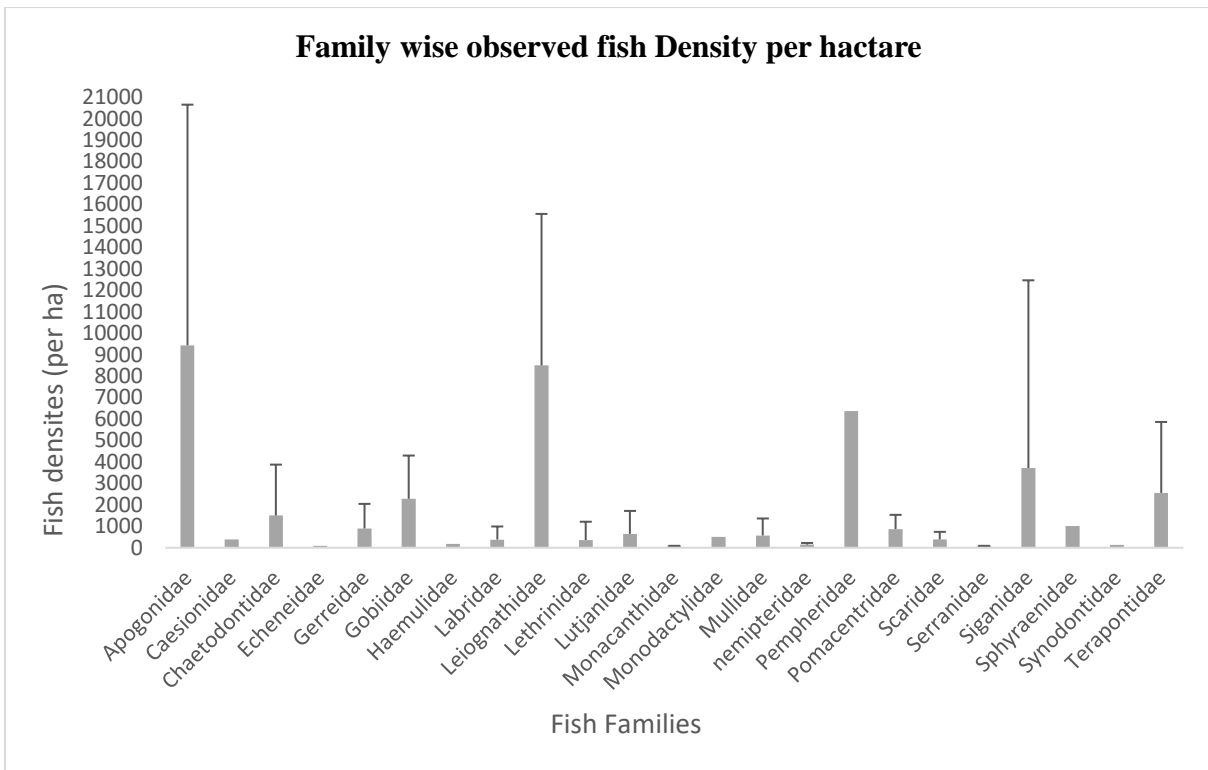


Figure 3.42: Family wise average fish density observed in sampled area of Gulf of Mannar between January and March, 2020

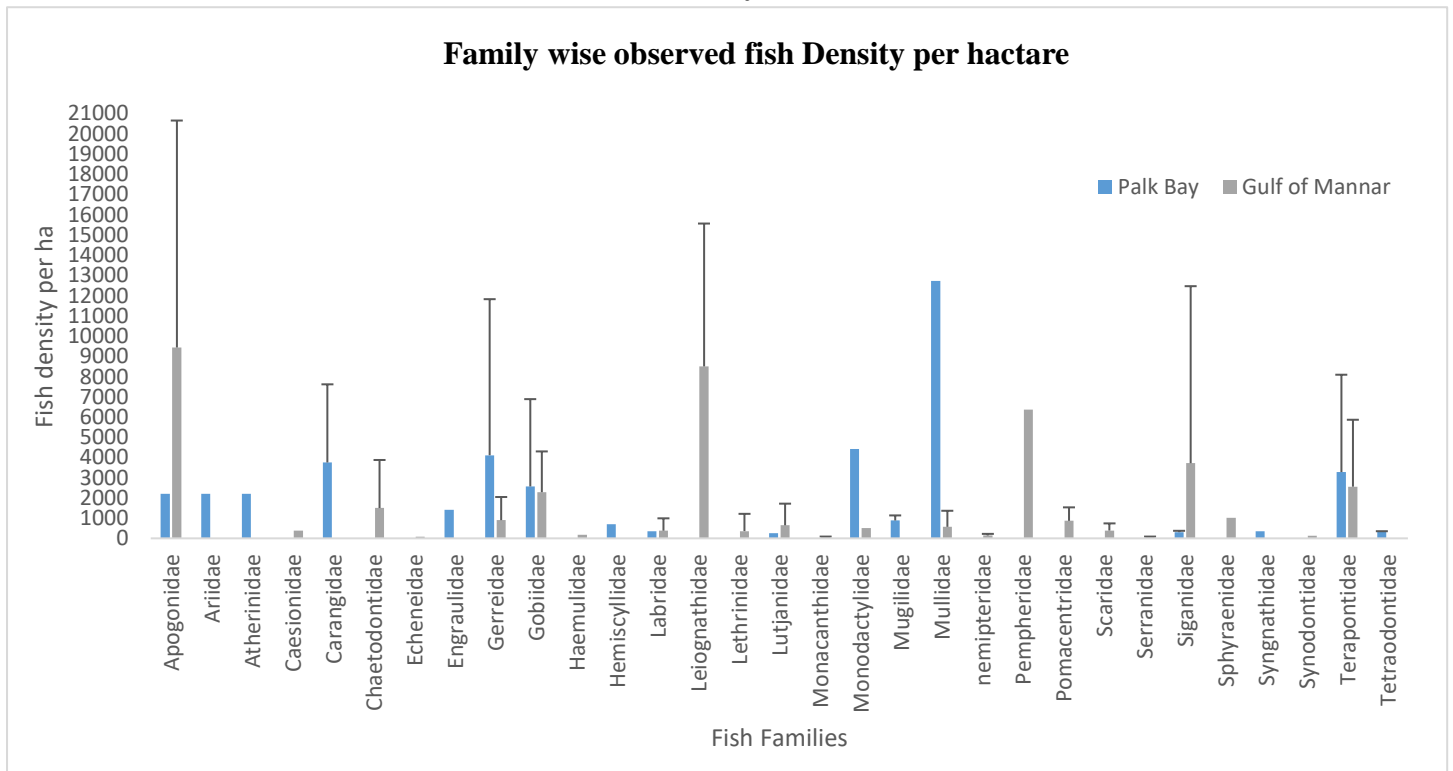


Figure 3.43: Family wise average fish density observed in sampled area of Tamil Nadu in 2019-2020

In each random point count, fish activities in the seagrass meadows were also documented in the sampling area in Gulf of Mannar. A total of 244 fish activity observations were recorded in 36 random point counts. In 39% of total observations, fish were moving/swimming in seagrass meadows while fish were passing by the seagrass meadow for 27% times. 21% of observations recorded with fishes feeding in the seagrass meadow whereas fishes were hiding in the seagrass leaves for 7% of times. 6% observations were specific to Shrimp-gobies as they guard the shrimp hole located in seagrass meadow (Figure 3.44).

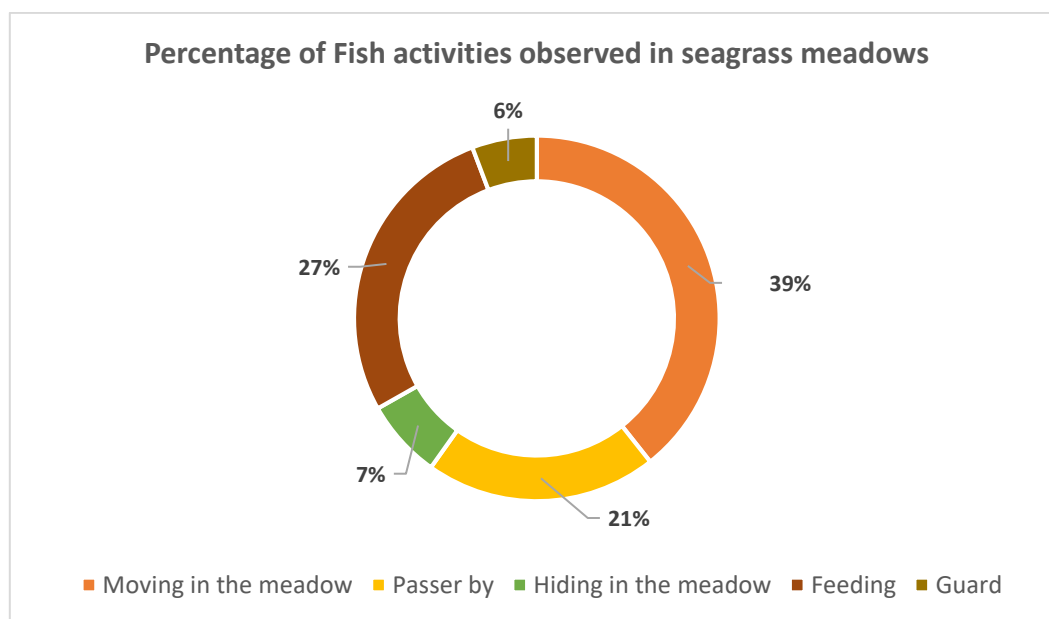


Figure 3.44: Percentage of fish activities observed in seagrass meadows of sampled area of Gulf of Mannar

Discussion

This study in Gulf of Mannar and Palk Bay provides baseline data about seagrass associated fish. The pilot study of gut content of two seagrass associated fish species revealed that different fish species may depend upon invertebrates in seagrass meadows. Further investigation of gut content of different fish species is required to understand dependence of these species on seagrass meadows. The length and weight relationship are one of the standard methods to estimate the fish health. Current study focused only on growth patterns of different fish species in seagrass meadows, additional study for water and habitat quality parameters is required to understand the health status of fish in the area.

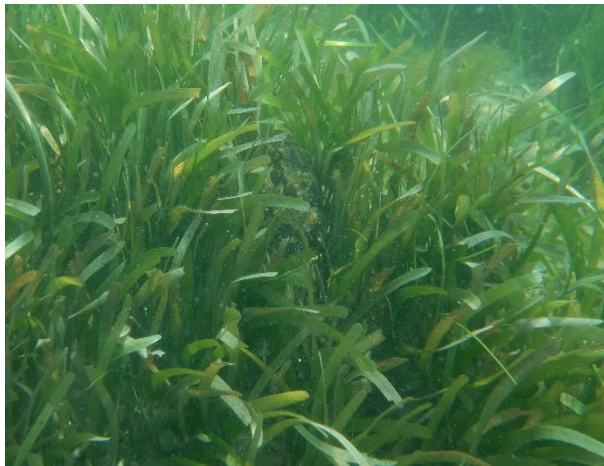
Variable radius point counts facilitated to understand diversity of fish in seagrass meadows. Fishes belonging to more than 20 families were recorded from seagrass meadows which indicates importance of these areas as fishing grounds. This study also revealed that fishes use seagrass meadows for feeding and hiding. This highlights importance of seagrass meadows as important feeding and refuge areas of fish in Palk Bay and Gulf of Mannar area. Hence these seagrass meadows can be prioritized for fishery management.



Cardinalfish



***Lutjanus fulviflamma* juvenile**



***Epinephalus coioides* hiding in leaves**



***Siganus* sp. shoal feeding**



Observer performing point count



Goby fish Guarding hole in meadow

Figure 3.45: Seagrass species and associated fish biodiversity at Tamil Nadu field sampling locations

3.2 Outreach and awareness activities

In the field season 2019-2020, a total of 35 outreach and awareness activities were conducted at Tamil Nadu field site, to aware people about dugongs, their importance and major project activities to the school students, teachers, locals and fishermen. Out of 35 events, 17 events were conducted for awareness and scholarship, 11 meetings were conducted with fishermen for questionnaire surveys and 882 questionnaire surveys were conducted, 5 meetings were conducted with others stakeholders like education officers and forest officials. This year, 3 events were organized for capacity building; the first event was in September 2019 “Wildlife sample collection methods & Techniques for forest officials” and second event was organized in February 2020 “Biodiversity monitoring assessment training”.

Table 3.10: Details of outreach and awareness activities conducted in different areas of Tamil Nadu in the year 2019-20

S. No.	Location	Date	Event	Stakeholders	No. of Attendees
1	Muthukuda, Ramanathapuram District	01-July-19	Beach clean-up	Officials of Marine police, NGO, and local people	30
2	SM Boys Govt. Hr. Sec. School, Thondi, Ramanathapuram District	02-July-19	Awareness Program	Officials of Marine police Forest Dept., Fisheries Dept., NGO, school students and staffs	400
3	Panaikulam, Ramanathapuram District	10-July-19	National Fish farmers Day Celebration, Community Meeting and Awareness program	Officials of Forest Dept., Marine police, Fisheries Dept., NGO, Fisherman heads and fisherman community	80
5	Karankadu, Ramanathapuram District	26 & 27-July-19	World Mangrove Day Celebration	Officials of Forest Dept., Fisherman head and school students	280
6	Sethubavachathiram, Thanjavur district	15-Aug-19	Independence Day Celebration	Headmaster, school students and staff	250
7	Thondi Beach, Ramanathapuram District	21-Sep-19	International Beach clean-up Day	Officials of Marine police, NGO, and local people	40
8	Alagappa University, Karaikudi	12 & 13-December-20	International conference on “Recent Advances in Marine Biodiversity and Conservation” RAMBAC 2019,	Scientist, Researchers, College students and staff	300

9	Devipattinam and Thirupalaikudi	16-Dec-19	Awareness program	Officials of Forest Dept., Arumbugal trust, NGO and local people	100
10	Karangkadu	17-Dec-19	Awareness program	Officials of Forest Dept., Arumbugal trust, NGO and local people	100
11	Thondi, Ramanathapuram District	14-Jan-20	Kadal Pasu Pongal Celebration	Officials of Forest Dept., Headmaster, school students and staff	150
12	Chozhaganpettai, Ramanathapuram District	26-Jan-20	Republic Day Celebration	School students & staff and local village people	100
13	Kodiyakkurai, Pudukattai District	04-Feb-20	Awareness Program	Officials of Marine police, Forest Dept., Fisheries, NGO, local people school students and staff	70
14	Kamaraj college, Tuticorin	25 to 27-Feb-20	Marine Exhibition	Officials of Forest Dept., Marine police, Fisheries, NGO, local people school & college students and staff	3700
15	Kulasekharapattinam, Tuticorin District	28-Feb-20	Beach Clean-up	Officials of Forest Dept., Marine police, school students and staff	70
16	PSM school, Kulasekharapattinam, Tuticorin District	29-Feb-20	Awareness Program	Officials of Forest Dept., school students and staff	100
17	Govt. school, Manapad, Tuticorin District	29-Feb-20	Awareness Program	Officials of Forest Dept., school students and staff	100
18	Manapad, Amali Nagar and Alanthalai, Tuticorin district	29-Feb-20	Awareness Program	Officials of Forest Dept., Fisherfolk	Each village 30
19	Stella Maris and Madras Christian College, Chennai	13 & 14 - Feb-20	Talks	College students and staff	150

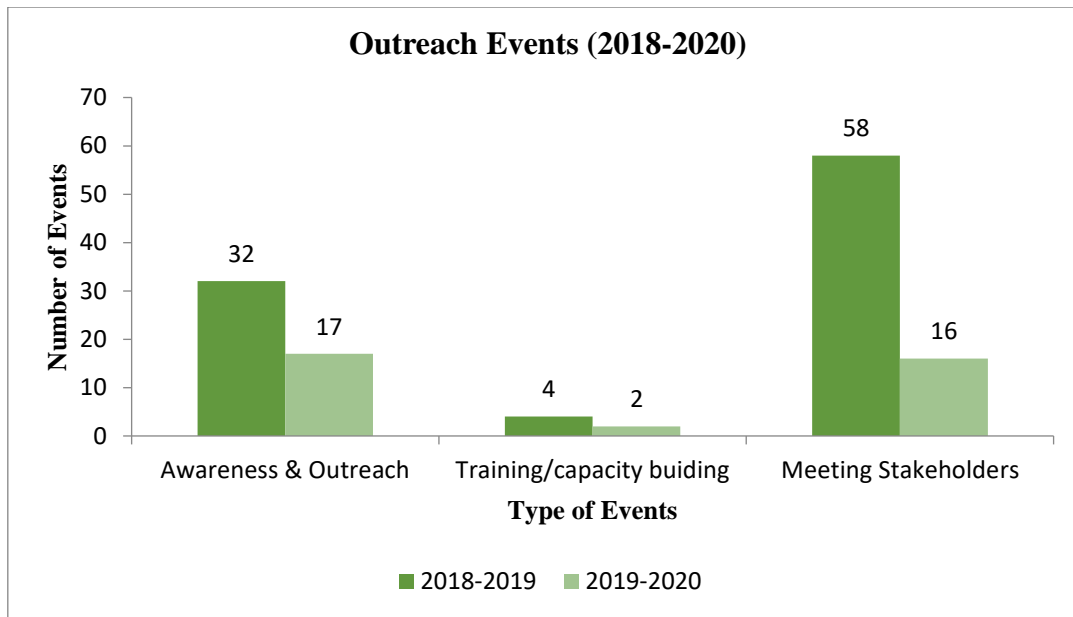


Figure 3.46: Details of various outreach events conducted in Tamil Nadu field-site in the year 2018-19 and 2019-20

In this field season 2019-20, 78.96 per cent of school and college students were targeted. The second highest targeted stakeholders were fishermen and locals 18.17 per cent as the knowledge and experience of fishermen and locals is important to conserve the species on the ground. Figure (3.70) shows a percentage of stakeholders targeted in the last two field seasons.

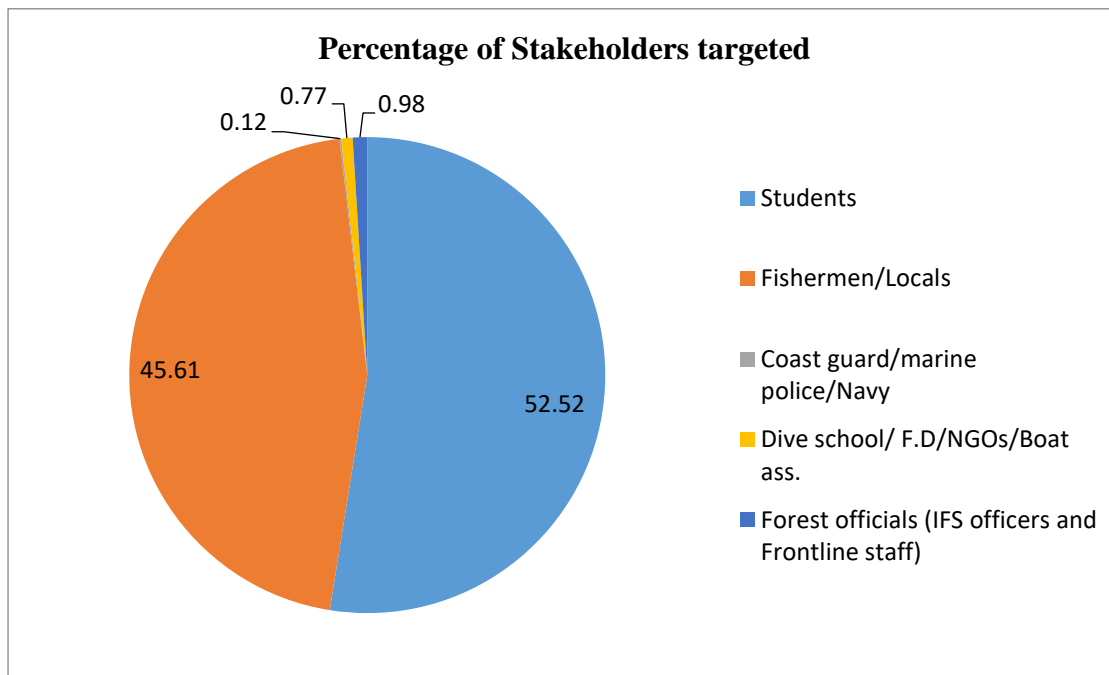


Figure 3.47: Percentage of stakeholders targeted in year 2018-19 at Tamil Nadu

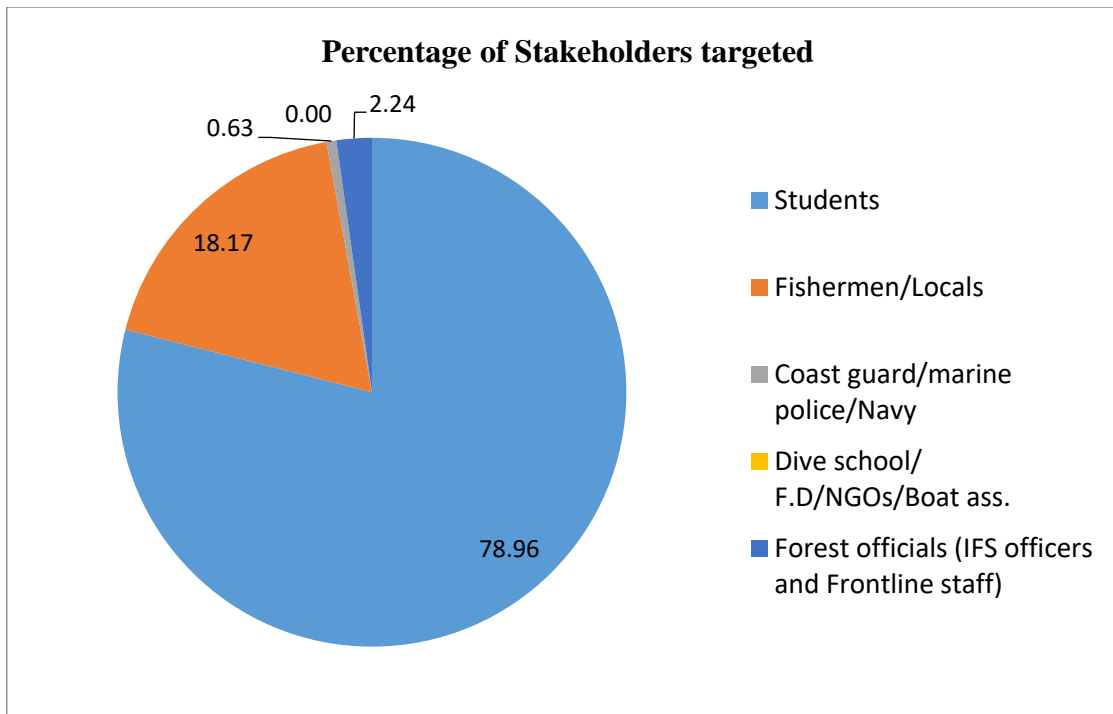


Figure 3.48: Percentage of stakeholders targeted in the year 2019-20 at Tamil Nadu field-site

3.2.1 Dugong scholarship programme

In Tamil Nadu, we have completed three years of the dugong scholarship program from July 2017 to July 2020. Till now, a total of 306 students have been awarded the dugong scholarship and the students selected under this program are identified as **Dugong ambassadors**.

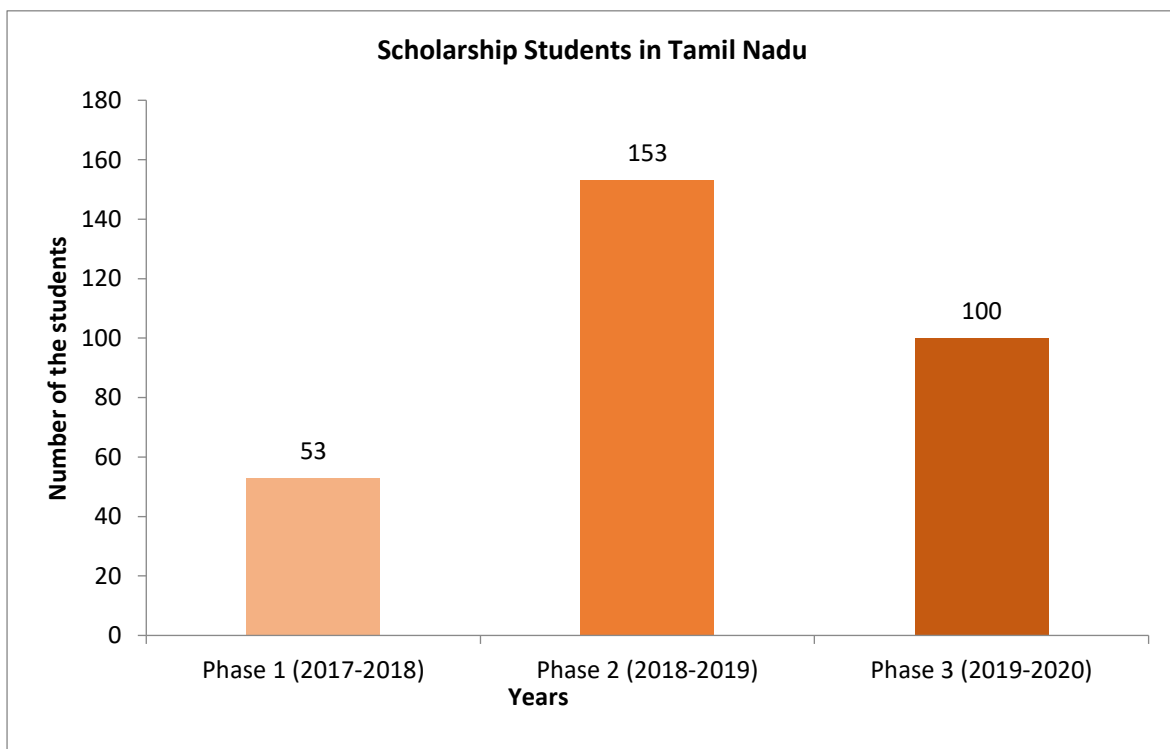


Figure 3.49: Number of students awarded scholarship over three years at Tamil Nadu

Table 3.11: Details of Dugong scholarship programs in Tamil Nadu

School Name	Village/ Town	District	Students Phase 1 2017-2018	Students Phase 2 2018-2019	Students Phase 3 2019-2020
Govt. Girls Hr. Sec. School, Adiramapattinam	Adiramapattinam	Thanjavur	2	5	3
Govt. Hr. Sec. School, Rajamadam	Rajamadam	Thanjavur	4	5	1
Govt. Hr. Sec. School, Mallipattinam	Mallipattinam	Thanjavur	4	7	3
Govt. High School, Sethuma Chathiram	Sethuma Chathiram	Thanjavur	2	5	3
Govt. High School, Pudutheru	Pudutheru	Thanjavur	2	3	1
Govt. Hr. Sec. School, Kattumavadi	Kattumavadi	Pudukkottai	4	6	2
Govt. Boys Hr. Sec. School, Manamelkudi	Manamelkudi	Pudukkottai	4	5	1
Govt. Girls Hr. Sec. School, Manamelkudi	Manamelkudi	Pudukkottai	4	6	2
Govt. Hr. Sec. School, Jagathapattinam	Jagathapattinam	Pudukkottai	2	3	1
Govt. Hr. Sec. School, Kottaipattinam	Kottaipattinam	Pudukkottai	4	5	1
Govt. Hr. Sec. School, Gopalapattinam	Gopalapattinam	Pudukkottai		1	1
Govt. Hr. Sec. School, Mimisal	Mimisal	Pudukkottai	4	6	2
Govt. High School, Vattanam	Vattanam	Ramanathapuram	2	3	1
Govt. Hr. Sec. School, S. P. Pattinam	S. P. Pattinam	Ramanathapuram	1	2	1
Govt. Hr. Sec. School, Solaganpettai	Solaganpettai	Ramanathapuram	1	1	
Wilhelm High School, Thondi	Thondi	Ramanathapuram	1	1	
IMMS HR. Sec. School, Thondi	Thondi	Ramanathapuram	2	2	0
S. M. Govt. Hr. Sec. School, Thondi	Thondi	Ramanathapuram	4	6	2
Govt. Girls Hr. Sec. School, Thondi	Thondi	Ramanathapuram	2	4	2

School Name	Village/ Town	District	Students Phase 1 2017-2018	Students Phase 2 2018-2019	Students Phase 3 2019-2020
Govt. High School, Nambuthalai	Nambuthalai	Ramanathapuram	2	4	2
Amala Annai Hr. Sec. School, Karangkadu	Karangkadu	Ramanathapuram	2	5	3
Govt. Hr. Sec. School, Uppoor	Uppoor	Ramanathapuram		3	3
Govt. Hr. Sec. School, Tiruppalaikudi	Tiruppalaikudi	Ramanathapuram		3	3
Govt. High School, Sambai	Sambai	Ramanathapuram		1	1
Govt. Hr. Sec. School, Devipattinam	Devipattinam	Ramanathapuram		1	1
Mohamedia Hr. Sec. School, Chittar Kottai	Chittar Kottai	Ramanathapuram		2	2
Govt. High School, Palanivalasai	Palanivalasai	Ramanathapuram		1	1
Arabi Oliyullah High School, Puduvalasai	Puduvalasai	Ramanathapuram		1	1
Govt. Girls Hr. Sec. School, Panaikulam	Panaikulam	Ramanathapuram		2	2
Bahrurdin Govt. Boys High School, Panaikulam	Panaikulam	Ramanathapuram		1	1
Govt. Hr. Sec. School, Alagankulam	Alagankulam	Ramanathapuram		2	2
Govt. Hr. Sec. School, Uchipulli	Uchipulli	Ramanathapuram		3	3
Govt. Hr. Sec. School, Irumeni	Irumeni	Ramanathapuram		2	2
Govt. Hr. Sec. School, Vedalai	Vedalai	Ramanathapuram		5	5
Govt. Hr. Sec. School, Mandapam Camp	Mandapam Camp	Ramanathapuram		1	1
Govt. Girls Hr. Sec. School, Mandapam	Mandapam	Ramanathapuram		4	4
Govt. Hr. Sec. School, Pamban	Pamban	Ramanathapuram		1	1
Govt. Hr. Sec. School, Thangachimadam	Thangachimadam	Ramanathapuram		3	3
Punitha Yagappan Hr. Sec. School, Thangachimadam	Thangachimadam	Ramanathapuram		4	4

School Name	Village/ Town	District	Students Phase 1 2017-2018	Students Phase 2 2018-2019	Students Phase 3 2019-2020
Govt. Hr. Sec. School, Rameswaram	Rameswaram	Ramanathapuram		6	6
Govt. High School, Karaiyur	Karaiyur	Ramanathapuram		2	2
Govt. Hr. Sec. School, Pudumadam	Pudumadam	Ramanathapuram		2	2
Govt. Girls Hr. Sec. School, Pudumadam	Pudumadam	Ramanathapuram		1	1
Govt. High School, Thamaraiikulam	Thamaraiikulam	Ramanathapuram		1	1
Govt. Hr. Sec. School, Periyapattinam	Periyapattinam	Ramanathapuram		2	2
Govt. high School, Kalimankundu	Kalimankundu	Ramanathapuram		1	1
Govt. Hr. Sec. School, Thinaikulam	Thinaikulam	Ramanathapuram		2	2
Mahdhoomia Hr. Sec. School, Kilakarai	Kilakarai	Ramanathapuram		1	1
Islamiah High School, Kilakarai	Kilakarai	Ramanathapuram		1	1
Hameediah Girls Hr. Sec. School, Kilakarai	Kilakarai	Ramanathapuram		2	2
Hameediah Boys Hr. Sec. School, Kilakarai	Kilakarai	Ramanathapuram		1	1
Govt. Hr. Sec. School, Ervadi	Ervadi	Ramanathapuram		6	6
			53	153	100



Figure 3.50: Depicting the outreach events of the year 2019-2020 at Tamil Nadu field site; (A-B) Awareness program conducted for fisher community, (C-D) Awareness events conducted for fisherfolks’ children and school students, (E-F) Beach cleaning drives at local sites, (G-H) Tamil Nadu field team participating in Republic day and Independence day celebration events in regional schools and organising competitions and awareness drive towards dugong conservation, (I) Tamil Nadu field team presenting CAMPA-Dugong project work at a conference at Alagappa University, Karaikudi, Tamil Nadu, (J) Tamil Nadu field team organizing exhibition stall at Kamaraj college, Tuticorin, (K) Awareness rally along with kayaking competition for fishermen at Karangkadu for creating awareness towards marine conservation, (L) Dr. K. Sivakumar (PI CAMPA-Dugong project) at an interview with Kadal Osai 90.4 FM Radio Station, (M-N) Meeting with Chief Education Officer of Tuticorin for dugong scholarship program and interaction with school students, and (O-P) Students participating in scholarship examination at various schools in Tamil Nadu field site.

3.2.2 Capacity building programs conducted at Tamil Nadu

Table 3.12: Details of capacity building events at Tamil Nadu

S.no.	Location	Date	Name of the Event	Type of Stakeholders	No. of people attended the event
01	Office of the Wildlife Warden, Ramanathapuram	20-July-19	Submission of final draft of 'Integrated Management Plan for the Gulf of Mannar Marine National Park and Biosphere Reserve (2018-27)' to Mr. Ashok Kumar IFS, Wildlife Warden, GOMMNP	Officials of Forest Dept.	4
02	Office of the Wildlife Warden, Ramanathapuram	23-Sep-19	Training on wildlife sample collection methods and techniques for TNFD staff	Officials of Forest Dept.	40
03	Kulasekharapattinam Beach, Tuticorin	28 -Feb-20	Biodiversity monitoring assessment training and basic techniques for frontline staff of Forest Dept. and Marine police	Officials of Forest Dept. and Marine Police	11

Integrated Management Plan for the Gulf of Mannar Marine National Park and Biosphere Reserve (2018-27)

Date: 20th July, 2019

Venue: Office of the Wildlife Warden, Ramanathapuram

After receiving the final corrections and suggestions from the Tamil Nadu Forest Department and the Forest officials of the Gulf of Mannar Marine National Park and Biosphere Reserve, Dr. K. Sivakumar, along with the CAMPA-Dugong Recovery team at Tamil Nadu, prepared the final draft of the Integrated Management Plan for the Gulf of Mannar Marine National Park and Biosphere Reserve (2018-27). The final document, along with copies of the summary of the document and a soft copy of the same was submitted to Mr. Ashok Kumar, Wildlife Warden, Gulf of Mannar Marine National Park and Biosphere Reserve, at the office of the Wildlife Warden, Ramanathapuram, on 20th July, 2019.



Figure 3.51: Submission of the integrated management plan for the Gulf of Mannar Marine National Park and Biosphere Reserve (2018-27)

Training on wildlife sample collection methods and techniques for Tamil Nadu Forest Department staff

Date: 23rd September, 2019

Venue: Office of the Wildlife Warden, Ramanathapuram

Wildlife sample collection methods & Techniques were explained to the Ramnad Forest Department by Veterinarians and researchers of AIWC, Chennai, at the Forest Department Office, Ramnad. They also requested the department to send samples to their institute for species identification and eco-toxicology studies to detect presence of disease.

As the study was skewed towards terrestrial animals, the WII team helped provide insights into the marine aspects of the same. A small activity was conducted, where parts of animals that are likely to be found (like hair, whiskers, spines, bones, blood, etc.) were placed in random locations in a marked-off area. Collection and preservation techniques were introduced, demonstrated, and hands-on training for the same was provided for the department staff.



Figure 3.52: Forest officials being trained in sampling methods and techniques at Ramanathapuram, Tamil nadu

Biodiversity monitoring assessment training and basic techniques for frontline staff of Forest Department and Coastal Security Group

Date: 28th February, 2020

Venue: Kulasekharapattinam Beach, Kulasekharapattinam, Tuticorin District (Palk Bay)

A small capacity building event was conducted for 8 frontline staff of the Forest Department and one Home Guard of the Coastal Security Group to introduce them to methodologies followed while assessing coastal marine biodiversity. They were also introduced to the biodiversity of the region. We also demonstrated techniques such as SCUBA Diving and snorkeling training was given for interested candidates. The Assistant Conservator of Forests and a Forest Range Officer of Tiruchendur Forest department were present throughout the event and were a source of encouragement to the frontline staff.



Figure 3.53: WII team training Tamil Nadu forest department frontline staffs for coastal marine biodiversity assessment

3.2.3 Dugong day celebrations- 28th May, 2020

On the occasion of Dugong Day – 2020, online competitions were conducted by the CAMPA Dugong Recovery Project Team at Tamil Nadu. The competitions were held for age groups 6-10 years, 11-15 years, 16-20 years and 21-25 years. There were 5 competitions, namely, 'Essay Writing', 'Poetry Writing', 'Drawing', 'Painting', and 'Video Making'. Two topics were given for each age group and we invited entries in 2 languages: English and Tamil. This enabled children from all backgrounds, especially the local fishing community of Tamil Nadu, to take part in the competitions. From age group 6-11 years, we received 85 entries, 95 entries from age group 11-15, 75 entries from 16-20 years age group and 60 entries from 21-25 years age group, resulting in a total of 315 entries. We received National and International entries as well. All participants were given participation certificates and winners (76 in number) were awarded with certificates and gifts consisting of awareness material and souvenirs from our project.

The winners of each competition are given below:

Table 3.13: Details of prize winners and events organised on 28th May,2020 to commemorate Dugong Day.

Essay Writing Competition (English)				
Age category	I Prize	II Prize	III Prize	Consolation Prize
10-Jun	Pranav Ganesh	Anila Michelle	-	-
15-Nov	M. Akash Nithilan	Chinmayee Indranil Bhattacharjee	Prarthana Panicker	-
16-20	Abirami N. S.	Phalguni Sarkar	Muzamil Hameed	-
			Mandira Roy	
21-25	Gokul Bhaskaran	Sushmita K.	-	-
		Sthithaprajna Nath Sharma		

Drawing Competition				
Age category	I Prize	II Prize	III Prize	Consolation Prize
6-10	S. P. Tejas Arathya	Aashalatha	A. Kathiravan	-
			Varshini Vinod	
11-15	Suresh	A. Sathiya Abitha	Evangeline Judith	S. P. Gayathri Vaibhavi
				Mariyam Fathima
16-20	Pavithra Sivalingam	Varshini V.	Phalguni Sarkar	S. Jamuna
21-25	Shraddha KumariK	Subaharini Murugesan	-	-
		Sandra V. Sathyan		

Painting Competition				
Age category	I Prize	II Prize	III Prize	Consolation Prize
6-10	M. G. Deepikashree	Nivetha Thangam	-	-
11-15	Ria Melanie	A. G. Elakkiya	-	-
		Swetha P.		
16-20	S. Induja	Kiinjalumari J. Patel	-	-
21-25	Claudia Pinherio	N. Supraja	-	-

Poetry Writing Competition (English)				
Age category	I Prize	II Prize	III Prize	Consolation Prize
10-Jun	Jessica Jannis	-	-	-
15-Nov	M. Akash Nithilan	-	-	-
16-20	Nikkitha Terasa	Amlanjyoti Pathak	-	-
		Phalguni Sarkar		
21-25	Rithika Ravishankar	Gokul Bhaskaran	-	-

Essay Writing Competition (Tamil)				
Age category	I Prize	II Prize	III Prize	Consolation Prize
10-Jun	Y. Lithika	Madhavan V.	S. P. Tejas Arathya	-
15-Nov		Akash	Thenijayashri M.	-

Video Making Competition				
Age category	I Prize	II Prize	III Prize	Consolation Prize
6-10	Yakshith K.	Viyan Naveen	-	-
	P. Nishita			
11-15	Godavari A.	Rohan Eugene	-	T. Samrish
		Tirth Pandey		
16-20	Simran Satoskar	-	-	-
21-25	P. Karthikeyan	-	-	-
	B. Dhanabalan		Noble Rajey	
16-20	Akila P.	Keerthiga M.	V. Ajithkumar	-
		Sathiya Jothi		
21-25	Mariselvi	Viswa Sarma	-	-

Poetry Writing Competition (Tamil)				
Age category	I Prize	II Prize	III Prize	Consolation Prize
10-Jun	R. Gurutharshini	S. Mani Sabari Rajan	-	-
15-Nov	Rajalakshmi S.	Samantha Preme J.	-	-
16-20	Sathiya Jothi	B. Vanmathi	M. Janani	-
21-25	Dhineshkumar	N. Supraja	Prem Abinesh Sam	-
		S. Manoshankari	A. R. Sameera Fathima	


भारतीय वन्यजीव संस्थान
Wildlife Institute of India

DUGONG DAY – 28TH MAY 2020

கடல் பசு தினம் – 28TH மே 2020

வணக்கம்! நான் உங்கள் கடல் பசு என்னை ஆவுரியா அல்லது ஆவுலியா என்று அழைப்பார்கள்.


நான் இந்தியாவில், மன்னார் வளைகுடா மற்றும் பாக் ஜலசந்தியில் (தமிழ் நாடு) அதிகமாக உள்ளேன், மேலும் குஜராத்திலுள்ள கட்ச வளைகுடா, அந்தமான் மற்றும் நிகோபார் தீவுகளிலும் வசிக்கிறேன்.

இந்திய வனஉயிர் நிறுவனம் மே 28 ஆம் நாள் எங்களுக்கு "கோங்" நாளாக அறிவித்துள்ளது!! வாருங்கள் அனைவரும் கொண்டாடலாம்!!!

படகுகளில் அடிப்படுவது, வலையில் சிக்கிக்கொள்வது, வேட்டையாடுவது மற்றும் கடல் மாசுபடுத்துதல் அனைத்தும் என் முன்னோர்கள் மற்றும் எனது நண்பர்களையும் கொன்றது.

தாவரங்களை மட்டுமே சாப்பிடும் ஒரே கடல் பாலூட்டி நான். கடல் தாழைகளை (பற்கள்) விரும்பி சாப்பிடுவேன்.




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DUGONG DAY – 28TH MAY 2020

கடல் பசு தினம் – 28TH மே 2020

உங்களுக்கு எழுத/வரைய/நடிக்கப் பிடிக்குமா? உங்கள் வீடியோக்கள் / கட்டுரைகள் / கவிதைகள் / கலைப் படைப்புகளை ஆங்கிலத்தில் / தமிழில் எங்களுக்கு அனுப்புங்கள் மற்றும் அற்புதமான பரிசுகளை வெல்லுங்கள்! அனைவருக்கும் சான்றிதழ்கள் கிடைக்கும்

கட்டுரை போட்டி: வார்த்தை வரம்பு : 50-100 (6-10 வயது): 100-150 (11-15 வயது): 300 க்கும் மேற்பட்ட இல்லை (16-25வயது)	வீடியோ தயாரித்தல் : 5 பேருக்கு மேல் ஈடுபட முடியாது. இது அதிகப்பட்சம் 3 நிமிடங்கள் இருக்க வேண்டும். மொபைல்களைப் பயன்படுத்தலாம்.	வரைதல் போட்டி: பென்சில்கள், கிரேயன்கள் மற்றும் வண்ண பென்சில்கள் பயன்படுத்தலாம்.
கவிதை போட்டி: அனைத்து வயதினரும் பங்கேற்கலாம்	ஒலியப் போட்டி: வண்ணப்பூச்சுகள் மட்டுமே வண்ணத்திற்கு பயன்படுத்தலாம்.	

வயது	தலைப்பு	கடைசி தேதி
6-10 வயது	1. கடல் பசு என் நண்பன் 2. எனக்கு பிடித்த கடல் விலங்கு	27 மே 2020
11-15 வயது	1. கடல் பசுக்கள் மற்றும் கடல் தழைகள் 2. கடல் வாழ் உயிரினங்களை ஏன் காப்பாற்ற வேண்டும்?	
16-20 வயது	1. கடல் பசு மற்றும் மீன்வளம் பாதுகாப்பு 2. கடல் தழைகள் மற்றும் சுற்றுச்சூழல் அமைப்பு	
21-25 வயது	1. சூழல் நட்பு பொருளாதார மேம்பாட்டு உத்திகள் 2. 2050-ல் கடல் பசுக்கள்	

அனைவரும் பங்கேற்கலாம்!

உங்கள் பெயர், வயது மற்றும் முகவரியுடன் உங்கள் உள்ளீடுகளை அனுப்பவும்

உங்கள் இறமையைக் காட்டுங்கள்! உங்கள் உள்ளீடுகளை அனுப்பவும்:

மின்னஞ்சல்: dugongday28may@gmail.com
 (Send your paintings and drawings as photos and essays and quotes as word documents/photos)
 தபால்: # 10, மரியம்மன் கோயில் தெரு, தெற்கு தோப்பு, தொண்டி- 623409, இராமநாதபுரம் மாவட்டம், தமிழ்நாடு

தொடர்புக்கு:
 8608601718/
 9500185039




Figure 3.54: Dugong day celebrations notification flyer (in Tamil)

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

OMCAR FOUNDATION

DUGONG DAY – 28TH MAY 2020

கடல் பசு தினம் – 28TH மே 2020

Hello! I'm a Dugong. I'm called Kadal Pasu or Avuliya or Avuriya by my local friends in Tamil Nadu.

The largest population of dugongs is found in Gulf of Mannar and Palk Bay of Tamil Nadu. Some of us also live in the Gulf of Kutch in Gujarat and in the Andaman and Nicobar Islands.

My previous generations and many of my friends today have been killed by being hit by boats and getting entangled in fishing nets. Some of us are hunted and some of us get poisoned by eating seagrass from polluted areas.

28th May has been chosen as a day for us, DUGONGS, by the Wildlife Institute of India! Come, let us celebrate together!!!

We are the world's only herbivorous mammals who are exclusively marine. We love eating fresh, tasty seagrasses!

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

OMCAR FOUNDATION

DUGONG DAY – 28TH MAY 2020

கடல் பசு தினம் – 28TH மே 2020

Do you love to write? Or draw? Do you like acting? Send us your Videos/Essays/Poems/Artwork in (English/Tamil) and **win exciting prizes!** All participants will receive certificates.

Essay Writing:
Word limit: 50-100 (6-10 yrs); 100-150 (11-15 yrs); not more than 300 (16-25 yrs)

Video-making:
No more than 5 people involved. Maximum length of video: 3 minutes. Mobiles can be used

Drawing:
Pencil sketches, Crayons and colour pencils allowed. Paints NOT allowed.

Painting:
Only paints to be used for colouring. Crayons and colour pencils NOT allowed.

Poetry:
Anyone can send their poems.

Anyone can participate!

Remember to send your entries with your **NAME, AGE and ADDRESS**

Age group	Topic	Last Date
6-10 yrs	1. Dugong 2. My Favourite Marine Animal	27 th May 2020
11-15 yrs	1. Dugongs and Seagrasses 2. Why should we save marine life?	
16-20 yrs	1. Dugong conservation and fisheries 2. Seagrass ecosystem	
21-25 yrs	1. Eco-friendly economic development strategies 2. Dugongs in 2050	

Show your talent! Send your submissions:

BY E-MAIL: dugongday23may@gmail.com
(Send your paintings and drawings as photos and essays and quotes as word documents/photos)

BY POST: No. 10, Mariamman Koil Street, Therukku Thoppu, Thondi, Ramnad District- 623409, Tamil Nadu

For details, contact:
8608601718/
9500185039

Figure 3.55: Dugong day celebrations notification flyer (in English)

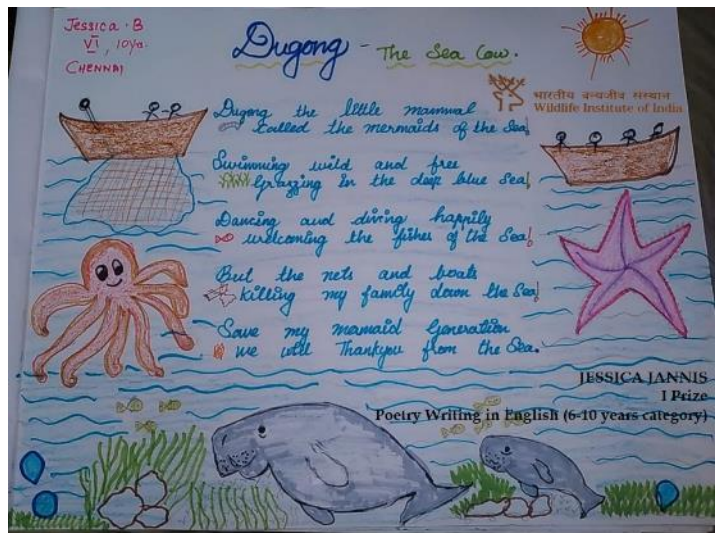
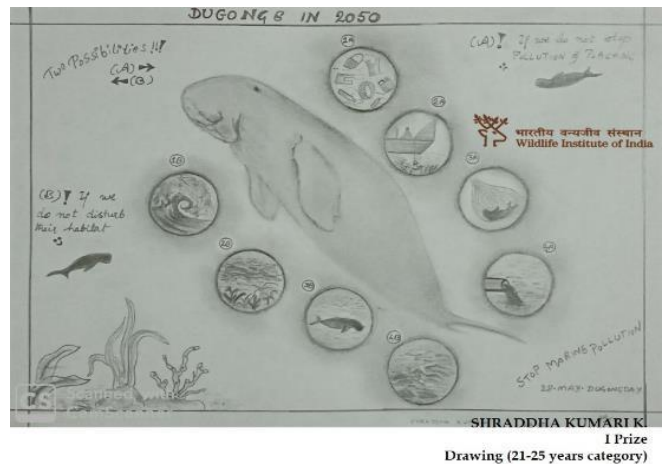
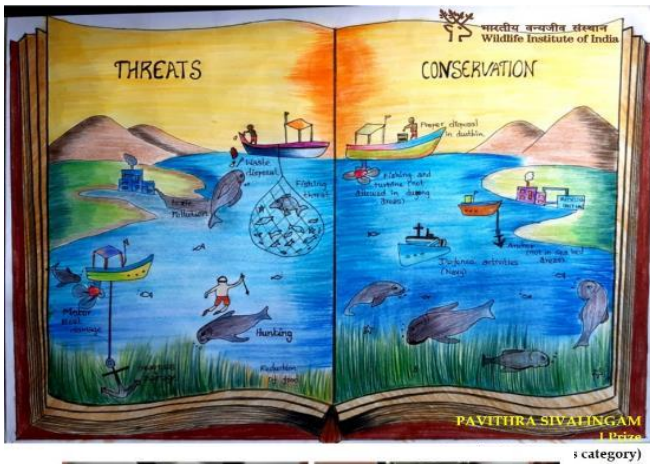
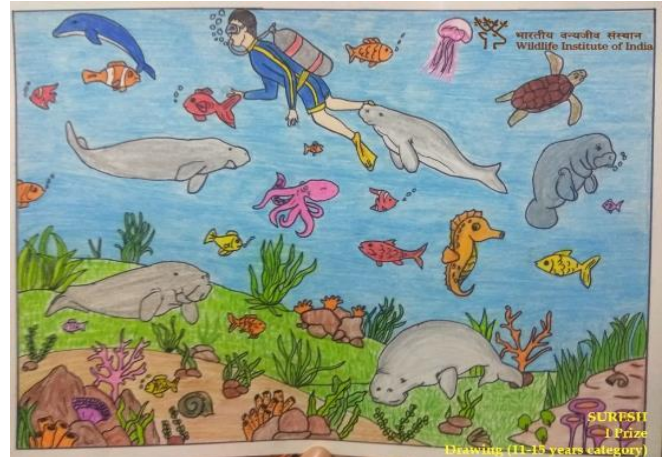
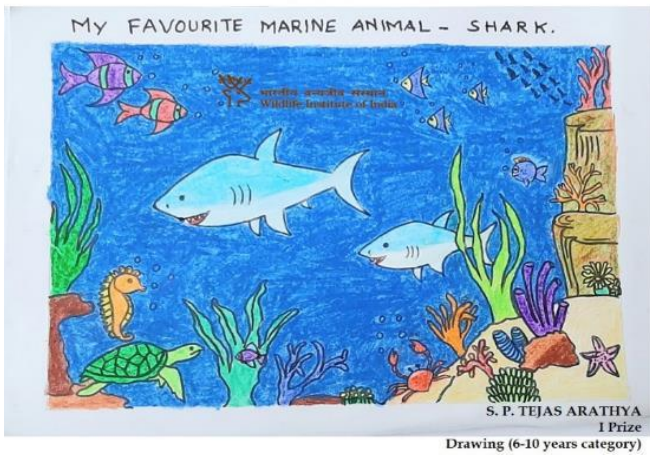


Figure 3.56: Winning entries of the Dugong Day competitions held on 28th May, 2020

3.3 Media reports and coverage

3.3.1 Stranding reports



Figure 3.57: Stranding reports of dugongs published in local newspapers

3.3.2 Dugong scholarship programme



Figure 3.58: Dugong scholarship articles in local newspapers of Tamil Nadu

3.3.3 Other outreach events

BIOSPHERE RICHNESS
3-day exhibition on marine life commences at Kamaraj college

EXPRESS NEWS SERVICE @ Theenthurai

A THREE-DAY exhibition, displaying specimens of endangered marine life, for school students was inaugurated at Kamaraj College here on Tuesday.

Wildlife Warden and Gulf of Mannar Biosphere Reserve Trust (Ram-anthapuram) Director S Marimuthu, in the presence of Forest Range Officer Raguvaran and Principal S Nagarajan, inaugurated the exhibition, organised by the Gulf of Mannar Biosphere Reserve Trust.

The exhibition displayed dead and live specimens of various species exclusive to the Gulf of Mannar biosphere. The dead specimens included Indo-Pacific humpbacked dolphin, electric ray, black-spotted stingray, sharpnose and grey guitarfish. The safety equipment used for scuba diving were also displayed. More than 1,000 students from different schools in the district participated.

Raguvaran said that the biosphere, spread over 10,500 square kilometers, has been the habitat of 4,200 species of marine life. Of these seven kinds of turtles known to the world, the biosphere is the habitat to five types and 123 varieties of corals, essential for the breeding of fish.

A research conducted by the biosphere reserve had identified 123 new species in the region," he said.

"Decline in dugongs"

A research student from the Wildlife Institute of India said that climate change, reckless boating, trawling, dredging, herbicide use, limited domestic pollution, and boat anchorage were potential threats to dugongs.

Marimuthu said that climate change has been despoiling in the country, especially due to getting stuck in fishing nets, and other coastal development programmes, said the student.

Marimuthu said that climate change has been posing a greater threat to the Gulf of Mannar ecosystem.

காரங்காடு கிராமத்தில் படகு போட்டி

தொண்டி, ஆகஸ்ட் 29: தொண்டி அருகே காரங்காடு கடற்கரை பகுதியில் வனத்துறையின் சார்பில் சதுப்புநில காடுகள் பாதுகாப்பு கழிப்பு விழா நடைபெற்றது. உலக சதுப்புநில காடுகள் தினத்தை முன்னிட்டு நேற்று வனத்துறை மற்றும் வனவளப் பராமேய நிழல் சின்ன நடைபெற்றது.

காரங்காடு கிராமத்தில் சதுப்புநில காடுகள் பாதுகாப்பு கழிப்பு விழா நடைபெற்றது. காரங்காடு வனவளப் பராமேய நிழல் சின்ன நடைபெற்றது. இதை நடத்துவது வனவளப் பராமேய நிழல் சின்ன அப்பாள் அமைதி அமைதி தலைமை தாங்கி நடைபெற்றது. காரங்காடு வனவளப் பராமேய நிழல் சின்ன அப்பாள் அமைதி அமைதி தலைமை தாங்கி நடைபெற்றது.

காரங்காடு கிராமத்தில் சதுப்புநில காடுகள் பாதுகாப்பு விழிப்புணர்வு

தொண்டி, ஆகஸ்ட் 29: தொண்டி அருகே காரங்காடு கடற்கரை பகுதியில் வனத்துறையின் சார்பில் சதுப்புநில காடுகள் பாதுகாப்பு கழிப்பு விழா நடைபெற்றது. உலக சதுப்புநில காடுகள் தினத்தை முன்னிட்டு நேற்று வனத்துறை மற்றும் வனவளப் பராமேய நிழல் சின்ன நடைபெற்றது.

காரங்காடு கிராமத்தில் சதுப்புநில காடுகள் பாதுகாப்பு கழிப்பு விழா நடைபெற்றது. காரங்காடு வனவளப் பராமேய நிழல் சின்ன நடைபெற்றது. இதை நடத்துவது வனவளப் பராமேய நிழல் சின்ன அப்பாள் அமைதி அமைதி தலைமை தாங்கி நடைபெற்றது.

கடலோர பாதுகாப்பு குழுமத்தின் 25ம் ஆண்டு வெள்ளிவிழா!

2.7.2019 அன்று கடலோர பாதுகாப்பு குழுமத்தின் 25ம் ஆண்டு வெள்ளிவிழா தொண்டி அருகே மேல்நிலைப்பள்ளியில் சிறப்பாக கொண்டாடப்பட்டது. விழாவில் மாணவர்களுக்கு பேச்சுப்போட்டி, கட்டுரைப்போட்டி, ஓய்வியப்போட்டி, பாட்டுப்போட்டி நடைபெற்றது. வெற்றி பெற்ற மாணவர்களுக்கு கழுதி முத்துரெத்தினம் பெண்கள் ஆதரவற்ற குழந்தைகள் காப்பகம் சார்பாக சான்றிதழ்கள், பரிசுகளும் வழங்கப்பட்டது. விழாவில்... இராமநாதபுரம் திரு. இளங்கோ, கருதல் காவல் கண்காணிப்பாளர் அவர்கள் தலைமை தாங்கினார். முன்னிலையாக திரு. பெரிகல் கரேஷ்பிட்டர் காவல் ஆய்வாளர், திரு. மணிமாறன் தலைமையாசிரியர், திரு. மதுமகேசு இந்திய வன உயிரின நிறுவனம், திரு. குகம்பினிசேகர், இந்திய வன உயிரின நிறுவனம், திரு. ப.மாணிக்கம் சார்பு ஆய்வாளர், மற்றும் ஜி. அய்யனார் சார்பு ஆய்வாளரும் கலந்துகொண்டு விழாவை சிறப்பித்தனர்.

கடலோர காவல் குழும ஆண்டு விழா காவல் முன்னிட விழிப்புணர்வு முகாம்

கோட்டைப்பட்டி, ஆகஸ்ட் 29: கோட்டைப்பட்டி மாவட்டம் கடலோர காவல் குழும 25வது ஆண்டு விழாவை முன்னிட்டு விழிப்புணர்வு கூட்டம் நடைபெற்றது. திரு. இளங்கோ, மாவட்டம் திருப்புவாய்ச்சல் கடலோர காவல் குழும காவல்தலைமை தாங்கி நடைபெற்றது. காரங்காடு வனவளப் பராமேய நிழல் சின்ன அப்பாள் அமைதி அமைதி தலைமை தாங்கி நடைபெற்றது.

34 **சூரியமைநகர்** ஜூலை: 2019

கீழை நியூஸ்

மண்டபம் கடலுக்கு அடியில் தேங்கிய 25 கோடி பிளாஸ்டிக் பொருட்கள் அகற்றும் அரிய காணொளி.

விகடன்

'20 ஆடி ஆழம், ஒரு மணி நேரம் தூய்மைப்பணி!' - கடலில் மூங்கி பிளாஸ்டிக் கழிவுகளை அகற்றிய வனத்துறையினர்

தினகர் புதுக்கோட்டை

கோடியக்கரையில் கடற்கரையை தூய்மைப்படுத்தும் பணி

மனமேல்குடி கோடியக்கரை கடற்கரை பகுதியை சுத்தம் செய்ய மரக்கன்று நட்சுவைக்கப்பட்டது.

மனமேல்குடி, ஜூன் 14: மனமேல்குடி கோடியக்கரை கடற்கரை பகுதியை சுத்தம் செய்ய மரக்கன்று நட்சுவைக்கப்பட்டது. மெய்யும் கடற்கரை தூய்மைப்படுத்தும் பணி பகுதியில் இயற்கை மனமேல்குடி கோடியக்கரை கடற்கரை பகுதியை சுத்தம் செய்ய மரக்கன்று நட்சுவைக்கப்பட்டது. மெய்யும் கடற்கரை தூய்மைப்படுத்தும் பணி பகுதியில் இயற்கை மனமேல்குடி கோடியக்கரை கடற்கரை பகுதியை சுத்தம் செய்ய மரக்கன்று நட்சுவைக்கப்பட்டது.

Figure 3.63: Media coverage of project events at Tamil Nadu

ANNUAL FIELD REPORT 2019-2020

ANDAMAN AND NICOBAR ISLANDS

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Acknowledgement

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Sh. G. Charlice Kullu (Forest guard, Mayabunder Wildlife Division)
Sh. Alagar Gopi (Forest Guard, Mayabunder Wildlife Division)
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Sh. Pradip Mondal (Forest guard, Wildlife Division, Wandoor)
Sh. Pradeep karmakar (Camp Officer Havelock Division)
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Ms. Kripa Singh (Forester, Havelock Division)
Ms. Sandhya Rani (Forester, Chatham Saw Mill Division)
Sh. Jagdeep Lall (Forest guard, Mount Harriet National Park)
Sh K. Kumar Swami (Forest guard, Diglipur division)

Indian Navy:

Commander Kishore Birra (INS Utkrosh)
Commander Ramanath (Director, Navy Children School)

Indian Coast Guard

**DIG Ashish Mehrotra Commandant L. Zou (Commander District headquarter No. 9-
N&M Andaman)**

Assistant Commandant Shubham Sharma (District headquarter No. 9- N&M Andaman)

Sh. Bhrigo Muni Das (Pradhan Navik)

Directorate of Fisheries, Port Blair



Citation: Gole S., Dudhat S., Prajapati S., Rajpurkar S., Seal S., Pillai A., Gokhale E., Saini H., Tripura V. (2020) Annual Field Report 2019-20, Andaman and Nicobar Islands, In Annual Field Report IV (2019-20), Recovery of Dugongs and their habitats in India: An Integrated Participatory Approach, Wildlife Institute of India, pp 127-188.

4.1 Research and monitoring

The Andaman and Nicobar archipelago situated in the Bay of Bengal, 1200 kms from the east coast of India, is a chain of more than 500 Islands stretched between 06° 5' and 14° 45' N latitude and 92° and 94° E longitude. The Islands along with its emerald blue water and pristine beaches, is also famous for its high rate of endemism and biodiversity owing to geographical isolation. Island waters are home to diverse mangrove forests and vibrant coral reefs, along with threatened coastal habitats like seagrasses. The Southern Andaman region is the first in the country to be declared as an 'Important Marine Mammal Area' (IMMA 2018), with a record of 17 species of marine mammals including the threatened marine herbivore, 'Dugong'.

Dugongs in the Islands presently are subjected to threats like gill net entanglement, heavy boat traffic increasing chances of boat hit and habitat loss due to coastal development. Since the inception of CAMPA-Dugong project, WII team has engaged different stakeholders throughout the Andaman Islands, disseminating information on importance of dugongs and seagrass habitats, and imbibing dugong conservation in local masses.



4.1.1 Understanding dugong distribution in the Islands, through a participatory multi- stakeholder citizen science approach

Dugong Monitoring Network

Duration: February 2017 to May 2020

Background and Objective:

Relict population of dugongs is distributed throughout the islands in pockets, and usage of these habitats might be either seasonal or driven by anthropogenic interference. Thus, it is imperative to consistently document the habitats used by dugongs over a spatio-temporal scale.

Owing to the geographical vastness of the islands and inaccessibility to certain regions, a 'citizen science' based approach was initiated, targeting several stakeholders to supplement dugong sightings through the Islands.

The primary objective of establishing a stakeholder based 'Dugong Monitoring Network' was:

To understand distribution of dugongs and seagrass habitats, and

To understand habitats frequented by dugongs through a citizen science approach

Study area:

The dugong monitoring network was established throughout the Andaman Islands including North, Middle and South Andaman Islands (Figure 4.1).

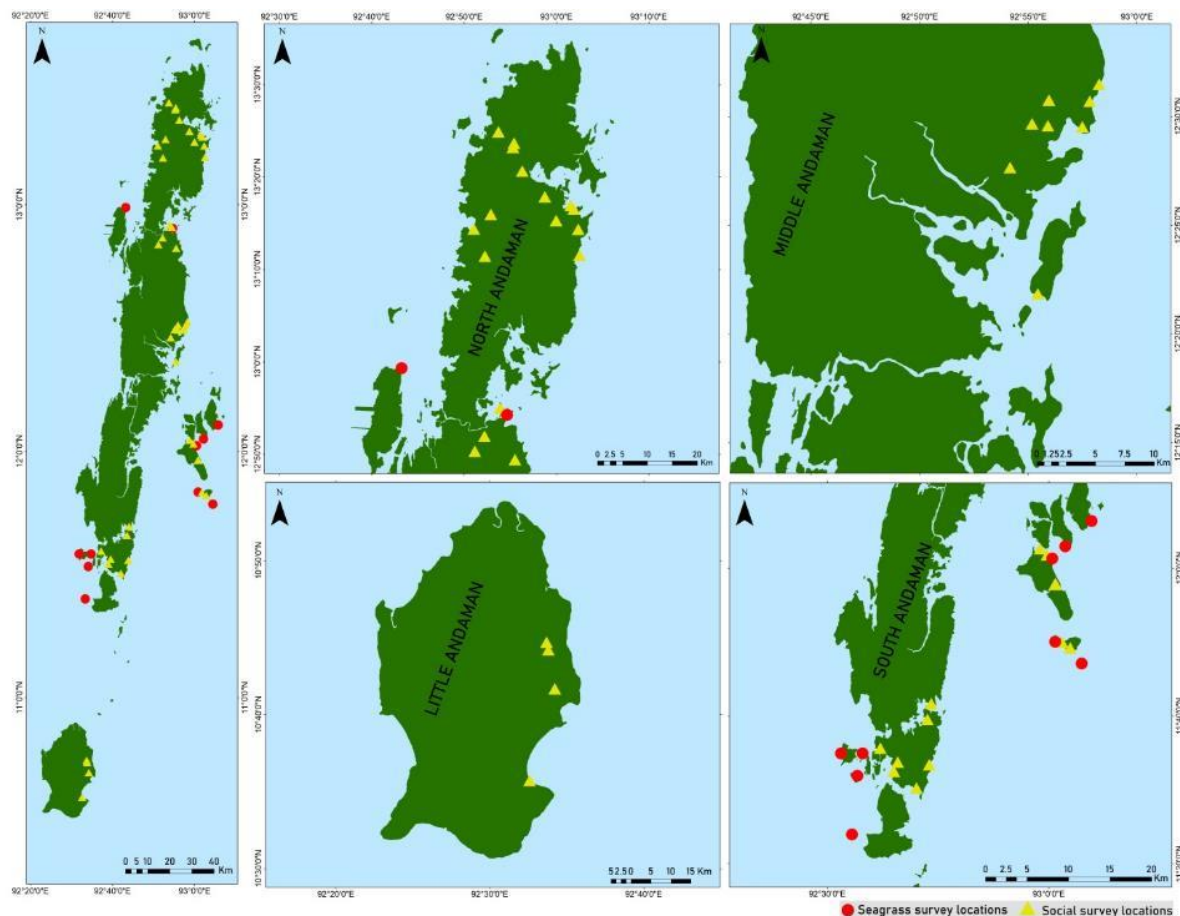


Figure 4.1: Map showing study sites for dugong monitoring network, social surveys and seagrass sampling sites in Andaman Islands

Methodology:

Total 340 regular seafarers including fisherfolk (n=90), forest department frontline staff (n=12), Indian Coast Guard and Indian Navy (n=109), school children of fisherfolk (n=110), and tourism sector viz; SCUBA divers (n=9), glass bottom boat operators (n=4), Life guards (n=4) and informants from 'other' category (n=2) which included sailors/ locals, were involved in the Dugong Monitoring Network.

An inventory of number, age class, time and locations of dugong sightings was created with photographs and videos along with the locations of dugong individuals and frequent sightings was also maintained to understand their movement patterns. All the involved stakeholders were followed up after a monthly interval to update this inventory. Data was also pooled in, through social media platforms like WhatsApp and Facebook, from volunteers having access to internet in the Islands.

Results and Major Outcomes

Since February 2017 to May 2020, eight different stakeholder groups were engaged in the Dugong Monitoring Network including fishers, tourism-allied operators, patrolling agencies and school children (Table 4.1). Total 238 dugong sightings were received throughout the Andaman Islands (Figure 4.2). With the dugong sightings shared through these informants, along with accessory data in form of photographs and videos, a database was created to generate heat maps for dugong distribution and photo-identification of individuals.

Based on 17 videos shared by divers three dugong individuals were photo- identified, one in the year 2017 and two individuals in 2018. Since then the team has been keeping a track of movements of these individuals through the data received, to understand the affinity they show towards the sea grass meadows in *Shaheed Dweep* Island. Out of the three individuals, IND- 1 (Figure 4.3) and IND- 3 (Figure 4.5) re- visited the waters in *Shaheed Dweep* Island after a year, whereas IND-2 (Figure 4.4) was a frequent visitor and possibly a resident dugong, as it was sighted nine times since December 2017 till December 2019.

Based on the dugong sightings received, heat maps (Figure 4.6) were generated using kernel density estimation tool in ArcGIS 10.5 to understand present dugong distribution in the islands. In the last one year, >10 mother-calf sightings were received which highlights the importance of habitats in the islands for dugong conservation as it supports a breeding population. Few sightings (n=4) shared by Indian Navy and Indian Coast Guard are from the coastline of Jarawa tribal reserve, an area not accessible to researchers due to its tribal protection status, thus, identifying new dugong habitats.

Table 4.1: Table showing different stakeholders engaged in 'Dugong Monitoring Network' in Andaman Islands

Sr. no.	Stakeholders	Number of members engaged
1	Dugong ambassadors	110
2	Fishers	90
3	Forest department frontline staff	12
4	Glass bottom boat operators	04
5	Indian Coast Guard and Navy	109
6	Life Guards	04
7	SCUBA divers	09
8	Others	02

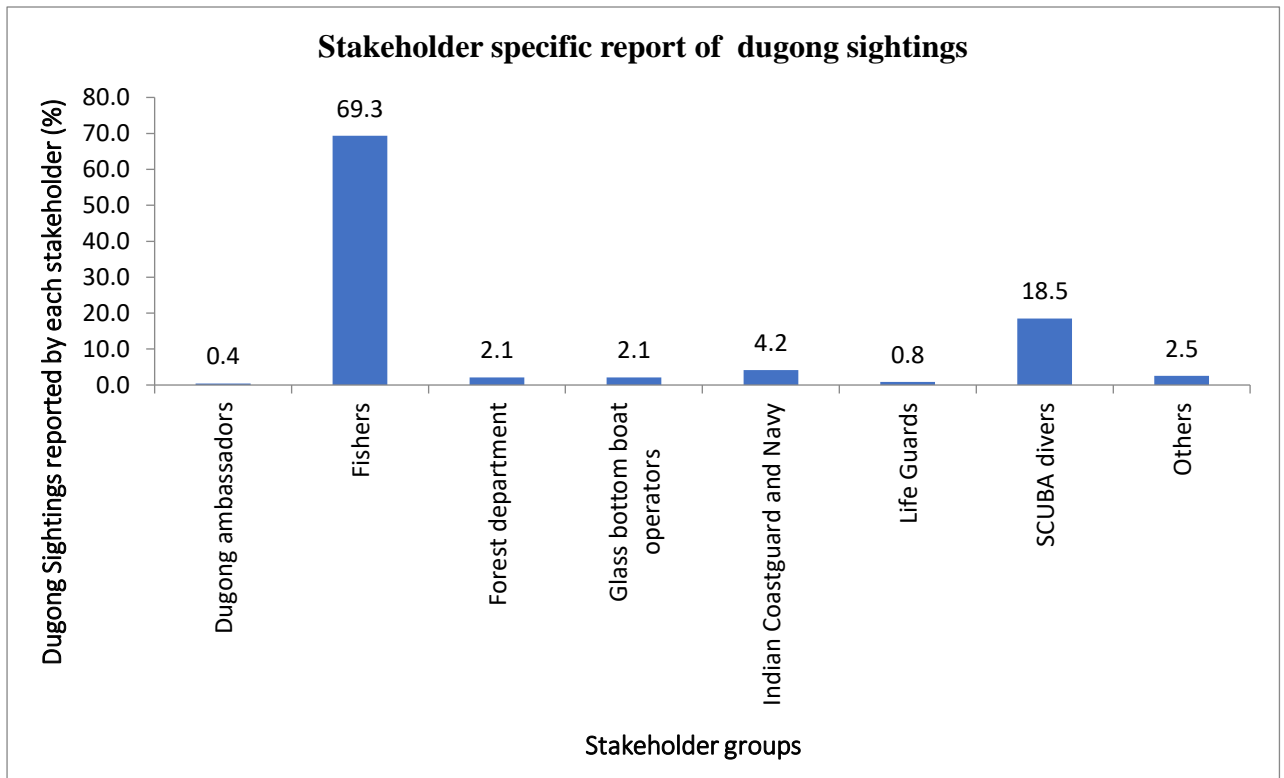


Figure 4.2: Contribution of dugong sightings by various stakeholders across Andaman Islands

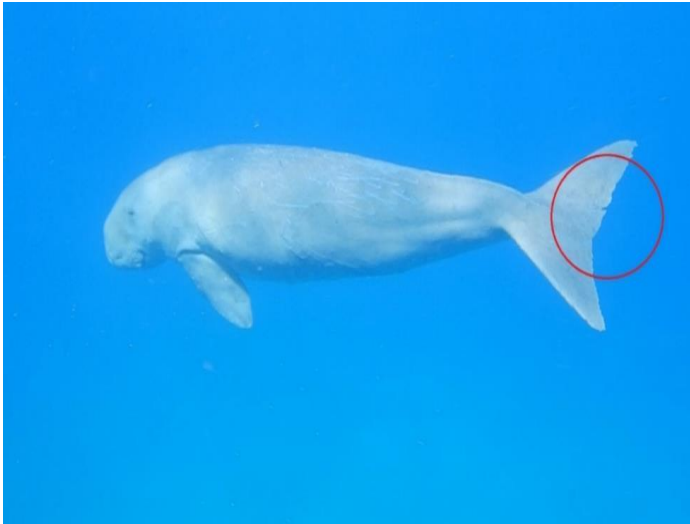


Figure 4.3: Photo identified IND-1 at Shaheed dweep, with oblique cut on the tail region as an identification mark (PC: Dharmesh Chaudhury (SCUBA love))



Figure 4.4: Photo identified IND-2 at Shaheed dweep, with marks on right flipper as an identification mark (PC: Dharmesh Chaudhury (SCUBA love))

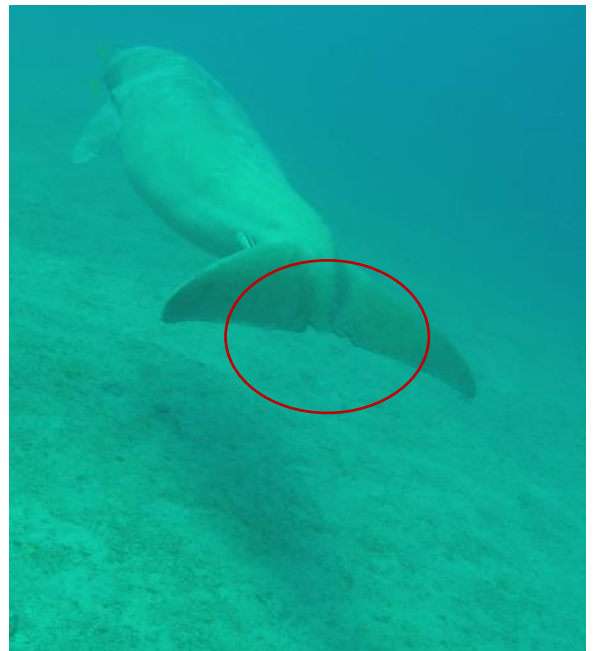


Figure 4.5: Photo identified IND-3 at Shaheed dweep, with deep notch on tail an identification mark (PC: Dharmesh Chaudhury (SCUBA love))

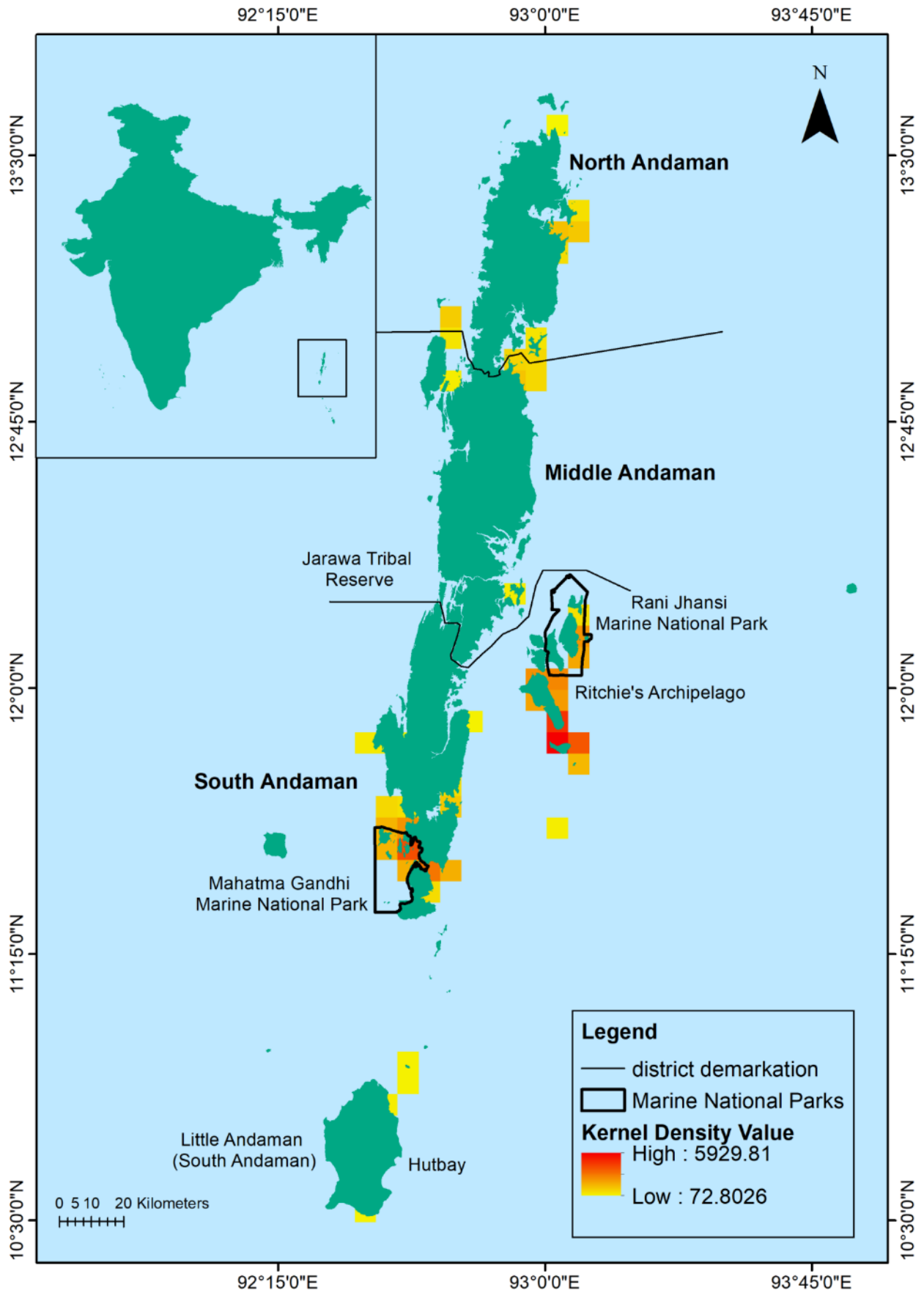


Figure 4.6: Heat maps showing dugong distribution across Andaman Islands through a citizen science approach

b. Interview based social surveys exclusively targeting fishers

Duration: December 2018 to July 2019 and December 2019 to March 2020

Background and Objective:

Small scale fisheries are known to contribute to accidental net entanglement, boat traffic and hunting, all major localised threats to dugongs in the Islands. Identifying spatial overlaps of fishing ranges with dugong habitats is imperative to delineate 'dugong trouble spots' which are defined as "areas, where number of dugongs is low and threats to their existence are high" (Pilcher et al 2017). On a similar line, a study was conducted by the Wildlife Institute of India in 2012-2013 (Sivakumar and Nair 2013), to identify such trouble spots for dugongs in the Andaman and Nicobar Islands. But owing to the changing scenario in the Islands since then, due to its strategic and tourism importance, several coastal developmental and tourism allied activities have witnessed a spike since this study. Thus, a need was felt to document the change in the dynamics of fisheries as well, in line with growing tourism and dugong conservation.

Therefore, in addition to establishing a 'dugong monitoring network' which targeted understanding only distribution of dugongs and their habitats, a fine-scale, detailed interview-based approach was adopted to pool traditional knowledge from fishers, who form a primary stakeholder community in marine conservation.

Primarily this study targeted to study changes over the last seven years (2013 to 2020) with following objectives:

- To identify spatial overlaps of small-scale fisheries with dugong distribution
- To assess intensity of negative interaction through dugong by catch and hunting rates
- To understand perception of fishers towards dugongs and seagrass conservation

Study area:

We surveyed 45 fishing villages throughout the Andaman Islands including North (n=18), Middle (n=8) and South (n=19) Andaman Islands (Figure 4.6).

Methodology:

A standardised dugong catch/ by-catch questionnaire developed with the support of the CMS-UNEP Dugong MOU (Pilcher and Kwan 2011) was adopted in the present study. A stratified sampling was carried out across gradients like age, gear type, craft type and gender to collect data related to ethnicity, fishing practices, fishing ranges, dugong sightings, strandings, locations of seagrass meadows and attitude of fishermen towards dugongs and seagrasses was obtained through these surveys. Questions which required validation of species were picture aided; for example: identifying a dugong from chart of marine mammals or identification of seagrass species fishers are familiar with.

Results:

A total of 187 interviews were conducted throughout the study period covering 45 fishing villages in the Andaman Islands. Major findings of the study are presented below:

Respondent profile (n=187):

The fishing culture in Andaman is male dominated with 99% of the total respondents being male fishers across all the villages while only 1% of the fishers interviewed were females involved in a single day fishing-trip where they mainly go for creek or near shore fishing using traditional fishing methods.

15% of respondents were young fishers belonging to the age group of 20-30 years from North and South Andaman, while 8% were senior fishers within age group of 61-70 years. Maximum respondents (>75%) belonged to the age group of 31-60 years (Figure 4.7).

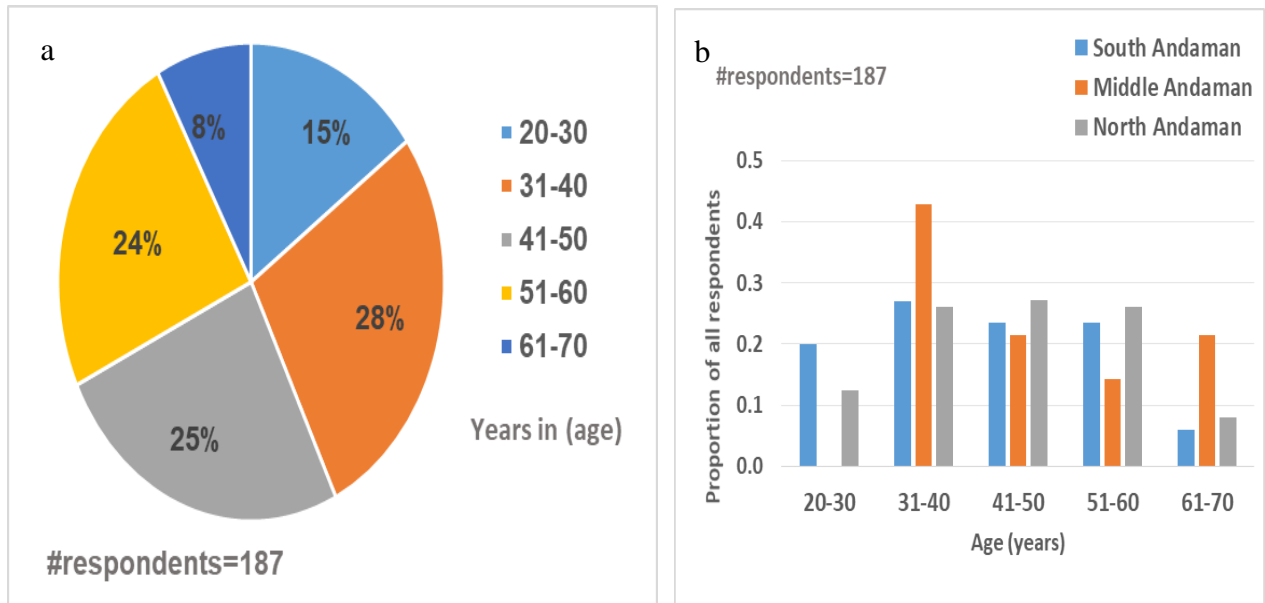


Figure 4.7: Age class distribution of respondents a) collective b) across study sites of Andaman Islands.

Fishing was primary source of income for more than 50% respondents with 30% completely dependent fishing for livelihood, followed by agriculture and tourism allied activities (Figure 4.8).

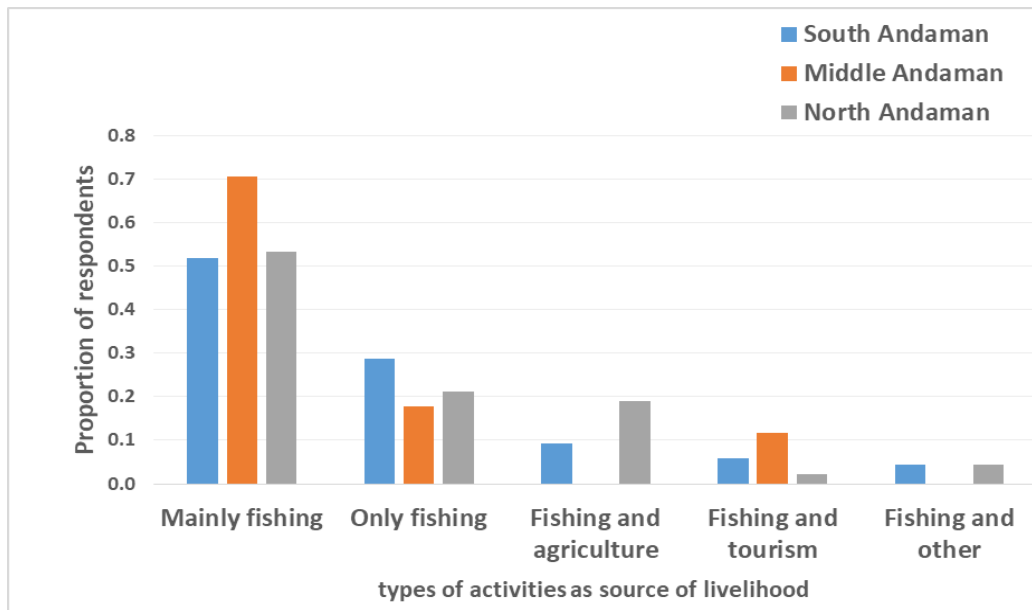


Figure 4.8: Sources of livelihood of respondents across study sites of Andaman Islands

Crafts and gears used:

Craft type (n=183): Usage of non-motorised boats commonly called as ‘Haleej Dunghis’ in the Islands was more pronounced in the Middle Andaman region (>50%) followed by the North Andaman (25%) and the least usage was observed in the South Andaman (n=5) (Figure 4.9).

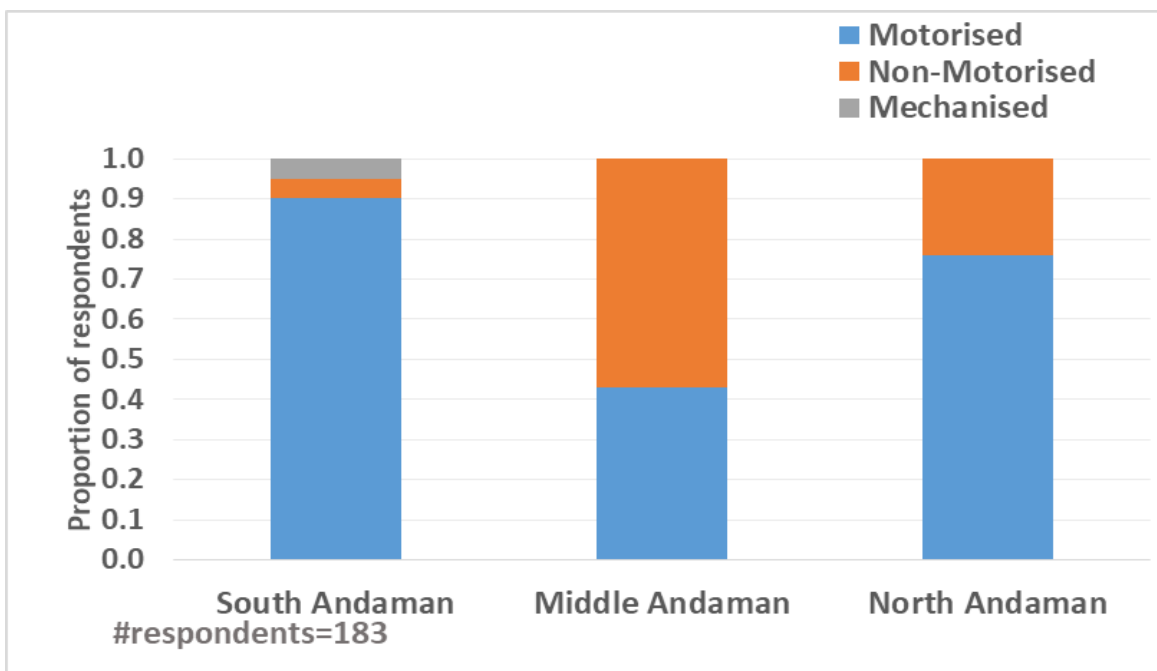


Figure 4.9: Comparison of types of boats used by respondents across study sites of Andaman Islands

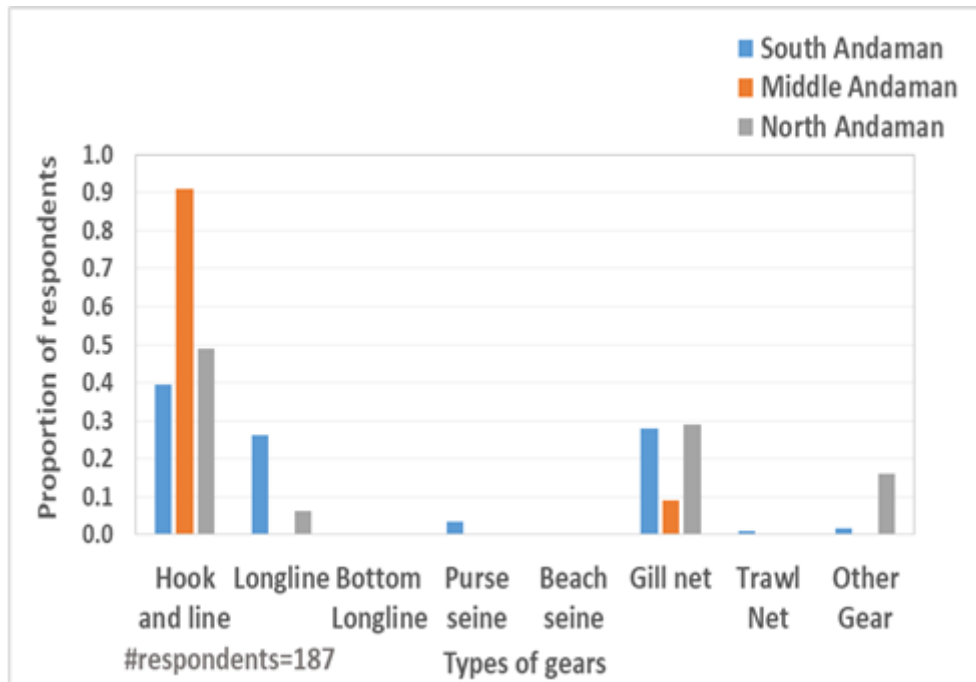


Figure 4.10: Comparison of types of gears used by respondents across study sites of Andaman Islands

On the other hand, fishers in the South Andaman majorly relied on motorised engine dunghis (90%) followed by North Andaman (76%) and the least in Middle Andaman (43%). Mechanised boats (4%) were used only in the South Andaman region for pelagic and demersal fishing by trawling or long line (Figure 4.9).

Gear type (n=187): Hook & Line (>40%) and gill nets (approximately 30%) were the most commonly used gears in all the three sites. Use of long line (average 15%) was restricted only to North and South Andaman while that of purse seine (3%) and trawl (1%) usage was restricted only to South Andaman. 'Other' category gears included cast net, fishing rod and spear fishing (which is a traditional fishing method used mainly by Karen community of North Andaman) consisted on an average 25% of the gear usage exclusively in the North and South Andaman (Figure 4.10).

Fishing effort (n=187): Days invested in one trip: In North Andaman, fishing trips extended over a period of 3 to 6 days mostly (56%), up to two days moderately (30%) and rarely extended, as long as 10 or more days. A typical fishing trip involved 1-2 days in the sea generally in the Middle Andaman (91%) with only few instances of trips extended up to six days (9%). For South Andaman, this aspect was quite spread out, as fishers mostly preferred short trips of two days maximum (39%), followed by long six days trips (33%) and 7-10 days trips (21%) and the least, stretched to more than 10 days trips (Figure 4.11).

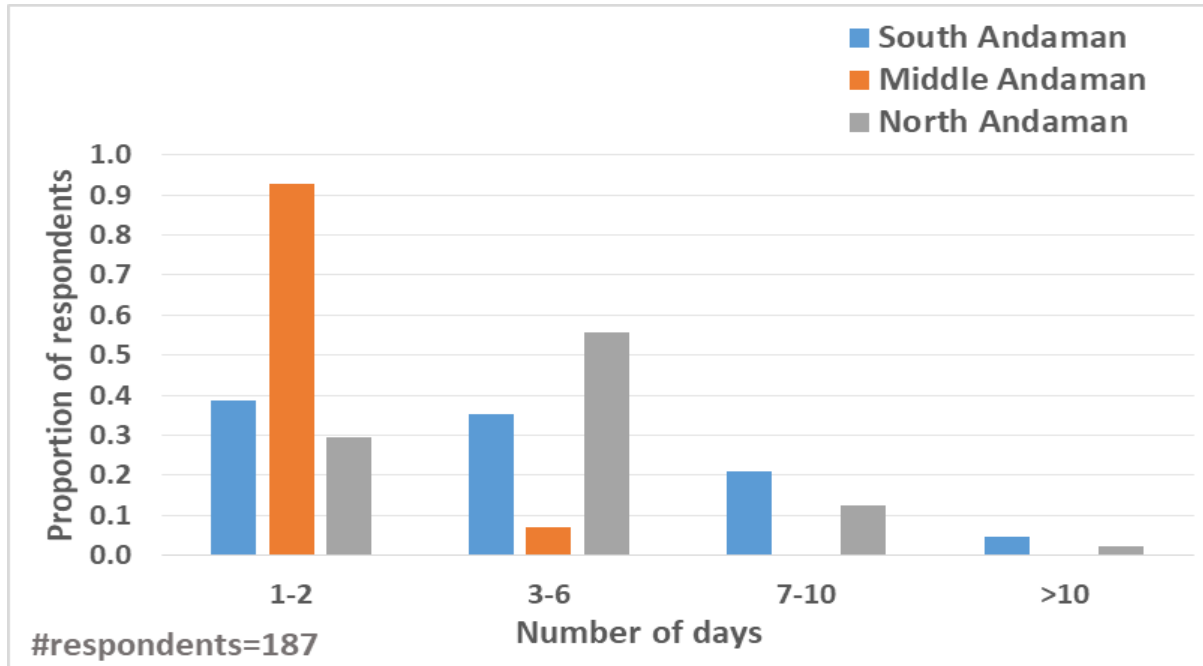


Figure 4.11: Days invested per fishing trip by respondents across study sites of Andaman Islands

Number of trips per month: The fishing trend showed that only fishers from North and South Andaman take 1-5 trips each month (on average 51%) whereas fishers from Middle Andaman take a greater number of fishing trips (>10 times/month) on an average (Figure 4.12).

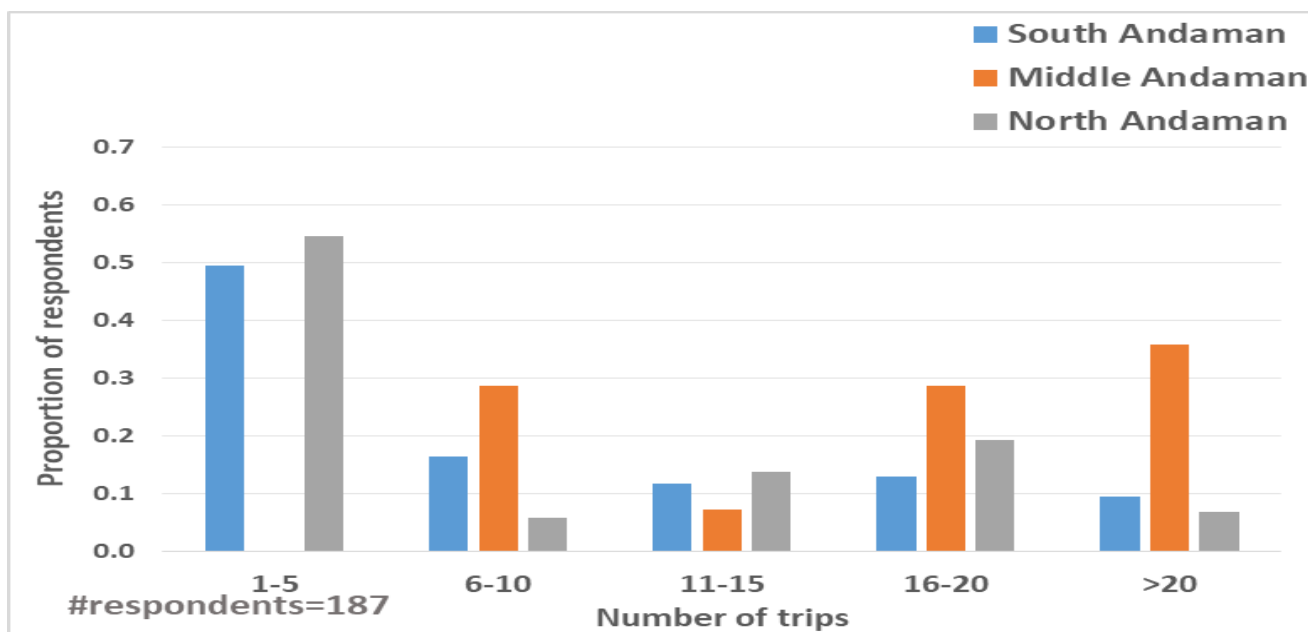


Figure 4.12: Details of number of fishing trips per month of respondents across the study sites of Andaman Islands

Manpower invested in fishing trips:

An ideal boat crew consisted of 1-5 members on the boat across all three sites, with more than 6 members only in North and South Andaman.

Status of dugongs:

Sighting of dugong was more common by fishers from South Andaman (90%) followed by North (75%) and Middle Andaman (50%) respectively (Figure 4.13).

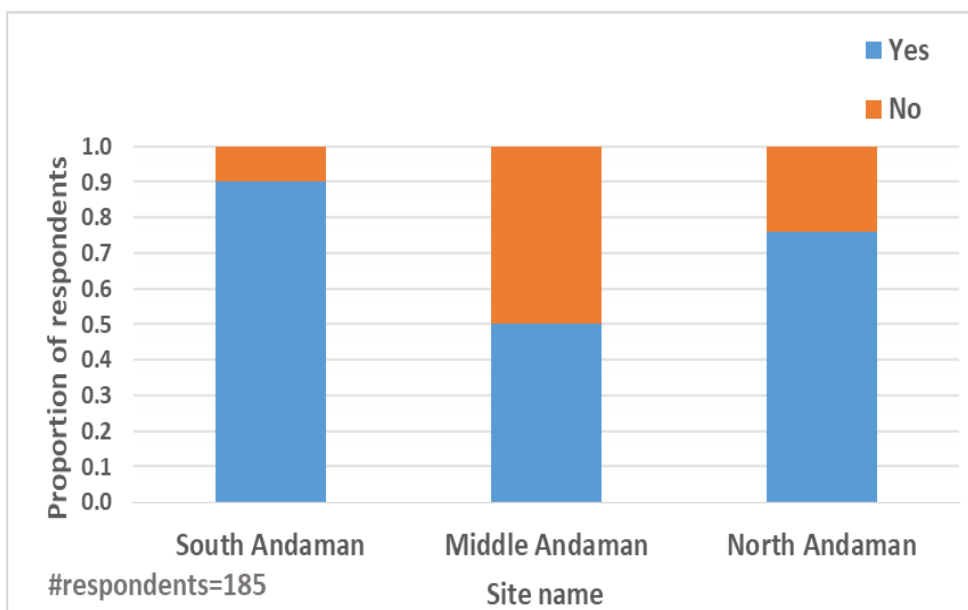


Figure 4.13: Proportion of respondents who have sighted dugongs across the study sites of Andaman Islands

Out of all the fishers interviewed, 95% of the respondents were aware of dugongs and could identify them as a marine mammal different than a dolphin (picture aided), whereas only few (5%) were not aware of this difference (Figure 4.14).

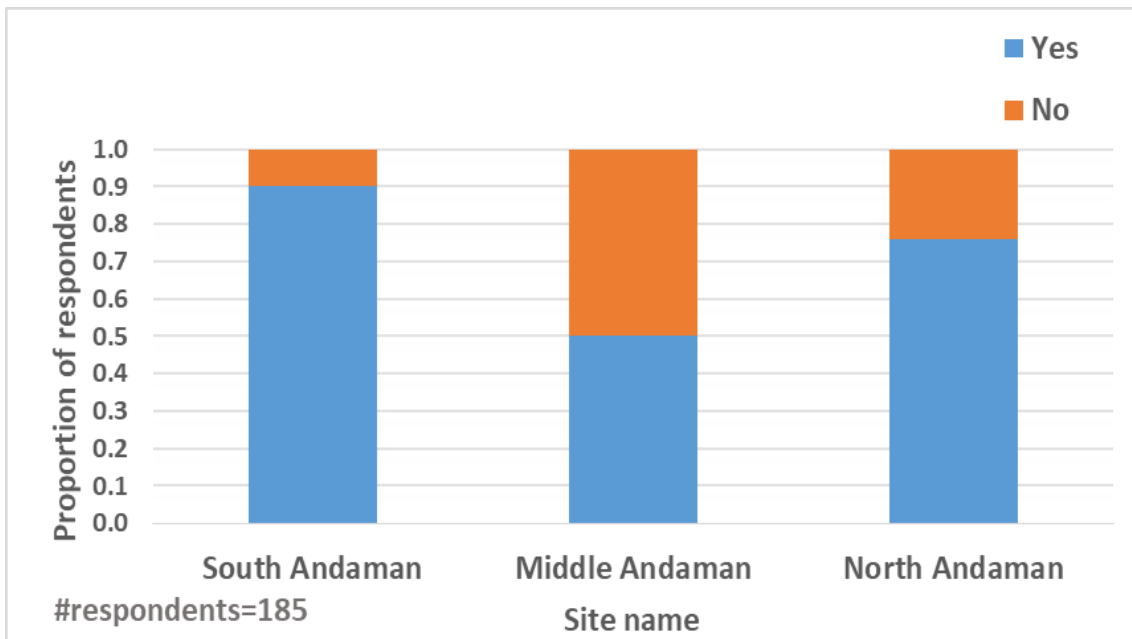


Figure 4.14: Awareness about dugongs amongst respondents of Andaman Islands

Dugongs were mainly sighted while fishing (on an average 51.5%) or in transit (on an average 30.5%) in the North and South Andamans while majorly when incidentally caught in nets for Middle Andaman fishers (22%). Percentage of accidental net entanglement was the least in the South Andaman while quite low in the North Andaman (See figure 4.15). Around 15% of the respondents have participated in hunting of dugongs, which is when they sighted the animal. Few instances of dugongs stranded on the beach were reported from the North and South Andaman (~1%) (Figure 4.15)

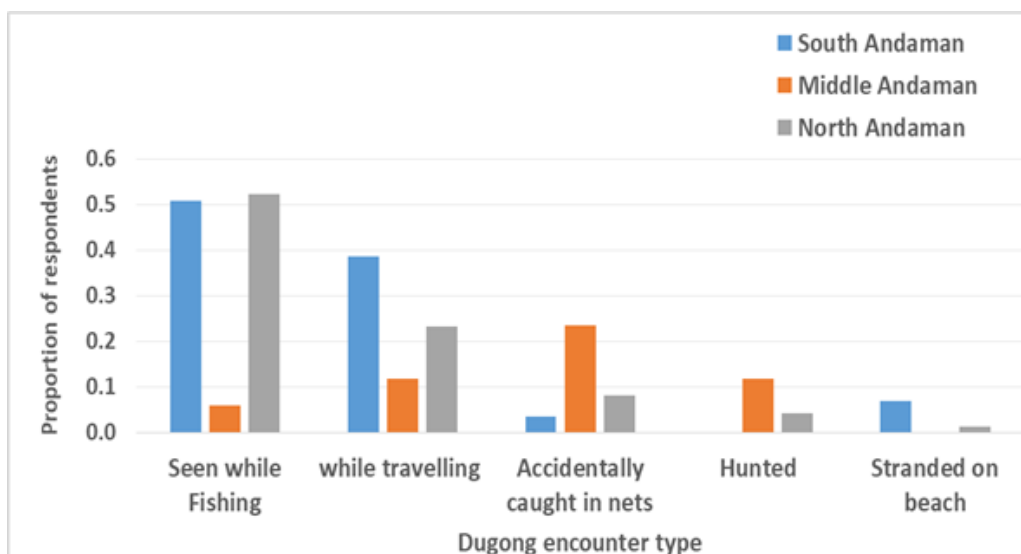


Figure 4.15: Ways in which dugongs were encountered by respondents across study sites of Andaman Islands

For the last seven years, the frequency of sighting of dugongs is the highest in fishers of South Andaman, followed by North and Middle Andaman (Figure 4.16). In the last one year, almost 70% of fishers from South Andaman have sighted a dugong, followed by the North Andaman (40%) with the least sighting records (30%) from the middle Andaman (Figure 4.16). Of these sightings in the last one year, on an average 29% sightings were of a mother and calf pair from the South and North Andaman collectively, with no calf sighting reported from Middle Andaman (Figure 4.17).

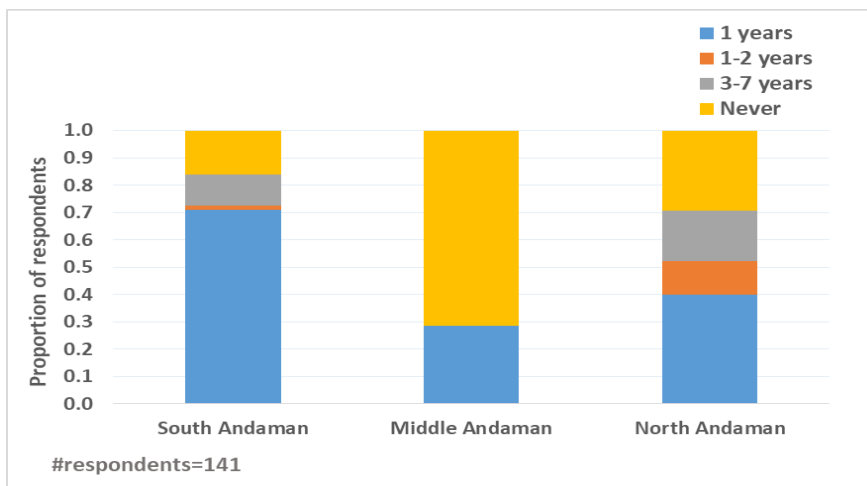


Figure 4.16: Frequency of dugong sightings by respondents last 7 years in Andaman Islands

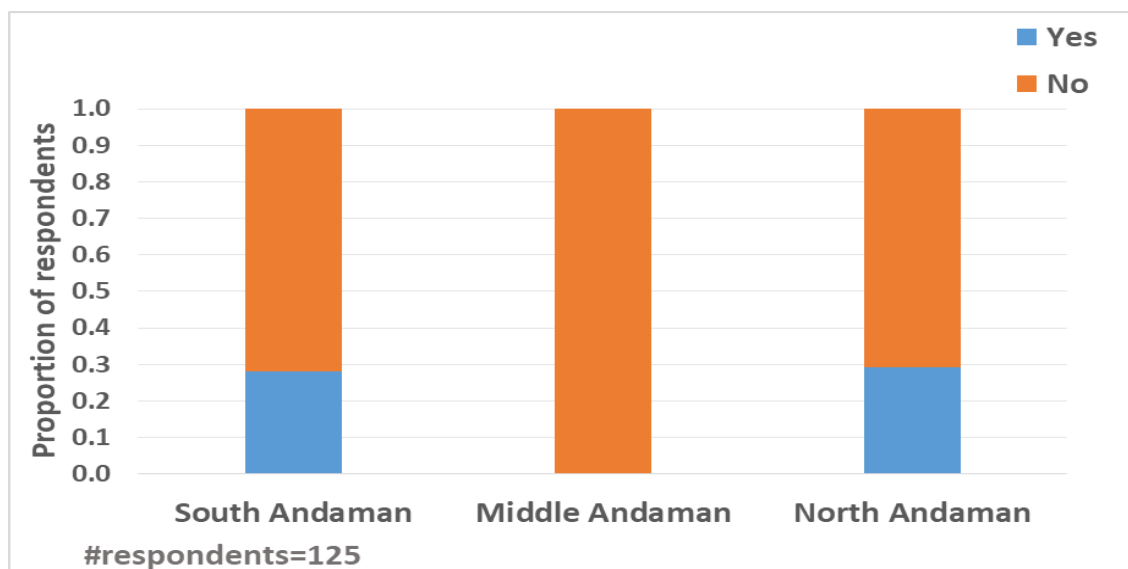


Figure 4.17: Frequency of mother-calf sightings by respondents in last 7 years in Andaman Islands

Threats to dugongs:

Hunting (n=110): On an average, 28.33% of the total respondents were engaged in dugong hunting in the past (10 years ago), and refrained from the same in the last seven years or more while <10% of the respondents have agreed to be engaged in dugong hunting at present, from North and South Andaman (Figure 4.18).

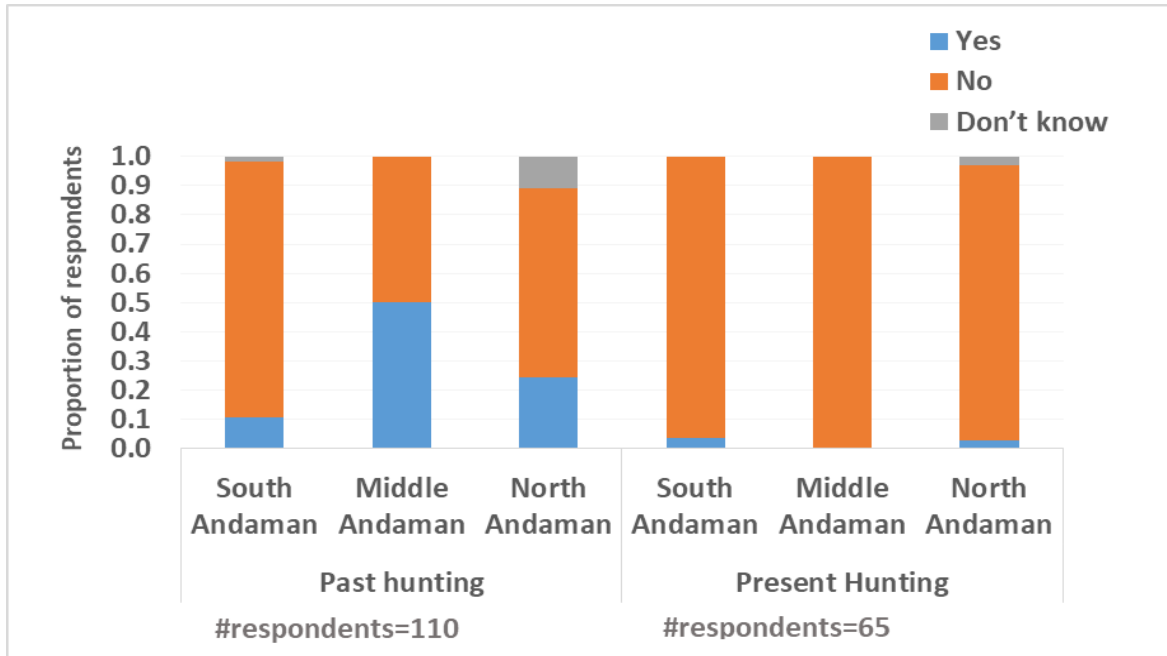


Figure 4.18: Comparison of current and historic dugong hunting rates by respondents in Andaman Islands.

Incidental net entanglement (n=99): Fishers were asked about incidental entanglement of dugongs in their nets in the last seven years, to which a very small proportion of fishers from the North (30%) and South Andaman (20%) responded positively, out of which on an average 7% of the entanglement cases were reported from last one year for both the sites. Due to sensitivity of the issue, only 20% respondents were asked about dugong catches in the Middle Andaman, with no entanglement reports in past seven years (Figure 4.19).

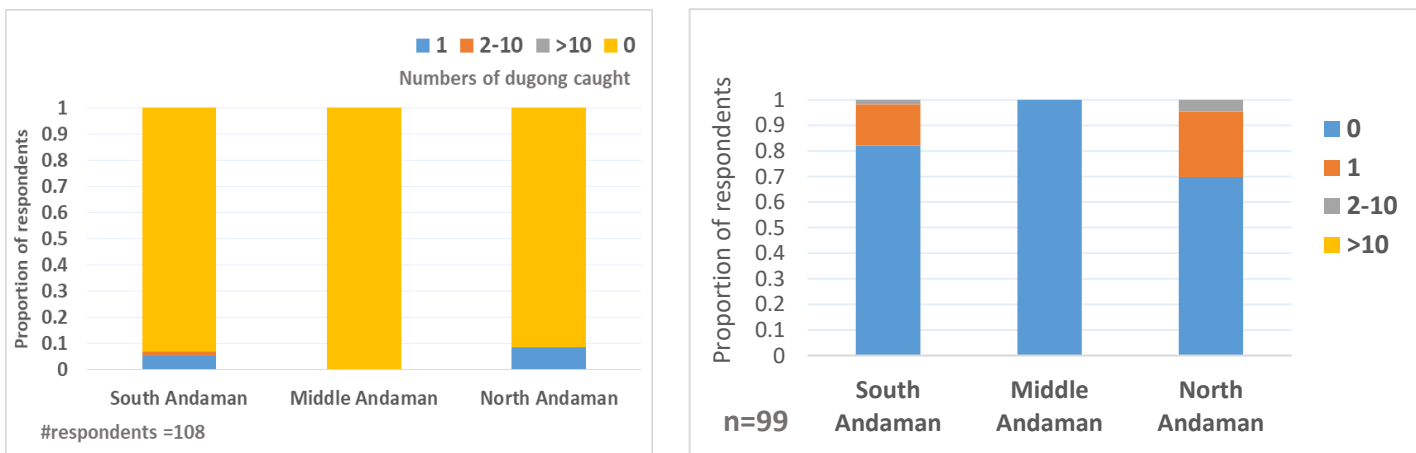


Figure 4.19: Incidental net entanglement cases of dugongs in Andaman Islands a) in last one-year b) in last seven years

Fishers were also asked about what they would do if dugongs got caught accidentally in their fishing nets, to which 66.66% of the total respondents were willing to rescue and release the animal from all three sites, whereas few respondents wished to sell or intake the caught individual (Figure 4.20).

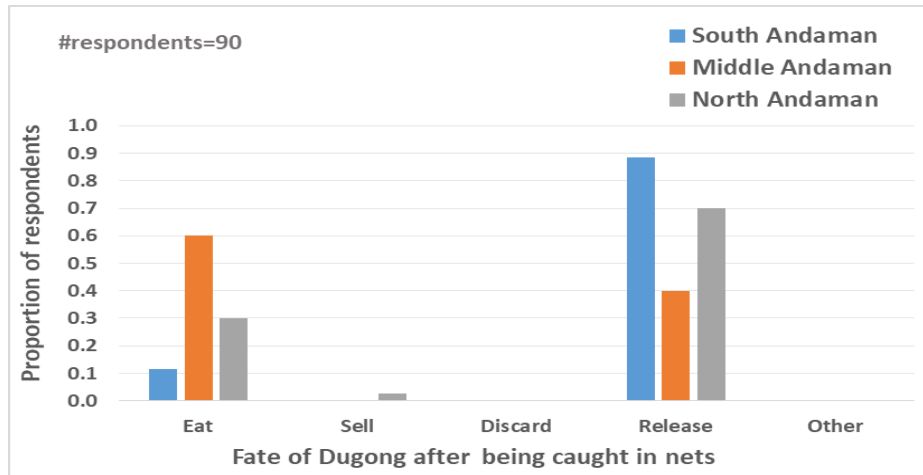


Figure 4.20: Fate of dugongs after incidental entanglement in nets of respondents of Andaman Islands

Status of seagrass habitats:

About >85% fishers of all three sites were aware of seagrass and 49% could differentiate between seagrass and sea algae (Figure 4.21 a and b). No common names were used by fishers for any of the seagrass species, but seagrasses were generally referred to as ‘Samudri ghaas’ locally. The most familiar species to the fishers were *Halophila* spp., *Halodule* spp., *Cymodocea* spp. (identified from the picture aided sheet).

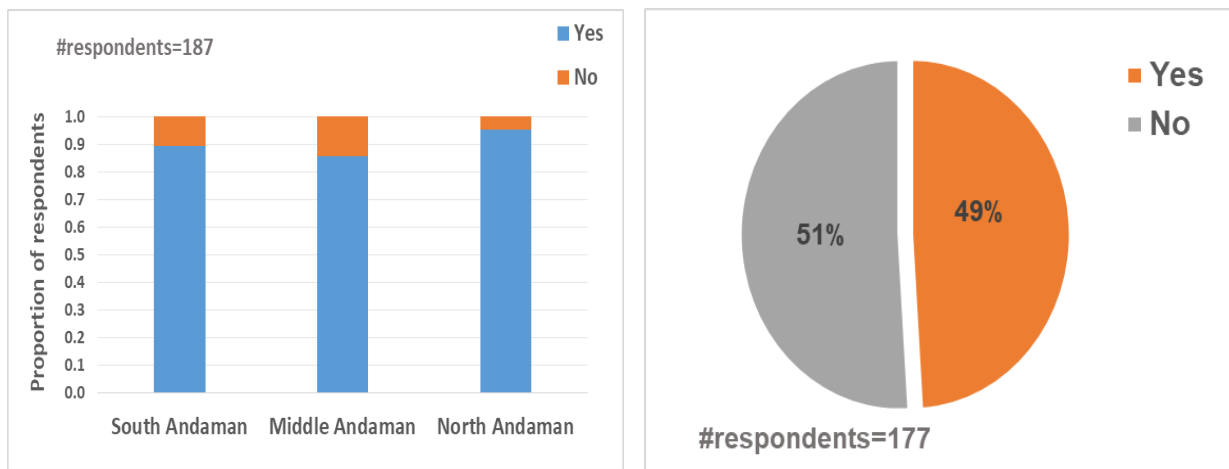


Figure 4.21: a) Awareness amongst respondents about seagrasses b) Awareness amongst respondents regarding difference between seagrass and sea algae

The major outcome of the present study is that local, fine scale 'dugong trouble spots' have been identified in 16 villages across the North and South Andaman, based on current scenario of threats to dugongs through hunting and by catch pressure in the Islands (Figure 4.22).

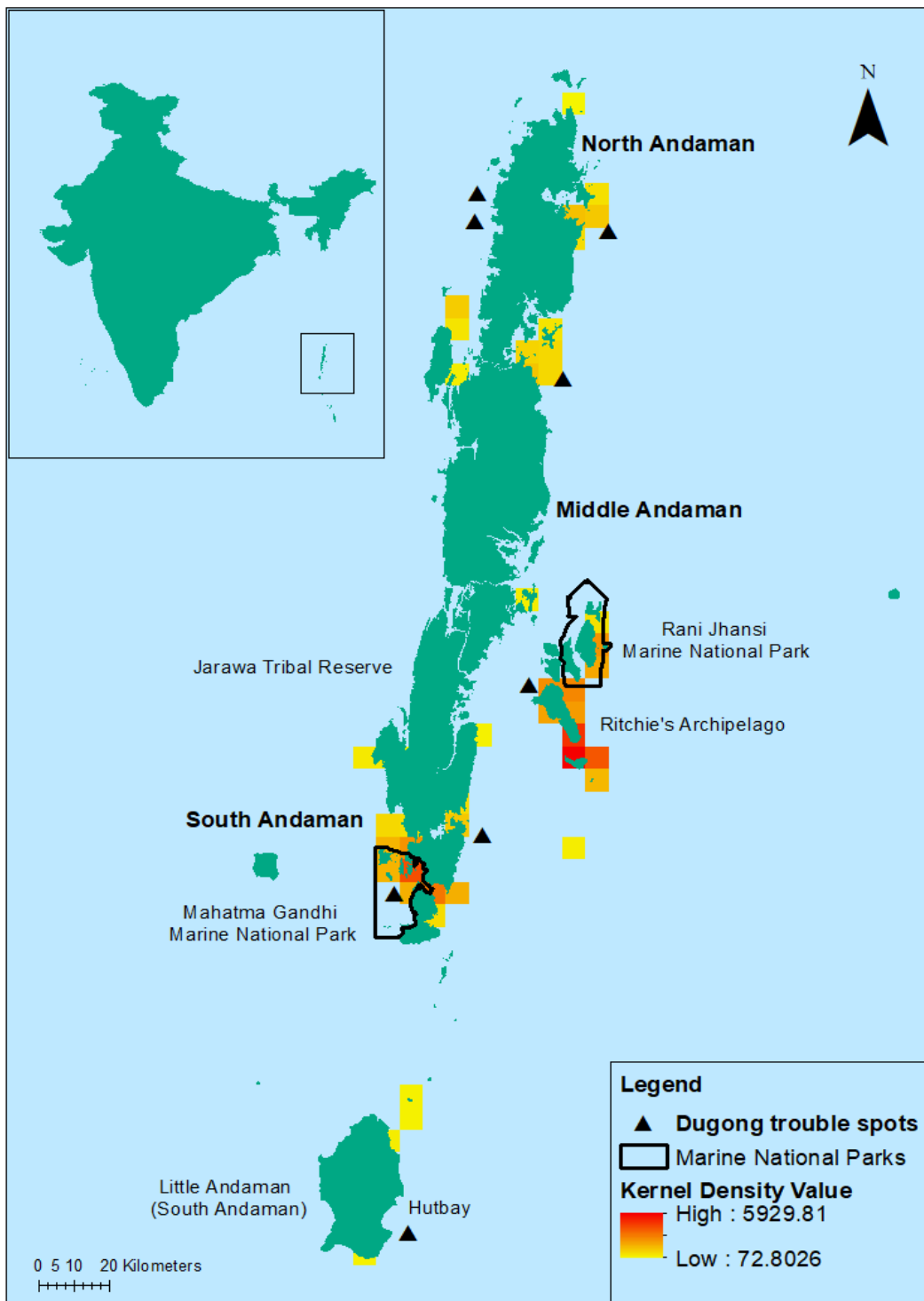


Figure 4.22: Heat map showing dugong sightings along with 'trouble spots' in Andaman Islands

Perception towards dugong and seagrass habitats:

Dugongs: More than 50% fishers across all three sites reported that dugong population is decreasing owing to Indian Ocean tsunami 2004, net entanglement and increasing boat traffic related mortalities. Around 8.5 % believed that the numbers were increasing due to protection of their habitats by patrolling agencies like forest department, whereas the remaining respondents either felt the numbers are constant or were unsure (Figure 4.23).

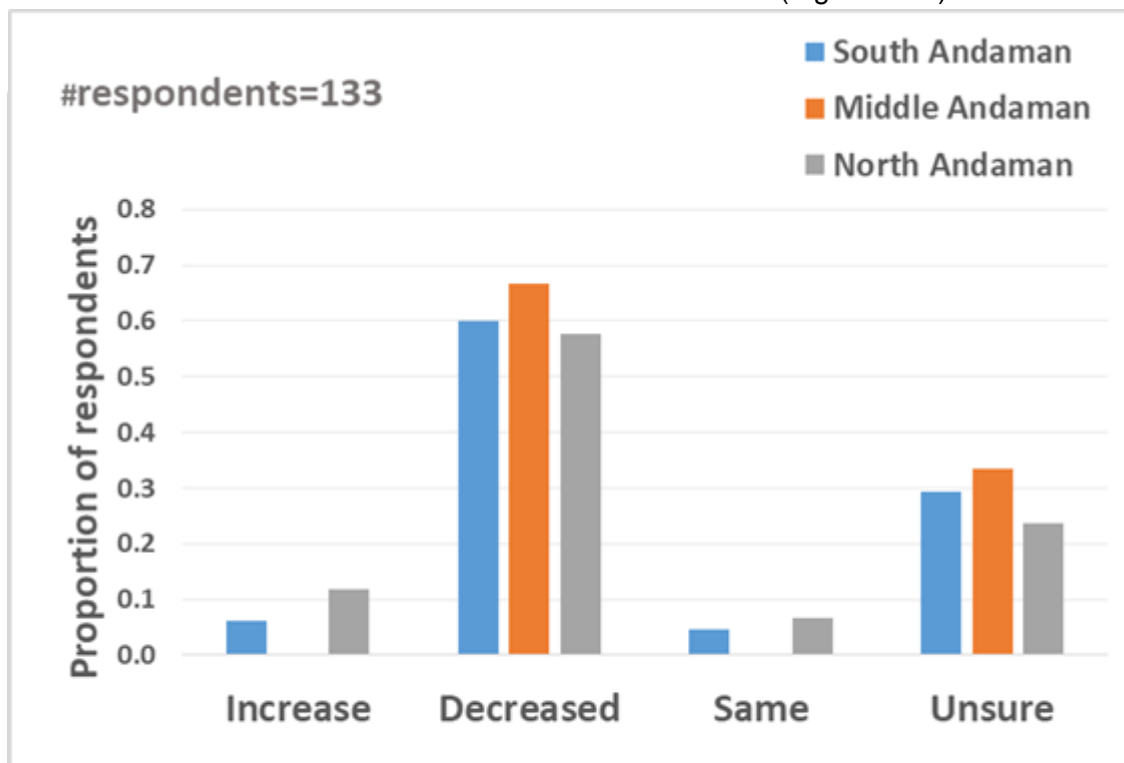


Figure 4.23: Change in dugong population as perceived by respondents of Andaman Islands

18% fishers believe that dugongs might locally go extinct if the incidental net entanglement and hunting (direct intake) continues in the Islands, while 29% are hopeful that if increased protection is given to the species and habitats, the extant population in the Islands will survive. Majority of the remaining respondents (53%) were not sure about dugong survival in the coming years (Figure 4.24).

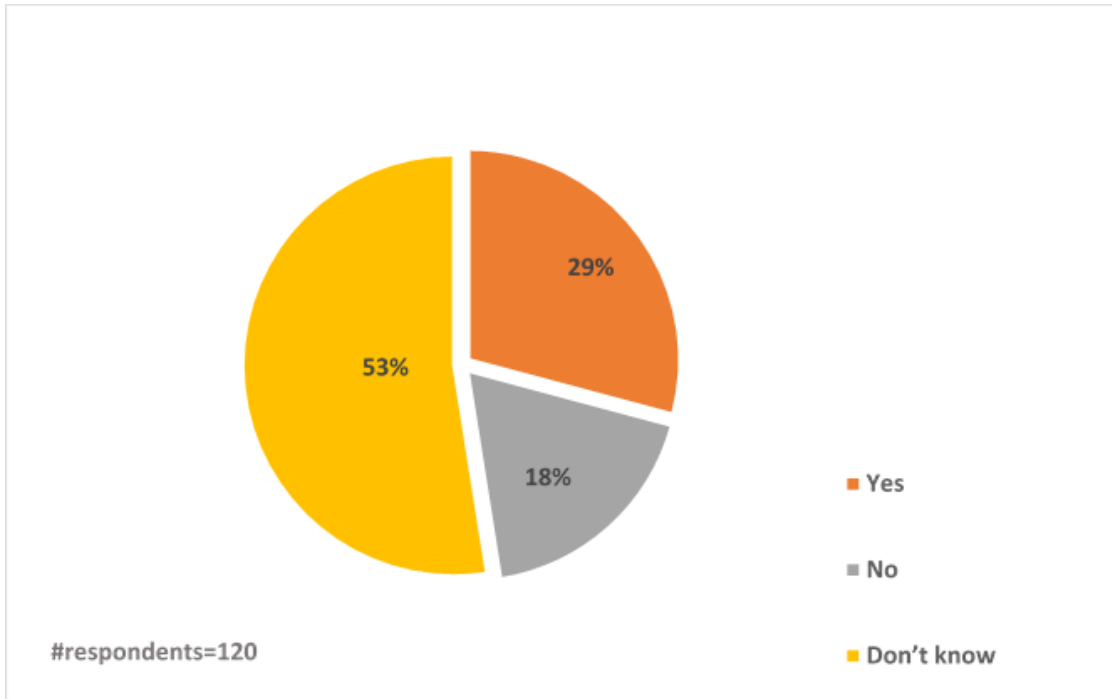


Figure 4.24: Perception among respondents of Andaman Islands regarding survival of dugong population in future

When asked on importance of dugongs for fishers and the environment, 38% respondents associated sentimental views to dugongs as their state animal, and felt it was important to conserve the same. 35% respondents did not find any significant importance of dugongs to them or the environment whereas the remaining proportion (27%) was not sure (Figure 4.25).

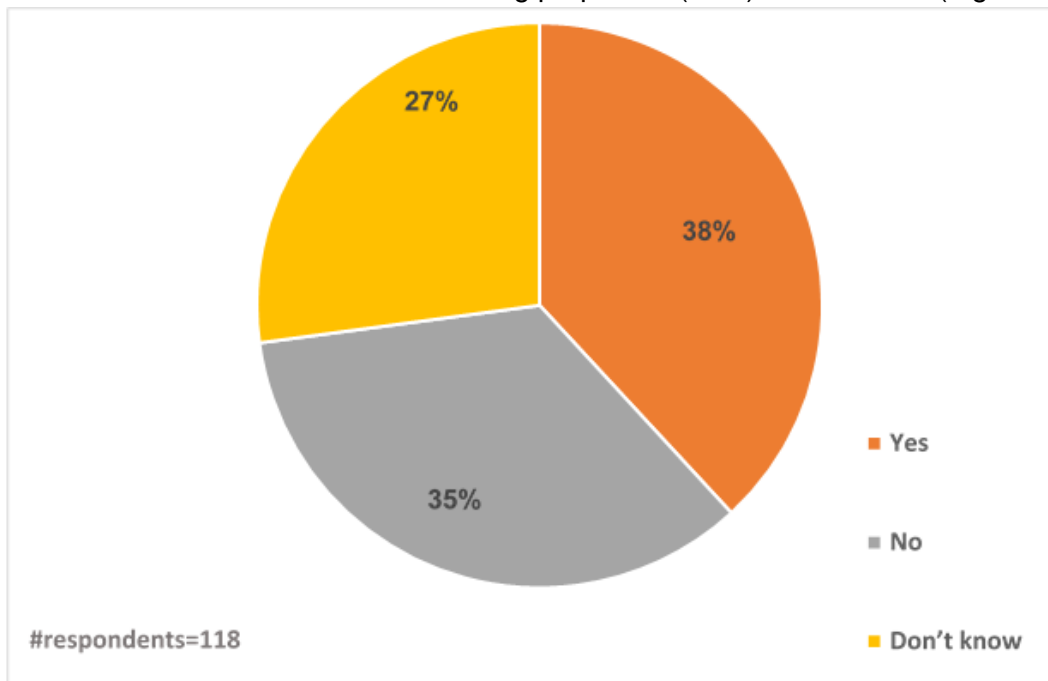


Figure 4.25: Perception of respondents of Andaman Islands regarding importance of presence of dugongs in their waters

Seagrass habitats: Overall 27.66% of the fisher folk knew about the importance of seagrass as habitats and crucial food source for dugongs, turtles, crabs and fishes; 54% did not feel seagrass habitats to be important while rest of the respondents were unsure of the same (Figure 4.26). Throughout all the study sites, 72% of the fishers reported decrease in seagrass cover, attributing this change majorly to tsunami, coastal development (jetty construction) and boat anchorage. On the other hand, 11% of the respondents felt the cover to have increased after tsunami; other 11 % felt there was no change in the cover, while remaining 6% were unsure of the same (Figure 4.27).

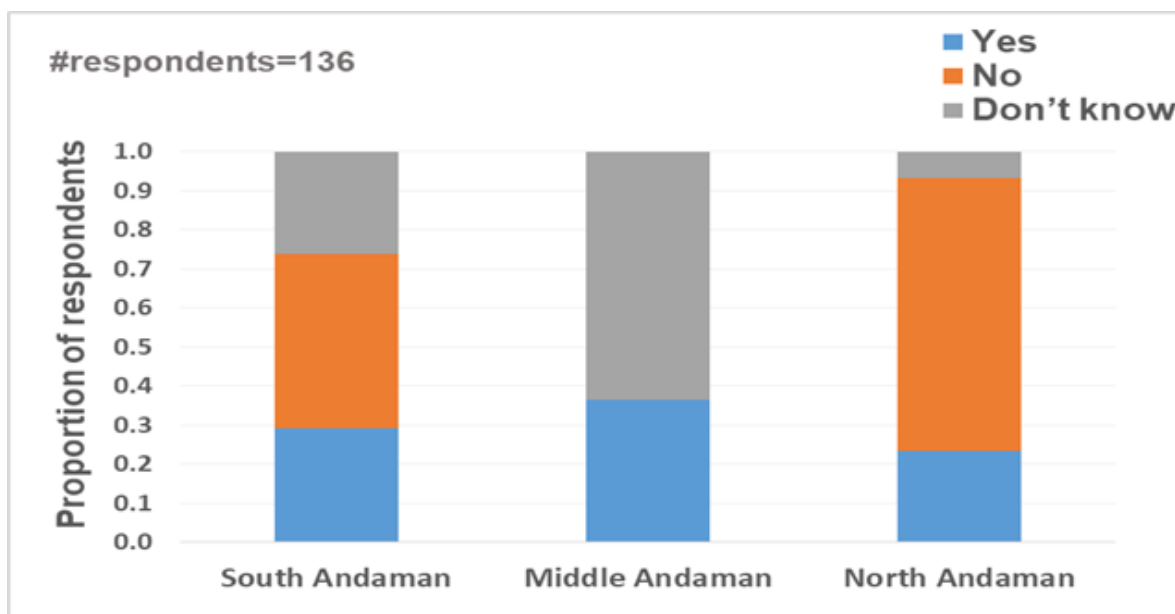


Figure 4.26: Perception of respondents of Andaman Islands regarding importance of presence of seagrasses in their waters

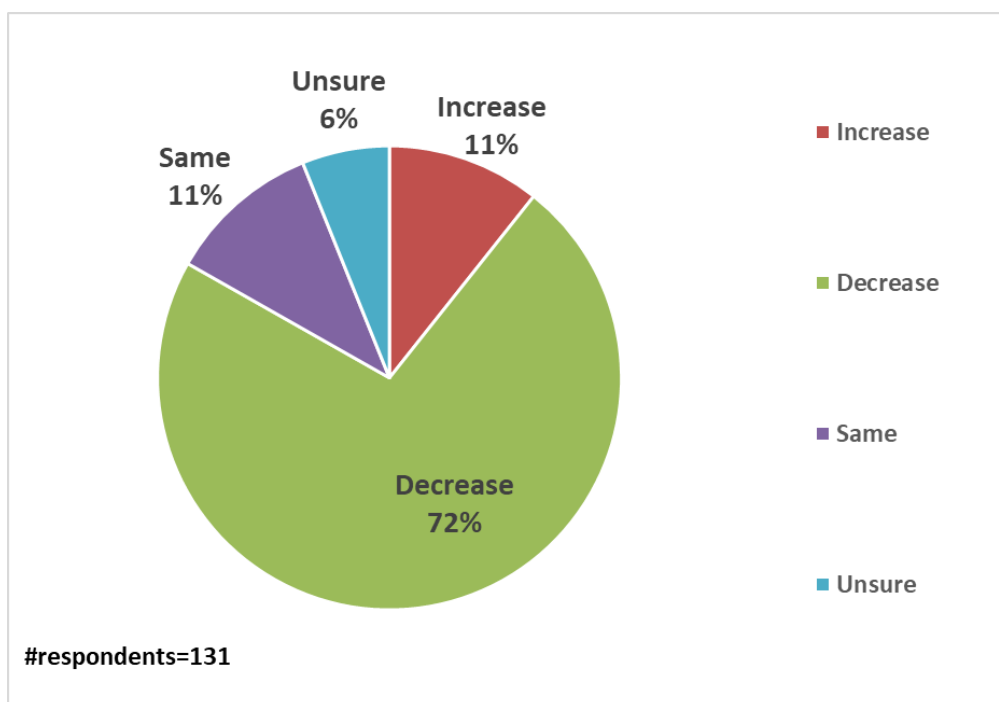


Figure 4.27: Changes in seagrass cover as perceived by respondents of Andaman Islands

Discussion:

Owing to the tourism influx in the Andaman Islands, which promises growth opportunities or a personal choice made to avoid hardships involved in fishing, we found that very low proportion of youngsters are taking up fishing profession. These factors seem to be majorly shaping livelihood choices islanders make, where younger generation is moving towards 'easy money' generated through tourism allied professions or opting for government/ private sector jobs. To understand this particular aspect and its influence on small scale fishing pressure on dugong habitats, more spatially spread efforts are recommended.

Usage of different boat types was found to be influenced by the geography of the study sites and surrounding habitats. Use of 'Haleej' boats was more pronounced in the Middle Andaman, due to denser mangrove vegetation present in the North and middle Andaman side of the Andaman Islands as compared to the Southern coast, with presence of major creeks. Since these creeks are sheltered, with open seas being kilometres away, fishers in the surrounding villages majorly are involved in creek fishing using 'Haleej', using traditional gears (rods/ spears/ nets) and do not much venture out in the open coasts. On the other hand, the South Andaman region is surrounded by open sea, and the fishers here venture out to faraway fishing grounds, thus, reliability on motorised or mechanised boats was more pronounced in this region. North Andaman fishers used both Haleej and motorised boats, as the Northern side of the Andaman Islands is characterised by both; open seas and sheltered mangroves creeks.

Similarly, hook & line and gill nets which are suitable for fishing in creek as well as open sea was maximally used by fishers across all three sites. Long lines where the length of the gear spreads out in kilometres, was restricted to North and South Andaman only and avoided in Middle Andaman, might be due to unsuitability of gear.

The duration of a fishing trip is dependent on factors like target fisheries, availability and accessibility of fishing grounds, market for the catch, and gear & crafts used. Long duration trips were undertaken only by fishers of North and South Andaman, as open sea is available at both the sites while middle Andaman fishers restricted their trips to smaller duration. Further, most of the fishers in North and South Andaman are involved in export fishing, which requires long trips till the pre-decided catch capacity is full. Short trips in these regions are generally done where the catch has local available market.

Type of crafts and gears used is an important aspect in dugong conservation, as it influences both, the sighting probability and threats to dugongs. Haleej boat users in the North and Middle Andaman, with limited movement have seen dugongs rarely, while motorised/ mechanised boat users who travel larger distances, have frequently sighted dugongs either while fishing or in transit, because of the overlap in their fishing ranges and dugong distribution. Further, these pose threats to dugongs in terms of destructive trawl/gill nets being used or boat strike.

The major outcome of our study was successful understanding of this spatial overlap and updated 'dugong trouble spots' with latest information on hunting and net entanglement pressures. On the other hand, the level of awareness and importance which fishers had about dugongs was not reflected for seagrass habitats, highlighting a strong need to carry out integrated species-habitat sensitization programs amongst these communities.

Although the severity of threats identified in this study appears to be of low intensity, on a local scale it does affect the existing dugong population, given the total count to be a guesstimate of less than 25 individuals, in the Islands. On a positive note, sightings of mother and calf pairs in the last one year, validates the importance of the Islands as crucial breeding grounds and demands strong local conservation initiatives, directed towards these identified trouble spots.

4.1.2 Quantifying and mapping threats to ‘Critical Dugong Habitats’ in the Andaman Islands in terms of boat traffic and plastic litter

Duration: March to May 2019 and December 2019 to March 2020

Background and Objective:

Despite localised threats known to remnant dugong population in the Islands, in terms of net entanglement, boat traffic and coastal development, there is lack of studies to quantify these threats through dedicated boat based surveys. Quantification of threats over a qualitative data, to dugongs and their habitats is crucial, to not just understand the intensity of threats, but also to study their distribution of threats and seasonality. This kind of data is valuable to identify ‘hotspots’ with greater intensity of threats, which further draws attention from managers and policy makers.

With a similar approach, to understand and quantify threats to dugongs and their habitats in the Islands, we carried out a threat mapping assessment in Critical Dugong Habitats in the North and South Andaman. Some of the major objectives of this study were:

- To quantify density threats in terms of boat traffic and plastic litter in critical dugong habitats
- To assess distribution of these threats around critical dugong habitats

Study area:

The present study was carried out from March to May 2019 and December 2019 to March 2020, across three critical dugong habitats, situated in the North and South Andaman region, namely Mayabunder in the North Andaman and the Ritchie’s archipelago (RA) and Wandoor in the South Andaman. Both the study sites in South Andaman also encompass two marine national parks viz; Rani Jhansi Marine National Park (RJMNP) in RA and Mahatma Gandhi Marine National Park (MGMNP) in Wandoor.

Methodology

A grid-based distance sampling approach was used, where grids of 2X2 km were divided as near and offshore grids, the latter being up-to approximately 20kms offshore from an island. The near shore grids were selected on the basis of distribution of seagrass habitats (point locations taken from literature available and ground sampling) whereas equal number of offshore grids were randomly selected to spatially represent the study area. At each point in the selected grid, a 360-degree point count method was followed, by scanning an area of 1km for 15 minutes, to document threats in terms of boat traffic and plastic pollution. On spotting of a boat or plastic debris, parameters like distance of the threat from observer’s boat, angle of spotting, type of boat (fishing/ ferry/ recreational) and size (in case of plastic) was recorded along with GPS location. Additionally, variables like depth of the water column and environmental variables (pH, Temperature and Salinity) were also recorded.

Results and Major Outcomes

[I] Mayabunder

Total 19 grids were sampled during May 2019 on both the West and East coast of Mayabunder in North Andaman. Low to moderate boat traffic and negligible density of floating plastic macro-litter was documented during the surveys (Figure 4.28). 60% of the boat traffic detected was of fishing boats either anchored or in transit, followed by 20% each of cargo vessels and patrolling boats of defence bodies (Indian Navy and Indian Coast Guard) (Figure 4.29).

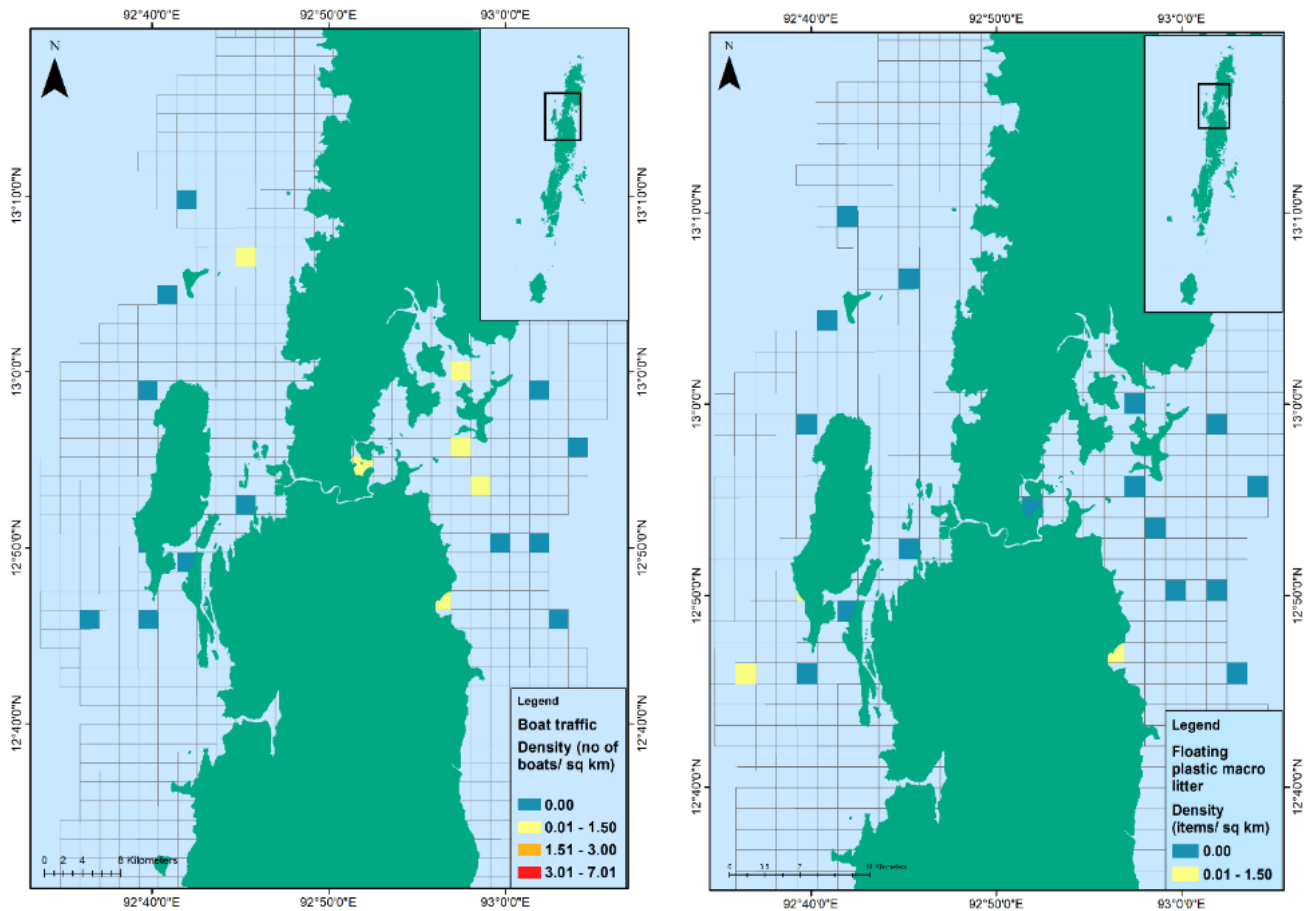


Figure 4.28: Map showing changes in density of boat (left) and macro-litter (right) in Mayabunder in May 2019

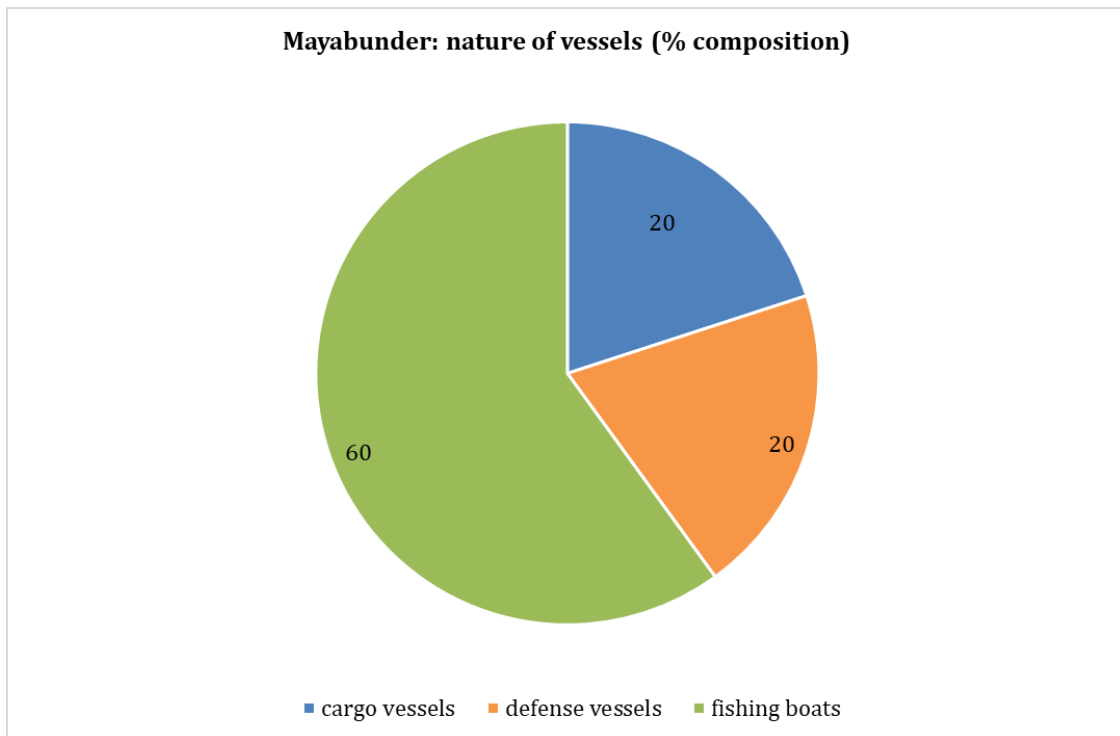


Figure 4.29: Nature of boat traffic in critical dugong habitats- Mayabunder (data points n=10) in May 2019

[II] Ritchie's archipelago

Spatial sampling of threat assessment was carried out in the Ritchie's Archipelago in February 2019 (57 grids) including Rani Jhansi Marine National Park (RJMNP). These grids were resampled in March 2020 (only 42 grids could be resampled due to unfavourable weather conditions) to understand differences on a temporal scale (See Figures). The overall boat traffic for the Ritchie's archipelago was low with only one grid of each sampling season, showing high boat density (7 boats/ km²) in 2019 and 18 boats/km² in 2020), while one grid had moderate boat traffic (1.5 boats/ km²) in March 2020. Rest of the grids either had low or nil boat traffic (Figure 4.30).

Comparison within spatial replicates showed slightly higher density of boat traffic localised around *Swaraj dweep* jetty area and throughout the RA in February 2020, as compared to March 2019. Even within the RJMNP, slightly higher number of fishing boat densities were localised either inside the MNP or around the boundary in February 2020 (Figure 4.30).

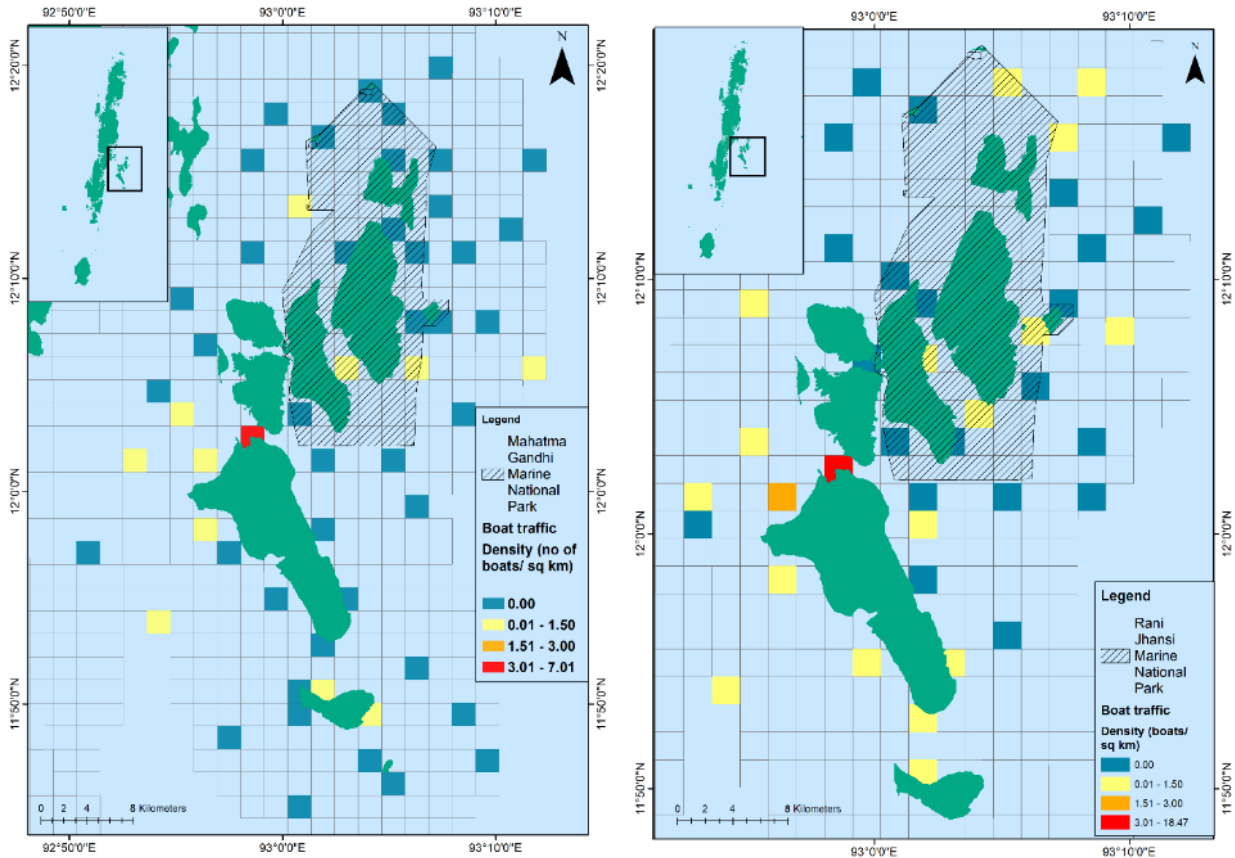


Figure 4.30: Map showing changes in density of boat traffic in Ritchie’s Archipelago in March 2019 (left) and February 2020 (right).

Collectively for both the spatial replicates carried out, a varied nature of boat traffic was observed. 41.46% of the total boats observed were fishing vessels, followed by recreational boats (38.21%), inter island passenger ferries (17.89%) and remaining proportion of cargo and defence patrolling vessels (Figure 4.31).

In case of plastic litter, February 2020 had comparatively less litter distribution as compared to March 2019, where moderate to high plastic debris were documented (Figure 4.32).

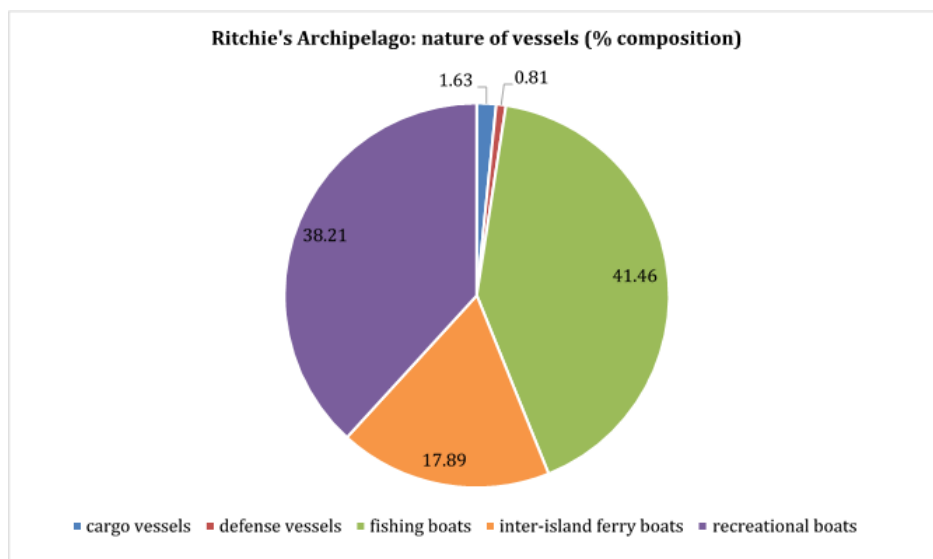


Figure 4.31: Nature of boat traffic detected during threat mapping of Critical Dugong Habitats in Ritchie’s Archipelago (data points n=123) collectively in 2019 and 2020

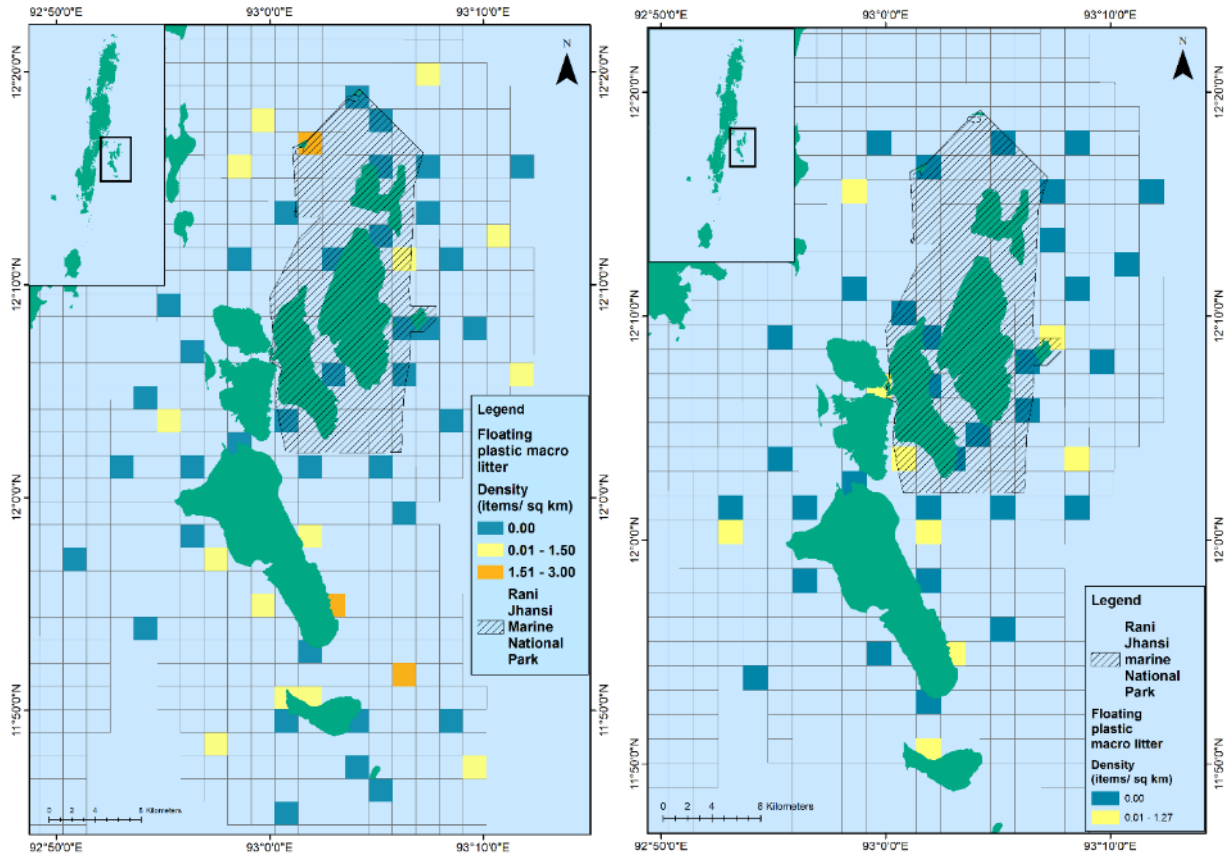


Figure 4.32: Nature of plastic litter detected during threat mapping of critical dugong habitats in the Ritchie’s archipelago in March 2019 (left) and February 2020 (right). (data points n=123).

[III] Wandoor

Sampling was carried out in the Wandoor region in and around the Mahatma Gandhi Marine National Park (MGMNP) in April 2019 (25 grids) and same grids were sampled in December 2020. Few more grids were sampled in December 2020 (total 27 grids) selected on the basis of frequent dugong sightings in those regions. Boat traffic was more pronounced spatially and in terms of intensity, in December 2020 replicates as compared to April 2019 as moderate to high boat traffic was observed only for this season (Figure 4.33).

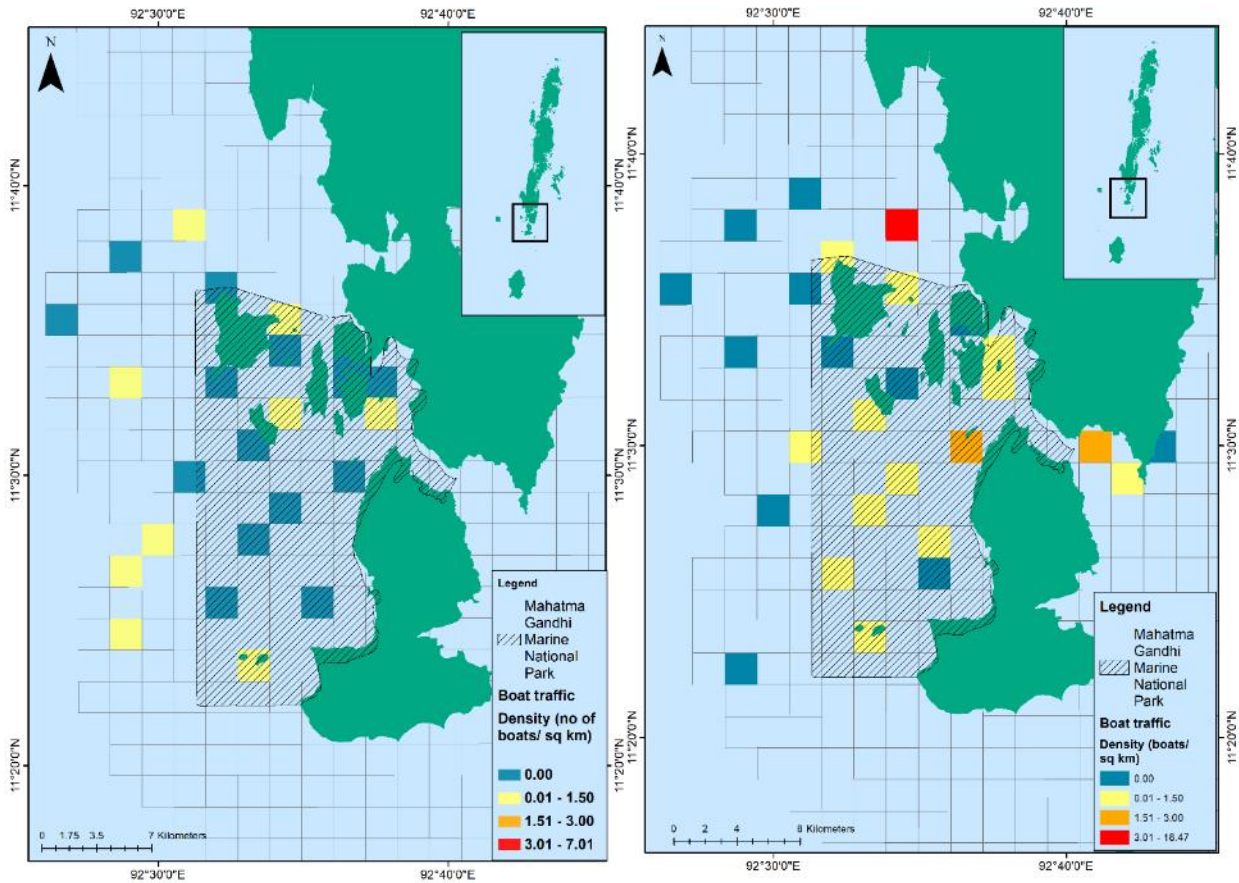


Figure 4.33: Nature of boat traffic detected during threat mapping of critical dugong habitats in Wandoor in April 2019 (left) and December 2020 (right). (data points n=41).

Boat traffic was majorly contributed by fishing vessels (81.67%) followed by recreational boats (15%) and defence vessels (3.33%) (Figure 4.34). Plastic litter was found to be negligible for both the spatial replicates taken (Figure 4.35).

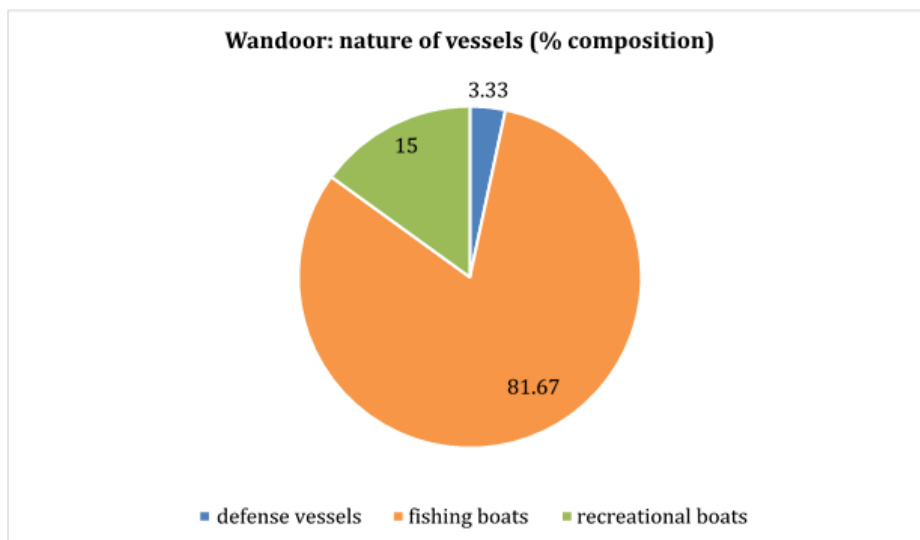


Figure 4.34: Nature of boat traffic detected during threat mapping of Critical Dugong Habitat- Ritchie’s Archipelago (data points n=60) collectively in 2019 and 2020

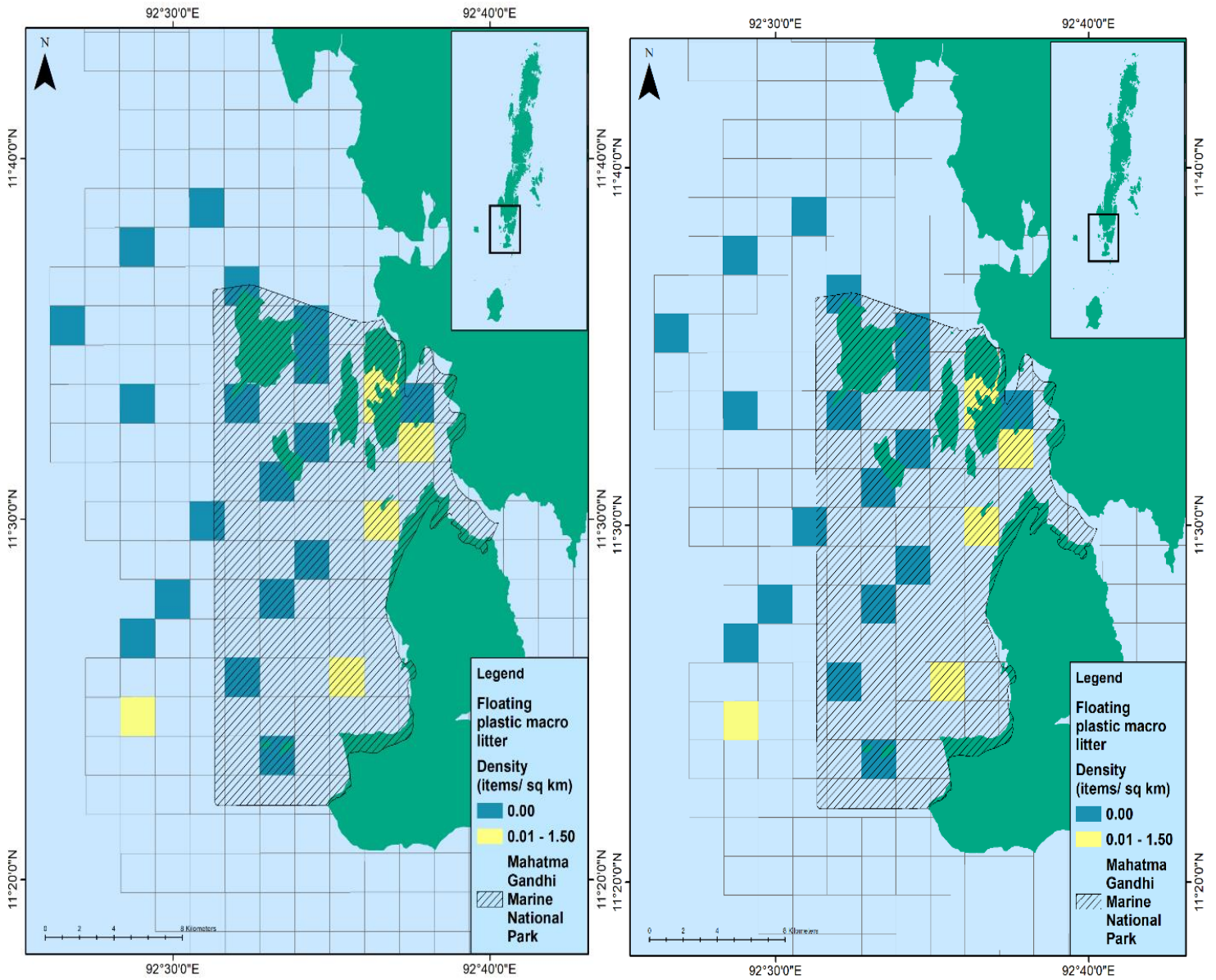


Figure 4.35: Map showing changes in density of floating plastic macro-litter in Wandoor in April 2019 (left) and December 2020 (right).

Nature of plastic litter (2019-20) (%)

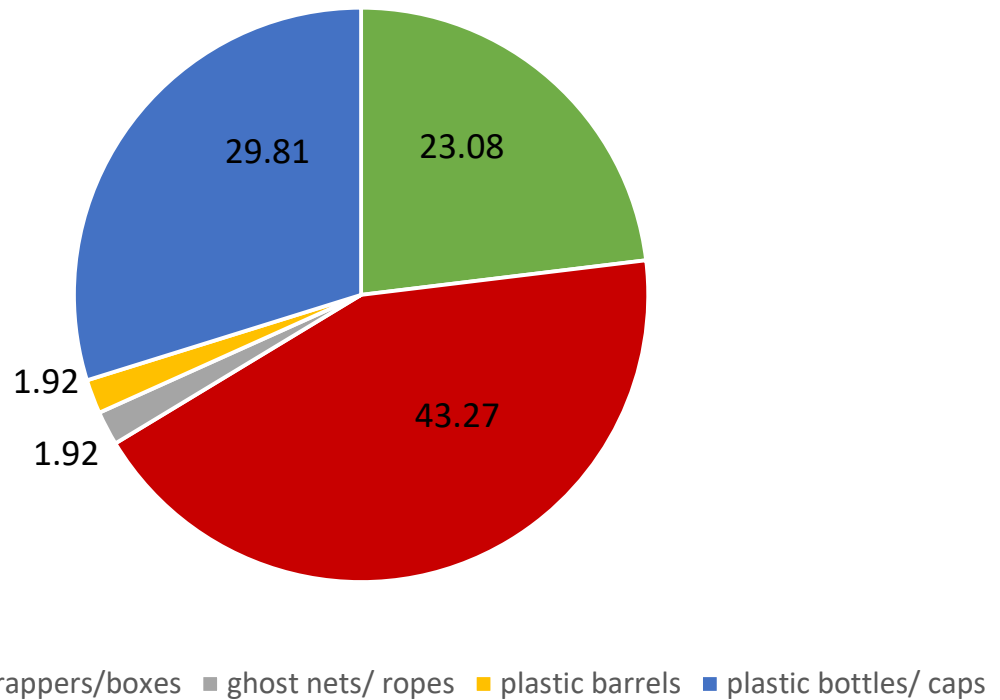


Figure 4.36: Nature of items found as floating plastic macro litter across the three sites of Andaman Islands (data points n=104) collectively in 2019 and 2020

It was observed that food wrappers/ boxes formed the most frequently found (43.27%) floating litter across all the three sites, followed by plastic bottles and cans (29.81%). On a positive note, the percentage of ghost nets or ropes (1.92%) was low (Figure 4.36).

In 2019, across all the three sites, mean boat traffic density were the highest in the Ritchie’s archipelago (1.48 ± 1.95 boats/ km²) followed by Wandoor (0.93 ± 0.99 boats/ km²) and the least mean boat density was observed for Mayabunder (0.53 ± 0.16 boats/ km²) (Figure 4.37).

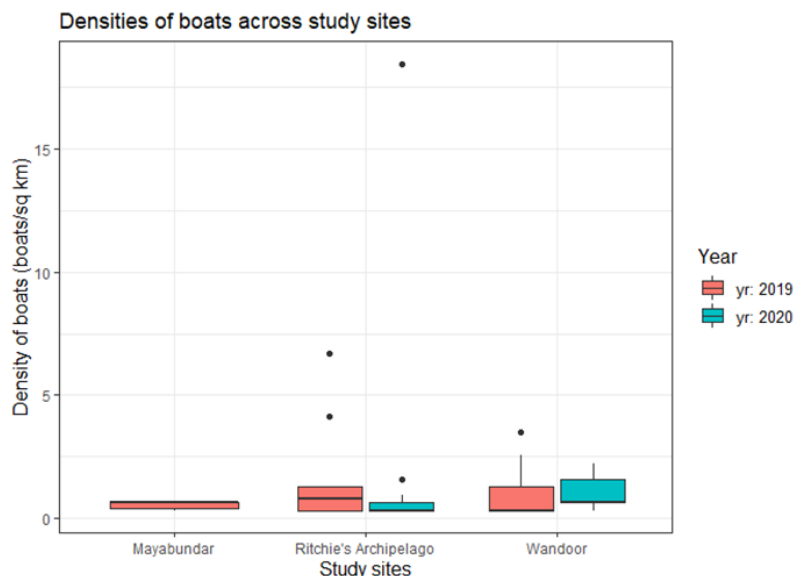


Figure 4.37: Comparison of boat densities across the study sites of Andaman Islands (data points n=51) and years 2019 and 2020

Whereas, in 2020, Ritchie’s Archipelago (1.52 ± 4.24 boats/km²) again had the highest mean boat density followed by Wandoor (1.08 ± 0.79 boats/km²) (Figure 4.37).

In case of plastic litter, in 2019, mean litter density in Ritchie’s Archipelago (0.81 ± 0.74 items/km²) was higher than that of Wandoor (0.71 ± 0.69 items/km²) and least at Mayabunder (0.32 ± 0 items/km²) (Figure 4.38). In 2020, very low density of litter was detected at Ritchie’s Archipelago (0.53 ± 0.63 items/km²) (Figure 4.38). No litter was detected at Wandoor in 2020.

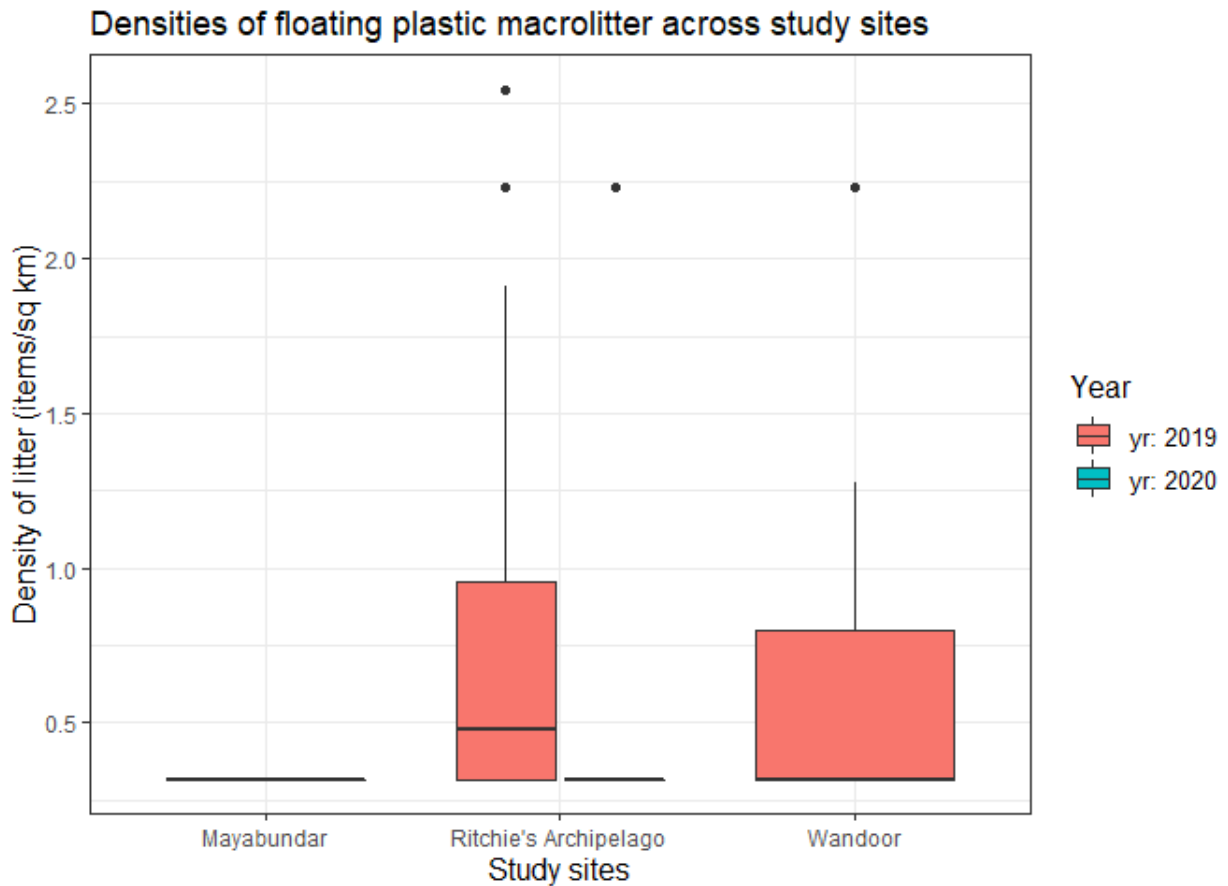


Figure 4.38: Comparison of litter densities across the study sites of Andaman Islands (data points n=36) and years 2019 and 2020

Discussion:

In the present study, the density and distribution of boat traffic was observed to vary across the three selected CDHs depending on the kind of activities carried out at the ports. Since Mayabunder is a major port area, moderate boat traffic was concentrated towards the jetty region only. Here, the major contributors to vessel traffic were the fishing vessels, followed by cargo vessels and patrolling defence bodies (Marine police and Indian Navy).

On the contrary, Ritchie's Archipelago which receives highest tourist influx had the highest density of fishing boats, recreational boats (diving, game fishing and speed boats to popular beaches) and inter-island ferries. The southern region namely *Swaraj dweep* and *Shaheed dweep* are the only inhabited islands in the Ritchie's Archipelago and popular tourist destinations thus, the boat traffic is seen to be highest here. Grids inside RJMNP which showed low boat densities were a result of transit fishing vessels in the MNP. Similarly, in Wandoor, the density of boats was higher in grids outside the MGMNP, where fishing is permitted. Moderate boat density observed inside the MNP was due to boats localised around the jetty and tourist passenger boats to one of the Islands opened for tourism within MNP.

The density of floating plastic litter was observed to be low throughout the sampled area, with an exception of few grids having moderate density near Ritchie's Archipelago. As litter can be carried by surface currents, identifying exact point sources is an impossible task. The major concern in this matter is the fact that these items can also be carried by currents to the 'Protected Areas' or get settled in shallow seagrass meadows, which might be harmful for dugongs and other species, if consumed. As the major contributors to floating litter are items generated through tourism activities- food wrappers and plastic bottles- it is strongly recommended that strict actions be taken by the management authorities to reduce the generation of this waste (finding alternatives to packaged drinking water, plastic straws) and also proper disposal be carried out if these wastes are generated.

Through the present study, for the first time, threats to dugong population have been quantified, which not just spatially helps us to understand threats to dugongs and their habitats, but provides the intensity of these threats and in turn, highlights areas with strong need of management as well. Few of the habitats frequented by dugongs, happen to be popular tourist destinations in Ritchie's Archipelago. Recreational activities like operation of speed boats is a major concern as it poses the risk of collision with dugongs, not to mention the disturbance caused due to noise pollution. Such activities need to be regulated by the management authorities at the identified locations to avoid such incidences, which our study has successfully highlighted.

4.1.3 Habitat characterization of seagrass habitats in ‘Critical Dugong Habitats’

Duration: April to May 2018, March to May 2019, December 2019 to March 2020

Background and Objective:

Seagrass meadows form one of the most dynamic and productive ecosystems in the World known to inhabit tropical and temperate marine waters except Antarctica (Hemminga and Duarte, 2000). Habitat structural complexity of seagrasses acts as nesting, nursery and refuge grounds supporting rich biodiversity of macro-invertebrates and commercially important fishes (Jagtap et al. 2003). In addition, they form the only feeding grounds for threatened species like dugongs, which are exclusively marine herbivore and have abundant feeding requirement. In the Andaman and Nicobar archipelago, although studies have focused to understand seagrass distribution, ecology and herbivory, continuity in spatio-temporal studies is required to fill basic ecological gaps like distribution status from habitat conservation perspective. Further seagrass habitats are subjected to threats like coastal developmental activities and boat anchorage in the Islands, as response to growing settlements and tourism activities. These habitats are important feeding and nursery grounds but are vulnerable to natural (cyclones, tsunami) and anthropogenic stressors (coastal development), thus, for conservation of dugongs, it is crucial to understand and conserve these vulnerable habitats too.

In the present study, with an aim of filling distribution gaps of seagrass habitats in line with dugong conservation, we carried out exploratory surveys with following major objectives:

To study present seagrass distribution trends across protected and unprotected islands

To highlight important seagrass meadows of conservation importance, with respect to anthropogenic influence

Study area:

The present study was carried across 12 Islands in the Andaman group, out of which two are located in the North Andaman namely; Mayabunder (Pokkadera) and Interview island, six are located in the Ritchie’s archipelago on the Eastern coast of Island group viz; Swaraj Dweep, Shaheed Dweep, Sir Hugh Ross, Henry Lawrence, John Lawrence and Inglis; while remaining four are located on the Western coast in Mahatma Gandhi Marine National Park, Wandoor viz; Twins, Boat, Chester and Tarmugli.

Three of these 12 Islands namely Mayabunder (Pokkadera), Swaraj Dweep and Shaheed Dweep are unprotected and habited in status, while the remaining nine are protected either as a part of marine national parks (MNP) or wildlife sanctuaries (WLS) viz; Henry Lawrence, John Lawrence, Inglis as a part of Rani Jhansi Marine National Park (RJMNP), Sir Hugh Ross (WLS), Interview (WLS) and Chester, Boat, Tarmugli and Twins as a part of Mahatma Gandhi Marine National Park (MGMNP).

Methodology:

From March 2018 to March 2020, intertidal (on foot) and sub tidal (using SCUBA diving) meadows across 12 Islands were surveyed to assess the habitat characteristics of seagrasses. After exploring and locating a meadow, Line Intercept Transects (LIT) methodology was used to document seagrass meadow characteristics such as meadow depth, species composition, total seagrass percentage cover, shoot density and

The LIT's were 50m long and at each site three replicates were taken spaced apart at 150-200m (n=45). On this transect line at every 5m; a 50 x 50 cm quadrat was used to record meadow characteristics. For biomass, shoot density and shoot length estimation three samples (from 0m, 25m and 50m on the transect line) were collected using a 20 X 20 cm quadrat area within the larger (50 x 50cm) quadrat of one shoot length, total biomass (above and below ground, dry weight) and non-epiphytic algal cover using McKenzie and Yoshida (2012). LIT.

Results:

Total 11 species belonging to six genera were recorded from the present study viz; *Halophila beccarii*, *H. decipiens*, *H. ovalis*, *H. minor*, *Halodule uninervis*, *Halodule pinifolia*, *Enhalus acoroides*, *Syringodium isoetifolium*, *Cymodocea serrulata*, *Cymodocea rotundata* and *Thalassia hemprichii*.

The seagrass meadows reported were either monospecific beds of *Halophila ovalis* (Interview, Chester and Twins), *Halodule pinifolia* (Inglis) or of mixed species meadows of two (John Lawrence, Sir Hugh Ross, Tarmugli, Boat) or more species up to five being the highest (Table 4.2).

Highest number of species (n=5) was recorded from Shaheed Dweep Island and Henry Lawrence in the Ritchie's archipelago whereas the lowest (n=1) monospecific beds were found in four of the protected Islands (Figure 4.39).

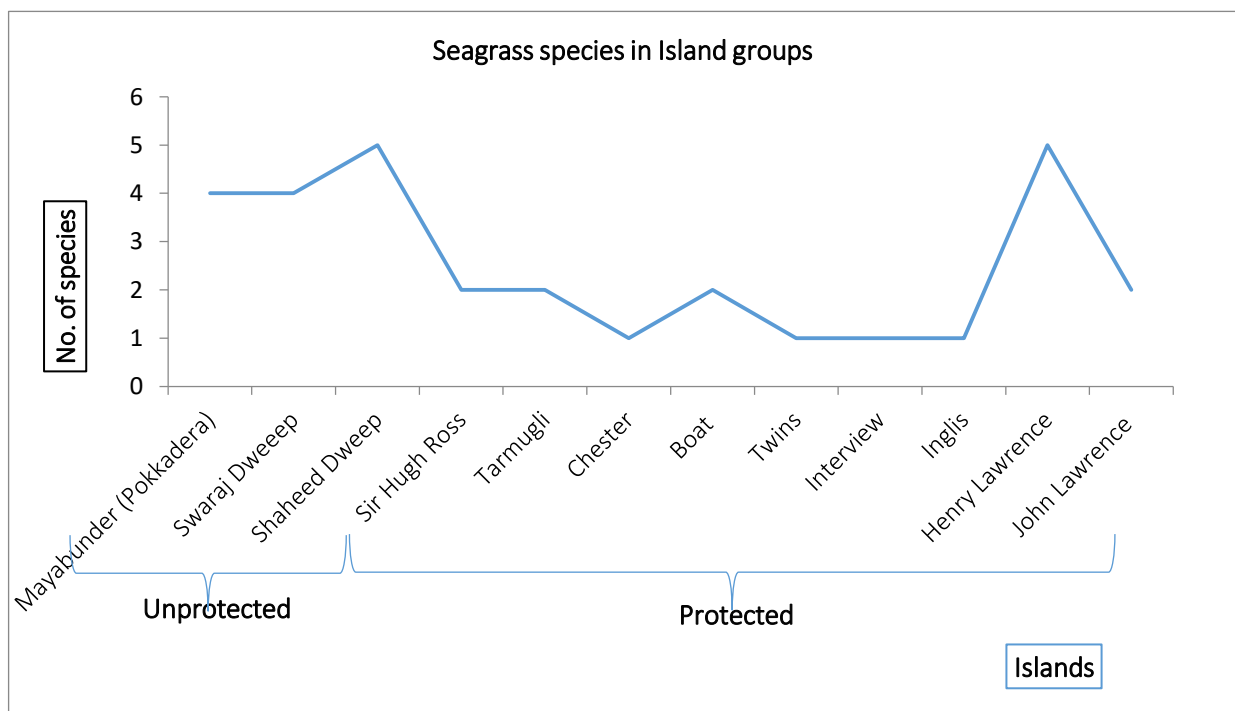


Figure 4.39: Species richness of seagrasses recorded at each sampled island of Andamans.

Factors affecting seagrass distribution:

Depth:

Six of the 11 species were intertidal in distribution recorded from a depth of 2m, while the genus *Halodule* sp. was restricted to shallow waters (up to 7m). The genus *Halophila* sp. showed a diverse depth wise distribution pattern, as *Halophila beccarii* was recorded from intertidal region (2m) whereas *Halophila decipiens* from around 16m (Figure 4.40).

Substratum:

The seagrass habitats were majorly characterised by six major categories of substrata namely: sand (sn), rubble (ru), dead coral (dc), live coral (lc), sand mixed with rubble (sn-ru) and rock (rk) (Figure 4.41). All the seagrass species preferred either a complete sandy substratum or sand interspersed with rubble. The substratum composition was observed to change with respect to depth, where intertidal habitats were mainly a mixture of either coarse or fine sand, along with rubble, rocks and corals (live/ dead).

Intertidal species: Within the intertidal habitats, a micro habitat preference was seen by seagrass species, as *Cymodocea rotunda* and *Cymodocea serrulata* were always found in extremely fine, silty-sand as opposed to other species. *Thalassia hemprichii* was the only species to occupy mixed substratum habitats was found distributed in coarse sediments. *Enhalus acoroides* and *Syringodium isoetifolium* preferred coarse sand dispersed in rocks and rubble. The only species of genus *Halophila*, *H. beccarii* was found in muddy sandy substratum.

Sub tidal species: Even though the sub tidal habitats were majorly characterized by sand and corals, the texture of the sand changed with increase in depth (pers. obsn.). Shallow sub tidal regimes where *Halodule pinifolia* and *Halodule uninervis* were distributed were dominated by fine sand sometimes with muddy texture. *Halophila ovalis*, *Halophila minor* and *Halophila decipiens* were found in moderately coarse to fine sediment.

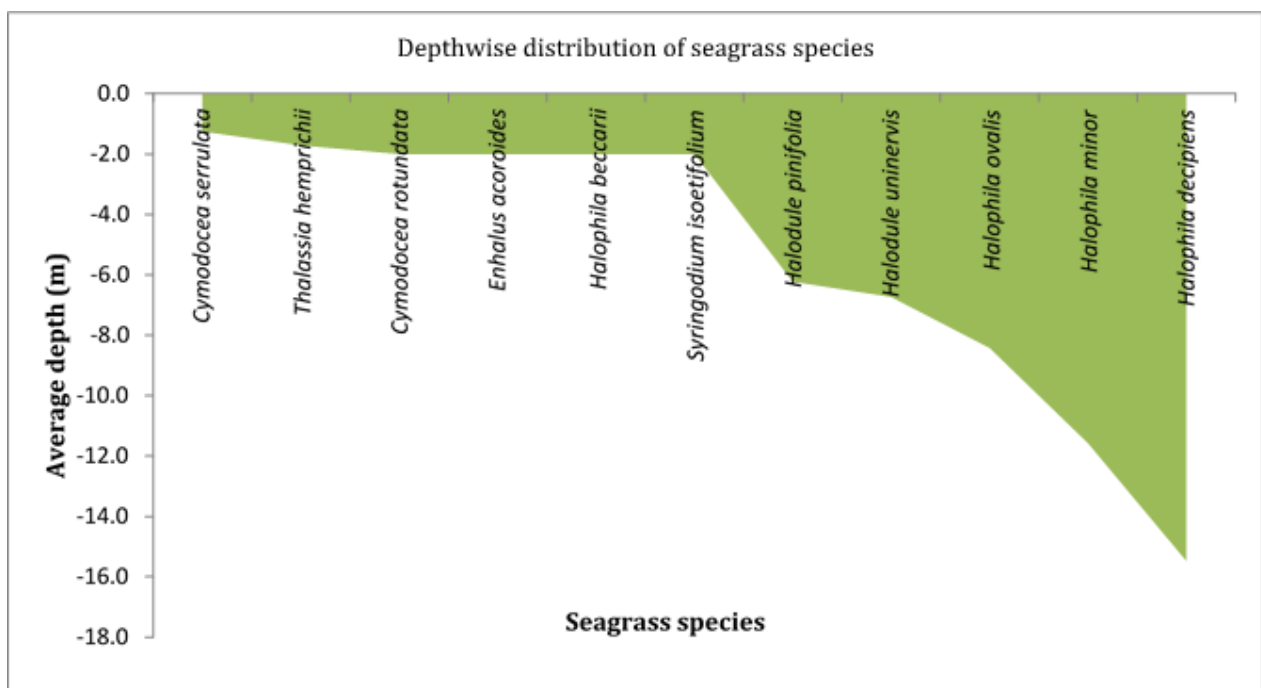


Figure 4.40: Depth wise distribution of seagrass species from each sampled island of Andamans.

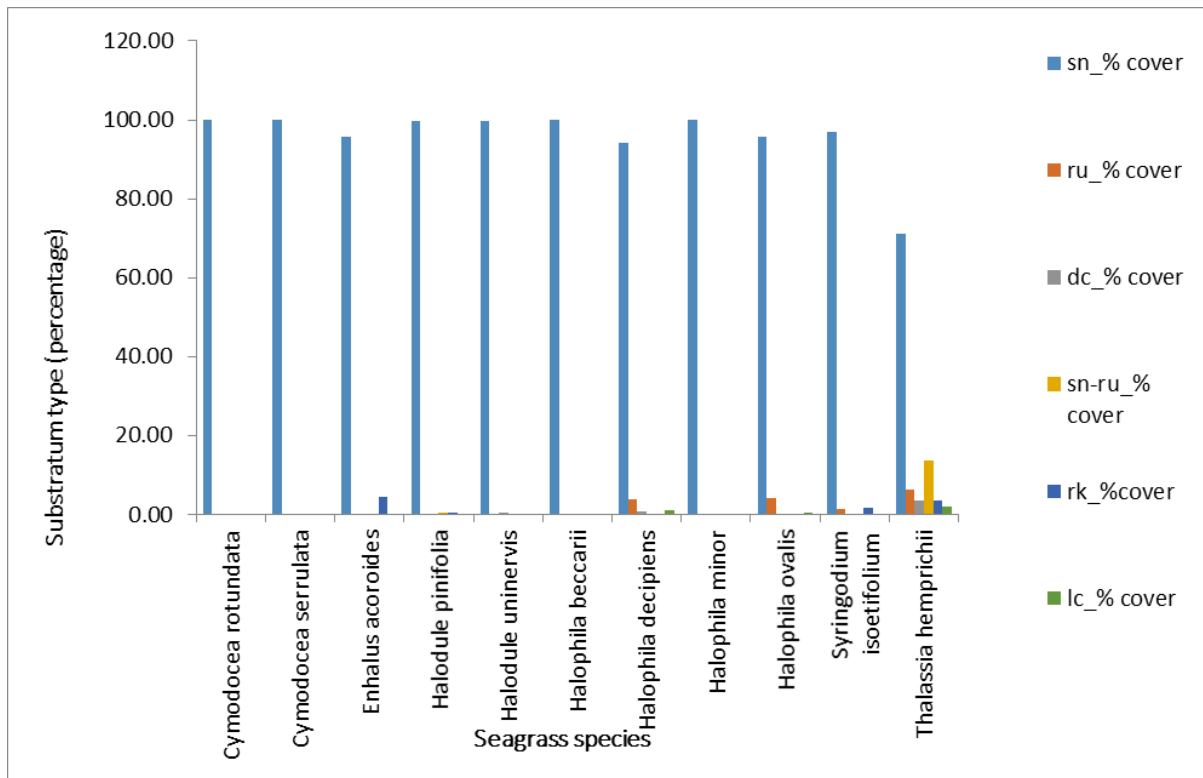


Figure 4.41: Graph showing substratum preferred by seagrass species (sand: sn, rubble: ru, dead coral: dc, live coral: lc, sand mixed with rubble: sn-ru and rock: rk) at meadows of Andaman Islands.

Seagrass distribution and meadow characteristics across the Islands:

Highest total percentage seagrass cover was 56.1 ± 36.6 (%) recorded for a mixed species meadow at Henry Lawrence in RJMNP whereas the lowest cover was recorded from Chester in MGMNP, from a monospecific meadow of *Halophila ovalis* (1.5 ± 2.7 %). Seagrass cover was found to be high in shallow waters and decreased towards deeper regimes (Figure 4.42). Shoot density (870.6 ± 131.9 / m^2) and total biomass (28.2 ± 7.3 gm / m^2) was highest for unprotected island; Swaraj dweep while lowest shoot density was recorded from Interview Island in the North Andaman (150 ± 10.4 / m^2). Canopy height was the highest at Inglis island of *Halodule pinifolia* (7.9 ± 1.5 cm) whereas it was the lowest at John Lawrence (1.4 ± 0.5 cm) for *Halophila* sp. Algal cover was the highest at John Lawrence in RA (77.8 ± 33.6 %) (Table 4.2).

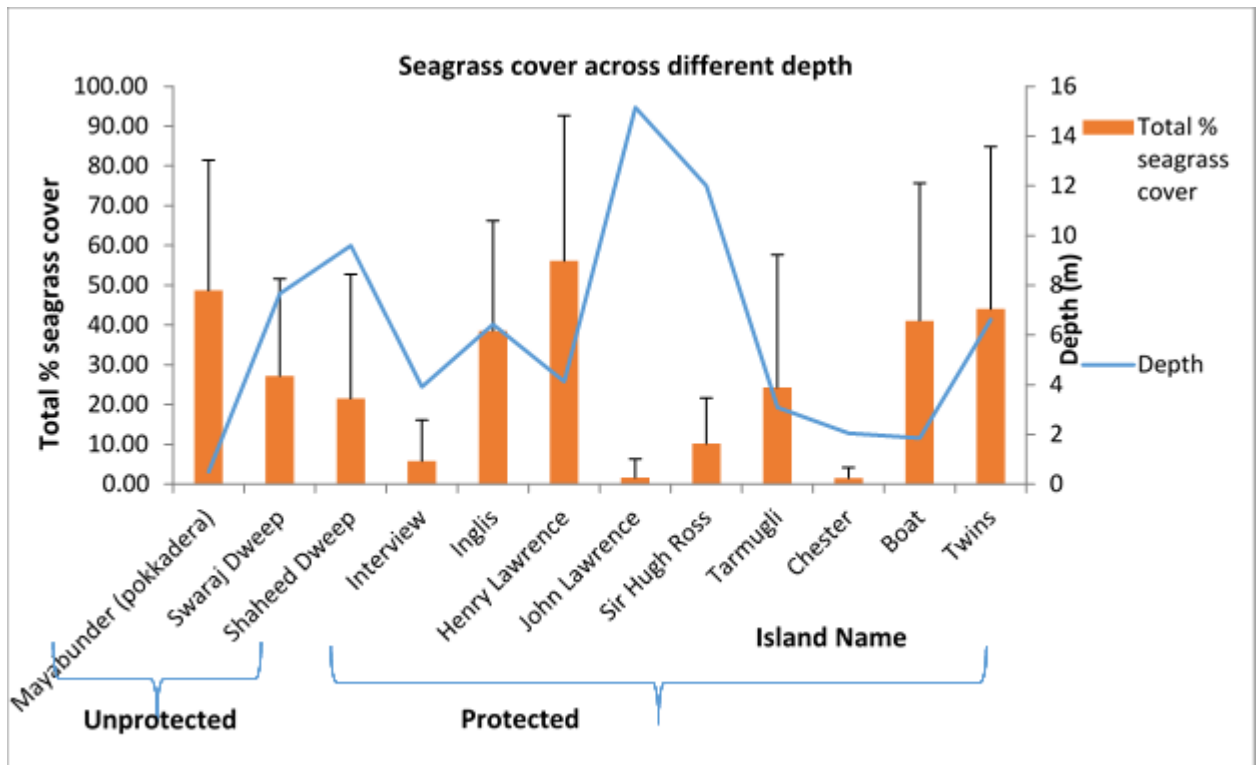


Figure 4.42: Changes in percentage seagrass cover according to depth across the sampling sites in Andaman Islands.

Table 4.2: Table showing Island specific seagrass meadow characteristics across study sites of Andaman Islands

Sn	Island name	Protection status	Species composition	Average depth (m)	Total % seagrass cover	Density (/m ²)	Total biomass (dry wt- gm/m ²)	Canopy height (cm)	Non epiphytic algal cover (%)
1	Mayabunder (Pokkadera)	Unprotected	<i>Halophila beccarii</i> , <i>Cymodocea rotundata</i> , <i>Thalassia hemprichii</i> , <i>Halodule pinifolia</i>	0.5	48.7 ± 32.8	334.3 ± 274.9	28.1 ± 224	5.3 ± 2	23.3 ± 38.1
2	Swaraj Dweep	Unprotected	<i>Cymodocea serrulata</i> , <i>Thalassia hemprichii</i> , <i>Halodule uninervis</i> , <i>Halophila minor</i>	7.7	27.2 ± 24.5	870.6 ± 131.9	28.2 ± 7.3	5.1 ± 3.8	33.1 ± 35.1
3	Shaheed Dweep	Unprotected	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i> , <i>Halophila decipiens</i> , <i>Halodule uninervis</i> , <i>Halodule pinifolia</i>	9.6	21.5 ± 31.2	378.9 ± 60.6	20.04 ± 13.1	6 ± 2.3	18.1 ± 31.3
4	Interview	Protected	<i>Halophila ovalis</i>	3.9	5.8 ± 10.3	150 ± 10.4	11	10	9.1 ± 30.2
5	Inglis	Protected	<i>Halodule pinifolia</i>	6.4	38.55 ± 27.7	241.7 ± 8.7	12.8 ± 0.4	7.9 ± 1.5	0
6	Henry Lawrence	Protected	<i>Halophila ovalis</i> , <i>Halophila minor</i> , <i>Thalassia hemprichii</i> , <i>Enhalus acoroides</i> , <i>Syringodium isoetifolium</i>	4.1	56.1 ± 36.6	422.5 ± 100.9	20.1 ± 10.9	4.9 ± 0.7	22.6 ± 39.1
7	John Lawrence	Protected	<i>Halophila decipiens</i> , <i>Halophila ovalis</i>	15.2	1.6 ± 4.7	283.3 ± 17.7	6.4 ± 0.2	1.4 ± 0.5	77.8 ± 33.6
8	Sir Hugh Ross	Protected	<i>Halodule pinifolia</i> , <i>Halophila ovalis</i>	12.0	10.2 ± 11.5	241.7 ± 8.7	8.5	3.3 ± 2.7	1.8 ± 4.1
9	Tarmugli	Protected	<i>Thalassia hemprichii</i> , <i>Halophila ovalis</i>	3.1	24.2 ± 33.3	248.8 ± 29.5	20.7 ± 0.6	4.6 ± 2.1	7.3 ± 19.6
10	Chester	Protected	<i>Halophila ovalis</i>	2.0	1.5 ± 2.7	433.3 ± 15.0	12.2 ± 0.2	2.4 ± 0.1	0

Sn	Island name	Protection status	Species composition	Average depth (m)	Total % seagrass cover	Density (/m ²)	Total biomass (dry wt-gm/m ²)	Canopy height (cm)	Non epiphytic algal cover (%)
11	Boat	Protected	<i>Halodule uninervis</i> , <i>Halophila ovalis</i>	1.9	41.1 ± 34.6	295.8 ± 76.6	10.3 ± 5.6	4.0 ± 2.5	0
12	Twins	Protected	<i>Halophila ovalis</i>	6.6	44.0 ± 40.8	362.5 ± 0.7	12.6 ± 0.2	2.6 ± 0.4	0

Seagrass distribution and meadow characteristics across unprotected and protected islands:

In the study period, total seagrass cover was found to be more spread out from sparse to moderate in the protected islands than the unprotected islands, where the cover was moderate (Figure 4.43). Range of shoot density was quite high in the unprotected meadows as compared to less shoot density observed in the protected meadows (Figure 4.44). Total biomass did not show much considerable difference between both the island groups; whereas canopy height and non-epiphytic algal cover range was much pronounced in the protected Island group (Figure 4.45, 4.46 and 4.47).



Figure 4.43: Comparison of percentage seagrass cover across protected and unprotected seagrass meadows of Andaman Islands

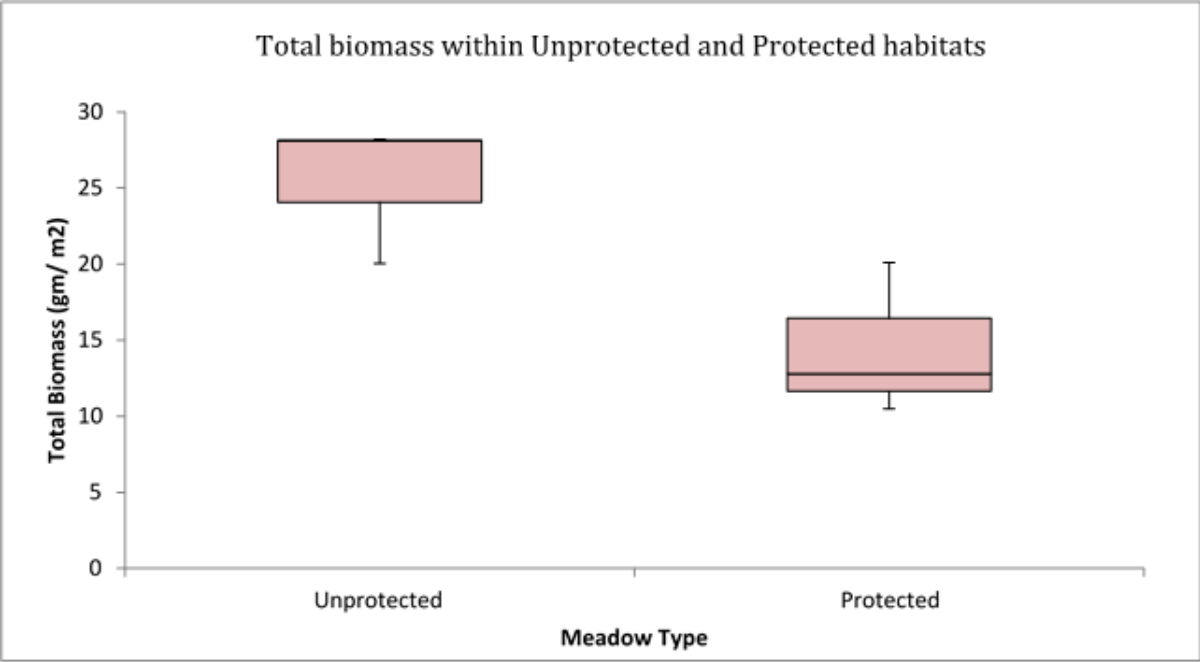


Figure 4.44: Comparison of seagrass shoot density across protected and unprotected seagrass meadows of Andaman Islands

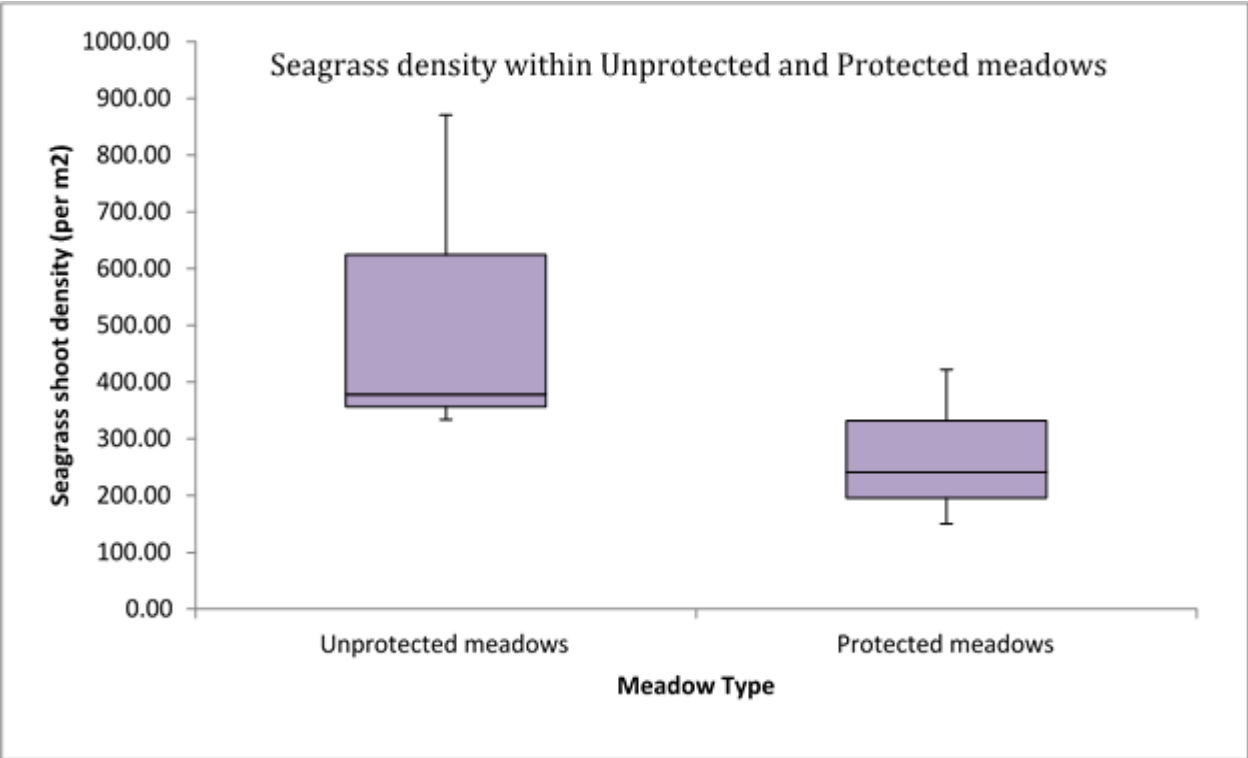


Figure 4.45: Comparison between biomass of seagrasses across protected and unprotected meadows of Andaman Islands.

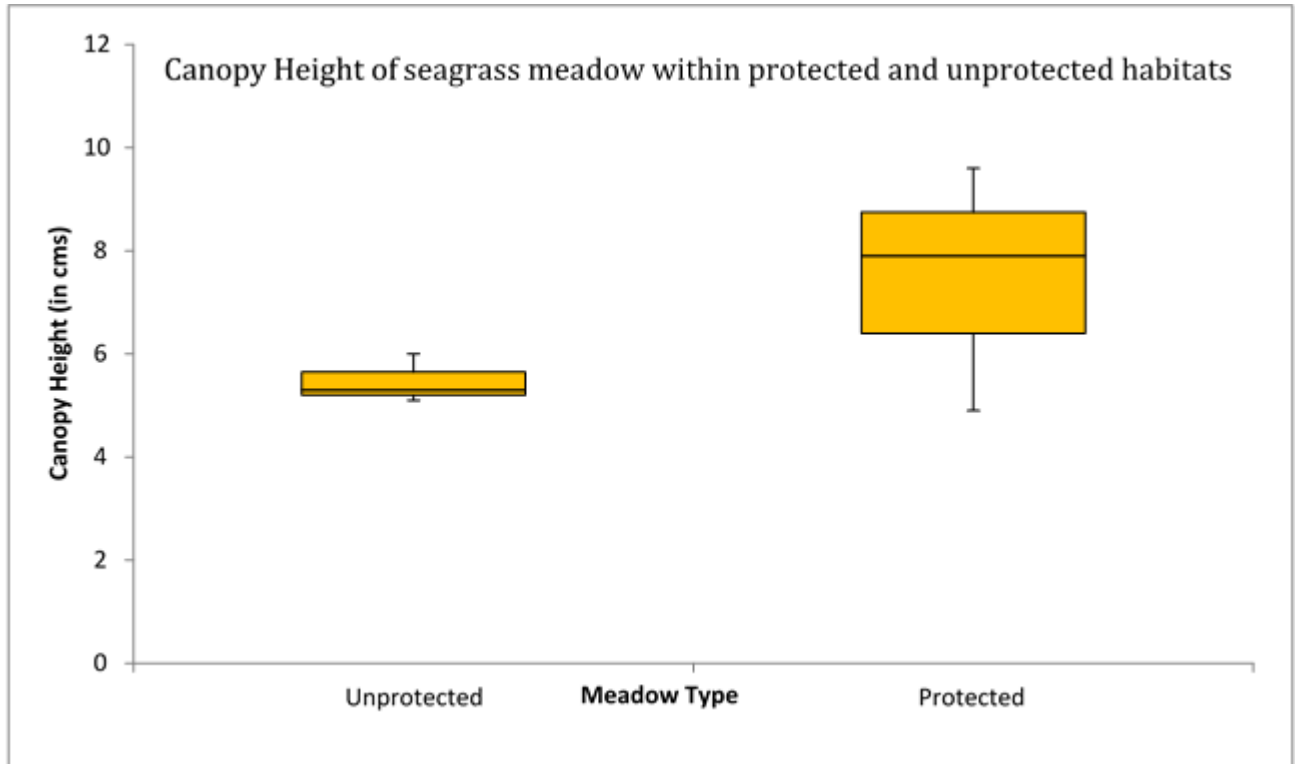


Figure 4.46: Comparison of seagrass canopy height between protected and unprotected meadows of Andaman Islands

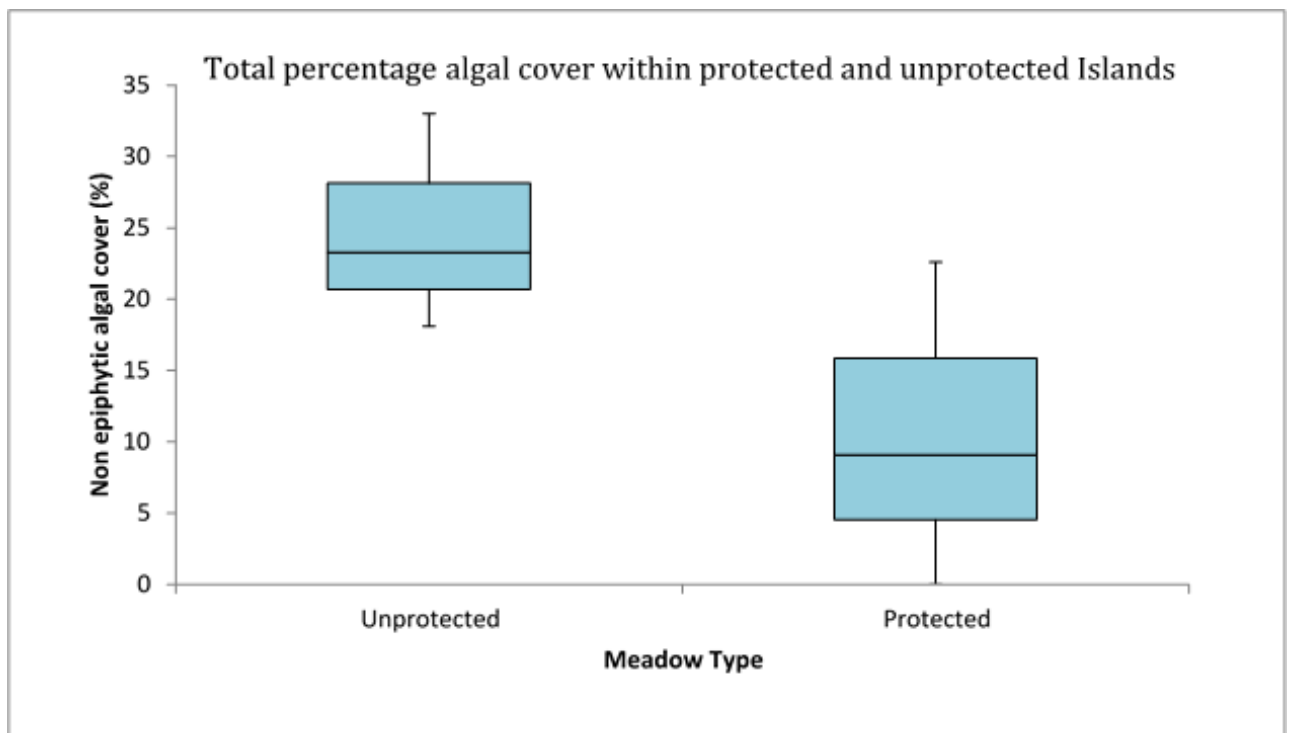


Figure 4.47: Comparison between percentage algal cover (non- epiphytic) across protected and non-protected meadows of Andaman Islands.

Discussion:

Depth is a regulating factor in seagrass species distribution, as each species has different growth requirements (such as light, nutrients and substratum) and its availability differs with depth. An intertidal region generally is characterized by heavy wave action, tidal fluctuations, over exposure to sun leading to desiccation and constant change in the physico-chemical parameters thus, limiting seagrass species distribution. On the other hand, a sub-tidal space means low availability of light and nutrients; and favors generalist species with no specific requirements for growth.

In the present study, we recorded late successional species like *Cymodocea* sp., *Thalassia hemprichii*, *Enhalus acoroides* and *Syringodium isoetifolium* from the intertidal habitats as these species are aided with a strong root system to withstand tidal fluctuations and anchorage in coarse sediments (Tussenbroek et al. 2006). Even within these habitats, a micro scale distribution pattern was observed where species like *Cymodocea* sp. occupied only finer sandy sediments might be due to a weaker root system than other species. *Halophila beccarii* was present in muddy-sandy substratum in line with previous observations of the species (Waycott et al. 2004). *Halodule* sp. and *Halophila* sp., both preferred by dugongs are early successional species, and were distributed in the sub-tidal waters. Genus *Halophila* known to be generalist in growth requirements was found at all depth regimes.

Change in seagrass cover with respect to depth could be due to species composition and lower availability of light at deeper regimes. All intertidal species recorded in the present study are known for colonization of a meadow, thus contributing to more cover at shallow depths, a characteristic of late successional species. Maximum shoot densities and biomass recorded from unprotected Swaraj Dweep Island could be due to vast intertidal regions in the islands and mixed substratum type, favouring a greater number of species. Seagrass meadows at John Lawrence had highest algal cover perhaps due to the inter-island shipping route which passes adjacent to the island. Ferry ships while passing might be causing consistent turbulence in the water column, and in turn affecting the turbidity and nutrient mixing to support algal growth.

Our study highlights the importance of unprotected seagrass meadows of tourism hotspots like Swaraj dweep and Shaheed dweep which harbour mixed species dense meadows, but are presently under anthropogenic pressure through coastal development, pollution and boat anchorage. Further, the importance of seagrass meadows as important dugong habitats is highlighted with strong frequency of dugongs sighted from Shaheed dweep and Swaraj dweep. Despite these pressures, the seagrass beds in the unprotected islands show luxuriant dense growth and diversity, as there was no considerable difference between meadow characteristics within protected and unprotected meadows, which attracts attention from policy makers.

4.1.4 Assessing seagrass associated faunal assemblages:**Seagrass associated Fish assemblages:**

Duration: April to May 2018 and February to March 2020

Background and Objectives:

Seagrass meadows are crucial habitats for associated faunal groups like fishes, as they provide refuge and act as foraging and nursing grounds for fishes. Fish assemblages form an

integral part of the seagrass ecosystem and are known to play an important role in structuring the seagrass community through herbivory (Scott et al. 2018). Studies have also shown that presence of herbivorous fishes helps keep epiphytic growth on seagrasses, in check, which helps build resilience of seagrass meadows (Campbell, Kartawijaya, and Sabarini 2011). Studies on fishes associated with seagrass meadows in the islands have mainly focused on providing checklists, thus, there is a major research gap in understanding the role of fishes in these meadows. Understanding the diversity and behaviour of fishes can provide more insights into the health and functionality of the seagrass meadows. Through our present study, we aim to fill these gaps in highlighting importance of seagrasses as crucial habitats to the associated fauna, beyond mega herbivores.

Objective:

To compare between and standardize appropriate methods to study fish fauna associated with seagrasses.

To assess the diversity and habitat use patterns of fish fauna associated with seagrass meadows.

Study site

The surveys were conducted at Shaheed dweep (n=2), Swaraj dweep (n=1) and Henry Lawrence Island (n=1).

Methodology:

In 2018, the focus of the surveys was to standardize method to study fishes associated with seagrasses. Two underwater visual census techniques were selected for this purpose- belt transects and point count transects. 14 belt transects and 8 point intercept transects were conducted at 9 meadows across Ritchie's archipelago. For the belt transects, the observer swam at a slow speed (2.5m/ min) approximately 1.5-2 m above substrate at each transect of 50 m length and 4 m width. Point intercept transects consisted of 6 points of a fixed radius of 5 m located adjacent to each other on a 50 m transect keeping 10 m distance between centres of adjacent circles. The observer hovered 2 m above the centre of the point for 10 minutes. Fish species, number of individuals, distance from the observer and their activity at the meadow was noted down. Further, during analysis, all the fish species were classified into guilds based on their feeding habits and preferred habitat/ substrate (sand/rock/coral) to understand the nature of assemblage and reasons for presence in the meadow.

As it was noticed that belt transects were of less use to spot and identify cryptic species in the meadows, in 2020, only point counts (variable radius) were conducted. Four meadows were sampled, which were selected on basis of their sea grass cover percentage and seagrass species richness to understand changes in fish assemblages across the gradient of these two parameters. Fish species, number of individuals, distance from the observer, their affinities to seagrass/corals or the substrate (sand/rock) and their activities were noted at each point for 10 minutes. Further, since presence of observers, might influence/ disturb activities of fishes, giving a bias in the results, video cameras were set on a tripod at a distance in the seagrass meadow, as a control point, to record the fish activities in absence of observers. Video of continuous 60 minutes were recorded at each meadow. Comparison between human observer point counts and video capture will help us understand change in fish behaviour in presence and absence of observer, if any.

Results:

In 2018, we observed fish from 28 genera belonging to 14 families by belt transects and 27 genera belonging 17 families by point counts.

Diversity indices did not indicate any difference between the two sampling methods. Fish diversity documented by these two methods also shows similar evenness in composition (Table 4.3)

Table 4.3: Diversity indices for fish families recorded during belt count and point count transects in Andaman Islands

	No. of Families	Simpson's Index	Shannon index	Evenness
Belt transect	14	0.7764	1.759	0.4147
Point count	17	0.7828	1.916	0.3995

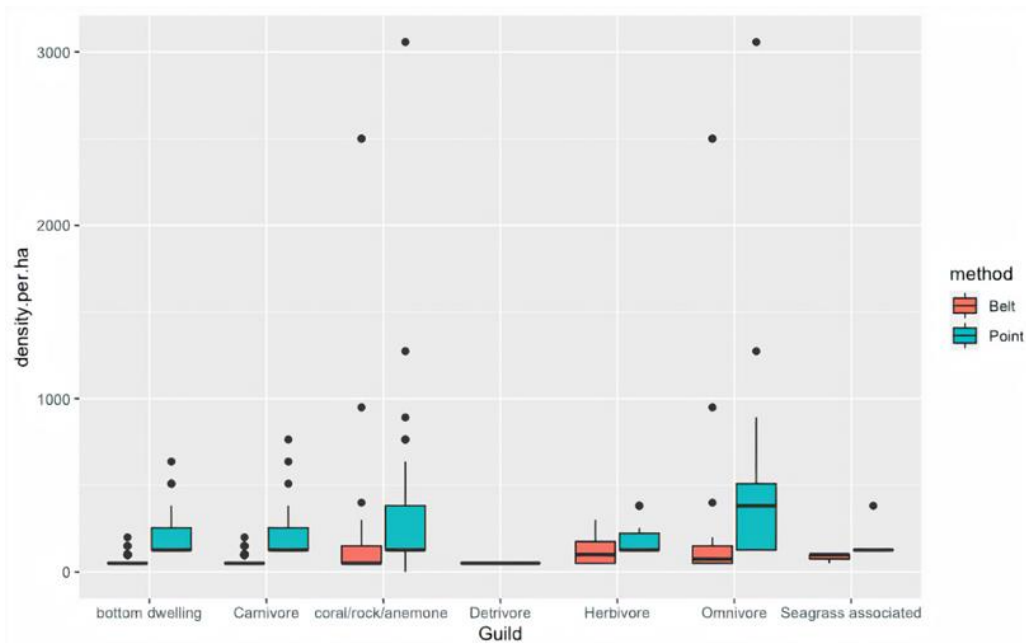


Figure 4.48: Guild wise fish densities observed by belt and point counts in sampled sites in Andaman Islands

It was observed that density of coral/ anemone associated fish was the highest (239.15 ± 429.07 Indi/ha) as compared to other habitat guilds (Figure 4.48). The densities of omnivorous fishes were found to be highest (338.44 ± 568.47 Indi/ha) as compared to other feeding guilds (Figure 4.48).

A generalized linear model was performed to understand which parameters might be contributing to changes in fish densities. A significant positive effect of live coral cover, rubble cover, sand cover and seagrass shoot density while the significant negative effect of algal cover and seagrass cover (Table 4.4) with AIC of 3998.3 was observed.

Table 4.4: Summary statistics of best of GLM (* denotes the significance of p-value) for fishes at Andaman Islands

	Estimate	Standard error	Z value	Pr(> z)
Intercept	-0.1550045	0.9652700	-0.161	0.87242
Algal cover	-0.0095586	0.0018222	-5.246	1.56e-07***
Dead coral cover	0.0170313	0.0112399	1.515	0.12971
Live coral cover	0.0990717	0.0217780	4.549	5.39e-06***
Rubble cover	0.1648107	0.0256438	6.427	1.30e-10***
Sand	0.0567878	0.0096417	5.890	3.87e-09***
Seagrass cover	-0.0305210	0.0043676	-6.988	2.79e-12***
Shoot density	0.0012441	0.0004678	2.659	0.00783**

In 2020, we found 54 species of fish belonging to 18 families. The fish density was highest at a meadow near Henry Lawrence Island (0.019 ± 0.012 Ind/m²) (Figure 4.49). Observed fish densities were found to be higher at meadows consisting of multiple seagrass species (fish density= 0.018 ± 0.011 Ind/m²) (Figure 4.50), and meadows with higher shoot length (fish density= 0.033 ± 0.02 Ind/m²) (Figure 4.51). It was found that seagrass cover percentage did not show any correlation with fish densities. Fishes were mostly observed to swimming through the meadow (52.3%) or in case of benthic species, found to be perched/ resting (41.8%) on the sea floor (Figure 4.52). Very few incidences of feeding were observed during the surveys. To avoid the influence of presence of observer in proximity of fishes, video transects can provide more insights into the activities of fishes in absence of observers. Analysis for the video transects is still in process.

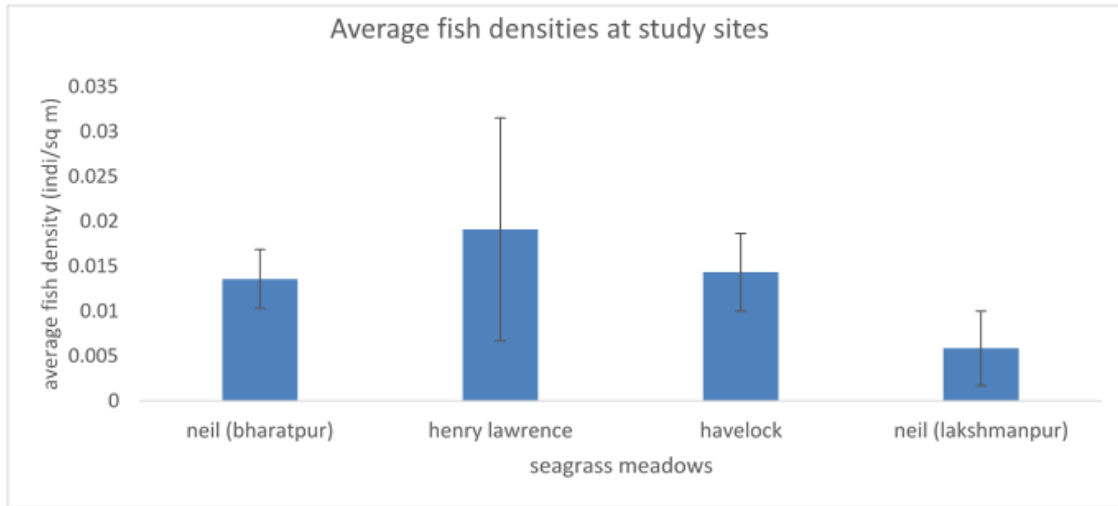


Figure 4.49: Average densities of fish across study sites of Andaman Islands

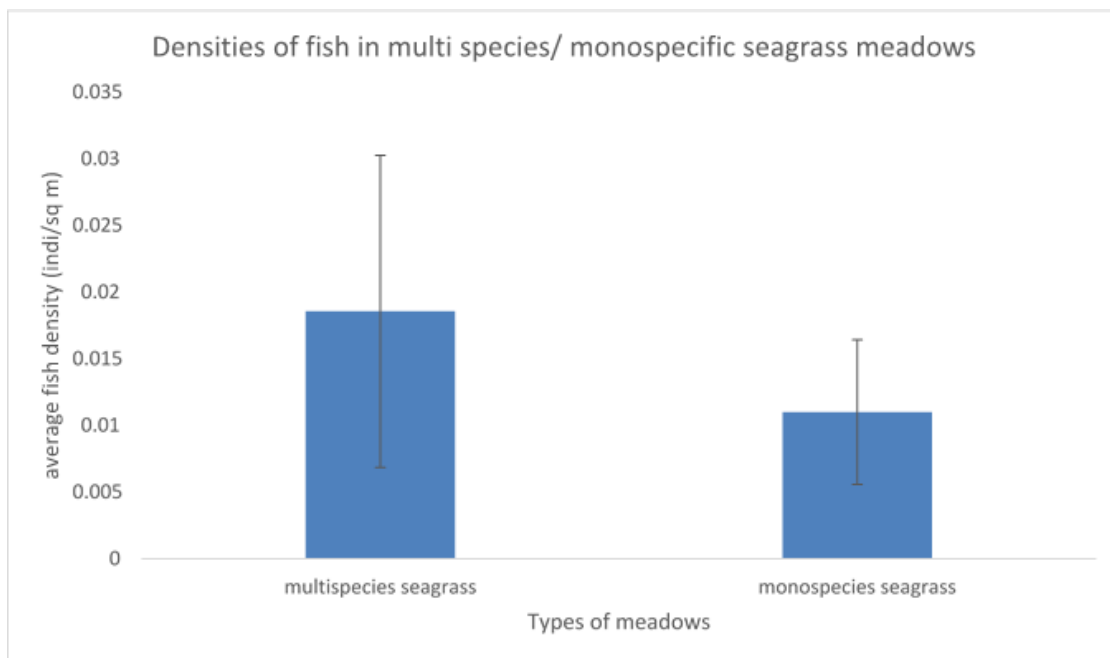


Figure 4.50: Comparison between fish densities across multi-species or monospecies seagrass meadows of Andaman Islands

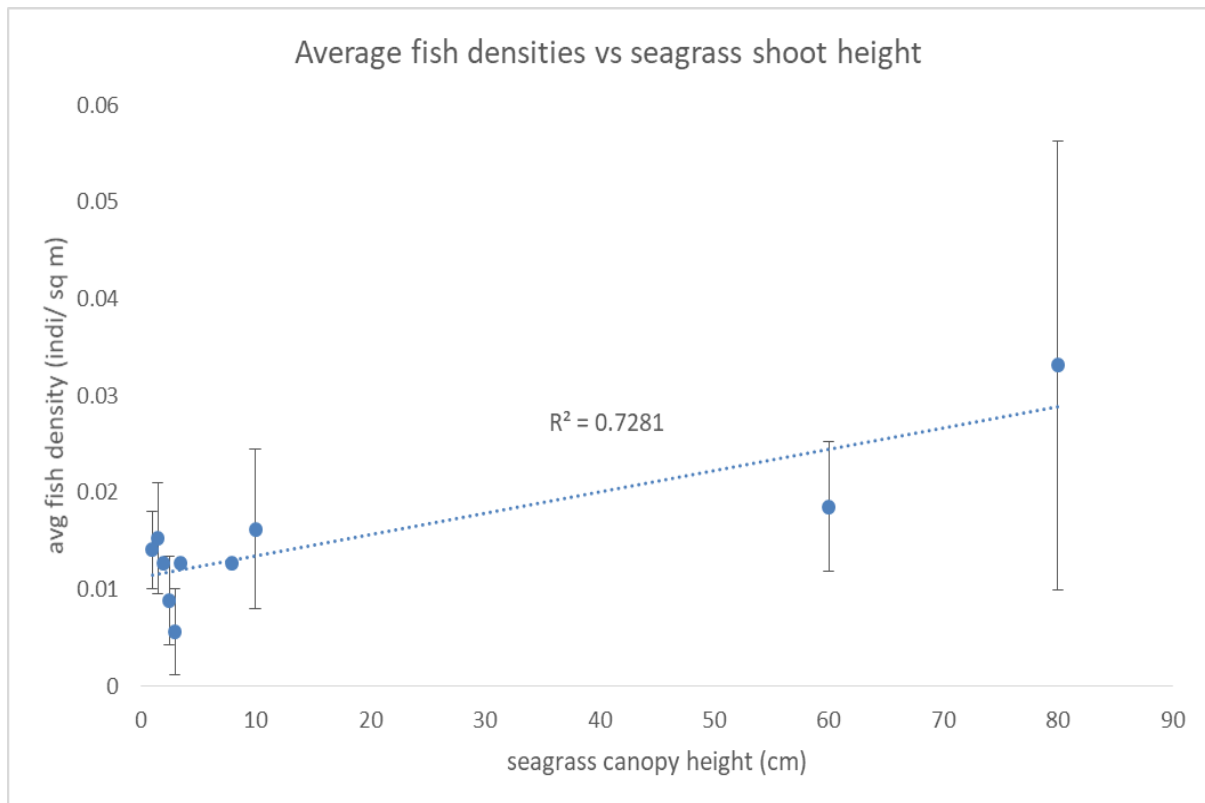


Figure 4.51: Correlation between average fish densities and seagrass shoot height across study sites in Andaman Islands

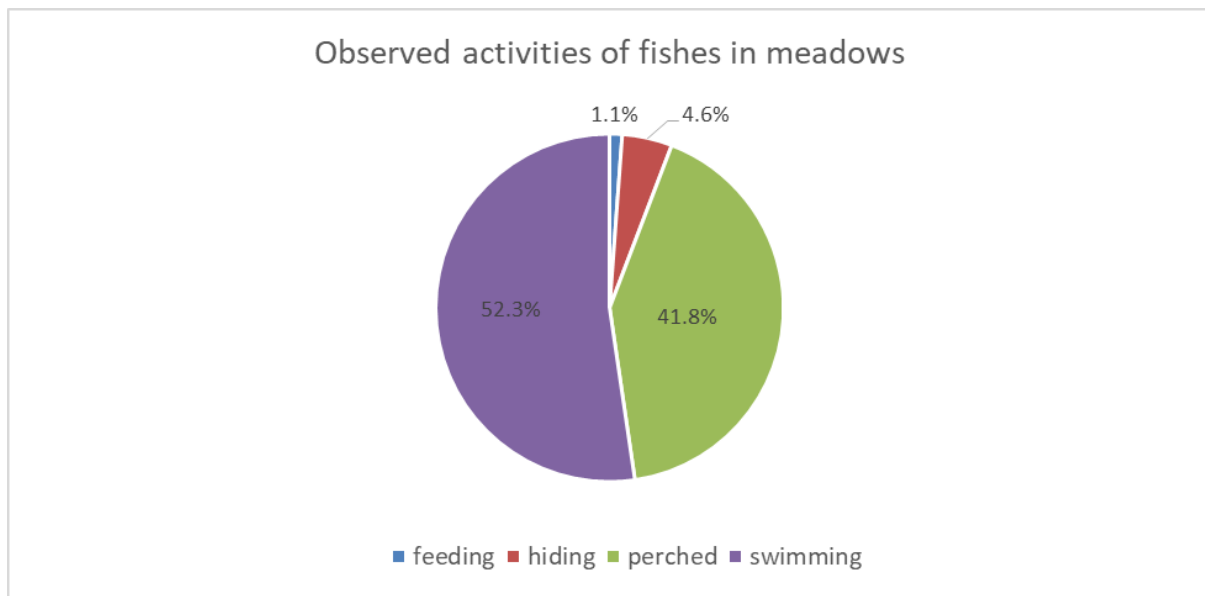


Figure 4.52: Percentage proportion of activities by fishes in seagrass meadows (data points n=86) of Andaman Islands



Figure 4.53: *Ctenogobiops maculosus* in *Thalassia hemprichii* meadow at Henry Lawrence Island in Andaman

Discussion:

Despite no significant differences observed in fish diversity and densities within belt and point transects, we suggest point count to be a more suitable method to study activities of fishes in seagrass habitats; as it allows better stability to spot cryptic species and document activities of fishes in seagrasses. Thus, the point count method was continued for the study in 2020. In addition, underwater video technique was also used for observing fish behaviour in meadows. Both the methods, point counts and video recordings proved to be appropriate to note certain aspects in studying the diversity and behaviour. While point counts (n=19) allowed better detection of smaller and seagrass mimicking fish species, video technique (n=5, 60 minutes each) provided better understand of fish behaviour in the meadow without being uninterrupted by presence of observers in vicinity.

According to the surveys conducted in both the seasons, it can be concluded that the complexity of the habitat played a major role in determining the diversity and density of fishes, may it be presence of corals/ anemones in the meadows or the seagrass characters like multiple species and higher shoot length. Possible reason for this to happen being the fact that habitat complexity can provide refuge to fish assemblages. As very few numbers of fishes were observed to be feeding on seagrasses, it can be concluded that the meadows in Ritchie's Archipelago majorly serve as refuge for fishes.

4.1.5 Use of UAV's in dugong conservation: Pilot drone testing to study dugongs in the Islands

Study period: June 2019 and January 2020

Background and Objective:

Aerial surveys are widely undertaken in the study of marine mammals globally, as they cover larger areas in a short duration and reduce the survey effort thus, making this approach cost effective. Drone surveys serve as an extremely useful tool for marine mammal distribution and population studies, especially for species thriving in shallow coastal waters like dugongs. Dugongs being marine herbivores spend most of the time feeding on seagrasses in coastal waters and surface every 5-6 minutes, making their detectability using drones much easier, as compared to oceanic marine mammals which dive for longer intervals in deep seas.

Manned aerial surveys using aircrafts have been widely used throughout dugong distribution ranges, to estimate populations (Marsh and Sinclair 1989a, b, Marsh 1995, Miller et al., 1998) or understand distribution trends and habitat use patterns (Anderson 1985). Unmanned aerial surveys using drones have been effective like manned aerial surveys and are excellent tools for monitoring rare and elusive marine species. Unmanned Aerial Vehicles have been used to study dugongs (Hodgson et al. 2013), manatees (Landeo-Yauri et al 2020) and dolphins (Fettermann et al 2019). But a similar approach is lacking in Indian waters, due to cost associated with such surveys and logistics. Further, unlike their Australian counterparts, dugongs in Indian waters exhibit fragmented population, distributed in pockets, with no solid population estimates given till date. In such scenario, where boat based detection of dugongs is rare due to low population, drones can prove to be extremely useful in filling major research gaps in dugong research. With this approach, we carried out a pilot testing of drones in South Andaman with the following objectives:

Standardise methodology to perform drone based surveys for detection of dugongs

Carry out pilot surveys in critical dugong habitats in the South Andaman, to check for dugong detection probability

Study area:

Aerial surveys were conducted across five sites in the South Andaman Islands which were earlier identified as Critical Dugong Habitats (CDH) by Sivakumar and Nair (2013). Two important CDH's were selected for the pilot studies viz; the Rani Jhansi Marine National Park (RJMNP) in the Ritchie's archipelago (RA) and the Mahatma Gandhi Marine National Park (MGMNP) in Wandoor. Besides these primary protected sites, few other unprotected sites around RA and Wandoor were chosen randomly namely Swaraj Dweep, Shaheed Dweep and Chidiyatapu.

Methods:

The Unmanned Aerial Vehicle, DJI Mavic Pro was used for the surveys. The areas for sampling were selected based on 1) literature review which highlights habitats with dugong presence, 2) sightings reported by informants of 'Dugong Monitoring Network' of the CAMPA-Dugong Project, and 3) stranding records given by the forest department.

Aerial surveys with random aerial scan sampling were undertaken to detect dugongs. The altitude for the surveys varied between 80 to 120 m and speed of the UAV was kept constant

at ~35 km/h. Necessary permissions were procured from the state forest department and all flights were undertaken from forest land, while accompanied by forest department personnel.

Results:

A total of 31 flights were undertaken using the UAV- DJI Mavic 2 Pro with a total flight time of 570 minutes and average flight time of about 18 minutes.

Total 11 flights were undertaken inside both the Marine National Parks (MNP's), out of which five flights were in RJMNP and six in MGMNP, with a total flight time of 211 mins. Another 20 flights were undertaken in different forest areas of South Andaman including Chidiyatapu, Swaraj Dweep and Shaheed Dweep islands with a total flight time of 359 mins. The flight paths and detection are depicted in (Figure 4.53).

Encounter rate based on total flight time of dugongs was calculated, one dugong detection per 142.5 mins of aerial survey effort. Dugong detection within the limits of the protected areas of marine national park was one detection per 52.75 mins as all encounters were within the marine national park.

Total four times, dugongs were detected throughout the study period, all within the protected areas of MGMNP (n=1) and RJMNP (n=3), out of which once mother and calf pairs were sighted in each of the MNP's.

No dugongs were detected outside the marine national parks but the UAV was successful in detecting a wide range of species like eagle rays, squids, sea turtles, needle fish, zebra shark, sting rays, and shoals of fish. Threats to dugong populations like marine litter, floating buoys, fishing boats and boats used for recreational activities like scuba diving and game fishing were recorded during the survey effort (Figure 4.54)

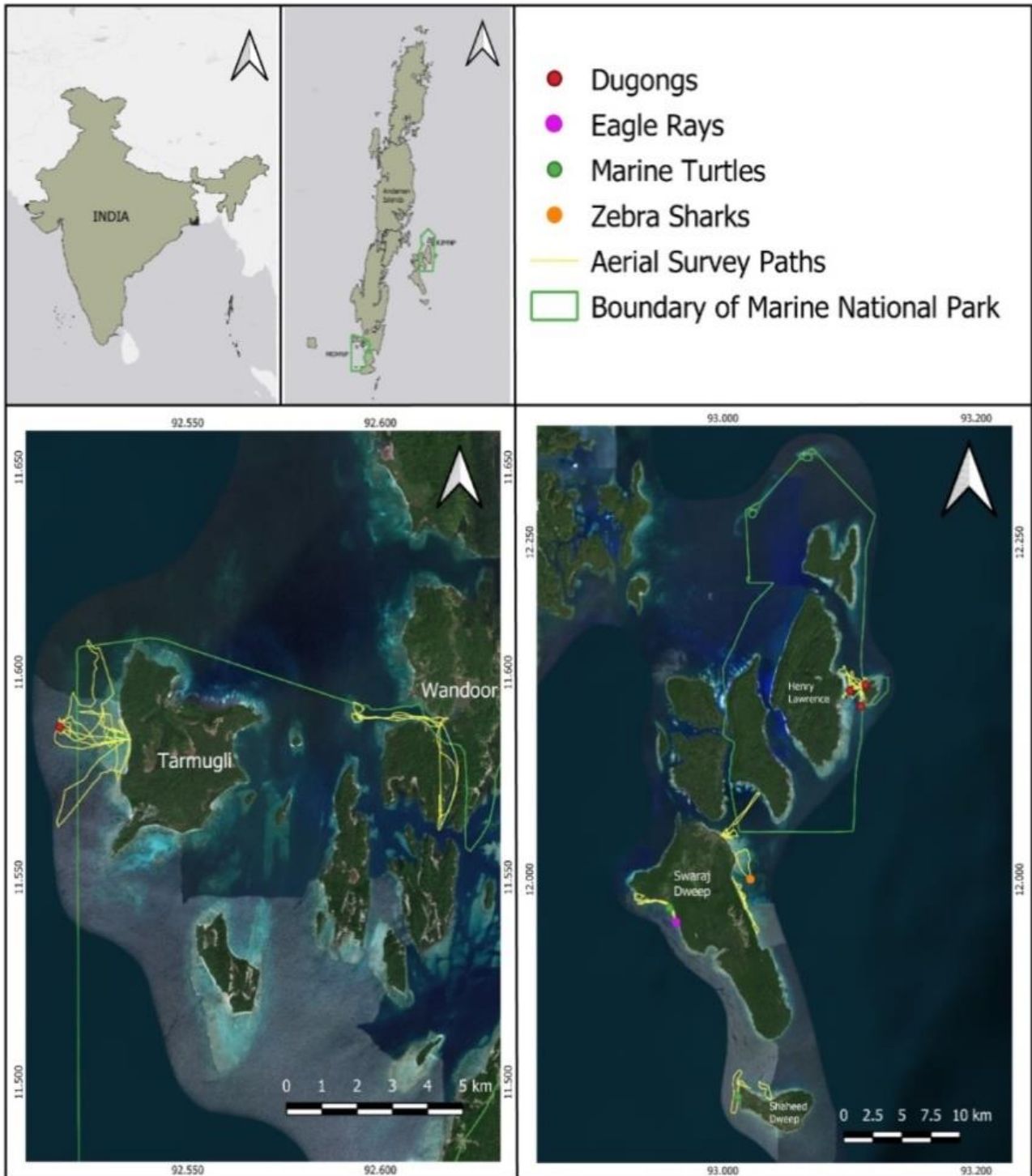
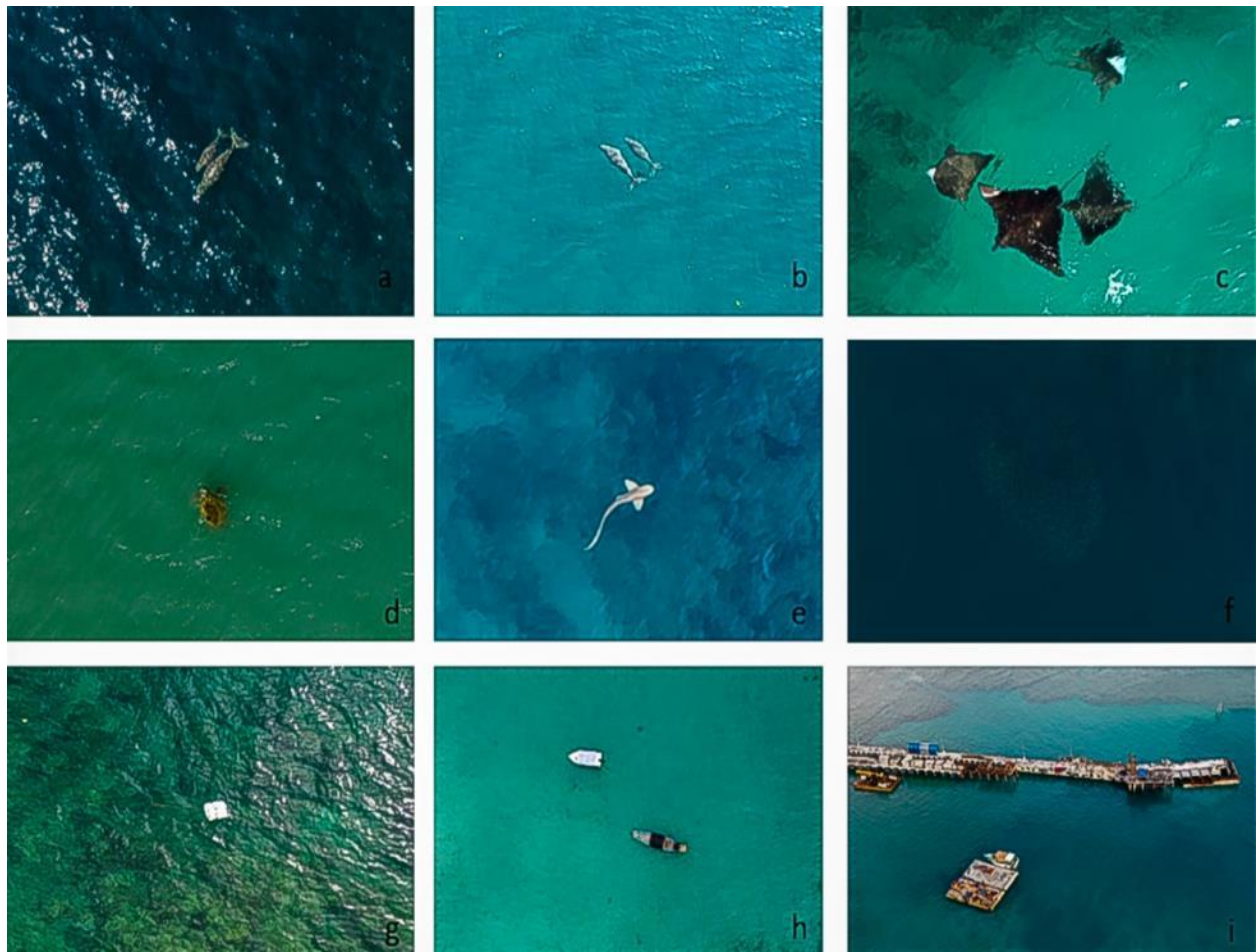


Figure 4.53: Map of Aerial Surveys and detections in Marine National parks of Andaman Islands

Our study being first of its kind is indicative that light weight UAVs can be used as an effective tool to monitor vulnerable dugong populations and threats in the coastal marine habitats in the Islands.



**Figure 4.54: Images of marine life captured through drone during surveys in Andaman Islands
a, b - Pair of dugongs, c - Spotted eagle rays, d - Marine turtle, e - Zebra Shark, f - Shoal of fish, g-
Floating buoy, h- Fishing boats, i -Jetty and dredging platform**

4.2 Awareness and Capacity Building

A bottom-up approach is essential for the success of conservation projects like the CAMPA Dugong Recovery Program, as involvement of local communities and stakeholders' is irreplaceable in species monitoring and rescue operations in case of standings. Thus, strengthening the local capacity through workshops and training programs, ensures quality of data received and enhances the performance of the stakeholders in emergency response on field. With a similar objective, the CAMPA Dugong project aims not only to engage these communities in dugong conservation, but also focuses to mass sensitize and train them through capacity building workshops.

In the third field season of the project (2019 - 2020), a total of 10 awareness, outreach and capacity building programs/ workshops were conducted to spread awareness about dugongs, their habitats and need of conservation (Table 4.5).

Stakeholders for these programs were identified from the following sectors:

Local communities using dugong habitats (Fishers),
Tourism sector (SCUBA divers and Glass Bottom Boat operators),
Government law enforcement agencies (Forest Department), and
Education sector (school educators and students)

Table 4.5: Details of outreach and awareness activities conducted in different areas of Andaman and Nicobar Islands in the year 2019-20

S.no.	Location	Date	Name of the event	Type of Stakeholders	Total no. of people attended the event	Type of event
1	Shaheed Dweep (Neil Island)	30-Nov-19	Follow up a program with DIVE INDIA for dugong sightings.	SCUBA divers	5	Meeting Stakeholders
2	Shaheed Dweep (Neil Island)	1-Dec-2020	Followup Programme with Dugong Informants (Glass bottom boat operators)	Glass bottom boat operators	3	Meeting Stakeholders
3	Shaheed Dweep (Neil Island)	02-Dec-19	Expanding the Dugong monitoring program to Diving schools	SCUBA divers	10	Capacity building

4	Shaheed Dweep (Neil Island)	04-Dec-19	Dugong Awareness Program	Dugong Ambassadors (School students)	104	Awareness Program
5	Swaraj Dweep (Havelock island)	12-Dec-19	Follow up in Government Senior Secondary School regarding list of scholarship kids	Dugong Ambassadors (School students)	1	Meeting Stakeholders
6	Swaraj Dweep (Havelock island)	20-Dec-19	Follow up a program with fishermen and dive schools for dugong monitoring program	Fishermen	6	Meeting Stakeholders
7	Bambooflat	16-Jan-20	Follow up Programme with Dugong Ambassadors at Government Secondary School	Dugong Ambassadors (School students)	80	Awareness Programme
8	Wandoor	22-Jan-20	Capacity building program with MGMNP frontline forest staff in drone training for monitoring	Forest Department Frontline Staff	11	Capacity building
9	Port Blair	11-Feb-20 to 16-Feb-20	One-week compulsory refresher training course for Indian Forest Service Officers on 'Ecotourism and Biodiversity Conservation'	IFS officers	29	Capacity building

10	Swaraj Dweep (Havelock island)	24-Feb-20	Dugong Monitoring Programme with Diving School (SCUBA Love)	SCUBA divers	4	Capacity building
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Out of these 10 events, 2 were awareness activities for dugong ambassadors and 4 events were capacity building programs with the Forest Department Staff and SCUBA divers for monitoring of marine wildlife (Figure 4.55). Rest of the events were follow-up meetings held with stakeholders as a part of 'Dugong Monitoring Program'. Awareness and capacity building events were halted in March due to COVID-19 restrictions and only followup through direct communication through phone calls and social media platforms like WhatsApp was conducted.

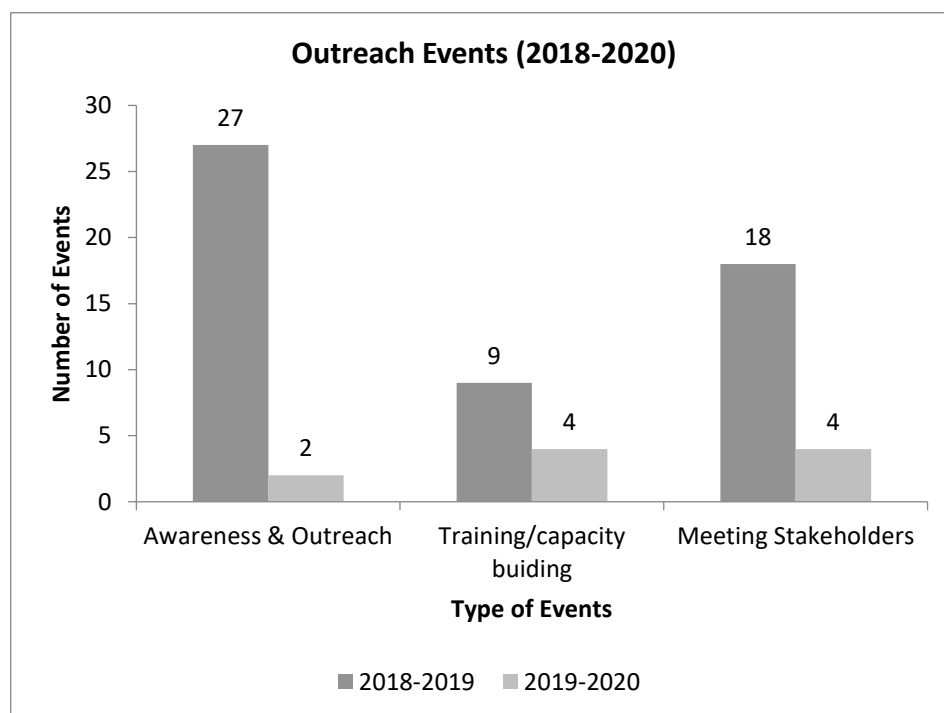


Figure 4.55: Details of various outreach events conducted in Andaman Islands in the year 2018-19 and 2019-20

The last field season, 2018-19, was targeted for mass awareness and outreach events (Figure 4.55). 27 events were conducted for awareness and outreach and majority of the stakeholders targeted were school children (84.42%), mostly involving classes 6th and above (Figure 4.55 and 4.56). This being an impressionable age, creating awareness amongst them would be beneficial to save the species in a longer run. The fisher parents of these students were also involved in awareness workshops (8.47% of total stakeholders). Figure 4.56 depicts the percentage composition of stakeholders involved in 2018-19.

In this field season (2019-20), the highest percentage of stakeholders targeted for awareness activities were again school students (68.58%) (Figure 4.57). Forest department officials were another group of stakeholders targeted (15.33%) for capacity building programs, as their involvement is very important for monitoring activities and enforcement of laws. Figure 4.57 shows the percentage of stakeholders targeted in 2019-20 field season. For the next field season, our target will be training the local bodies and forest frontline staff, in emergency response to dugong and marine standings.

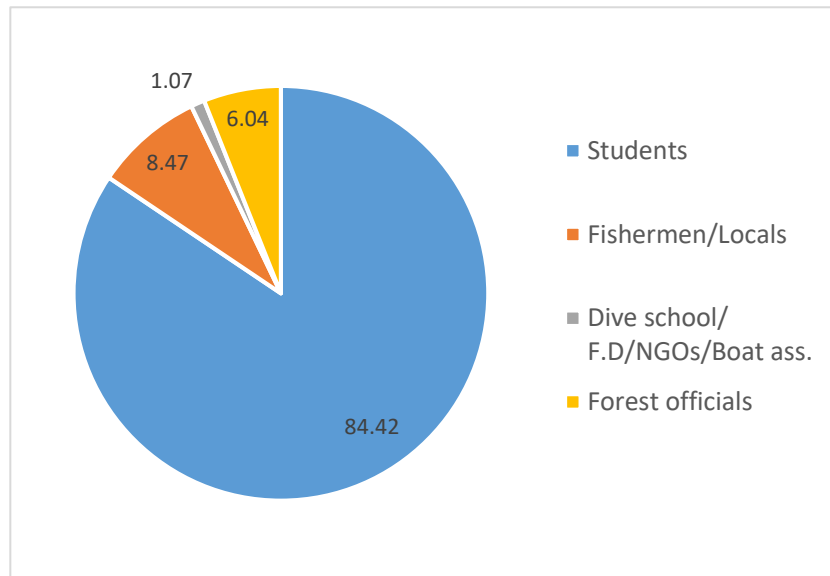


Figure 4.56: Percentage of stakeholders targeted in year 2018-19 for awareness activities in Andaman Islands

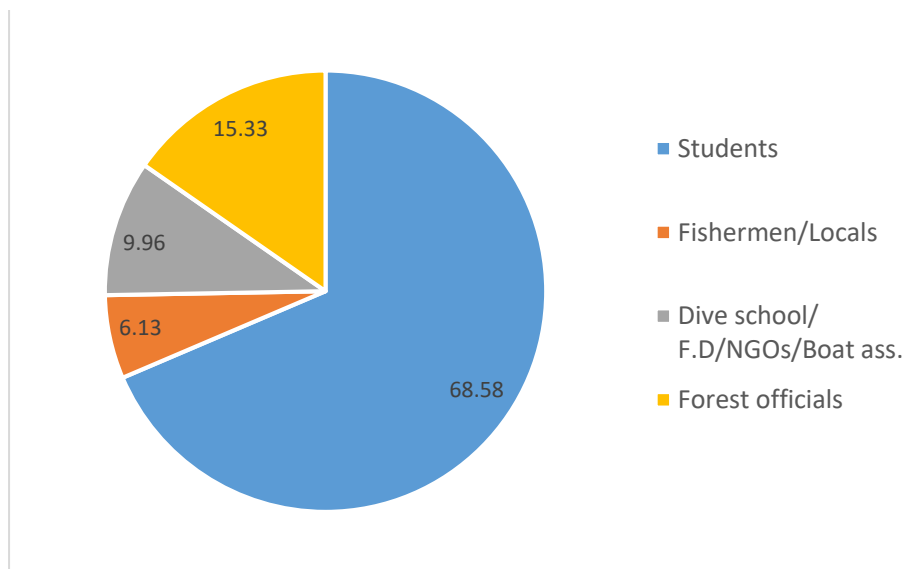


Figure 4.57: Percentage of stakeholders targeted in the year 2019-20 for awareness activities in Andaman Islands

Dugong Scholarship Programme

Dugong Scholarship Program (DSP) was started in July 2017 and aimed at providing financial support for school students from fishing background. Three years since its commencement, 7 schools across the Andaman Islands were targeted for DSP (Table 4.6).

Table 4.6: Details of Dugong scholarship programs in Andaman and Nicobar Islands

School Name	Village/ Town	District	Students Phase 1 2017-2018	Students Phase 2 2018-2019	Students Phase 3 2019-2020
Government Secondary School	Shaheed dweep (Neil)	South Andaman	19	19	18
Government Middle School	Shaheed dweep (Neil)	South Andaman	3	3	3
Government Secondary School	Swaraj Dweep (Havelock)	South Andaman	35	35	28
Government Middle School	Guptapara	South Andaman	-	10	10
Government Middle School	Wandoor	South Andaman	-	11	9
Government Senior Secondary School	Rangachang	South Andaman	-	16	12
Government Senior Secondary School	Bambooflat	South Andaman	-	16	16

As of August 2020, 110 students have been awarded this scholarship and the students selected under this program are identified as Dugong ambassadors. Figure 4.58 depicts the number of students added for DSP in every phase.

We shall be expanding DSP to other districts in the Andaman and Nicobar Islands in coming field season.

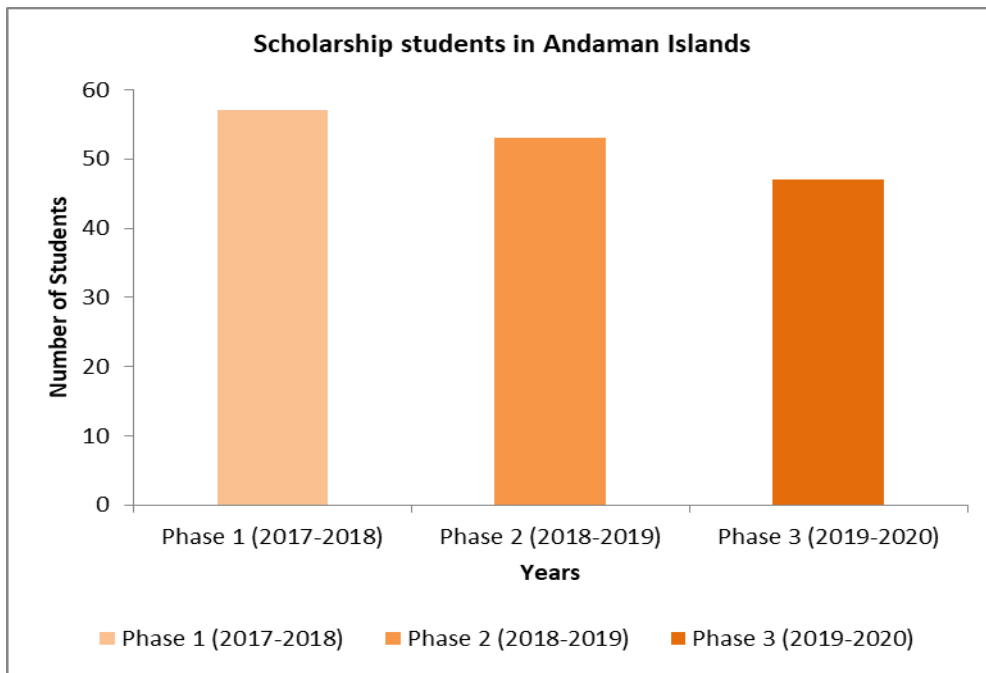


Figure 4.58: Number of scholarship students over three years in Andaman Islands



Figure 4.59: Depicting the outreach and capacity building programme events of the year 2019-2020 in Andaman Islands:

A-E: Dugong Awareness programme conducted for school children, F-H: Drone handling workshop conducted for Mahatma Gandhi Marine National Park frontline forest department staff, I: Dugong Awareness programme conducted for SCUBA divers

4.3 Management Recommendations

Enhancing Capacity Building of the Frontline Forest Staff

Imparting structured training to frontline forest staff in data collection and documentation, dugong stranding response and sample collection from dead dugongs, using standard protocols is strongly recommended, as this stakeholder group is the first responder to marine mammal strandings.

More frontline forest staff to be trained in certified SCUBA courses, and involved in long term seagrass and coral monitoring in the islands.

Rigorous patrolling is recommended jointly by forest department, Indian Coast Guard in 16 sites identified as 'dugong trouble spots'.

Adopting multi stakeholder integrated management and planning for dugong conservation

Engaging crucial stakeholders like tourism department, directorate of shipping services, chamber of commerce, SCUBA diving associations and other tourism allied sectors, to help minimize direct or indirect impacts caused by tourism activities on dugongs.

With the help of the above-mentioned stakeholders, official 'speed regulation' could be enforced on high-speed vessels (jet skis, dive boats, inter island ferry boats) in tourism influenced critical dugong habitats (eg: Bharatpur in Shaheed dweep, Beach No. 2 to 5 and Elephanta in Swaraj Dweep).

Plastic litter in critical dugong habitats was another threat we documented during the present study, which could be due to ocean currents and localised anthropogenic activities. In case of the latter, it is recommended to encourage eco-friendly alternatives like bamboo/ metal straws, installation and encouraging use of RO water filters in restaurants and resorts. It is also important to set up good waste disposal and management methods and take strict actions against improper waste disposal. A complete ban on single-use plastic products is recommended in all tourist sites at the islands.

It is strongly recommended that, infrastructural developmental activities like construction of ports/ jetties and dredging activities be avoided in proximity of the meadows which have been identified as critical foraging grounds for dugongs.

Community based dugong conservation through an integrated approach:

We recommend involving local communities like fishers, young generation involved in government/ private sectors, school teachers, gram panchayat representatives along with forest department, to start a '**dugong rescue centre**' on each identified critical island.

This centre, can involve one or two representatives of each above-mentioned groups, and will be supervised by the local forest department personnel posted on each island with scientific input and training to be given by Dugong project team, of Wildlife Institute of India.

A structured training can be imparted to these identified representatives, to report illegal dugong crime activities, handle and rehabilitate entangled dugongs following standard procedures and collecting scientific data through a citizen science approach.

Mass sensitization of different stakeholders:

Raising awareness and education campaigns targeting tourists, fishers, school children, forest officials, fisheries department etc.

Tourists and locals must be sensitized about littering and its consequences on dugong habitats and marine life by putting up bill boards at beaches.

4.4 Media reports and coverage

<http://www.andamanchronicle.net/index.php/18885-dugong-awareness-day-to-be-celebrated-by-wii-amidst-covid-19-lockdown-2>

Dugong Awareness Day to be Celebrated by WII Amidst COVID-19 Lockdown

Port Blair, May 19: In a novel initiative to sensitize people about the sea cow 'Dugong', which also happens to be the state animal of the islands, Wildlife Institute India (WII) has organized a social media event called 'Dugong Awareness Day' to be held on 28th May 2020.

This ten-day long sensitization program has begun on the 19th May 2020 across different social media platforms (Facebook, Twitter, Instagram) and



aims to spread awareness about importance of dugongs, threats to their existence and need to conserve them, by

Continued on P 4

Figure 4.60: Coverage of Dugong day celebration 2020 by Andaman Chronicle newspaper

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ANNUAL FIELD REPORT 2019-2020
EX-SITU ANALYSIS FOR DUGONG CONSERVATION

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Citation- Yellapu S., Sharma S., Bayyana S., Bose S., Christian G., Semwal R., Pacha A. (2020), Ex-situ analysis for dugong conservation, In Annual Progress report IV (2019-2020), Recovery of dugongs and their habitat in India: an integrated participatory approach, Wildlife Institute of India, Dehradun, pp 191-249.

5.1 Mitochondrial phylogeography of Indian Dugongs (*Dugong dugon*)

Introduction

Dugong [*Dugong dugon* (Müller)] or sea cow is the only strictly marine herbivore species of the order Sirenia. Historically, dugongs were distributed across the tropical and subtropical regions of the Indo-Pacific Ocean, inhabiting shallow coastal waters ranging from the east coast of Africa to western Pacific Ocean (Marsh, Penrose, Eros & Hugues, 2002). Currently classified as 'vulnerable' by the IUCN Red List, their distribution is restricted to Australia, parts of Southeast Asia, Indian subcontinent, Arabian Gulf and eastern coast of Africa (Marsh & Sobotzick, 2015). Within their range, Australian coast retains the largest dugong population, followed by Arabian Gulf. All remaining dugong populations across Southeast Asia, Indian sub-continent and East African coast are small and fragmented (Hines et al., 2012; Marsh & Sobotzick, 2015). Their coastal distribution, exclusive dependence on seagrass habitats, long lifespan and slow reproduction rates make them vulnerable to human-mediated impacts across their range. Major threats for dugongs include accidental entanglement in fishing nets, hunting/poaching for meat, vessel strikes, degradation of seagrass habitats and coastal infrastructure development (Marsh, O'Shea & Reynolds III, 2011; Hines et al., 2012; Sivakumar, 2013; D'Souza, Partaker, Arthur, Alcoverro & Kelkar, 2013). Despite various protection measures implemented internationally, their numbers are declining across their range with local extinctions from Mauritius, Maldives and Taiwan (Marsh & Sobotzick, 2015).

India retains the largest dugong population in the South Asia sub-region and thus plays a significant role in dugong conservation at the regional and global scale (Sivakumar, 2013). Recent estimates indicate less than 200 individuals distributed in isolated populations along Gulf of Kutch (Gujarat, west coast), Gulf of Mannar & Palk Bay (Tamil Nadu, south-east coast) and the island archipelago of Andaman & Nicobar (Pandey, Tatu & Anand, 2010; Sivakumar, 2013; Sivakumar & Nair, 2013; D'Souza, Patankar, Arthur, Alcoverro & Kelkar 2013). With a decreasing population trend and regionally 'Endangered' status, it is absolutely critical to focus on reviving their population and restoring seagrass habitats. However, current ecological knowledge on the status of Indian dugongs is limited due to low population densities, rare sighting records and inadequate spatial survey efforts. Lack of long-term monitoring and systematic sampling has also resulted in a paucity of reliable information on their genetic lineage in comparison to other dugong populations. So far, genetic status of dugong populations is known from published studies in Australia (Tikel, 1997; McDonald, 1997; Seddon et al., 2014, Blair et al., 2014), Thailand (Palmer, 2004; Bushell, 2013) and western Indian Ocean (Plon, Thakur, Parr & Lavery, 2019). These studies indicate three major dugong genetic lineages viz. Australian (restricted and widespread), south-east Asian and western Indian Ocean (Blair, Marsh & Jones, 2013; Plon, Thakur, Parr & Lavery, 2019). Recent work by Plon, Thakur, Parr & Lavery (2019) suggests that the Sri Lankan dugongs are genetically divergent from other populations, based on very limited samples (n=4). Given rapidly declining populations of dugongs in South Asia with recent local extinctions in Mauritius, Maldives and parts of Indian and Sri Lankan coasts (Marsh, Penrose, Eros & Hugues, 2002), adequate sampling to ascertain their position vis-à-vis global populations is of critical importance.

In this paper, we conducted comprehensive genetic sampling of Indian dugongs to describe a) genetic lineage and phylogeography of the Indian dugongs in relation to other dugong populations at a global scale and b) the genetic diversity, differentiation and demographic patterns of dugong populations in India. We believe that the results from this study will be

critical in developing population-specific management plans and thus help in the long-term conservation of this globally threatened marine mammal.

Materials and Methods

Permits

The permission to carry out fieldwork and genetic sampling of dugongs was provided by the Ministry of Environment, Forest and Climate Change, Government of India (CAMPA Authority letter number: 13-28(01)/2015-CAMPA). Due to the non-destructive sampling approach used in this study, no ethical committee approvals were needed.

Sample collection

Given low population size of dugongs in the Indian subcontinent (<200 individuals), fragmented distribution along the coastal region and rare live sightings (Sivakumar, 2013), it was logistically difficult to conduct systematic sampling of biological material. Hence, most of the sampling was opportunistically conducted from dead stranded dugongs from coastal areas of Gulf of Mannar, Palk Bay, Gulf of Kutch and Andaman Islands. All samples were stored in ethanol at the field sites and later shipped to Wildlife Institute of India for storage at -20°C until further analysis. In addition to opportunistic sampling, historical samples (bone scrapings) were collected with associated geolocation information from State Forest Departments' collections. The details of the samples and their geographical sampling location are provided in Table 5.1.

Table 5.1: Details of samples used in Indian dugong alignment analysis

SN	Sample ID	Sample Type	Sampling Location	Year of Sampling	Gen Bank Accession Sequence ID
	Dug-1	Tissue	Gulf of Mannar, Tamil Nadu	2017	MK986797
	Dug-2	Tissue	Gulf of Mannar, Tamil Nadu	2017	MK986798
	Dug-3	Tissue	Gulf of Mannar, Tamil Nadu	2017	MK986799
	Dug-4	Tissue	Gulf of Mannar, Tamil Nadu	2017	MK986800
	Dug-6	Tissue	Gulf of Mannar, Tamil Nadu	2017	MK986801
	Dug-7	Bone	Gulf of Kutch, Gujarat	2017	MK986813
	Dug-8	Tissue	Gulf of Kutch, Gujarat	2017	MK986814
	Dug-9	Tissue	Palk Bay, Tamil Nadu	2017	MK986806
	Dug-10	Tissue	Palk Bay, Tamil Nadu	2017	MK986807
	Dug-11	Bone	Palk Bay, Tamil Nadu	2017	MK986808
	Dug-12	Tissue	Gulf of Kutch, Gujarat	2018	MK986815
	Dug-13	Bone	Port Blair, Andaman Islands	2018	MK986809
	Dug-14	Bone	Port Blair, Andaman Islands	2018	MK986810
	Dug-15	Bone	Port Blair, Andaman Islands	2018	MK986811
	Dug-16	Tissue	Gulf of Mannar, Tamil Nadu	2018	MK986802
	Dug-17	Tissue	Gulf of Mannar, Tamil Nadu	2018	MK986803
	Dug-19	Tissue	Gulf of Kutch, Gujarat	2018	MK986816
	Dug-20	Tissue	Gulf of Kutch, Gujarat	2018	MK986817
	Dug-21	Tissue	Shaheed Dweep, Andaman & Islands	2018	MK986812
	Dug-22	Tissue	Gulf of Mannar, Tamil Nadu	2018	MK986804
	Dug-23	Tissue	Palk Bay, Tamil Nadu	2019	MK986805

DNA extraction, marker selection and PCR amplification

Total genomic DNA was isolated from all fresh tissue samples using standard protocols mentioned in DNeasy blood and tissue kit (Qiagen, Germany). However, for poor quality museum samples, a modified protocol was used to extract DNA (Mondol, Brufford & RamaKrishnan, 2013). In brief, all samples were cut into small pieces, washed with EDTA and macerated into tiny fragments. The fragments were then completely digested with 40 µl proteinase K for two days, followed by DNA extraction using DNeasy blood and tissue kit (Qiagen, Germany). For museum samples, extractions were carried out in a space dedicated to low quality DNA samples where no earlier dugong DNA extraction has been conducted. Negative controls were included for every batch of extractions to monitor any possible contamination.

We used a universal mammalian primer (A24- Kocher et al., 1989) and dugong-specific primers A58, A77 and A80 (Tikel, 1997) to amplify the mitochondrial DNA (mtDNA) control region from dugong samples. Post-temperature standardizations of these primers, PCR reactions were performed in 10µl volume with 5µl Qiagen multiplex PCR mixture (Qiagen,

Germany), 0.2 mg/ml Bovine Serum Albumin (BSA), 0.5 μ M primer mixture and 2 μ l (2-40 ng/ μ l concentration) of DNA. PCR conditions included an initial denaturation of 96°C for 15 minutes, followed by 35 cycles of denaturation (96°C for 30s), annealing (45°C for 30s) and extension (72°C for 60s); followed by the final extension (72°C for 10min). During all amplifications, PCR positive and negative controls were included to monitor any possible contamination.

However, it was challenging to amplify the above-mentioned markers in poor quality/degraded bone samples collected in the study. We designed primers to amplify small amplicon sizes from dugong DNA. All published whole mtDNA sequences were downloaded from GenBank with Accession numbers AY075116.1, AJ421723.1, NC003314.1 and were aligned with the sequences generated from tissue samples collected in this study using MEGA v.6.0 (Tamura, Stecher, Peterson, Filipski & Kumar, 2013). Conserved regions within the sequences were visually identified and primers were designed to amplify <250bp amplicon size to ensure high amplification success from degraded samples. Post-temperature standardization and validation with tissue samples, bone DNA was amplified in 10 μ l reaction mixture with 5 μ l Qiagen multiplex PCR buffer, 0.2 mg/ml BSA, 0.5 μ M primer and 2 μ l of DNA. PCR conditions included an initial denaturation of 96°C for 15 minutes, followed by 40 cycles of denaturation (96°C for 30s), annealing (50°C for 60s) and extension (72°C for 90s); followed by a final extension (72°C for 10min). During all amplifications, positive extraction control and PCR negative controls were included to monitor any possible contamination. The amplicon sizes of newly designed primers ranged between 140 - 243 bps (see Table 5.2 and Figure 5.1 for more details on primers).

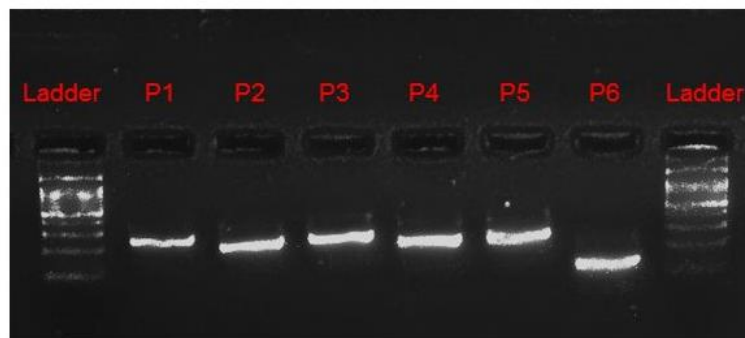


Figure 5.1: Gel picture showing the lengths of amplification of designed primers with ladder on both the sides

All amplified products were cleaned using Exonuclease-Shrimp Alkaline Phosphatase (GE Healthcare, USA) mixture and sequenced bi-directionally using ABI 3510xl Genetic Analyzer (Applied Biosystems Inc., USA). Sequences were aligned using MEGA v.6.0 (Tamura, Stecher, Peterson, Filipski & Kumar, 2013) and analyzed for missense or frame-shift mutations, possibly arising from sequencing errors. All sequences were then visually examined, matched against GenBank sequences and deposited in GenBank (Accession numbers: MK986797-MK986817).

Table: 5.2 List of primers designed to amplify the mitochondrial DNA control region in dugongs**Data Analyses**

S no.	Primer	Primer Sequence (5'-3')	Amplicon Size	Annealing Temperature
1	Dug SSF1	AAT GAA GGT CCC CGT AGT	234	50°C
	Dug SSR1	TGC ACG ATT ATA CAT AGG		
2	Dug SSF2	CGC GCT ATG TAC TTC GTG	203	50°C
	Dug SSR2	ATG GAC TGG ACA ATA TCC		
3	Dug SSF3	GTA GGA TTC ATG CTC TAA	243	50°C
	Dug SSR3	GCC CGG AGC GAG AAG AGA		
4	Dug SSF4	TTG ACT ACC AAG CTT CGA	217	50°C
	Dug SSR4	CAC AGT TAT GTT ATG ATC		
5	Dug SSF5	TTC CCC TTA AAT AAG ACA	223	50°C
	Dug SSR5	TCG AGC ATT GAC TGA ATA		
6	Dug SSF6	AGG CAA ATA ACT TGT AGC	143	50°C
	Dug SSR6	GCG GGA AAT GGG GT TTG		

Data analyses were performed independently on two dataset alignments:

A) *Global dugong alignment* of 537 sequences (309 bp) consisting of Indian dugong sequences generated in this study (n=21) and sequences downloaded from GenBank (n=516) from previously published studies (Haile, 2008; Jayasankar et al., 2009; Bushell, 2013; Seddon et al., 2014; Blair et al., 2014; Plon, Thakur, Parr & Lavery, 2019). Only 88 sequences (out of 163) were used from Plon et al. (2019) due to ambiguous site calls. The sequences were arranged into global dugong distribution representing Pacific (Australia=383, Papua New Guinea=5, New Caledonia and Palau=1 each); south-east Asia (Thailand=56, Indonesia=7, Japan=2, Philippines and Malaysia/Sabah=1 each); South Asia (India=24, Sri Lanka =4 and Mauritius=2); north-west Indian Ocean (Djibouti=8, Bahrain and Red sea=6 each, Egypt=5, United Arab Emirates=4 and Sudan=2); and south-west Indian Ocean (Tanzania=7, Madagascar=5, east Africa, Mozambique and Kenya=2 each and Comoros=1) regions.

B) *Indian dugong alignment* consisting of 21 sequences (789 bp) of mtDNA control region sequences generated in this study. These sequences were obtained from samples collected from Gulf of Kutch (n=5), Gulf of Mannar (n=8), Palk Bay (n=4) and Andaman Islands (n=4).

Genetic lineage and phylogeography

The genetic lineage of Indian dugongs' vis-à-vis global dugong populations and genetic structure within Indian populations was determined using three different approaches:

Genetic structure was estimated using Bayesian Analysis of Population Structure (BAPS) v 6.0. (Corander, Marttinen, Sirén & Tang, 2008) to identify the population clusters within both the *global dugong alignment* and *Indian dugong alignment* datasets. Models using spatial clustering of groups followed by admixture analysis were implemented in the program, with K values set between 1 to 15. Each value of K was then analyzed using 500 iterations and 100 burn-ins for each referenced individual per population.

Median-joining haplotype network was constructed using program PopArtv 1.7 (Leigh & Bryant, 2015) to assess the genetic lineage within the *global dugong alignment* as well as for the *Indian dugong alignment* datasets. Haplotype network calculations were carried for both analyses by assigning equal weights to all the variable sites.

Phylogenetic relationship of dugong populations was assessed only for the *global dugong alignment*. The best-fit nucleotide substitution and partition schemes for the DNA dataset were selected using the Akaike Information Criterion (AIC; Akaike, 1974) implemented in program jModelTest (Posada, 2008). The best-fit substitution model was found to be HKY+I+G. Phylogenetic analysis implemented in program MrBayesv.3.2 (Ronquist et al., 2012) was conducted using a Bayesian inference approach (Yang & Rannala, 1997). The chain length consisted of 21 million generations of Markov Chain Monte Carlo (MCMC) simulations, sampled every 1000 generations, with the first 3 million runs discarded as burn-ins. West Indian manatee, *Trichechus manatus* (Accession number: AY963860.1) was kept as an outgroup in the phylogenetic analysis. Finally, FigTree v.1.4 (<http://tree.bio.ed.ac.uk/software/figtree/>) was used to view and annotate the consensus phylogenetic tree. A posterior probability value ≥ 0.95 and above was considered for indicating strong relationships (Leache & Reeder, 2002).

Genetic differentiation among global dugong populations

Pairwise genetic differentiation values (F_{ST}) were computed in program Arlequin v 3.5 (Excoffier & Lischer, 2010) for *global dugong alignment* between the dugong population groups derived from multiple structure analysis. Statistical significance was considered with p -values < 0.05 between all the pairs of populations after Bonferroni correction for multiple tests.

Genetic diversity estimates, differentiation and demography of Indian dugongs

Genetic diversity estimates including the number of haplotypes (H), the total number of polymorphic sites (S), nucleotide diversity (π) and haplotype diversity (h) were calculated for the Indian dugong dataset ($n=21$, 789 bp sequence) using program Arlequin v 3.5 (Excoffier & Lischer, 2010). Tajima's D (Tajima, 1989), Fu's F_S (Fu, 1997) and R_2 (Ramos-Onsins & Rozas, 2002) statistics and associated significance values were inferred using Arlequin v 3.5 (Excoffier & Lischer, 2010) and DnaSP v6.12 (Rozas et al., 2017) to test for demographic signatures. Tajima's D values are indistinguishable from 0, if the populations are experiencing equilibrium state due to selective neutral variations; D= negative, during demographic expansion or mutational selection and; D=positive, during demographic contraction. Similarly, in the case of Fu's F_S statistics (Fu, 1997), negative Fu's F_S values are observed during

demographic expansion or departure from the null hypothesis of neutral selection and population equilibrium. Additionally, mismatch distributions for Indian dugong samples were computed using DnaSP v6.12 (Rozas et al., 2017) to test whether the populations underwent demographic changes in the recent past. Mismatch distributions display right-skewed unimodal peaks for populations undergoing expansion whereas ragged and multimodal peaks for populations in demographic equilibrium (Roger & Harpending, 1992). The distribution patterns were further assessed by quantifying the raggedness index (Harpending, 1994) and the sum of squared deviations (SSD), tested for significance with 10,000 simulations using Arlequin v 3.5 (Excoffier & Lischer, 2010).

Pairwise genetic differentiation values (F_{ST}) were computed in program Arlequin v 3.5 (Excoffier & Lischer, 2010) between the populations derived from Bayesian clustering analysis. Statistical significance was considered with p -values <0.05 between all the pairs of populations after Bonferroni correction for multiple tests. A hierarchical analysis of molecular variance (AMOVA) was conducted using program Arlequin v. 3.5 (Excoffier & Lischer, 2010) to understand genetic variation among individuals, within and between populations, as discussed earlier.

5.1.3. Results

Phylogeography and genetic differentiation in dugongs

The Bayesian clustering, phylogeographic and phylogenetic analyses of the global dugong dataset revealed five major genetic clusters corresponding to a) three clusters grouped in the Pacific region (Australia, New Caledonia, Palau and Papua New Guinea); b) one cluster in southeast Asia (Thailand, Philippines, Japan, Malaysia/Sabah and Indonesia) and c) one cluster comprising of South Asia (Mauritius, Sri Lanka and India), northwest Indian Ocean (Red sea, UAE, Egypt, Sudan, Djibouti and Bahrain) and southwest Indian Ocean (East Africa, Tanzania, Madagascar, Mozambique, Comoros and Kenya) (Figure 5.2 & 5.3 and Figure 5.4). While reporting our results, we now use the same nomenclature (Pacific, Southeast Asia, South Asia, northwest Indian Ocean and the southwest Indian Ocean) in this paper. In total, 76 haplotypes were identified from 537 dugong sequences. Highest numbers of unique haplotypes were identified from Pacific region ($n = 39$) followed by Southeast Asia ($n=20$), South Asia ($n=8$), northwest Indian Ocean ($n=6$) and southwest Indian Ocean ($n=2$). Only two haplotypes were shared between these regions; one between Pacific, southeast Asia and South Asia and; another between Pacific, South Asia, northwest Indian Ocean and southwest Indian Ocean (Figure 5.3).

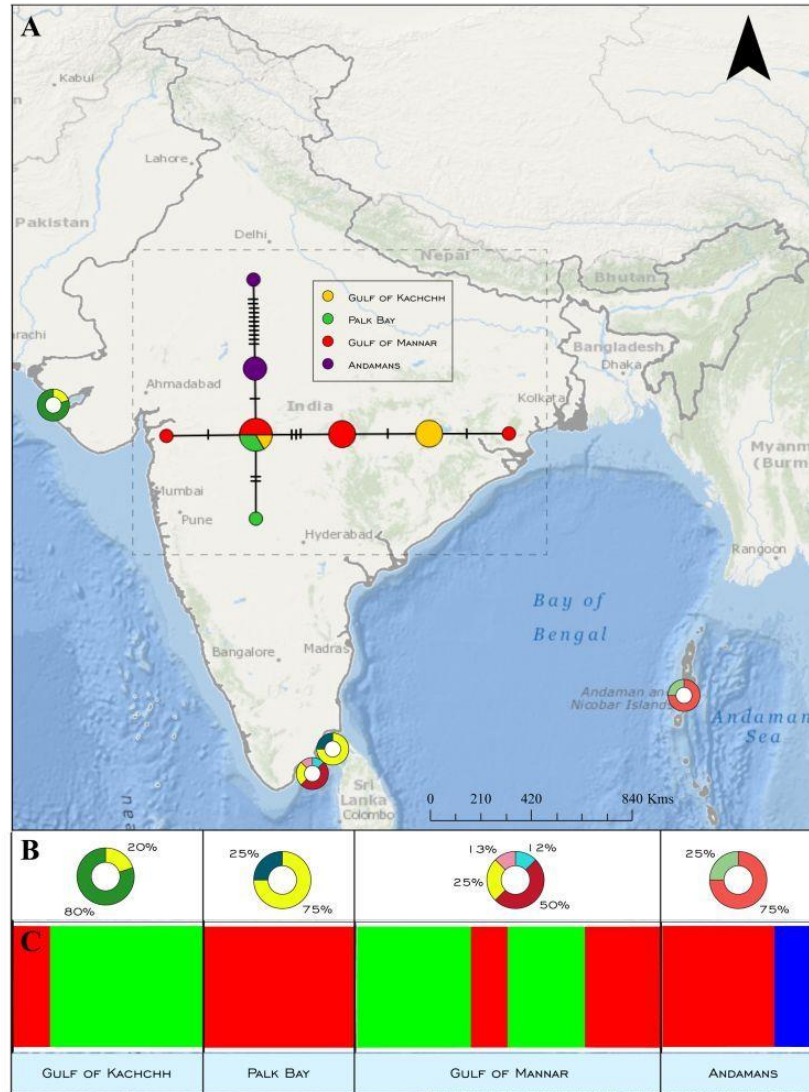


Figure 5.2: A) Global dugong distribution range and region-wise control region haplotype network generated from dugong sequences. Within each region, circles represent unique haplotypes, different colors represent the country of sample origin, and size of the circle represents frequency. B) Population structure using Bayesian clustering (BAPS) analysis for global dugong dataset indicating a total of five clusters using a priori estimate of probable groups. The acronyms are as followed: i) SEIO: southeast Indian Ocean; ii) NWIO: northwest Indian Ocean; iii) SA: south Asia; iv) SEA: Southeast Asia and v) PAC: Pacific region

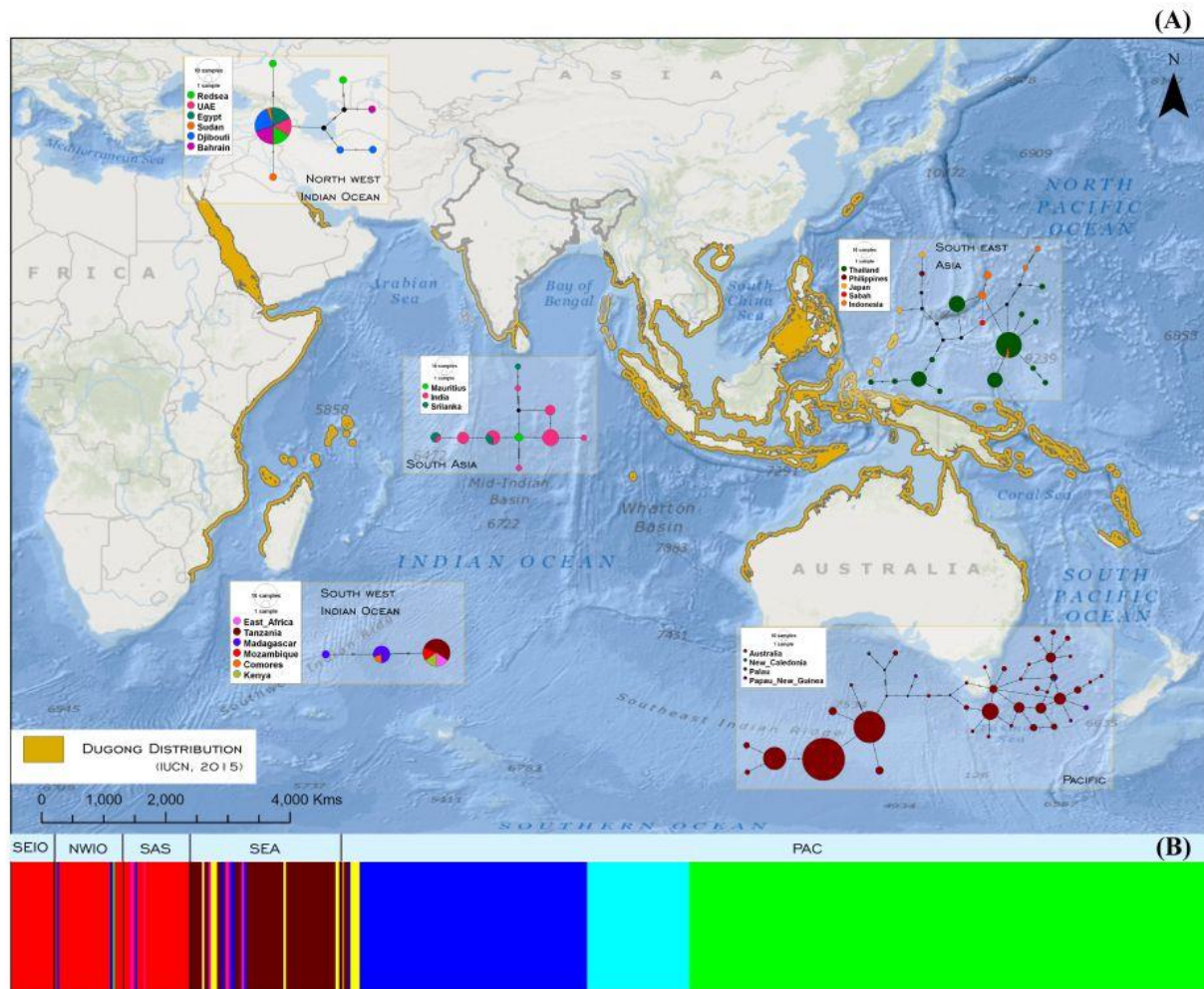


Figure 5.3: A) Median-joining haplotype network generated from control region sequences obtained from Indian dugong populations. Each circle represents a unique haplotype, colors represent sampling locations, and the size of the circle represents frequency. Donuts represent sampling locations. B) Donut colors represent the proportion of unique haplotypes within each sampling location C) Population structure using Bayesian clustering (BAPS) analysis for Indian dugong dataset indicating a total of three clusters using a priori estimate of probable groups.

The network and phylogenetic analyses indicate a strong phylogeographic structure and divergent mtDNA lineages among different dugong genetic clusters. The genetic differentiation (pairwise F_{ST} value) ranged between 0.09-0.66 across different regions (Table 5.3), indicating variable genetic connectivity among regions. Within each of the dugong distribution regions, relatively high haplotypic diversity ($h \pm SD$) was found in South Asia (0.87 ± 0.03), Southeast Asia (0.84 ± 0.03) and Pacific (0.81 ± 0.01) in comparison to the southwest Indian ocean (0.49 ± 0.1) and northwest Indian Ocean (0.35 ± 0.11) regions. Overall nucleotide diversity ($\pi \pm SD$) was considerably lower for all regions ranging from 0.01 ± 0.004 to 0.02 ± 0.01 signifying low intra-regional variations (Table 5.4).

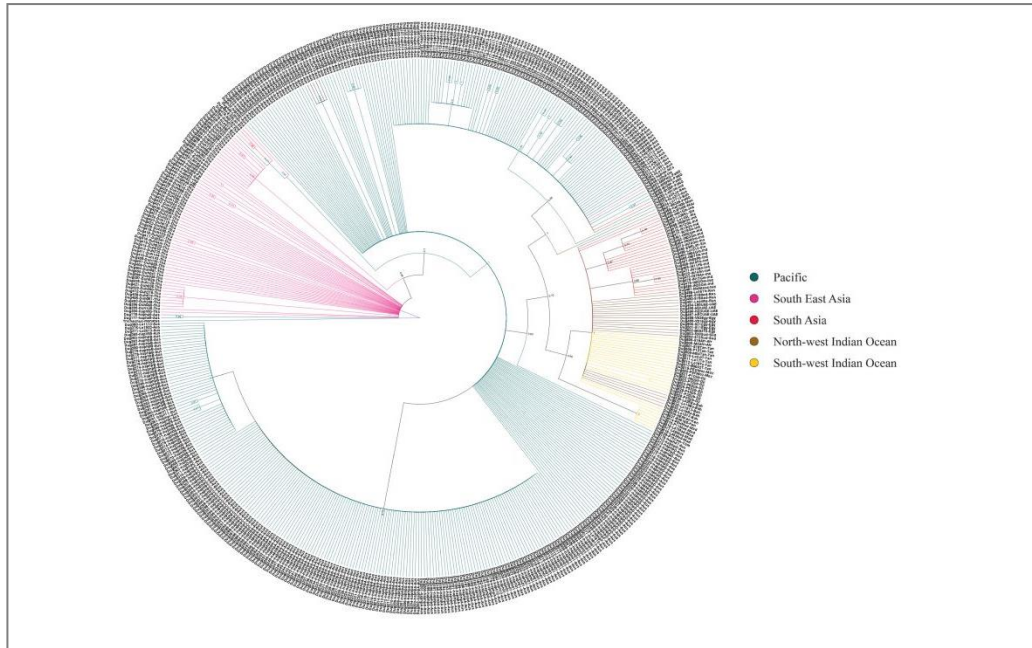


Figure 5.4: Median-joining haplotype network for global dugong dataset indicating three distinct population groups. Only two haplotypes are shared among these three population groups as depicted in the figure.

Table: 5.3 Pairwise F_{ST} values for comparison among global dugong distribution regions

	Pacific	South East Asia	South Asia	North West Indian Ocean	South West Indian Ocean
Pacific	-	0	0	0	0
South East Asia	0.25*	-	0	0	0
South Asia	0.42*	0.60*	-	0	0
North West Indian Ocean	0.44*	0.66*	0.10*	-	0.01
South West Indian Ocean	0.43*	0.64*	0.16*	0.09*	-

Pairwise genetic distance values are mentioned below diagonal while above diagonal are p-values. *indicates significant differentiation values ($p < 0.05$) after Bonferroni corrections.

Table: 5.4 Molecular diversity estimates and demographic indices of global dugong distribution regions.

Region	Sam ples (n)	Haplot ypes (n)	Polymo rphic sites (n)	Haplo type diversi ty \pm SD	Nucleo tide diversi ty \pm SD	Tajima's <i>D</i>		Fu's <i>F_s</i>	
						value	<i>p</i> value	valu e	<i>p</i> valu e
Pacific	390	40	46	0.81 \pm 0.01	0.02 \pm 0.01	- 0.106	0.547	- 4.78 8	0.18 5
South East Asia	67	21	44	0.84 \pm 0.03	0.02 \pm 0.01	- 1.077	0.129	- 2.63 5	0.21 7
South Asia	30	10	25	0.87 \pm 0.03	0.01 \pm 0.01	- 1.215	0.099	- 0.24 9	0.48 7
North West Indian Ocean	31	7	20	0.35 \pm 0.11	0.01 \pm 0.004	- 2.085	0.004	- 0.40 8	0.44 8
South West Indian Ocean	19	3	7	0.49 \pm 0.1	0.01 \pm 0.004	0.229	0.637	3.36 6	0.93 8

Genetic lineage, diversity and demography of Indian dugongs

All three different analytical approaches with the global dugong dataset ($n=537$, 309 bp sequence) confirm that the Indian dugongs belong to the South Asia- northwest Indian Ocean southwest Indian Ocean genetic cluster with unique divergent mtDNA haplotypes. We identified a total of seven unique Indian haplotypes within the South Asia region, where two of them were shared with Sri Lanka (Figure 5.2). One haplotype sampled from Andaman Islands was also observed within the southeast genetic cluster (Figure 5.3). We generated a longer 789 bp sequence for the Indian dugong samples collected in this study ($n=21$). A total of eight unique haplotypes were identified from these samples (Figure 5.5). Palk Bay, Gulf of Kutch and Andaman Islands samples showed two haplotypes each, whereas the Gulf of Mannar showed four haplotypes. One haplotype was shared between the Gulf of Mannar, Palk Bay and Gulf of Kutch. Overall, three haplotypes were unique to Gulf of Mannar, two were unique to Andaman Islands and one each for Gulf of Kutch and Palk bay, respectively. Mean haplotype diversity (h) and nucleotide diversity (π) was 0.85 ± 0.04 and 0.005 ± 0.001 , respectively (Table 5.5). Our Bayesian clustering analyses (BAPS) indicated three genetic signatures in the sampled areas. Gulf of Mannar has two clusters: one shared with Palk Bay and Andaman's whereas the other one shared with Gulf of Kutch (Figure 5.5). One sample from Andamans was genetically unique. These three areas were genetically differentiated at a significant level, with F_{ST} values ranging between 0.1-0.64 (Table 5.6). Further, AMOVA

results showed higher within-population variance (63.41%) than among populations (36.59%), indicating population structure within the Indian dugongs (see Table 5.7).

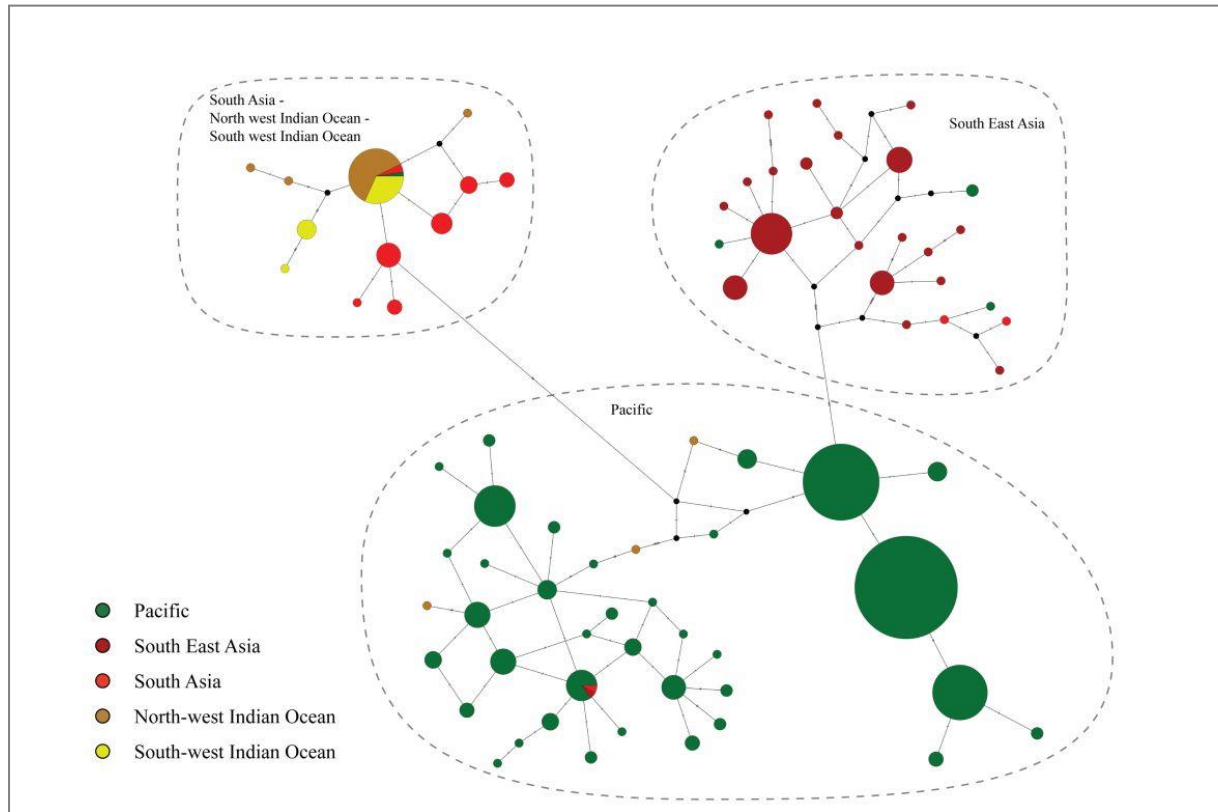


Figure 5.5: Median-joining haplotype network for global dugong dataset indicating three distinct population groups. Only two haplotypes are shared among these three population groups as depicted in the figure.

Different demography analyses (Tajima's D, Fu's F and mismatch distribution) showed contrasting, but non-significant patterns of population demography across these areas. Gulf of Mannar samples showed a positive Tajima's D value (0.086, $p=0.55$), indicating population decline, whereas Palk Bay, Gulf of Kutch and Andaman Islands samples showed negative values (-0.70, $p=0.29$; -0.83, $p=0.10$ and -1.09, $p=0.11$, respectively), indicating population expansion or selection. For Fu's F, all these regions showed positive values (Gulf of Mannar- 0.49, $p=0.57$; Palk bay- 1.09, $p=0.62$; Gulf of Kutch- 2.2, $p=0.82$ and Andaman Islands- 4.22, $p=0.96$, respectively) indicating population decline (Table 5.5). Mismatch distribution analyses reveal multi-modal peaks under both constant population size and population growth-decline models, indicating past demographic equilibrium (Figure 5.6). The observed mismatch values showed a statistically non-significant value of Harpending's raggedness index $r = 0.56$, $p=0.88$ ($SSD=0.11$, $p=0.39$, $R_2 = 0.12$), indicating a population equilibrium (Table 5.5).

Table: 5.5 Molecular diversity estimates and demographic changes in Indian Dugong populations

Popul ation	N	N h	S	h ± S D	π ± SD	Tajima's D		Fu's Fs		SSD		r		R2	Refer ence
						val ue	p val ue	val ue	p val ue	val ue	p val ue	val ue	p val ue		
Gulf of Manna r	8	4	6	0.75 ± 0.13	0.02 ± 0.02	0.086	0.55	0.49	0.57	0.01	0.95	0.08	0.90	0.17	This study
Palk Bay	4	2	6	0.50 ± 0.26	0.01 ± 0.01	-0.70	0.29	1.09	0.62	0.13	0.23	0.75	0.86	0.43	This study
Gulf of Kutch	5	2	4	0.40 ± 0.23	0.02 ± 0.01	-1.09	0.11	2.20	0.82	0.10	0.14	0.68	0.87	0.40	This study
Anda man Island s	4	2	11	0.50 ± 0.26	0.06 ± 0.05	-0.83	0.10	4.22	0.96	0.20	0.26	0.75	0.90	0.43	This study
India Overal l	21	8	19	0.85 ± 0.04	0.04 ± 0.00	-0.63	0.26	2.00	0.74	0.11	0.39	0.56	0.88	0.12	This study
Austra lia	115	52	59	0.97	2.29	-1.53 (R) -1.5		-3.81 (R) -10.01 (W)							McDo nald, 2005

						4 (W)									
Australia	1 8 8	5 6 0	6 0 0	0 .9 4	0.0 2			-2.13						0.0 7	Blair <i>et al.</i> ,2014
Australia	1 8 4	1 2		0. 74 ±	0.3 6 ±										Sedd n <i>et al.</i> , 2014
Thailand	5 3	1 2	2 7	0. 77 ±	1.2 6 ±	- 0.1 7	0.4 9	1.23	0.7 1						Bushel l 2013
Thailand	4 0	1 4		0. 75	0.0 09										Palme r 2004

Table: 5.6 Pairwise F_{ST} values for genetic differentiation between Indian Dugong populations.

	Gulf of Mannar	Palk bay	Andaman Islands	Gulf of Kutch
Gulf of Mannar	-	0.05	0.009	0.221
Palk bay	0.334*	-	0.029	0.041
Andaman Islands	0.374*	0.235*	-	0.014
Gulf of Kutch	0.103	0.639*	0.487*	-

Pairwise genetic distance values are mentioned below diagonal while above diagonal are p-values. * indicates significant differentiation values ($p < 0.05$) after Bonferroni corrections.

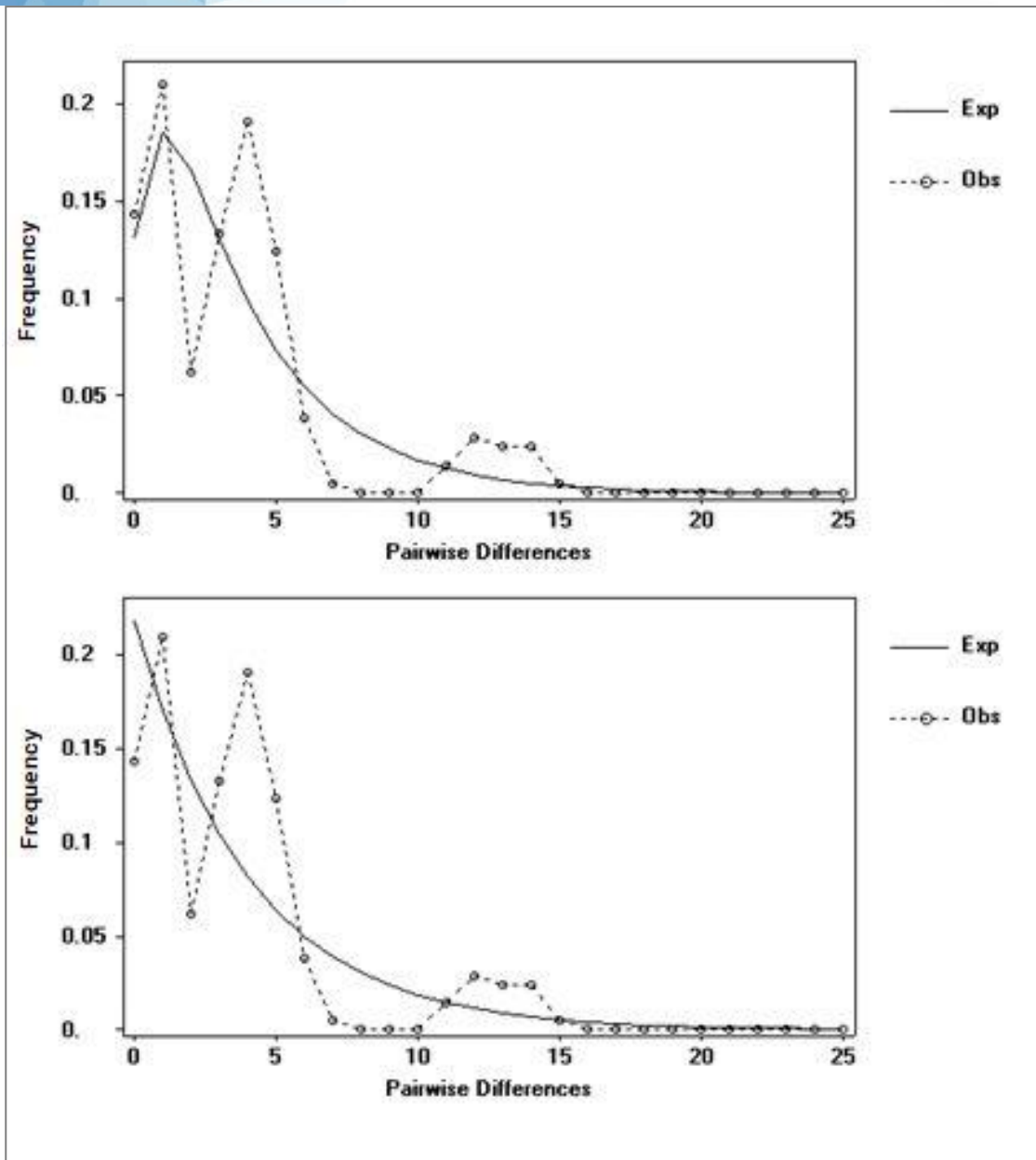


Figure 5.6 Mismatch distributions of pairwise differences for Indian Dugong populations. Observed (dashed lines) and expected (solid lines) frequencies are depicted using a model assuming constant population size (A) and Population growth and decline (B).

Table: 5.7 AMOVA values for genetic structuring within and between population groups in Indian dugongs.

Structure	Source of Variation	df	Sum of Squares	Variance components	Variation (%)	Fixation index	<i>p</i> -value
All 4 populations grouped together	Among populations	3	14.705	0.71949 Va	36.59	ϕ_{ST} : 0.36	0.0003
	Within populations	17	21.200	1.24706 Vb	63.41		
Group 1: Gulf of Kutch; Group 2: Gulf of Mannar & Palk Bay; Group 3: Andaman Islands	Among groups	2	11.121	0.35179 Va	17.27	ϕ_{CT} : 0.17	0.32
	Among populations	1	3.583	0.43805 Vb	21.51	ϕ_{SC} : 0.25	0.05
	Within groups						
	Within populations	17	21.200	1.24706 Vc	61.22	ϕ_{ST} : 0.38	0.0004

5.1.4. Discussion

This study provides the most exhaustive description of genetic groups of dugong at a global scale till date, and first in-depth investigation of genetic diversity and structure of Indian dugong populations. Given that our sampling represents ~10% of the available population estimates of dugongs from India (Sivakumar, 2013), the results are crucial for their conservation at a regional scale. Earlier work on dugong from Pacific (Tikel, 1997; McDonald, 1997; Seddon et al., 2014, Blair et al., 2014), southeast Asia (Palmer, 2004; Bushell, 2013, Blair et al., 2014) and western Indian Ocean (Plon, Thakur, Parr & Lavery, 2019) provided an incomplete picture of genetic groupings due to limited samples from the central part of their global distribution (i.e. South Asia). Our findings fill this gap and show that the Indian samples are part of a single genetic cluster, comprising South Asia, northwest Indian Ocean and southwest Indian Ocean populations with low genetic differentiation. This pattern of genetic clustering is in accordance with earlier studies by Blair et al. (2013). However, these results show a slightly different pattern from Plon et al., (2019), where Madagascar/Comoros formed a unique lineage within the western Indian region. It is also noteworthy to point out that such patterns could also be driven by the use of poor quality sequence data from historical samples. We feel that the addition of critical dugong samples from India helped in getting a clear picture of genetic groups within this region. Overall, the global data showed a very structured phylogeographic pattern with very limited sharing of haplotypes among the identified regions. While such pattern could arise from incomplete sampling effort across the dugong range, it could also indicate potential loss of gene flow among these regions due to fragmentation of contiguous dugong habitats (Marsh, O'shea & Reynolds III, 2011).

This study elucidates divergent mtDNA lineages of South Asian dugongs within the western Indian Ocean populations. Indian dugong population genetically grouped within the South Asia region, although not genetically unique, consists of unique mtDNA haplotypes. Addition of novel mtDNA haplotypes from Indian dugong samples points towards high genetic diversity within South Asia. Two of the previously reported haplotypes from Sri Lanka (Plon, Thakur, Parr & Lavery, 2019) were found to be shared with the southern part of dugong distribution in India at Gulf of Mannar, whereas one haplotype sampled from Islands was observed within Southeast Asian lineage. This indicates potential genetic connectivity between these populations in the recent past, and future work should focus on further fine-scale sampling for in-depth investigation. With local extinctions from Mauritius and Maldives and a highly imperilled dugong population in Sri Lanka (Marsh, Penrose, Eros & Hugues, 2002; Marsh & Soltzick 2015), India holds the largest and potentially the last viable dugong populations within the south-Asia region thereby requiring immediate conservation attention.

Within India, we identified novel haplotypes from each sampling site i.e. Gulf of Mannar, Palk Bay, Gulf of Kutch and Andaman Islands. Overall haplotype and nucleotide diversity for dugong populations in India were comparable to Australia (McDonald, 1997; Blair et al., 2014; Seddon et al., 2014) and Thailand (Palmer, 2004; Bushell, 2013) dugong populations. Gulf of Mannar population showed higher haplotype diversity within the Indian regions. Presence of shared haplotypes across Gulf of Mannar, Palk Bay and Gulf of Kutch suggests potential genetic connectivity among these populations. We found a new haplotype with longer sequences generated in this study ($n=789$ bp) when compared with earlier studies from Australia (McDonald, 1997; Blair et al., 2014; Seddon et al., 2014) and Thailand (Palmer, 2004; Bushell, 2013), suggesting that longer sequence data is required to assess genetic variation at regional/global scale. Finally, it is important to point out that our Indian dugong data show contrasting patterns of population differentiation, where we found shared haplotypes among the sampled areas but high F_{ST} values. Further, the AMOVA analyses indicated signatures of within-population structures. We feel that these contrasting patterns probably arise from a low sample size from each area and short sequences (less polymorphic sites) leading to the effects of genetic drift. Further efforts through intensive sampling and more genetic data would clarify these genetic patterns in Indian dugong populations.

Similarly, our demography analyses with mtDNA show contrasting (but non-significant) signals across the sampled area thus could not be used to deduce population growth or decline. While mitochondrial DNA has been used to assess the demographic pattern (for example see Mizuno, Sasaki, Kobayashi, Haneda & Masubuchi, 2018 for Japanese harbor seals), it generally indicates evolutionary signals at a longer time frame. Future work should focus on more systematic sampling effort and generate nuclear data (microsatellite, Single nucleotide polymorphisms etc.), which provide much clear signatures of recent population demography (Lah et al., 2016; Komoroske, Jensen, Stewart, Shamblin & Dutton, 2017).

Increasing human population in coastal areas and subsequent coastal developments have adversely affected nearshore ecosystems including seagrass meadows throughout their distribution range (Unsworth & Cullen, 2010), thereby impacting historically exploited seagrass-dependent dugong populations (Hines et al., 2012; Reynolds III & Marshall, 2012). These rapidly declining dugong populations (Marsh, O'Shea & Reynolds III, 2011), are further imperilled by the lack of reliable scientific data on their genetic status. This study addresses the gaps in knowledge of the genetic status of Indian dugongs in comparison with the global dugong populations. Indian dugong populations retain the global significance being the largest

and genetically unique population in the South Asia region (Dugong CMS MoU). Based on these results, we recommend that Indian dugong populations should be managed as a “Conservation or Management Unit” to strengthen conservation strategies for ensuring their long-term survival. With the concurrent implementation of Dugong Recovery Program at all the dugong distribution ranges in India (Sivakumar et al., 2018; Sivakumar et al., 2019), we hope that recovering dugongs through a scientifically robust multidisciplinary research and participatory action would safeguard remnant dugong populations in the country.

Citation: Srinivas et al., (2020) Srinivas, Y., Pande, A., Gole, S., Jothi, P. P., Magesh, M. K., Pathan, S., ... & Mondol, S. (2019). Mitochondrial phylogeography reveals high diversity and unique divergent lineage in Indian Dugongs (*Dugong dugon*). *bioRxiv*.

5.2 Nutrient quality analysis of dugong foraging habitats

5.2.1. Introduction

Seagrasses, are vital to the existence of Dugong (*Dugong dugon* (Müller, 1776)) population. Seagrasses are food for sea turtles, fishes and dugongs, and also support complex food webs because of their physical structure and primary productivity. Seagrass meadows support a rich and diverse fauna and flora, providing sheltered, nutrient-rich habitat. Seagrasses are unique amongst flowering plants in that they have adapted to live immersed in seawater.

The present study data shows the health, distribution and abundance of the seagrass ecosystem.

5.2.2 Study points, Collection, Processing and analysis of Samples

For the study of nutrients in the sediment and seagrass the representative samples were collected from the sampling points in the three study sites i.e. Gulf of Kutch (Gujarat), Palk Bay (Tamil Nadu) and Andaman Islands (Table 5.8).

Table: 5.8 Sampling points and dominant species in the selected study sites

Site	Number of sampling points	Dominant Species
Gujarat (Gulf of Kutch)	10	<i>Halophila ovalis</i> , <i>Halophila beccarii</i> , <i>Halodule uninervis</i>
Tamil Nadu (Palk Bay)	16	<i>Cymodacea serrulata</i> , <i>Enhalus aceroides</i> , <i>Thalassia hemprichii</i> , <i>Halodule uninervis</i> , <i>Syringodium isoetifolium</i>
Andaman Islands	8	<i>Halophila beccarii</i> , <i>Halodule pinifolia</i> , <i>Thalassia hemprichii</i> , <i>Cymodacea rotundata</i>

For the study, 123 sediment samples and 89 seagrass samples from Gulf of Kutch (Gujarat), 36 sediment samples and 5 seagrass samples from Andaman Islands, 27 sediment samples and 22 seagrass samples were collected in November 2019.

Seagrass samples were collected using a stratified random sampling method. Quadrats of size 50x50 cm² were plotted randomly on a meadow. Seagrass samples were collected from 20x20 cm² within each quadrat. The samples were uprooted and gently washed with water to remove loose sediment from the roots. The root hairs were pulled off with tweezers and placed in micro-centrifuge tubes. The samples were then sun-dried and further processed to remove

sediment particles like small pebbles, dead calcareous biota like algae, gastropods adhered to the plants. The samples were then oven-dried for 48 hours at 60°C and on drying they were powdered in a pestle and mortar and stored in an air-tight container for further analysis.

Sediment samples were collected from the same 20x20 cm² quadrat. Around 50 gm of samples were collected from each quadrat. Care was taken to avoid excavating sediment from the same area as seagrass samples. The samples were air-dried and composited by a grid in order to make them homogeneous. The composite samples were sieved through a 200 mm sieve to remove coarse sediment and detrital materials. The samples were then ground and homogenized with a mortar and pestle and stored in air-tight poly-bags before analysis.

Organic carbon in the sediment samples was determined using Walkley and Black's (1934) rapid titration method while in seagrass samples total organic carbon was determined by dry combustion technique (Bojko and Kabala, 2014). Nitrogen was determined using Micro-Kjeldahl method (Miller and Houghton, 1945). Sodium and Potassium was determined using Flame Photometer method (Barnes et al., 1980). Phosphorus was determined using a colorimetric method (Syers et al., 1968). 0.1 gm seagrass samples and 1 gm sediment samples were taken for the analysis. The analysis of samples was done between the months of December to February 2020.



Figure 5.7: Air drying and preparation of sediment and seagrass samples for nutrient analysis at WII laboratory

5.2.3. Result and Discussion

Nutrients are considered as one of the most important parameters in influencing growth, reproduction and metabolic activities of biotic components. The concentration of nutrients is based on the season, tidal conditions and flow of fresh water from the land. Distribution of nutrients is also mainly based on these season, tidal conditions and freshwater flow from land. The concentration of nutrients in the sediments among the study sites varied significantly (figure 5.8). All the parameters were observed to be maximum in the site Gujarat, except for phosphorus the concentration of which was observed to be higher in Andaman Islands.

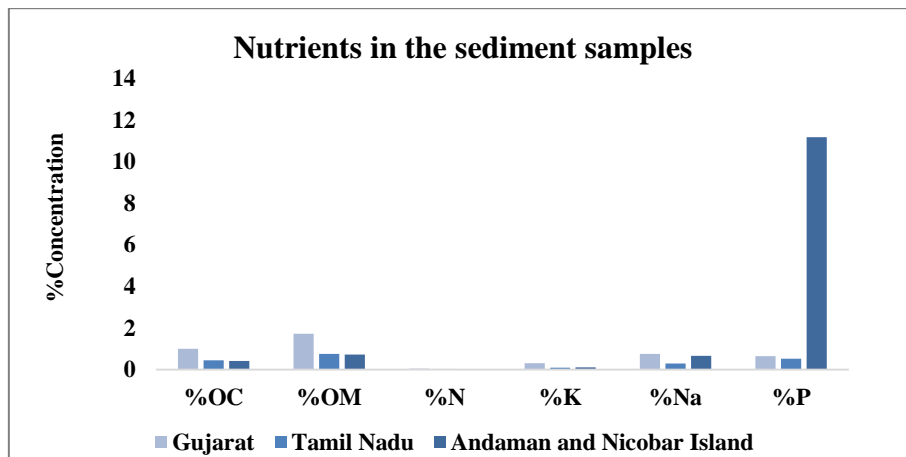


Figure 5.8: Nutrient concentration in the sediment samples of dugong habitats of India

The concentration of nutrients in the seagrass samples also varied significantly among the study sites (Figure 5.9). N, P, K, Na and ash content was observed to be more in the seagrasses of Tamil Nadu. Whereas, Total Organic Carbon (TOC) and Total Organic Matter (TOM) in Andaman Islands.

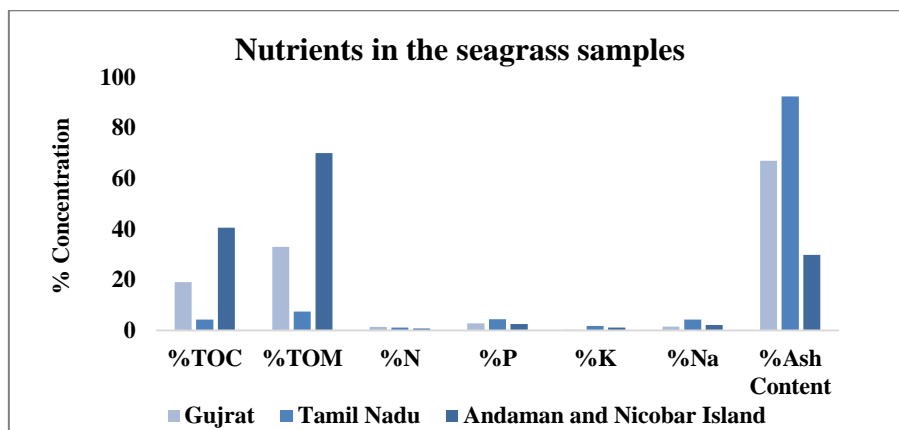


Figure 5.9: Nutrient concentration in the seagrass samples of dugong habitats of India

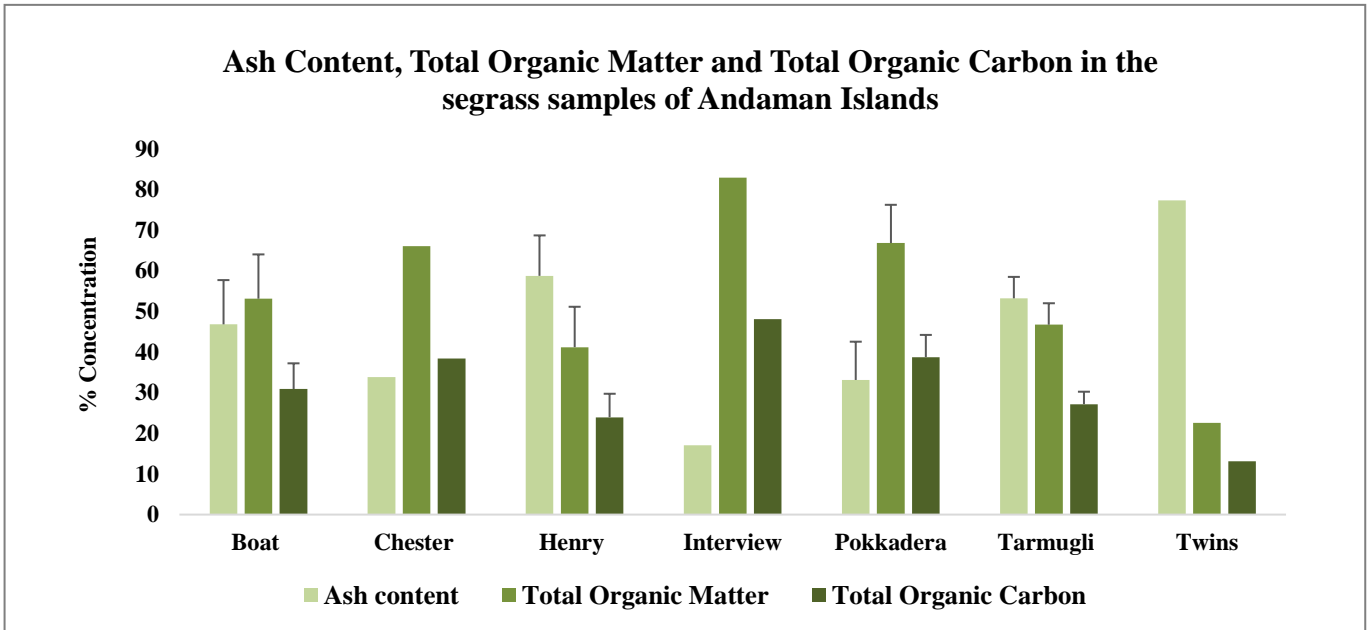


Figure 5.10: Ash Content, Total Organic Matter and Total Organic Carbon in the seagrass samples of Andaman Islands

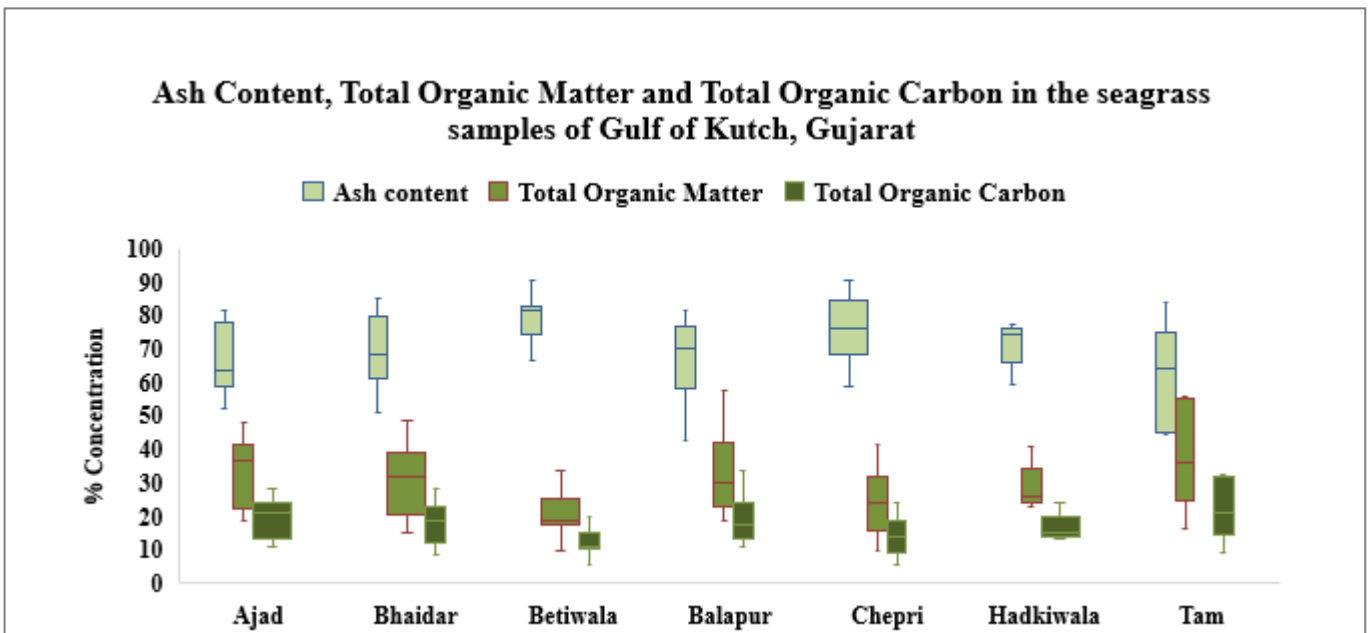


Figure 5.11: Ash Content, Total Organic Matter and Total Organic Carbon in the seagrass samples of Gulf of Kutch, Gujarat

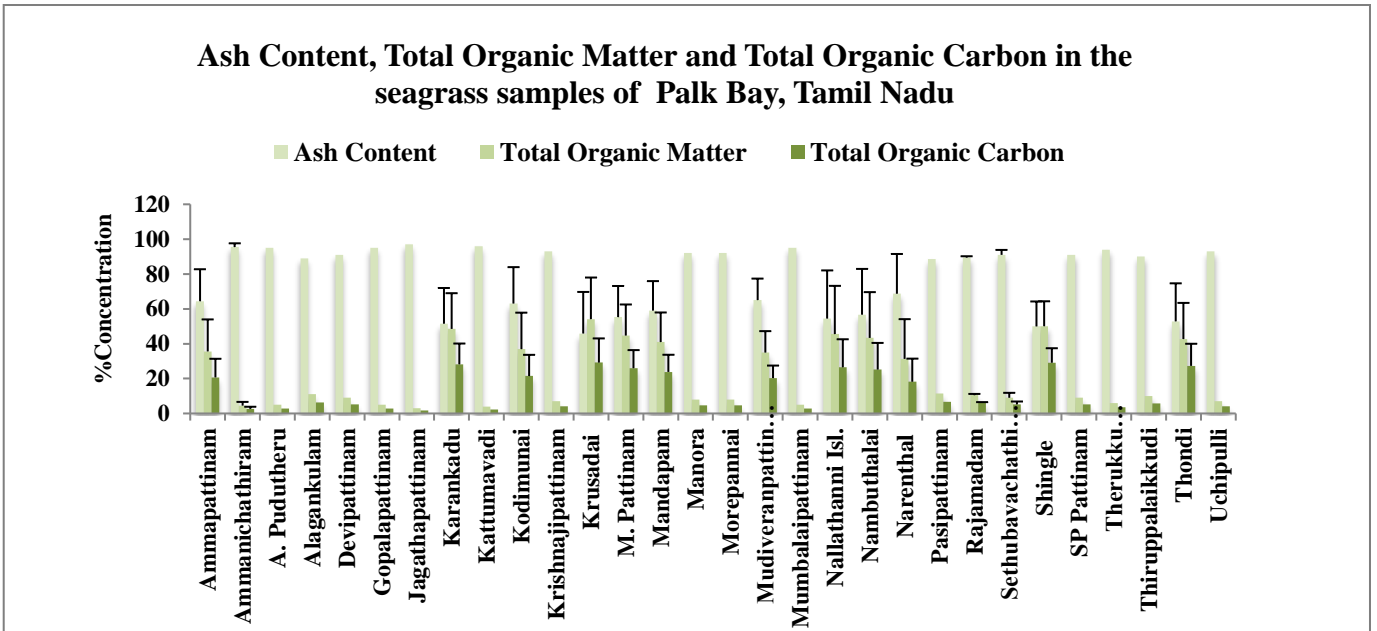


Figure 5.12: Ash Content, Total Organic Matter and Total Organic Carbon in the seagrass samples of Palk Bay, Tamil Nadu

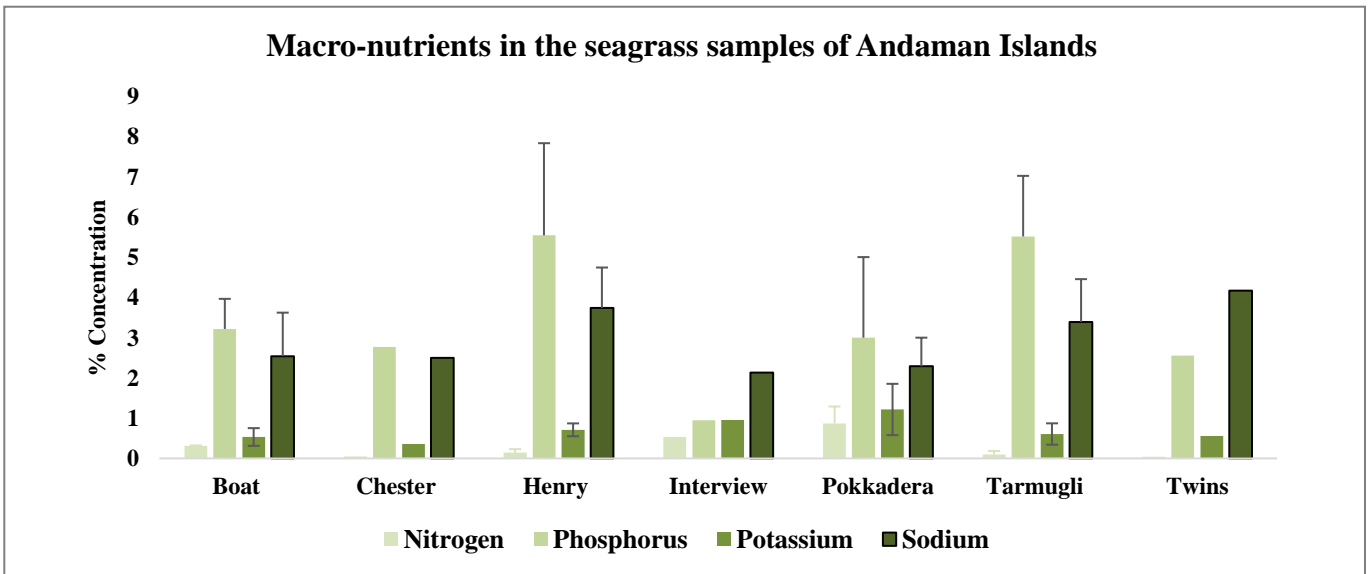


Figure 5.13: Macro-nutrients in the seagrass samples of Andaman Islands

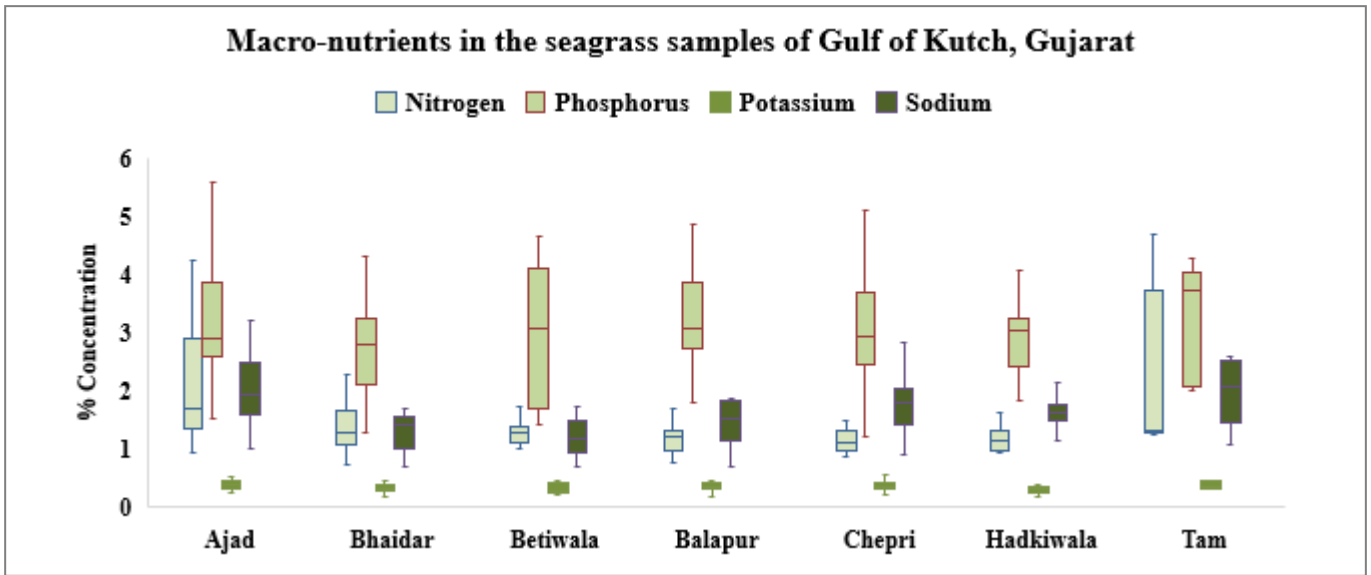


Figure 5.14: Macro-nutrients in the seagrass samples of Gulf of Kutch, Gujarat

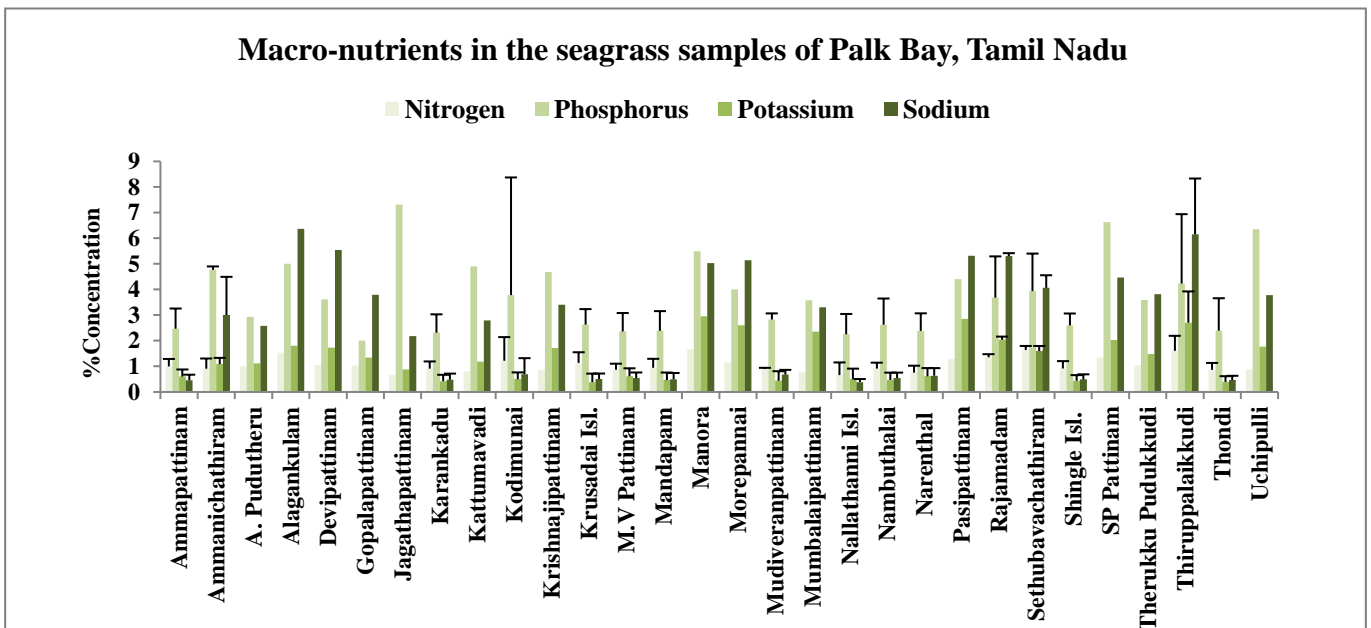


Figure 5.15: Macro-nutrients in the seagrass samples of Palk Bay, Tamil Nadu

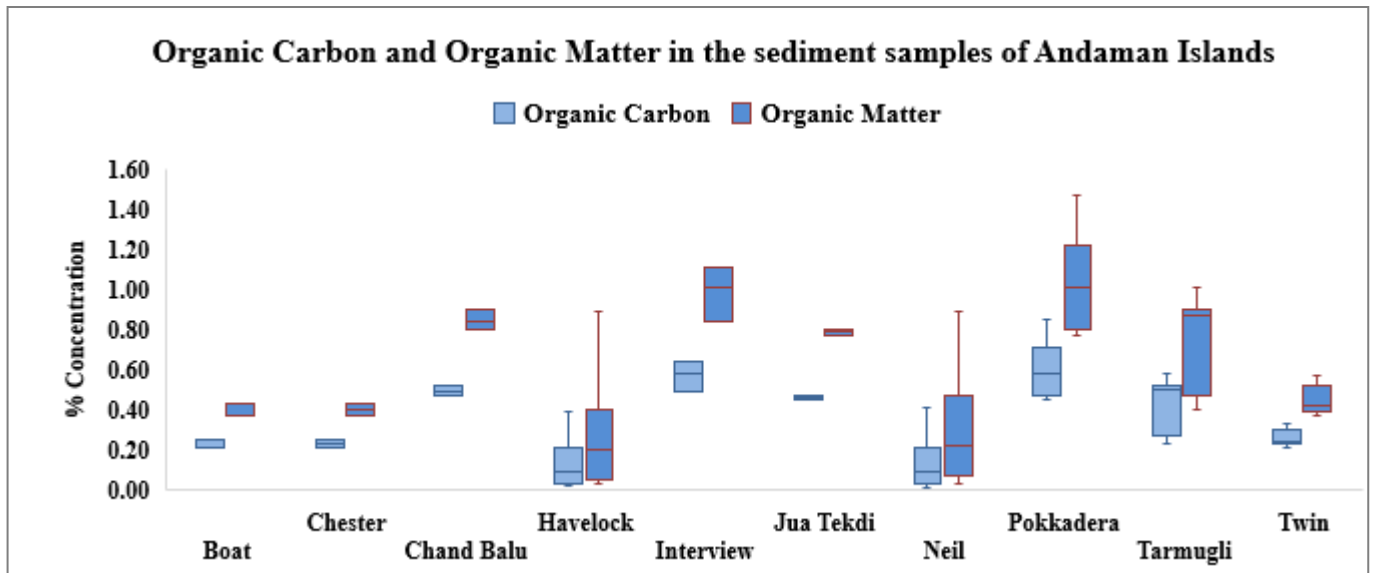


Figure 5.16: Organic Carbon and Organic Matter in the sediment samples of Andaman Islands

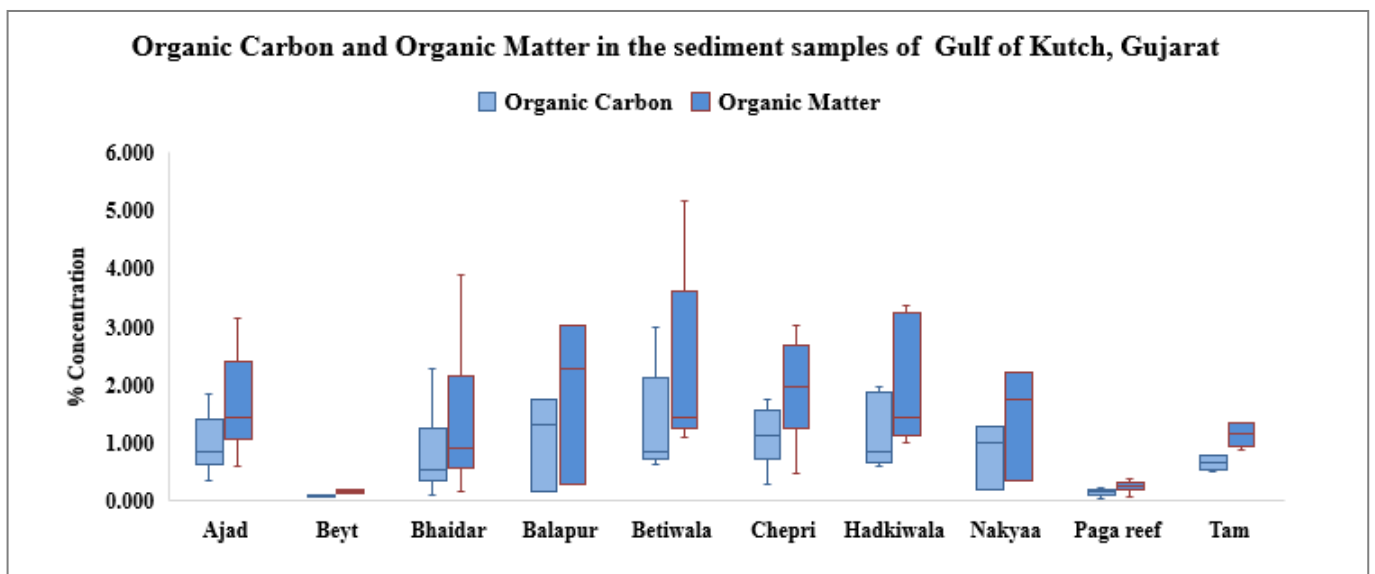


Figure 5.17: Organic Carbon and Organic Matter in the sediment samples of Gulf of Kutch, Gujarat

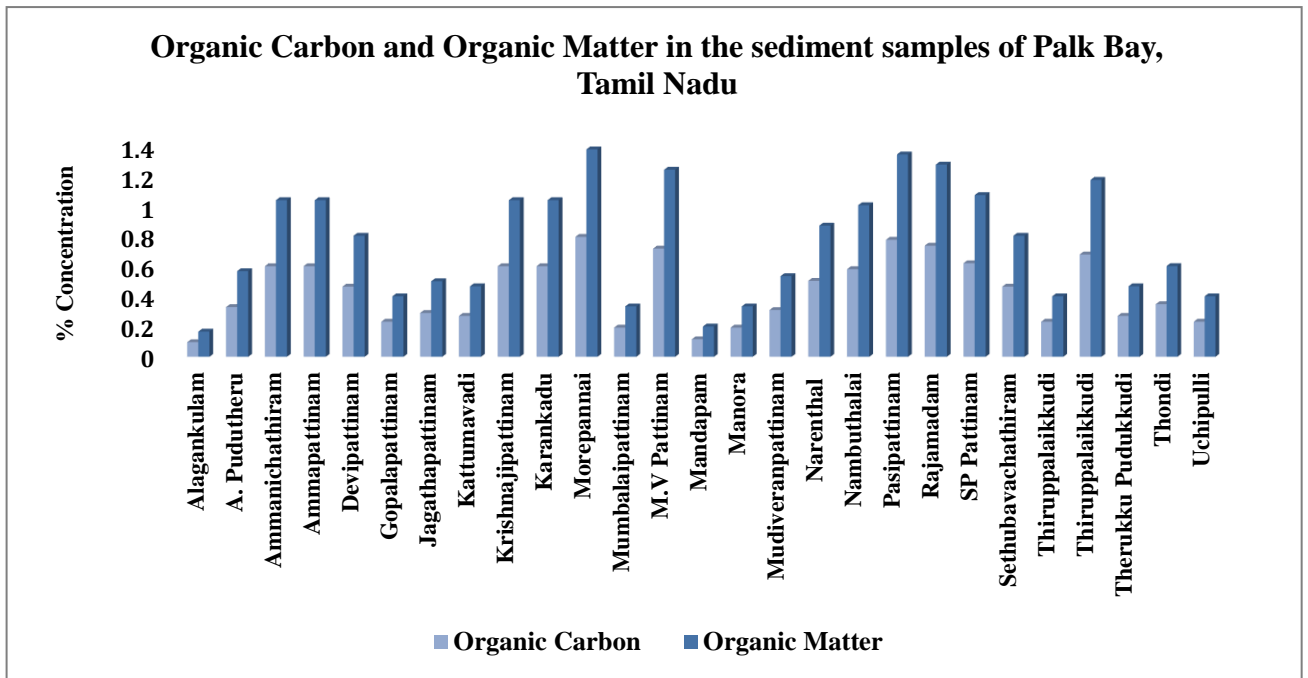


Figure 5.18: Organic Carbon and Organic Matter in the sediment samples of Palk Bay, Tamil Nadu

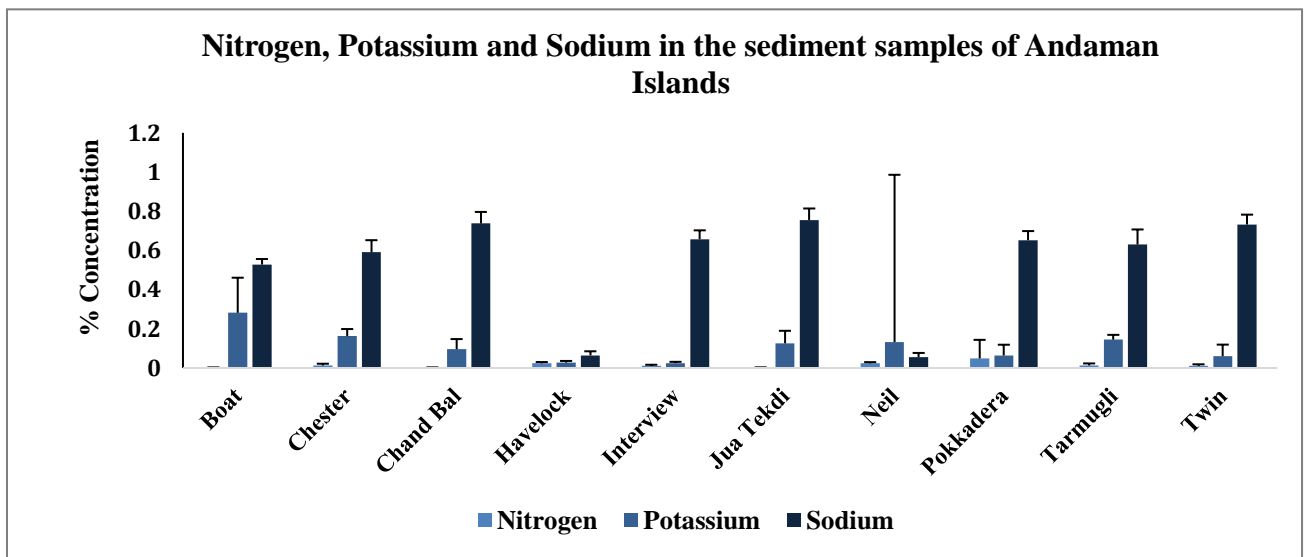


Figure 5.19: Nitrogen, Potassium and Sodium contents in the sediment samples of Andaman Islands

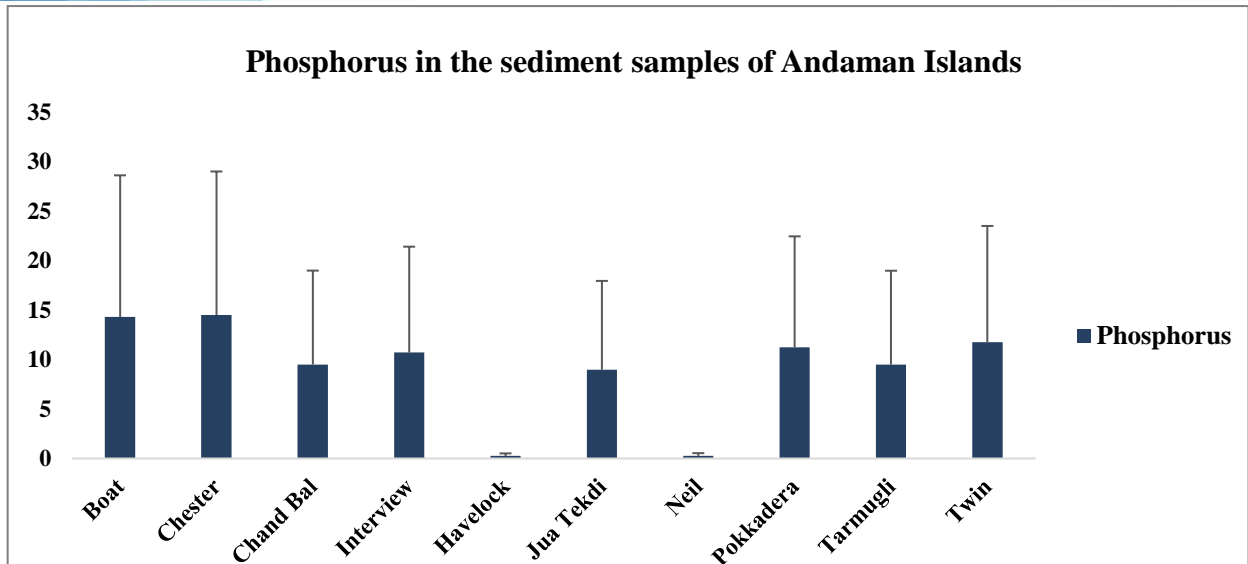


Figure 5.20: Phosphorus contents in the sediment samples of Andaman Islands

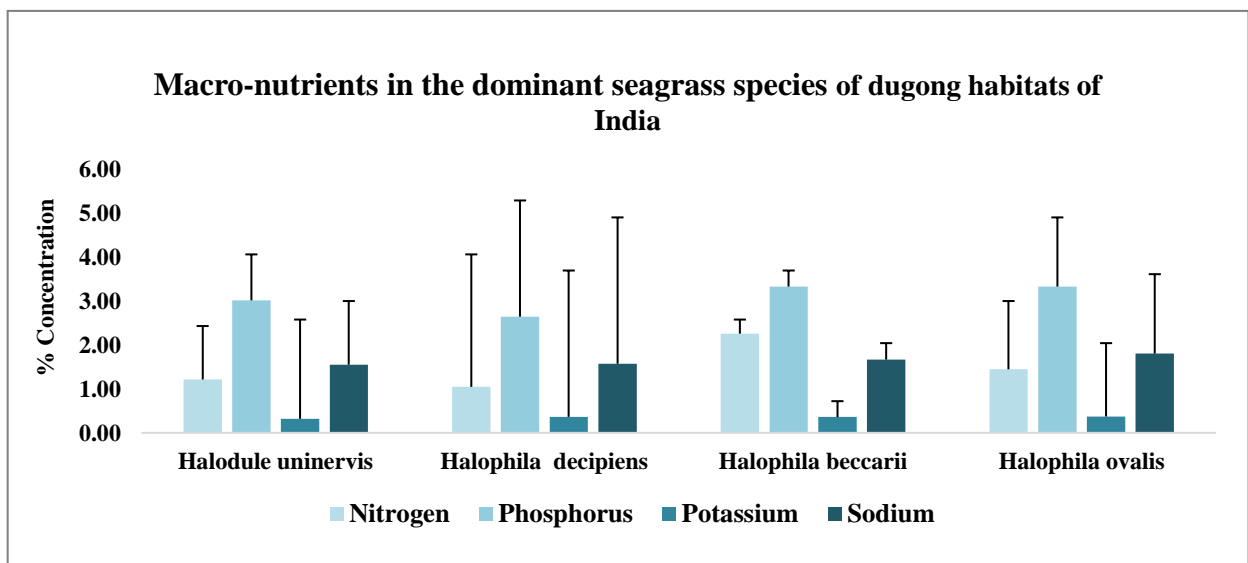


Figure 5.21: Macro-nutrients in the dominant seagrass species of dugong habitats of India

5.3 Seagrass- associated infaunal benthic macrofauna from seagrass meadows of Andaman Islands

5.3.1 Introduction

Seagrass is the major source of food for dugongs. Seagrass habitat supports greater macrobenthic species diversity, abundance and biomass than adjacent vegetative habitats. Macrofauna communities are known to play an important role for ecosystem & ecosystem services (including coastal stabilization, nutrient and carbon cycling and storage, tropic transfer). Macrofauna are sedentary and tropically diverse and their communities mix the effects of water and sediment changes overtime (Lenihan & Micheli 2001). Macrofauna communities can also alter physical and chemical conditions at the sediment-water interface, promote decomposition of sediment organic matter (OM), and are important mediators in nutrient recycling from the sediment to the water column through bioturbation and suspensionfeeding activities (Aller & Yingst, 1985).

The macrofauna that usually constitutes the dominant biomass of organisms in marine sediments are a group of invertebrates that can be defined as animals large enough to be retained on a 500 μm sieve. Benthic macrofauna like Annelid worms, bivalves, gastropods, crustaceans, tunicates, and insect larvae are the most commonly encountered macrofauna in estuarine and coastal areas. According to habitat, benthic fauna is of two types' infauna and epifauna. Epifauna live attached to a surface and infauna live within bottom sediments. The present study is on infaunal macrobenthic organism present in the seagrass bed.

5.3.2 Study area

For the study of macrobenthic fauna of seagrass meadows, the samples have been collected from 12 transect (S1-S12) in Andaman Islands.

Henry Lawrence is the second largest island in Ritchie's Archipelago. The total area of the island is 54.7 Km^2 with a coastline of 36.5 Km.

Tarmugli, Chester, Boat and Twin islands are part of Mahatma Gandhi Marine National Park (MGMNP). Tarmugli Island is the largest island in MGMNP.

Interview Island is part of the Andaman Islands. Island area is 101 km^2 with a coastline of 66.0 Km^2 .

Pokkadera is a village located in Mayabundar, North and Middle Andaman.

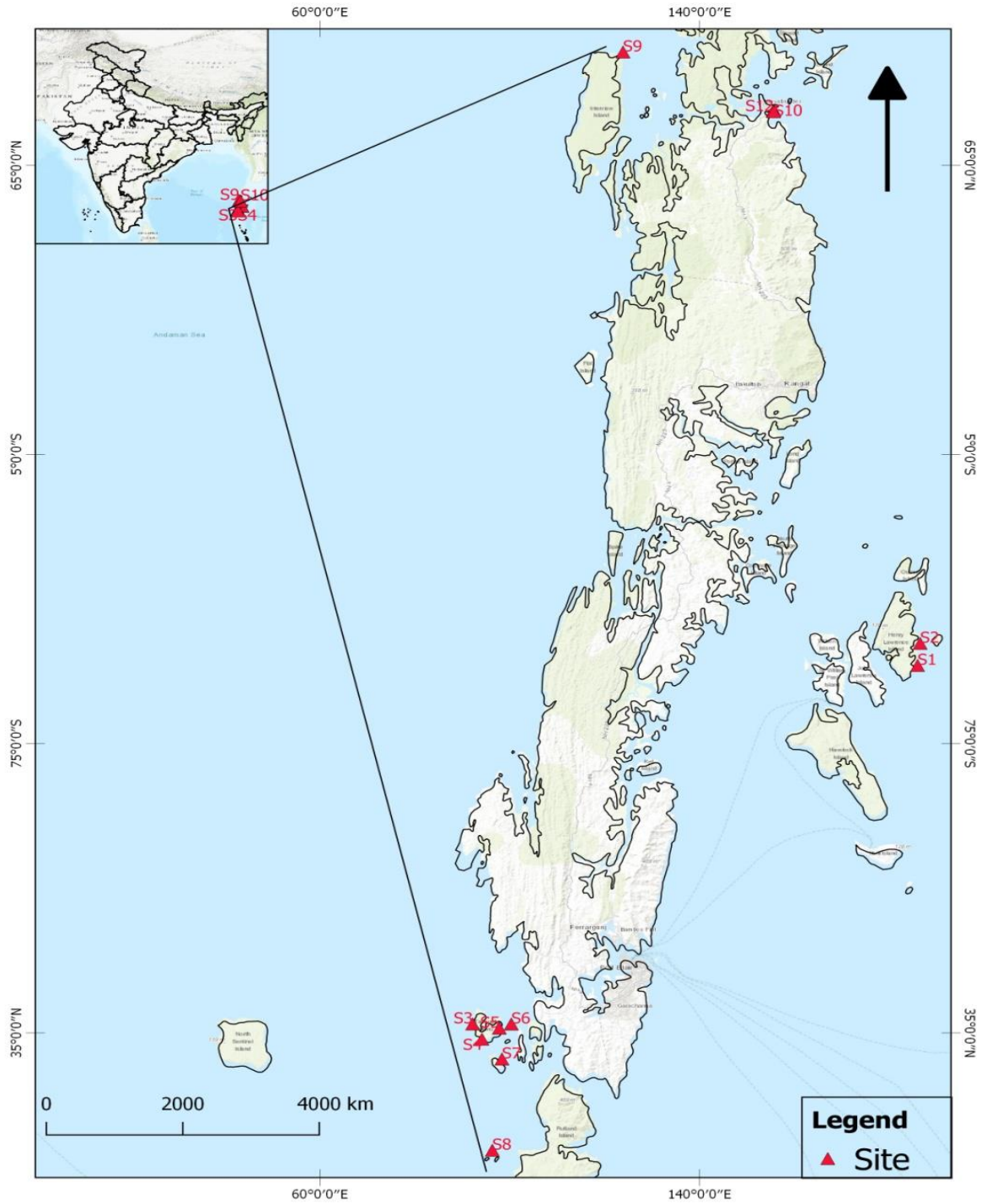


Figure 5.22: Sampling locations for seagrass associated macrobenthic fauna at Andaman

5.3.3 Methodology

Sample collection

The samples were collected from 20x20 cm quadrat from seagrass bed. The collected sediments were hand-scooped from 10 cm topsoil layer. The collected samples were kept in zip lock bags and later preserved in 4% Rose Bengal buffered formalin solution.

Sieving and sorting

The sediment samples collected were further sieved using 500 μ sieve and segregated in the lab at WII Headquarter. From each sediment sample, 4 subsamples of 100gm were isolated for sorting of macrobenthic organisms. From all 36 samples, the macrobenthic organisms were sorted and preservation in 2 and 5 ml tubes with 5% formalin respectively to their sub-sample ID.

Identification and analysis

The individuals have been identified and sorted till group level and its diversity has been analysed per m²

5.3.4 Result

Total 36 samples have been collected from Henry Lawrence (n=5), Tarmugli (n=7), Chester (n=3), Boat (n=3), Twin (n=6), Interview (n=3) and Pokkadera (n=9) during March – May 2019. Total 1351 macrobenthic individuals have been sorted from samples collected from 20X20 cm quadrat. the individuals have been classified and sorted in 7 groups viz. Gastropod(GS), Bivalve(BV), Polychaete(PL), Nematodes(NM), Amphipod(AP) and Foraminifera(FM).

The overall biomass of organisms varied from 0.0025- 69.32 gm/m² and number of individual vary from 1750-25 no./m². The highest biomass and lowest biomass were found in Twin and Chester respectively whereas, the highest and the lowest number of individual were found in Tarmugli and Interview islands respectively.

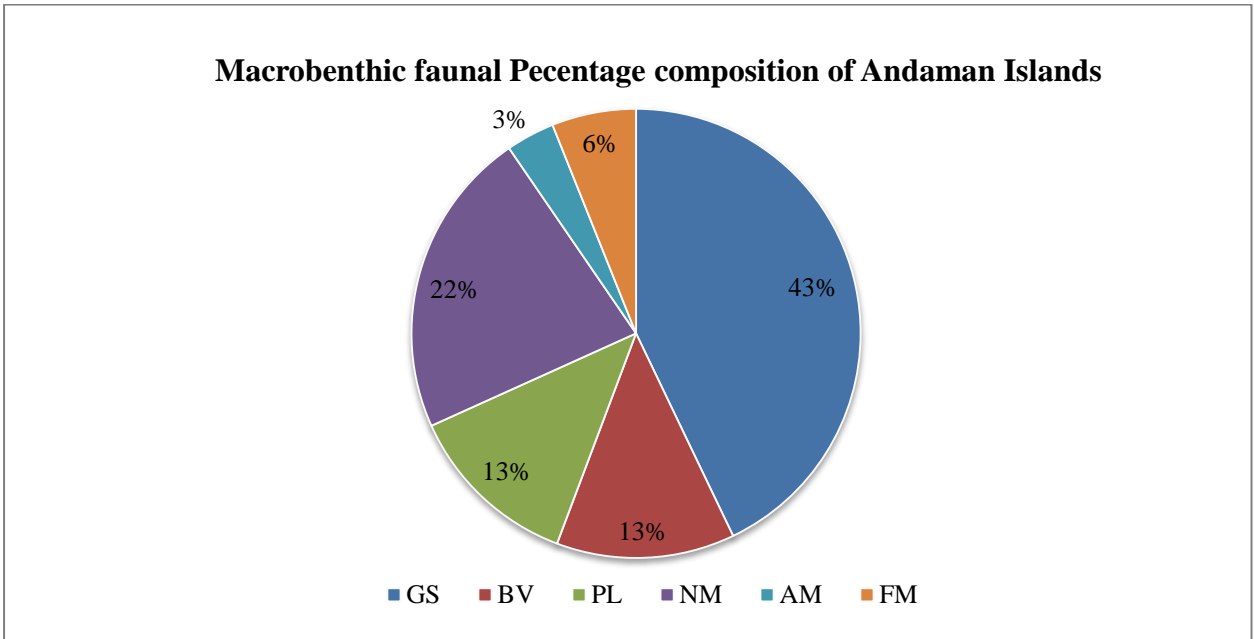


Figure 5.23: Macrobenthic faunal percentage compositions of Andaman islands

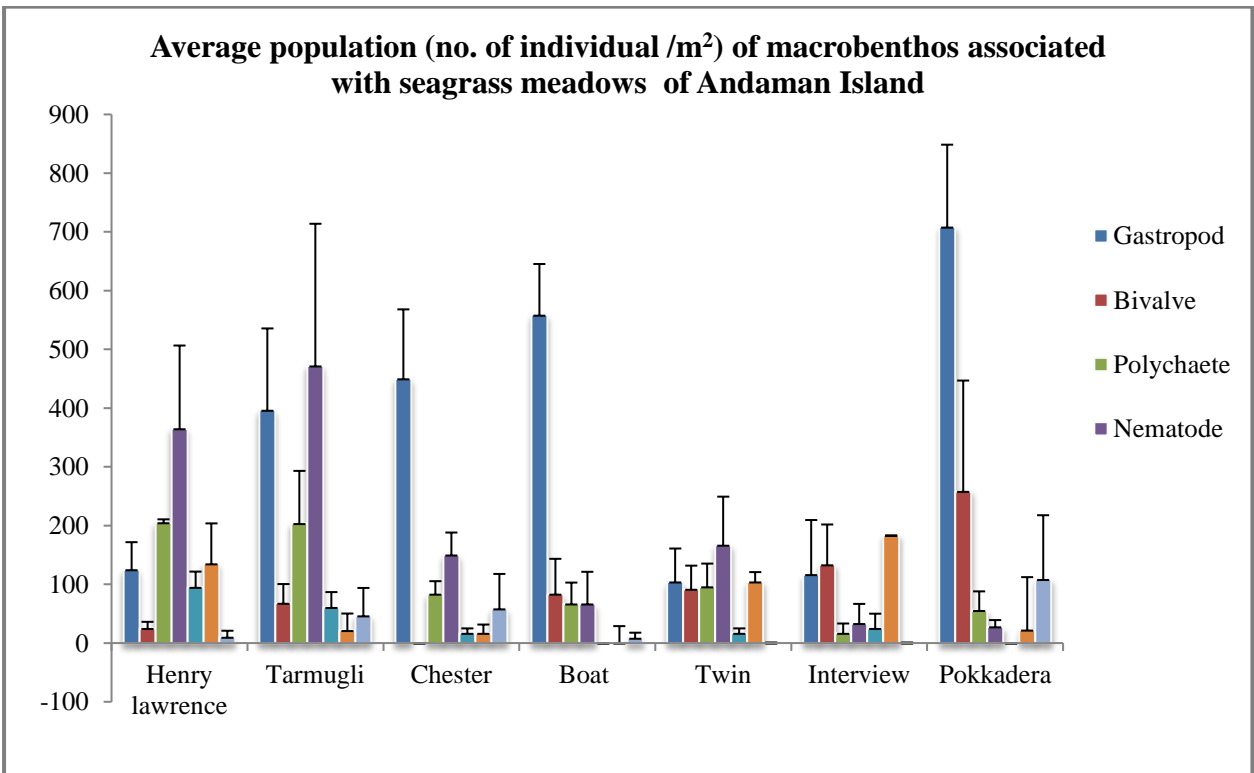


Figure 5.24: Average population (no. of individual /m²) of macrobenthos associated with seagrass of Andaman Islands

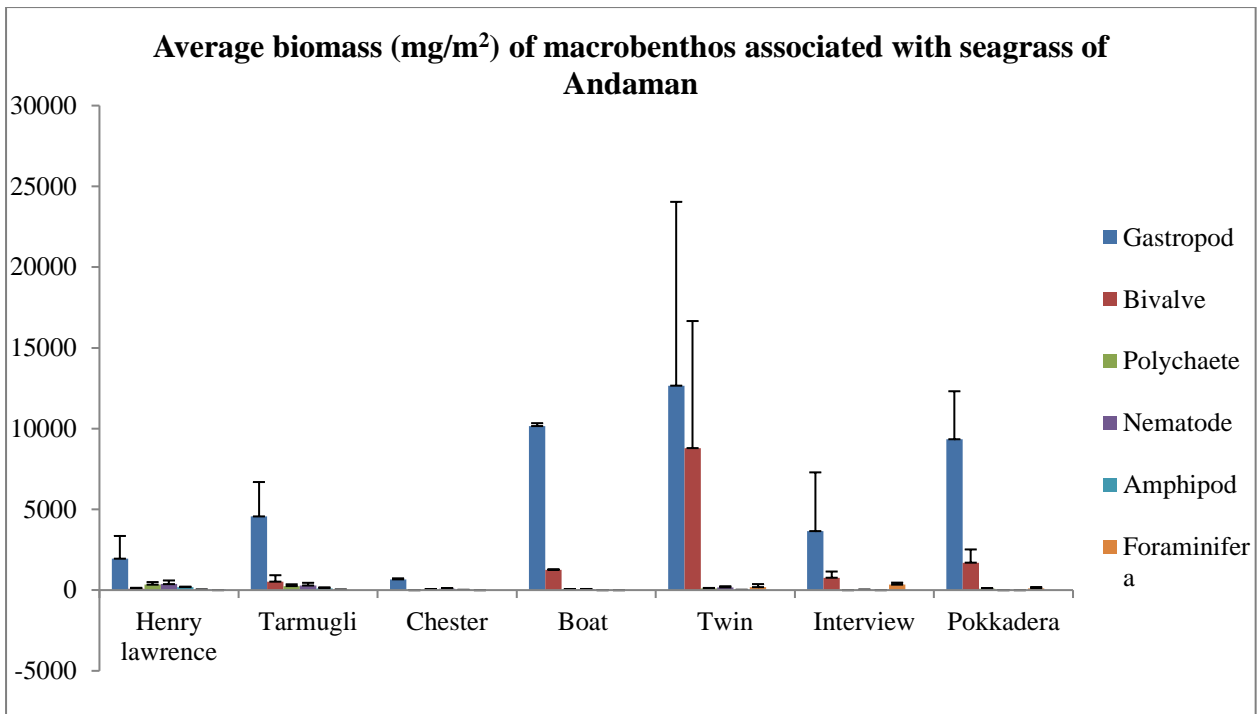


Figure 5.25: Average biomass (mg/m²) of macrobenthos associated with seagrass of Andaman Islands

Henry Lawrence Island

Total 5 quadrats {2 transect(S1 and S2)} were laid. The seagrass composition in the area was dominated by *Thalassia hemprichii* followed by *Halophila ovalis* and *Syringodium isoetifolium*. Total 5 samples from this area is constituted with 7 groups viz. Gastropod (13.02%; 25-300 indi/ m², N=5; Avg 125; SE ±46.78), Bivalve(2.604%; 0-50 indi/m², N=5; Avg 25; SE±11.18), Polychaetes (21.35%; 0-550 indi/m², N=5; Avg 205; SE ±93), Nematode (38.02%; 25-775 indi./m², N=5; Avg 365; SE±141.55), Amphipod (9.89%; 50-200indi./m², N=5; Avg 475; SE±26.69) and foraminifera (14.06%; 0-300indi./m², N=5; Avg 135; SE 68.74)

Nematode (38.02%) is the dominant group but biomass of Gastropods (65.75%) is highest in Henry Lawrence Island followed by Nematodes (12.57%), Polychaete (11.4%), Amphipods (6.3%), Bivalve (3.07%) and Foraminifera (0.59%).

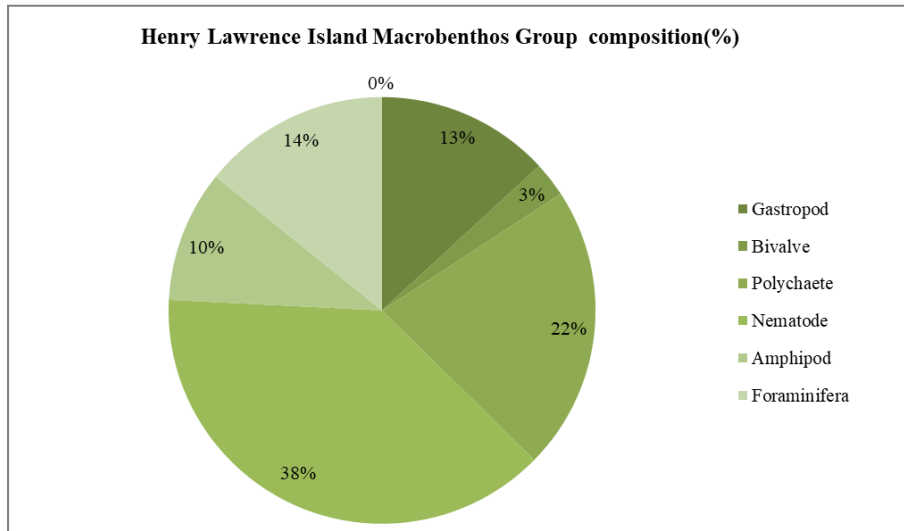


Figure 5.26: Percentage compositions of various benthic taxonomic groups at Henry Lawrence Island, Andaman Islands

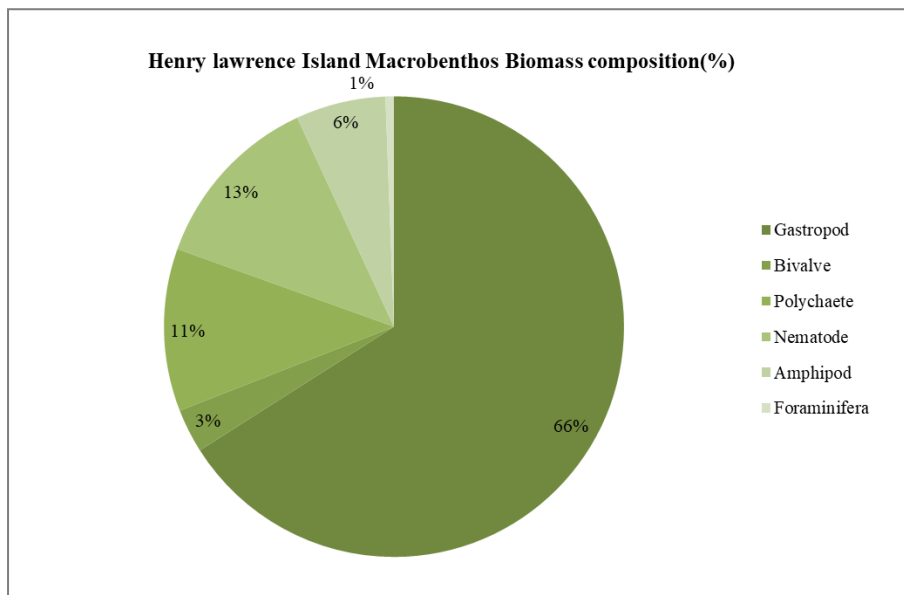


Figure 5.27: Percentage compositions in terms of the biomass of various benthic taxonomic groups at Henry Lawrence Island, Andaman Islands

Tarmugli Island

Total 7 quadrats {3 transect (S3, S4 and S5)} were laid. The seagrass composition in the area was dominated by *Halophila ovalis* followed by *Thalassia hemprichii*. Total 7 samples from this area constituted of 7 groups viz. Gastropods (34.206%; 0-1125 individual/ m², N=7; Avg 396.43; SE±139.24), Bivalve(5.123%; 0-250 indi/m², N=7; Av 67.857; SE±32.60), Polychaetes (15.36%; 0-575indi/m², N=7; Avg 203.57; SE±89.55), Nematodes (35.5932%; 0-1575 indi./m², N=7; Avg 471.43; SE±241.92), Amphipod (4.58%; 0-175 indi./m², N=7; Avg 60.714; SE±26.08) and Foraminifera (1.618%; 0-100indi./m², N=7; Avg 21.429; SE±14.87).

Though Nematode community (35.02%) is dominant, the biomass of Gastropods (79.00%) is highest in Tarmugli Island.

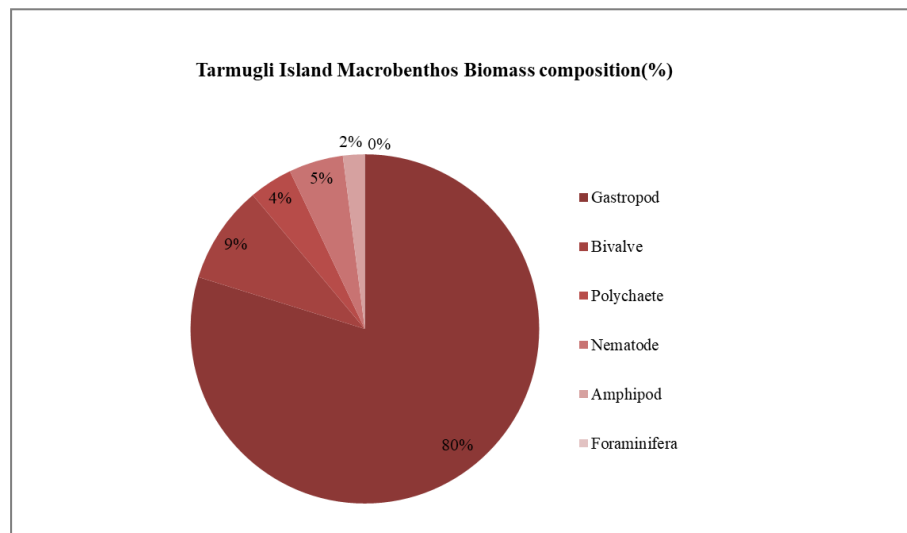


Figure 5.28: Percentage compositions in terms of the biomass of various benthic taxonomic groups at Tarmugli Island, Andaman & Island

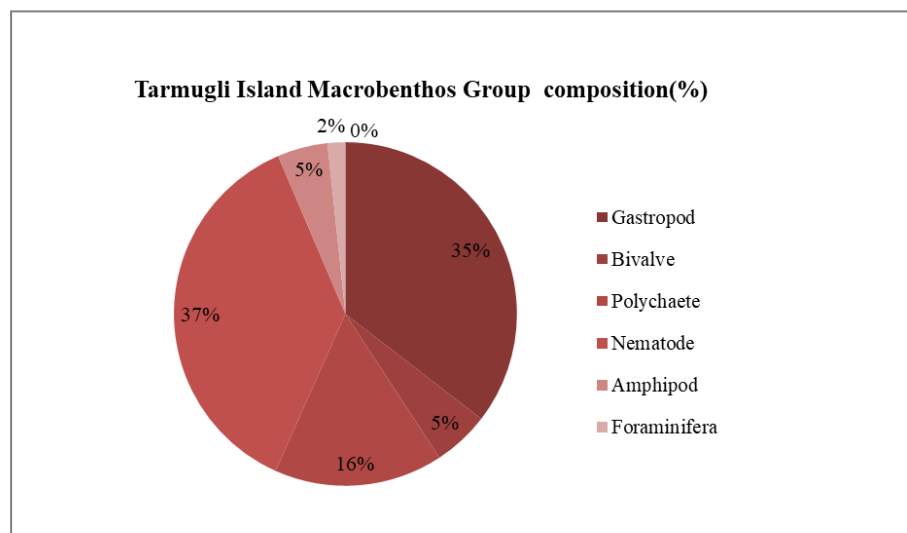


Figure 5.29: Percentage compositions in terms of individual of various benthic taxonomic groups at Tarmugli Island, Andaman & Island

Total 3 quadrats {1 transect (S6)} were laid. The seagrass composition in the area was dominated by *Halophila ovalis*. Total 3 samples from this area constituted of 6 groups viz.

Gastropod (58.06%; 275-675 individual/ m², N=3; Avg 450; SE \pm 118.15), Polychaetes (10.75%; 50-125 indi/m², N=3; Avg 83.33; SE \pm 22.048), Nematode(19.35%; 75-200 indi./m², N=3; Avg 150; SE \pm 38.188), Amphipod (2.15%; 0-25 indi./m², N=3; Avg 16.667; SE \pm 8.33) and Foraminifera (2.15%; 0-50indi./m², N=3; Avg 16.667; SE \pm 16.667).

Gastropod community is dominant with 58.06% of the total macrobenthic assemblages, along with highest biomass of 63%.

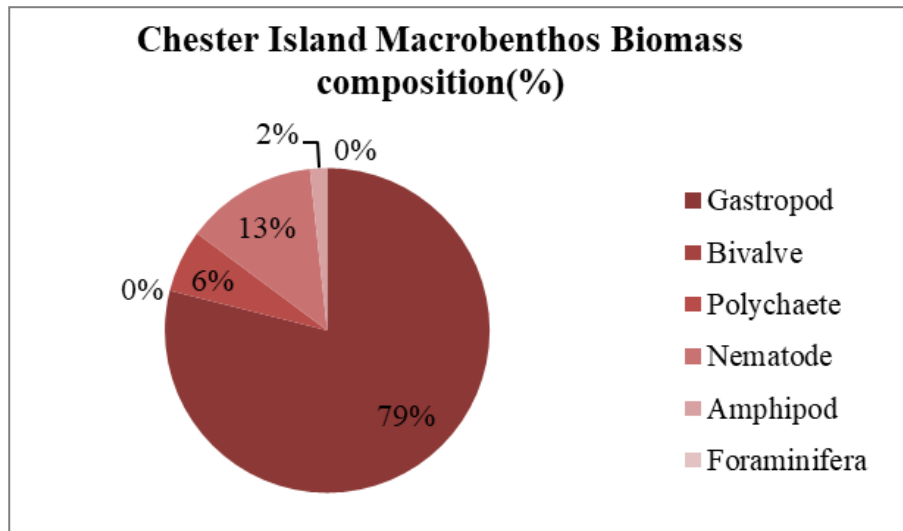


Figure 5.30: Percentage compositions in terms of the biomass of various benthic taxonomic groups at Chester Island, Andaman & Islands

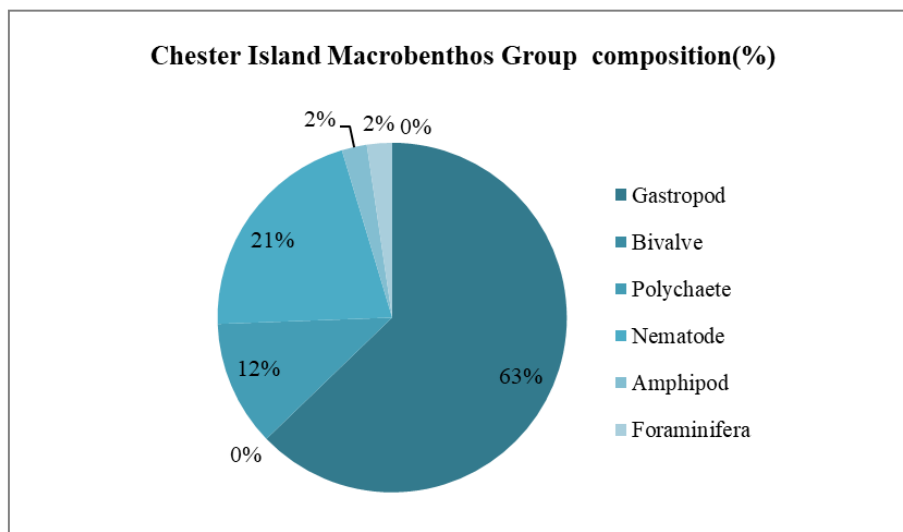


Figure 5.31: Percentage compositions in terms of individual of various benthic taxonomic groups at Chester Island, Andaman Islands

Boat Island

Total 3 quadrats {1 transect (S7)} were laid. The seagrass composition in the area was dominated by *Halophila ovalis* followed by *Halodule uninervis*. Total 3 samples from this area constituted of 5 groups viz. Gastropod (71.27%; 400-700 individual/ m², N=3; Avg 558.33; SE \pm 87.002), Bivalve (10.64%; 0-200 indi/m², N=3; Avg 83.333; SE \pm 60.093), Polychaete (8.51%;

0-125 indi/m², N=3; Avg 66.667; SE ±36.324), and Nematode (8.51%; 0-175 indi./m², N=3; Avg 66.667; SE ±54.645).

Gastropod community is dominant forming 71.27% of total macrobenthic assemblage along with the the highest biomass of 88% at Boat Island.

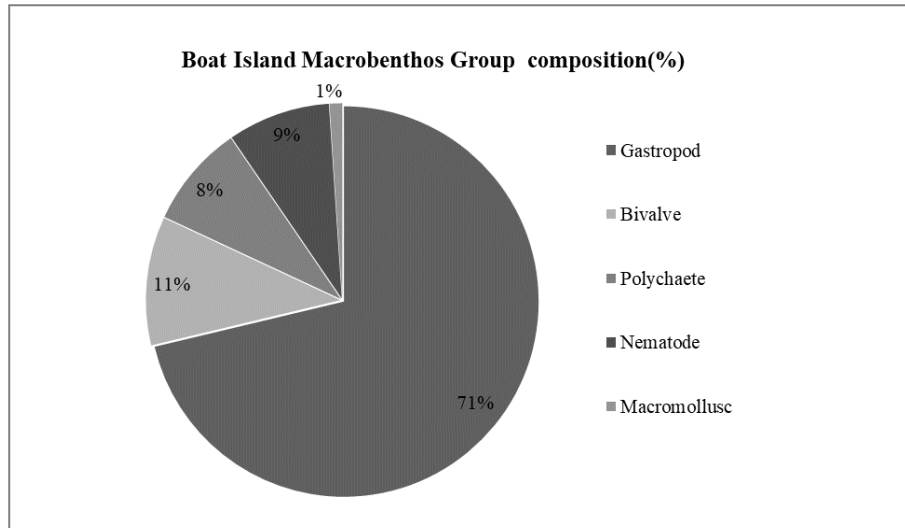


Figure 5.32: Percentage compositions in terms of individual of various benthic taxonomic groups at Boat Island, Andaman

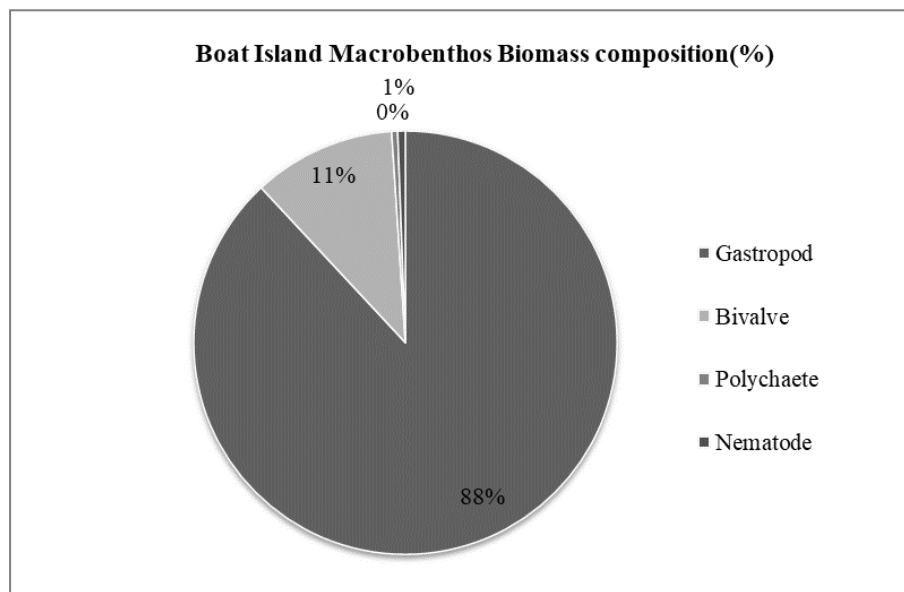


Figure 5.33: Percentage composition in terms of biomass of various benthic taxonomic groups at Boat Island, Andaman Islands

Twin Island

Total 6 quadrats {1 transect (S8)} were laid. The seagrass composition in the area was dominated by *Halophila ovalis*. Total 6 samples from this area constituted of 6 groups viz. Gastropod (16.54%; 0-250 indi/m², N=6; Avg 95.833; SE ±39.485), Nematode (28.77%; 0-

550 indi./m², N=6; Avg 166.67; SE \pm 82.58), Amphipod (3%; 0-50 indi./m², N=6; Avg 16.67; SE \pm 8.333) and foraminifera (18%; 0-550indi./m², N=6; Avg 104.17; SE \pm 90.004).

Foraminifera and Gastropod community (18%) as found to be dominant and the biomass of Gastropod (58%) was the highest in Twin Island.

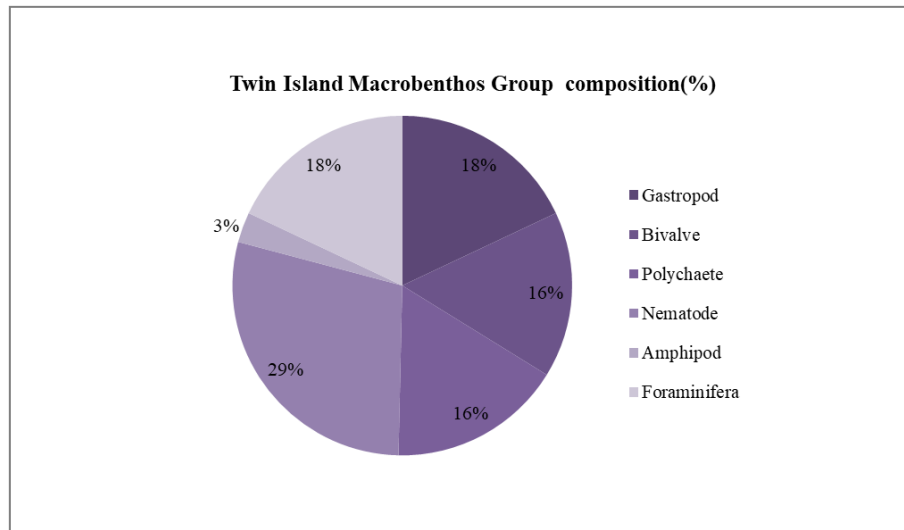


Figure 5.34: Percentage compositions in terms of individual of various benthic taxonomic groups at Twin Island, Andaman Islands

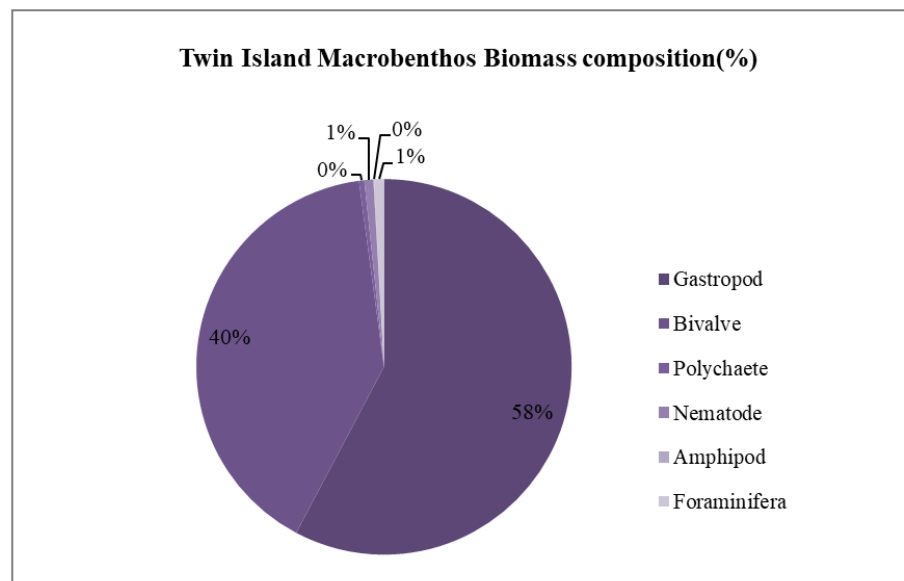


Figure 5.35: Percentage compositions in terms of the biomass of various benthic taxonomic groups at Twin Island, Andaman Islands

Interview Island

Total 3 quadrates {1 transect (S9)} were laid. The seagrass composition in the area was *Halodule pinifolia*. Total 3 samples from this area constituted of 6 groups viz. Gastropod (23%; 0-300 individual/ m², N=3; Avg 350; SE \pm 92.796), Bivalve(26%; 0-225 indi./m², N=3; Avg 133.33; SE 68.2113), Polychaete (3%; 0-50 indi./m², N=3; Avg 16.66; SE \pm 16.6667),

Nematode (7%; 0-100 indi./m², N=3; Avg 33.33 ; SE ±33.333), Amphipod (5%; 0-75 indi./m², N=3; Avg 25; SE ±25) and Foraminifera (36%; 150-225indi./m², N=3; Avg 183.33; SE ±22.04).

Though foraminifer (36%) was dominant, the biomass of Gastropod (77.00%) was found to be highest at Interview Island.

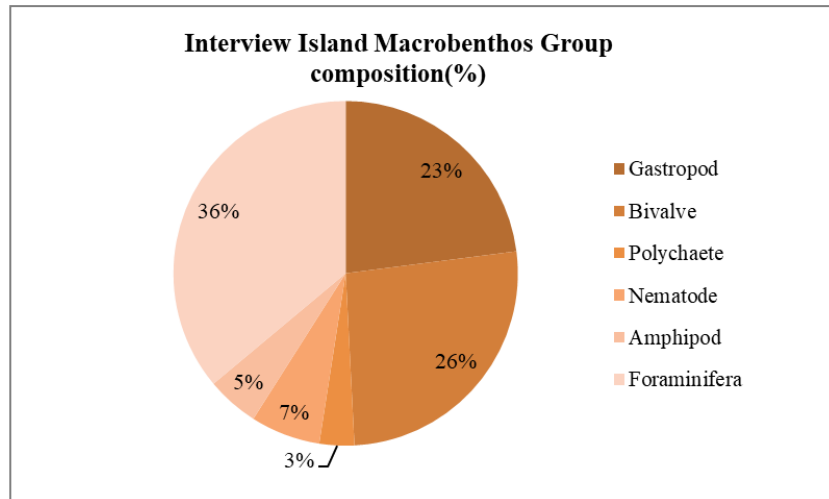


Figure 5.36: Percentage composition in terms of individual of various benthic taxonomic groups at Interview Island, Andaman Islands

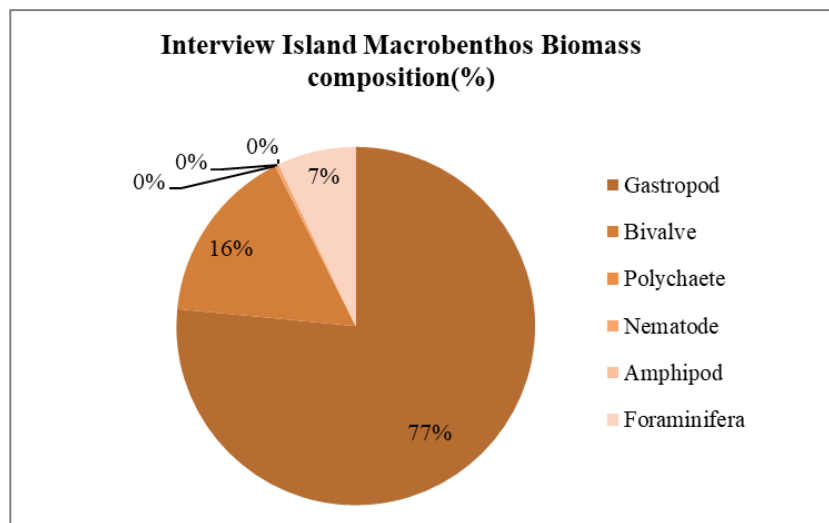


Figure 5.37: Percentage composition in terms of biomass of various benthic taxonomic groups at Interview Island, Andaman Islands

Pokkadera

Total 9 quadrats {3 transects (S10, S11 and S12)} were laid. The seagrass composition in the area is dominated by *Cymodocea Rotundata* followed by *Thalassia hemprichii*, *Halodule pinifolia* and *Halophilla beccarii*. Total 9 samples from this area constituted of 6 groups viz.

Gastropod (60%; 150-1700 individual/ m², N=9; Avg 708.333; \pm SE 140.19), Bivalve(22%; 0-1750 indi/m², N=9; Avg 258.333; \pm SE 188.60), Polychaete (5%; 0-300 indi/m², N=9; Avg 55.56; SE 32.48), Nematode (2%; 0-75 indi./m², N=9; Avg 27.78; \pm SE 11.37) and foraminifera (2%; 0-150indi./m², N=9; Avg 22.22; \pm SE 16.9)

Gastropod community was dominant with 60% along with biomass of 82% at Pokkadera

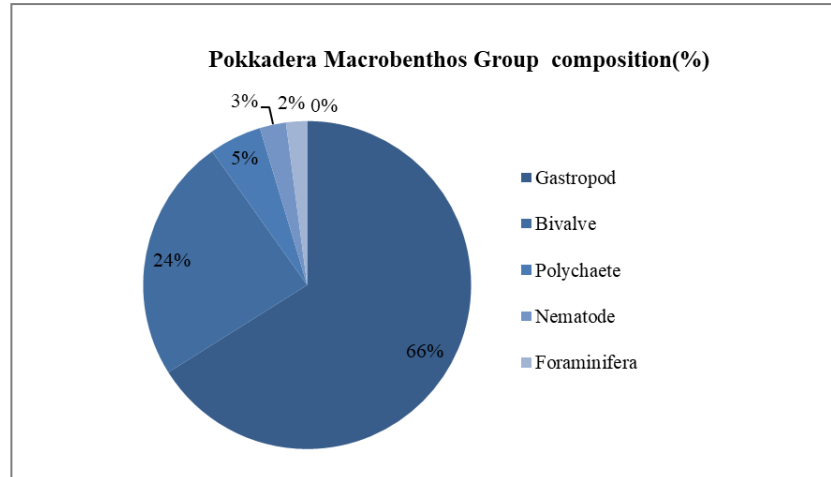


Figure 5.38: Percentage compositions in terms of individual of various benthic taxonomic groups at Pokkadera, Andaman Islands

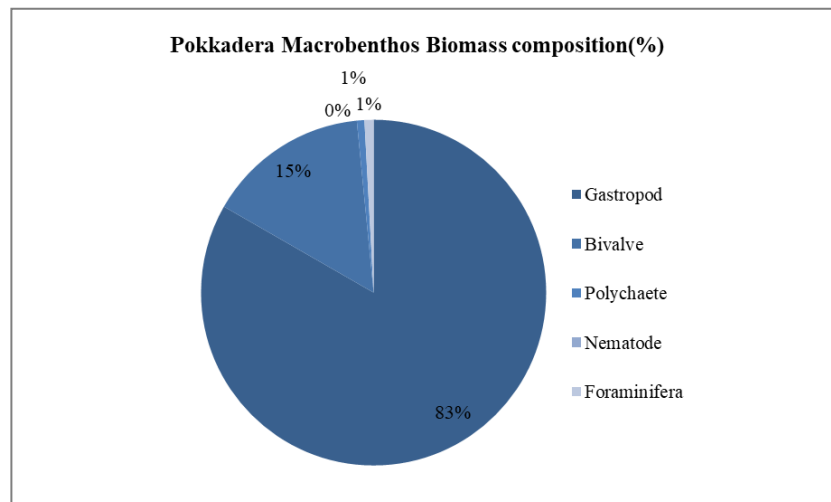


Figure 5.39: Percentage compositions in terms of biomass of various benthic taxonomic groups at Pokkadera, Andaman Islands

Intertidal Zone

The seagrass meadows at Henry Lawrence, Chester, Boat and Pokkadera were in the intertidal zone, which contribute to 20 out of the total 36 samples. The highest composition was of Gastropod community, whereas the lowest was Amphipod. The highest biomass was found to be of Gastropods ($6314.95 \text{ mg/ m}^2 \pm 1711.62$) in this area.

Subtidal Zone

The seagrass meadows at Tarmugli, Twin and Interview Islands were in the intertidal zone which contributes to 16 out of the total 36 samples. The highest composition of the macrobenthic assemblages was of Nematode ($275 \text{ indi/ m}^2 \pm 118.98$) community, whereas the Gastropod community ($7428.75 \text{ mg/ m}^2 \pm 4431.57$) constitutes the highest biomass in this area.

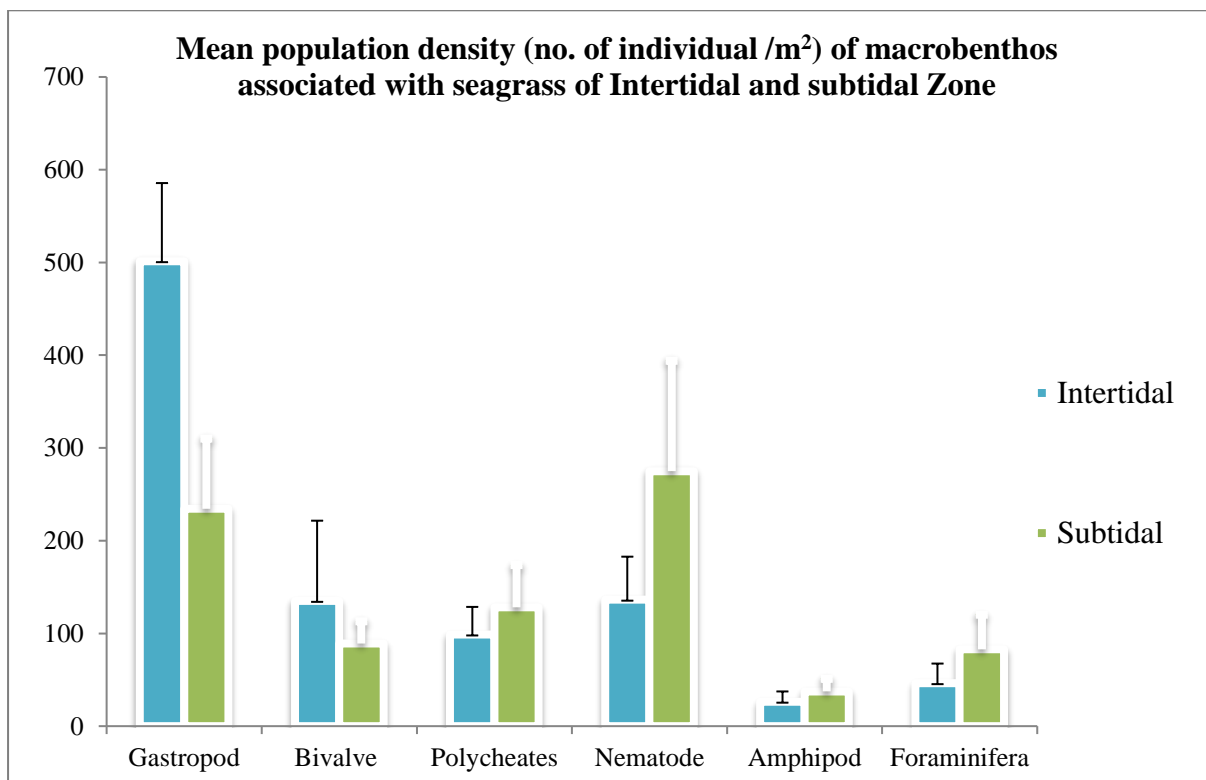


Figure 5.40: Mean population density (no. of individual /m²) of macrobenthos associated with seagrass of intertidal and subtidal zone

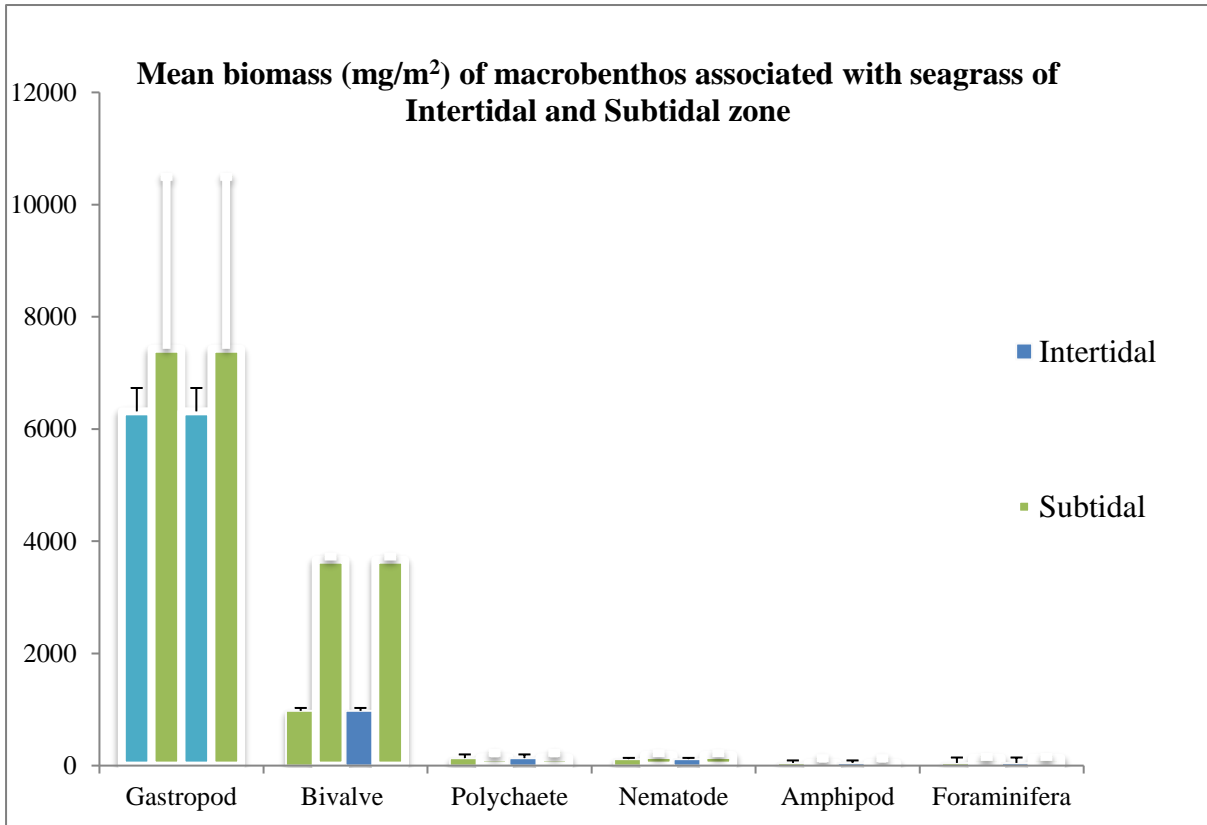


Figure 5.41: Mean biomass (mg/m²) of macrobenthos associated with seagrass of intertidal and subtidal zone

Table: 5.9 Distribution of macrobenthic faunal group in Andaman Islands [GS-Gastropod, BV-Bivalve, PL-Polychaetes, NM-Nematode, AP-Amphipod, FM-Foraminifera]

SN	Island	Sample id	Type of meadow	GS	BV	PL	NM	AP	FM
1	Chand Balu	CB 1.1	Intertidal	+	+	-	+	+	-
2	Chand Balu	CB1.6	Intertidal	+	+	+	+	+	+
3	Chand Balu	CB1.11	Intertidal	+	-	+	+	+	-
5	Jua tekdi	JT 1.6	Intertidal	+	-	+	+	+	+
6	Jua tekdi	JT 1.11	Intertidal	+	+	+	+	+	+
7	Tarmugli	TAR1.1	Subtidal	+	+	+	+	+	-
8	Tarmugli	TAR1.5	Subtidal	+	+	+	+	+	+
9	Tarmugli	TAR1.11	Subtidal	-	-	-	-	-	-
10	Tarmugli	TAR2.1	Subtidal	+	+	-	-	-	-
11	Tarmugli	TAR2.6	Subtidal	+	+	+	+	+	-
12	Tarmugli	TAR3.1	Subtidal	+	+	-	+	-	-
13	Tarmugli	TAR3.6	Subtidal	+	+	+	+	+	+
14	Chester	CHE1.1	Intertidal	+	-	+	+	+	-
15	Chester	CHE1.6	Intertidal	+	-	+	+	+	-
16	Chester	CHE1.11	Intertidal	+	-	+	+	-	+
17	Boat	BT1.1	Intertidal	+	+	+	+	-	-
18	Boat	BT1.6	Intertidal	+	+	-	-	-	-
19	Boat	BT1.11	Intertidal	+	-	+	+	-	-
20	Twin	TW1.1	Subtidal	+	-	+	+	+	-
21	Twin	TW1.6	Subtidal	+	+	+	+	+	-
22	Twin	TW1.11	Subtidal	-	-	+	+	-	-
23	Twin	TW2.1	Subtidal	+	+	+	+	-	+
24	Twin	TW2.6	Subtidal	+	+	+	+	+	+
25	Twin	TW2.11	Subtidal	+	+	-	-	-	-
26	Interview	INT 1.1	Subtidal	+	+	+	+	+	+
27	Interview	INT 1.6	Subtidal	+	+	-	-	-	+
28	Interview	INT 1.11	Subtidal	-	-	-	-	-	+
29	Pokkadera	PKD1.1	Intertidal	+	+	-	-	-	+
30	Pokkadera	PKD1.6	Intertidal	+	+	-	-	-	-
31	Pokkadera	PKD1.11	Intertidal	+	+	+	-	-	-
32	Pokkadera	PKD2.1	Intertidal	+	-	+	+	-	-
33	Pokkadera	PKD2.6	Intertidal	+	+	+	+	-	-
34	Pokkadera	PKD2.11	Intertidal	+	-	-	+	-	+
35	Pokkadera	PKD3.1	Intertidal	+	+	+	-	-	-
36	Pokkadera	PKD3.6	Intertidal	+	+	+	+	-	-
37	Pokkadera	PKD3.11	Intertidal	+	+	-	-	-	-

5.4 Identification of round worms from stranded dugong in Tamil Nadu

The Gut content samples of two stranded Dugongs were collected from the field sites of Tamil Nadu and Gujarat. Out of which two of the samples had roundworms in it. The worms were further being identified in ZSI, Kolkata under the guidance of Dr. Anjum N. Rizwi.

5.4.1 Materials and Methods

Two dead dugongs, measuring 290-299 cm long and respectively, were reported washed ashore in Vembar and Thondi village in Tamil Nadu on 17 February 2018 and 20 June 2018 respectively. The cause of death, from preliminary observation of the carcass condition, was found to be poaching. Vembar (9.081579° N and 78.363025° E) is a village panchayat located in the Tuticorin district of Tamil-Nadu state. Thondi (9.7438° N, 79.0185° E) is a Panchayat town in Ramanathapuram district in the Indian state of Tamil Nadu. The morphometric measurements were taken with the measuring tape as per methods suggested by Heinsohn, 1981. The worm samples were collected from the stomach, foregut and hindgut of dugong and preserved in 90% ethanol for further study. The specimens were examined in the laboratory at Wildlife Institute of India, Dehradun and Zoological Survey of India, Kolkata. The morphological observation was carried out using a stereomicroscope (Olympus SZX16) and photographed using the computer camera (model Olympus U-TV1X-2 Tokyo Japan). These were used to illustrate the details of the features of the specimen. Identification of specimens was based on the taxonomic books of Yamaguti (1971). Identification of specimens was done in consultation with the relevant literature and was confirmed by the photographs (Figure 5.42).

5.4.2 Results

The specimens ranged from 9-15.5 Cm in length. All specimens were identified as *Paradujardinia halicoris*. Out of 9 individual 7 were female and 2 were male. According to the Morphological details of the worms, the male is slightly smaller than female. This roundworm has three well-defined lips, longer than they are wide, with small triangular inter labia between them, distinctly offset from the anterior end. The inner surface of the anterior lip margin lacked a denticulate ridge and was smooth. The dorsal lip had two papillae and the sub ventral lips featured one papilla on the sub ventral side and an amphid on the lateral side. There were no cervical alae. Male worms had two spicules with rounded tips and alae. There were four papillae in the pre cloacal region and two laterals to the cloaca. The female had a tapering tail with a conical tip (Angsinco, 2013).

Taxonomic Classification –

Kingdom-Animalia

Phylum-Nematode

Class- Chromadorea

Order- Rhabditida

Family- Ascarididae

Genus- *Paradujardinia*

Species- *Paradujardinia halicori*

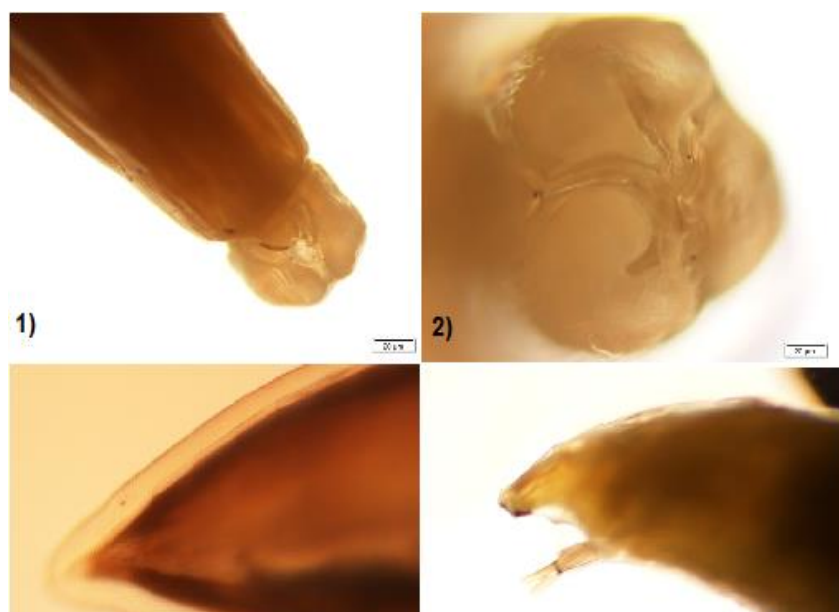


Figure 5.42: 1)Anterior end of the female parasite Paradujardinia halicoris, 2)Anterior end of female Paradujardinia halicoris showing mouth parts, 3)Posterior end of female Paradujardinia halicoris showing alae, 4) Anterior end of male Paradujardinia halicoris showing spicule

Table: 5.10 Details of sample collection

Date of collection	Location	Gut	Sex of Dugong	Size of parasite in (Cm)	Sex of the parasite	Colour of worms
20 June 2018	Thondi	Stomach	Male Adult	10.7	Female	Pale Yellow
20 June 2018	Thondi	Stomach	Male Adult	14	Female	Pale Yellow
20 June 2018	Thondi	Stomach	Male Adult	15.5	Female	Pale Yellow
20 June 2018	Thondi	Stomach	Male Adult	12.5	Female	Pale Yellow
20 June 2018	Thondi	Stomach	Male Adult	13.5	Female	Pale Yellow
20 June 2018	Thondi	Stomach	Male Adult	9	Female	Pale Yellow
20 June 2018	Thondi	Stomach	Male Adult	9.4	Female	Pale Yellow
07 Dec. 2018	Vembar	Hindgut	Unknown	13	Male	Green
07 Dec. 2018	Vembar	Foregut	Unknown	11	Male	Green

Table: 1.11 Morphometric measurements of the carcass at Vembar, Thoothukudi and Thondi, Ramanathapuram, Tamil Nadu

SN	Measurements	Vembar	Thondi	SN	Measurements	Vembar	Thondi
1	Total Body length	290	299	26	Nostril Width	-	3
2	Head length	40	43	27	Nostril length	-	4
3	Snout length	23	20	28	Total Nostrils	-	9
4	Chin length	16	14.5	29	Eye to Nostril Distance	-	13
5	Flipper length	34	50.5	30	Ear Diameter	-	1
6	Flipper max. width	20	25	31	Snout to Flipper	-	62
7	Fluke width	85	41	32	Chin Width	-	16
8	Fluke length	37	82	33	Upper Lip Length	-	30.5
9	Anal opening length	4	-	34	Upper Lip Width	-	34
10	Snout width	24	-	35	Mouth Gap	-	32
11	Mouth width	27	-	36	Anal Length	-	8
12	Eye diameter	2.5	-	37	Genital Opening Length	-	17.5
13	Head to eye length	26	-	38	Long Intestine Length	-	1500
14	Head to flipper	56	-	39	Small Intestine Length	-	1200
15	Anal girth	129	-	40	Lung Length	-	77
16	Tail stock girth	56	-	41	Lung Width	-	23.5
17	Approximate weight	-	300	42	Kidney Length	-	23
18	Standard Length	-	229	43	Kidney Width	-	10
19	Maximum Girth	-	188	44	Liver Length	-	27
20	Snout to Eye Distance	-	29	45	Liver Width	-	22
21	Snout to Ear Distance	-	45	46	Heart Length	-	24
22	Snout to Nostril Distance	-	16	47	Heart Width	-	20
23	Eye Length	-	2.5	48	Stomach Length	-	38
24	Eye Width	-	2.5	49	Stomach Width	-	24
25	Distance between Eyes	-	31	50	Length of Male Genitalia	-	22



Figure 5.43: Dugong stranded in Vembar, Tamil Nadu



Figure 5.44: Dugong stranded in Thondi, Palk Bay, Tamil Nadu

5.5 Geospatial analysis of seagrass meadows of Ritchie's archipelago

Satellite imageries and geospatial tools were used to attempt the detection of submerged seagrass meadows along the coast of islands of Ritchie's archipelago. Machine learning algorithms such as Random Forest, Support Vector Machine and Nearest Neighbour was incorporated for seagrass detection and mapping. This work was carried out in collaboration with Centre for Space Science and Technology Education in Asia and the Pacific (affiliated to United Nation) at Indian Institute of Remote Sensing, Dehradun as part of dissertation work. This work was eventually published as a research communication article in *Current Science* journal on 25th April 2020.

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Detection and mapping of seagrass meadows at Ritchie's archipelago using Sentinel 2A satellite imagery**Sharad Bayyana^{1*}, Satish Pawar¹, Swapnali Gole², Sohini Dudhat², Anant Pande², Debashis Mitra³, Jeyaraj Antony Johnson⁴ and Kuppusamy Sivakumar²**¹Indian Institute of Remote Sensing, Dehradun 248 001, India²Department of Endangered Species Management, Wildlife Institute of India, Dehradun 248 002, India³Marine and Atmospheric Science Department, Indian Institute of Remote Sensing, Dehradun 248 001, India⁴Department of Habitat Ecology, Wildlife Institute of India, Dehradun 248 002, India

This study presents an attempt to utilize seagrass data acquired from field surveys to compare classification models for mapping seagrasses using Sentinel-2A satellite data. Out of three models tested, viz. Random Forest, Support Vector Machine and K-Nearest Neighbor; Random Forest classification model proved most effective in the given scenario with 0.99 model accuracy. Seagrasses present as deep as 21 m were detected post water column correction, presenting the capability of Sentinel-2A satellite in detecting submerged benthic habitat.

Keywords: Depth Invariant Index, Ritchie's archipelago, seagrass, Sentinel-2A.

SEAGRASS meadows, one of the most productive ecosystems on the planet, are estimated to lose 7% of their global area annually¹. Spatial data analysis for seagrass studies towards their sustainable management and conservation has been an emerging field. Globally, satellite remote sensing tools have proven to be cost effective in comparison to conventional field surveys²⁻⁸ and traditional geospatial methods such as aerial photography⁹. Since, satellite sensors are repeatable in their path and are geometrically accurate, change detection in seagrass distribution over temporal scale is possible¹⁰⁻¹². Landsat imagery has been efficiently used in seagrass and benthic substrate mapping, despite its spectral and spatial limitations¹²⁻¹⁵. Multispectral imagery from compact airborne spectrographic imager (CASI) with satellite imagery of Landsat and Spot, has been shown to exhibit more accurate results from airborne high-resolution sensor compared to aerial photography in classification of submerged benthic features including seagrasses².

Sensing of submerged benthic vegetation in the coastal waters is achieved with multispectral observations (400–650 nm) of reflected radiance in the visible range which is enhanced with finer spatial resolution¹⁶. Certain regres-

sion models developed for mapping benthic features have opened up the doors to overcome the limitations of attenuation of radiance within the water column¹⁷⁻¹⁹. Assuming that variance in reflectance from same benthic substrate is primarily due to its presence at various depths and the diffused attenuation coefficient (K_d) is same for all the bands^{17,18}, regression from logarithmic values of individual bands provides proxy attenuation coefficients which are independent of depth²⁰. Assessment of submerged sea grasses is reliable with remote sensing when appropriate correction (such as water depth correction) is applied to satellite images²¹. Medium resolution multispectral satellite images from Landsat OLI were effective in mapping of submerged benthic features with application of depth invariant index (DII), which is independent of depth effect²². High resolution multispectral imagery such as Sentinel-2A with 10 m spatial resolution has also proved effective to detect and estimate the cover of seagrass beds along the coast of Lombok in Indonesia²³. The quality of results post DII when utilized for VHR Worldview-2 imageries was significantly high (up to 83% at Kotok Island in Indonesia)²⁴.

In India, seagrass are distributed along the coastline of nine states and two union territories with major patches found along Tamil Nadu (Palk Bay and Gulf of Mannar), Odisha, Gujarat, Lakshadweep Islands and Andaman and Nicobar Islands²⁵. Remote sensing for the seagrass detection was first initiated at Lakshadweep islands to study the coral reefs and seagrass beds using black and white aerial photographs²⁶. Later, loss of seagrass habitats in Gulf of Mannar group of islands due to anthropogenic activities was detected using LISS III satellite imagery²⁷. Seagrass area was estimated to be around 85.5 sq. km around the islands of Gulf of Mannar based on IRS-1D LISS III satellite data from 1998 (ref. 28).

Earlier, a few studies have utilized conventional field survey methods to map seagrass ecosystems in the Andaman and Nicobar group of islands²⁹⁻³¹. One study used satellite geospatial data (LISS III and LISS IV) for the mapping across the entire Andaman islands³². Seagrass meadows in Andaman and Nicobar Islands serve as foraging grounds for globally threatened species such as dugongs, green sea turtles³³, and act as nurseries for several species of fish and invertebrates and thus support fisheries in the islands. In the light of proposed infrastructure developments in the islands³⁴, understanding the extent of seagrass distribution in the islands will be useful in identifying critical areas to aid their conservation and management.

In this study, we mapped the seagrass meadows at Ritchie's archipelago (henceforth RA; 11°46'N–12°19'N and 92°54'E–93°08'E) within the Andaman and Nicobar group of islands using multi-spectral imager (MSI) Sentinel-2A satellite imagery ([Supplementary Table 1](#)). Ritchie's archipelago is a group of 13 islands, east of the main group of Andaman islands, consisting of two

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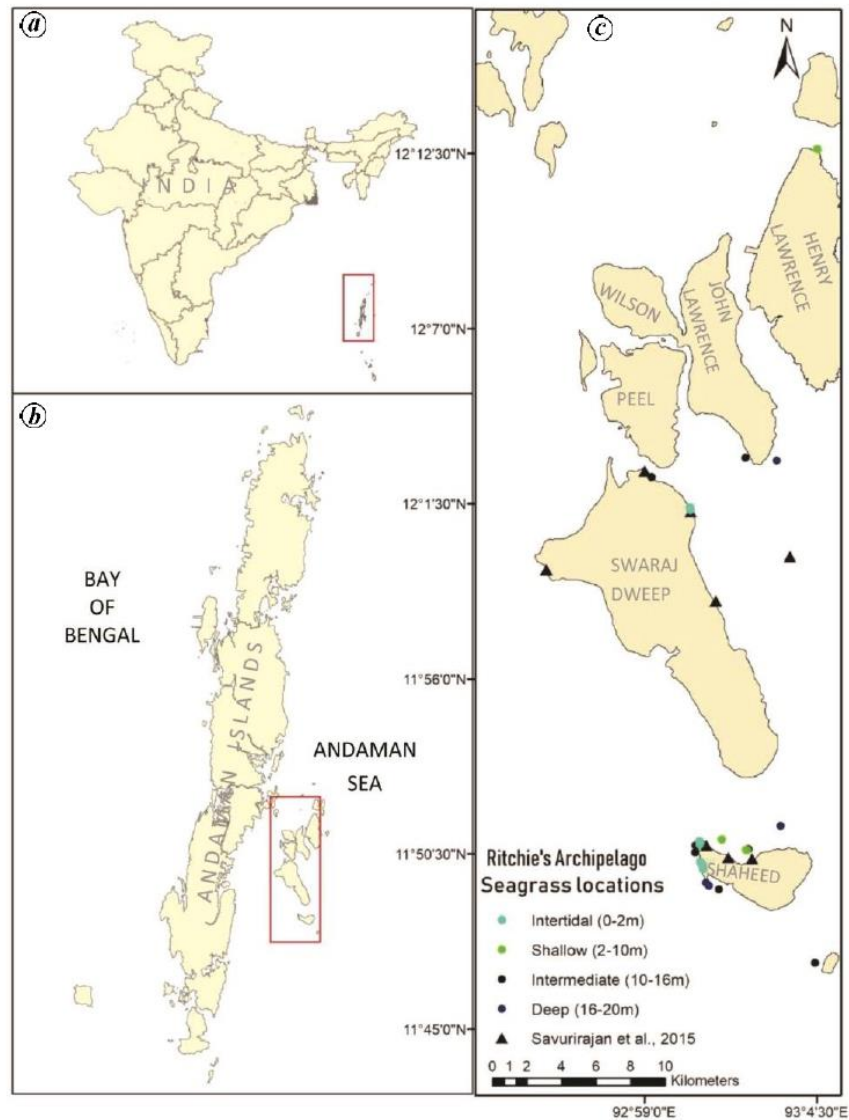


Figure 1. Study area map of Ritchie' Archipelago, Andaman and Nicobar Islands with seagrass locations.

inhabited (Havelock, now *Swaraj Dweep* and; Neil, now *Shaheed Dweep*) and 11 uninhabited islands (North button, middle button, south button, Outram, Inglis, Henry Lawrence, John Lawrence, Wilson, Nicholson, Peel and Sir Hugh Ross) spread across an area of 225 sq. km (ref. 35) (Figure 1). Seven of these islands, viz. North button, middle button, south button, Outram, Inglis, Henry Lawrence and John Lawrence, form part of the Rani Jhansi Marine National Park protected area whereas Sir Hugh Ross is a Wildlife Sanctuary. With a tidal amplitude of 3 m during spring and neap tide, semidiurnal tide is seen in the region.

We carried out seagrass surveys using line intercept transects (LITs; Figure 2) at intertidal and sub tidal areas

at various depths at RA in the month of March and April 2018 ([Supplementary Table 2](#)). Subtidal areas were characterized using SCUBA diving whereas the intertidal areas were surveyed on-foot. Line intercept transects (50 m long; LIT) were deployed perpendicular to the shore to assess meadow characteristics (McKenzie and Yoshida 2012). At each transect, seagrass cover, species composition, algal cover and substrate type were recorded using a 50 × 50 cm quadrat ([Supplementary Figure 1](#)) along with GPS location (Garmin etrex 30) and depth (Aqualung i300 dive computer) for generating training sets for supervised classification and for training data accuracy assessment of the prediction models. In addition

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Table 1. Depth-wise segregation of seagrass locations at Ritchie’s Archipelago, Andaman and Nicobar Islands

Island	Transect points	Seagrass class	Depth range
<i>Shaheed Dweep</i>	NB1, NB2, NB3, NB4 LX1, LX2	Intertidal	0–2 m
<i>Swaraj Dweep</i>	DL1, DL2		
<i>Shaheed Dweep</i>	AQ, BH2, BH3	Shallow	2–10 m
Henry Lawrence	HL		
<i>Shaheed Dweep</i>	NU1, NU2, NU3, MG3, BH1	Intermediate	10–16 m
<i>Swaraj Dweep</i>	NR		
Hugh Ross	CHN		
John Lawrence	JL2		
<i>Shaheed Dweep</i>	MG1, MG2, BB,	Deep	16–20 m
John Lawrence	JL1		

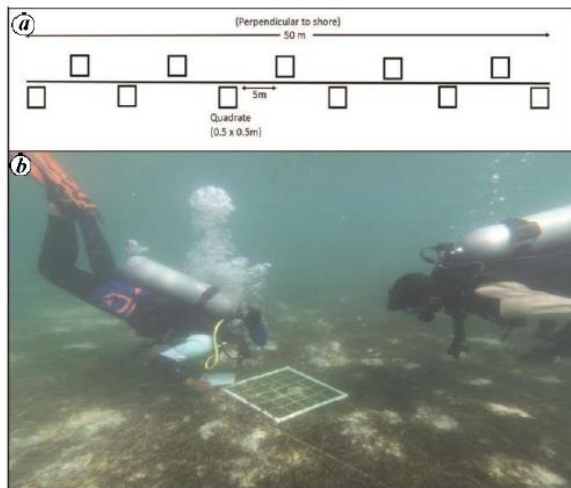


Figure 2. a, Illustration of Line Intercept Transect survey method. b, Image showing quadrant survey along the transect line.

to this, we used seagrass locations provided for RA from Savurirajan *et al.*³¹, to cross-validate the efficiency of the prediction models.

We accessed the Sentinel-2A level 1C (top of atmosphere radiance) imagery acquired on 22 March 2018 (10:30 local time overpass) over the South Andaman region by European Space Agency (ESA) (<http://scihub.copernicus.eu>). The tidal range on the date of acquisition was 0.28–2.06 m. Atmospheric correction was done to ‘top of surface, water leaving reflectance’ product using ‘sen2cor’ additional plug-in³⁶ on SNAP 6.0 platform by ESA (<https://step.esa.int/main/download/snap-download/>) for Sentinel series image processing. Visible bands (band 2-blue, 3-green and 4-red) of 10 m spatial resolution were utilized considering their capability to penetrate water up to considerable depth¹⁶. We used the Lyzenga method¹⁸ to obtain coefficient values to generate a normalized index value independent of the depth factor. Reflectance values from each band were extracted using ‘point sampling tool’ plug-in in QGIS. Simple linear regression was carried out using the logarithmic values of reflectance between two bands. The coefficient of the slopes of

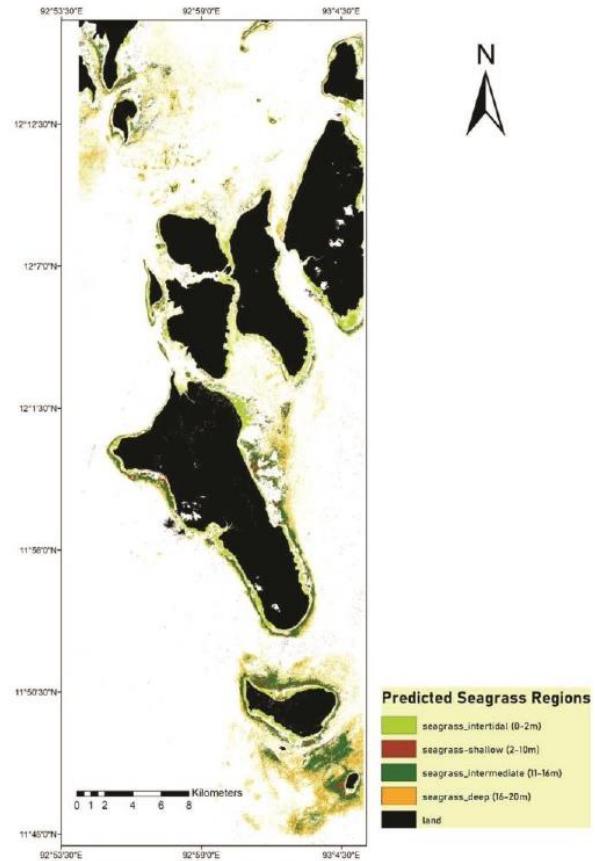


Figure 3. Random Forest Classification Map of Ritchie’s archipelago from Sentinel 2A image. Image was acquired on 22 March 2018 at approximately 10:30 local time (satellite over-pass time). Tidal range on the particular day was 0.28–2.06 m.

regression were utilized as attenuation coefficient. Three bands generated from original band combination (i.e. band blue–green, green–red and red–blue) were stacked to produce an RGB layer of depth invariant index.

We carried out supervised classification to derive four depth-based classes for seagrass locations obtained from

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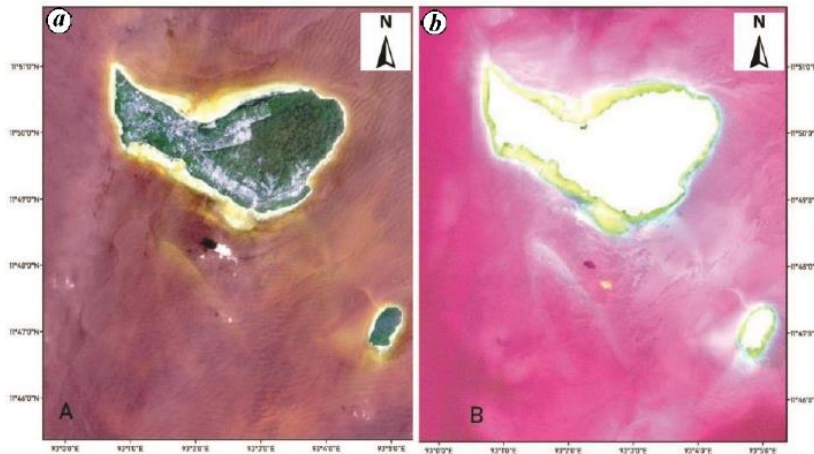


Figure 4. *a*, True colour composite of subset of *Shaheed Dweep* Island from Sentinel-2A image. *b*, RGB stack of depth invariant Index of bands of same image.

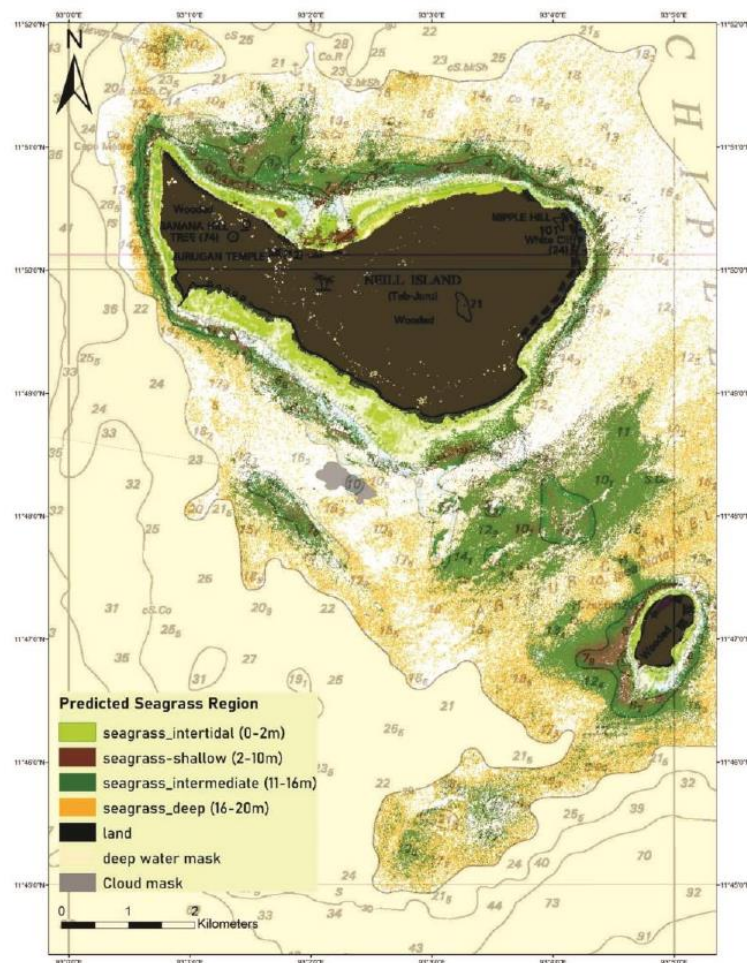


Figure 5. Classified map of *Shaheed Dweep* Island from Sentinel-2A image using Random Forest model.

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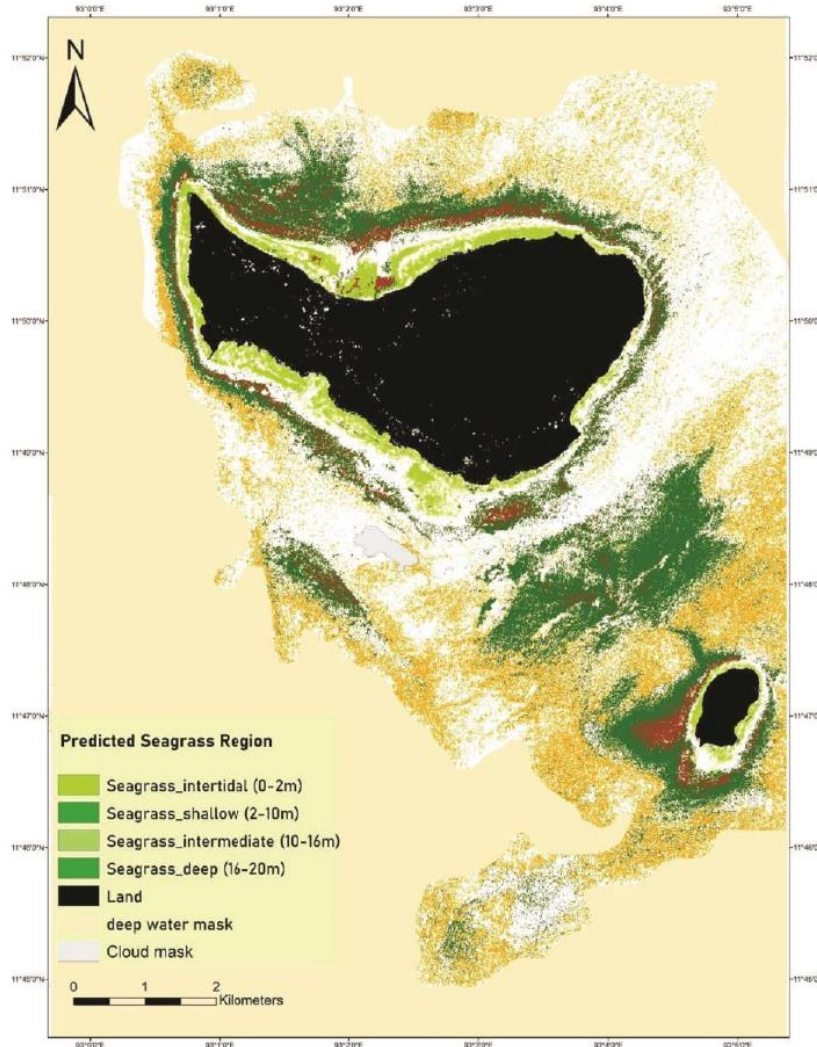


Figure 6. Classified map of *Shaheed Dweep* Island from Sentinel-2A image using K-Nearest Neighbor model.

Table 2. Training data accuracy of respective models used for supervised classification of Sentinel 2A images

Classification models	Overall accuracy	Kappa accuracy
Random forest	0.99	0.97
Support vector machine	0.96	0.93
K-nearest neighbor	0.96	0.93

field surveys (intertidal: 0–2 m; shallow: 2–10 m, intermediate: 10–16 m and; deep: 16–20 m) and validated with NHO bathymetry chart (Chart 4016, NHO; see Table 1). We used 70% of the seagrass locations obtained from field surveys to generate Region of Interests (RoIs) to train three different models (Random Forest (RF), Sup-

port Vector Machine (SVM) and K-Nearest Neighbor (KNN)) on Program-R (<https://www.R-project.org/>) using remaining 30% field data for model validation. For the cross validation of the classification models, transect NB3 LX2 for Intertidal, AQ for Shallow, CHN NU2 for Intermediate class and MG1 for Deep class were utilized. Classification models were run on R-studio IDE platform using ‘caret’, ‘rgdal’, ‘raster’, ‘e1071’ and ‘tidyverse’ packages. Further validation was done using previously published seagrass locations³¹ for *Swaraj Dweep* and *Shaheed Dweep* islands. Later, classified outputs were presented for *Shaheed Dweep* to clearly illustrate segregation of depth classes obtained from each model.

During field surveys, we recorded seagrasses at 24 locations within the RA, namely at Henry Lawrence

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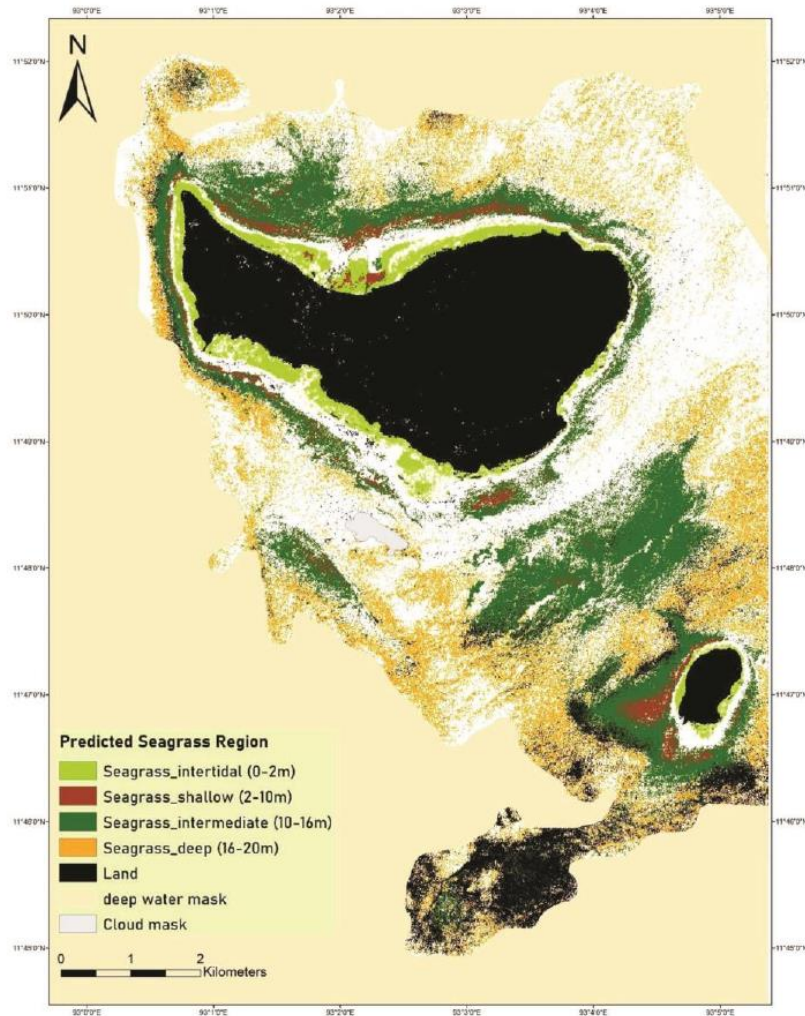


Figure 7. Classified map of *Shaheed Dweep* Island from Sentinel-2A image using Support Vector Machine model.

($n = 1$), John Lawrence ($n = 2$), *Swaraj Dweep* ($n = 3$), *Shaheed Dweep* ($n = 17$) and Sir Hugh Ross ($n = 1$) islands.

RF model (Figure 3) produced highest training data accuracy (0.99) for detecting seagrass in the study area followed by SVM and KNN (0.96) (Table 2). We obtained better signatures for the benthic features (Figure 4) using the water column correction method resulting in better classification. Seagrasses were detected at the depth of 20 m around *Shaheed Dweep* Island, complementing the field observations (Figure 5). Random Forest model (Figure 5) and K-Nearest Neighbor model (Figure 6) were able to detect all depth classes whereas SVM model was unable to detect the 'Deep – 16 to 20 m' class in addition to misclassification of land over the sea (Figure 7). All the models used in the study detected

seagrasses in deep water (>25 m) which were ignored considering the limitations of Lyzenga Method¹⁸ to detect seagrass beyond 25 m. The results show 50% accuracy using the data points obtained from Savurirajan *et al.*³¹.

The sea around Andaman and Nicobar Islands are oligotrophic waters due to less nutrient availability³⁷. This results in low turbidity and hence deeper penetration of sunlight which allows seagrasses to grow at deeper regions. In our study, there is a high possibility of mixed signals, as seagrass distribution in the Andaman Islands is known to be sparse and interspersed with sandy patches^{32,33}. Moreover, the accuracy of the models might be affected due to seasonal shifting of seagrass with respect to the sand dunes and thus their locations might change from previously reported studies^{38,31}. In comparison

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to previously used LISS III and IV data^{4,28,32}, Sentinel-2A was efficient in seagrass detection at higher depths. Previous studies were restricted to a depth of 5 m only^{22,32}.

Our results establish the efficacy of Sentinel 2A satellite imagery for seagrass mapping at higher spatial scale as well as for deeper coastal waters. Supervised classification using RF model method proved to be better model for seagrass classification in the given scenario with limited field data (Supplementary Figure 2). Depth variant index improved the classification of underwater features for Sentinel-2A imagery. Seagrass detection was successful at the ground points used for the cross validation of the classification even for the deepest locations mapped in the study area (~21 m).

Despite mounting anthropogenic pressure on seagrass ecosystems and its associated species across the world^{39,40}, there is limited data on seagrass ecosystems in India^{41,25}. With acceleration in human activities in the islands³⁴, threats such as coastal pollution including oil and plastic waste, mechanical damage from vessel anchors, higher turbidity from vessel movement and port construction activities, etc. are likely to intensify in the near future. Spatial mapping of seagrass beds in the islands using high resolution satellite imagery will be helpful in delineating critical areas for long-term change monitoring at a larger spatial scale.

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Development of wind speed retrieval model using RISAT-1 SAR cross-polarized observations

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In this study, a method for retrieving ocean surface wind speed using C-band cross-polarization SAR observations has been outlined. A linear least square technique has been used to develop a Geophysical Model Function (GMF), C2P. The GMF was derived using NRCS observations from RISAT-1 and wind-speed observations from ASCAT. The correlation between observed and simulated NRCS values obtained from C2P was 0.66, with a negative bias of 0.01 dB and the corresponding root mean square difference of 1.13 dB. Subsequently, the developed GMF was tested with 774 RISAT-1 MRS datasets to retrieve wind speed along the Indian coast and also of the tropical cyclone 'Megh'. The measured intensity and radius of maximum wind speed were 30 m s⁻¹ and 16.65 km respectively. Subsequently, the retrieved wind speed was validated with ASCAT wind-speed observations. The statistical comparison of RISAT-1 and ASCAT observed wind speed showed negative biases of 0.90 and 0.34 m s⁻¹ with the corresponding RMSD of 2.11 and 1.77 m s⁻¹ respectively, for CMOD5.N and C2P. The developed GMF C2P showed 16% more accuracy than that of CMOD5.N.

Keywords: Cross-polarization, geophysical model function, ocean surface, wind speed retrieval.

OCEAN surface winds are highly important for numerical weather and ocean state forecasting, study of oceanic transportation and processes occurring at the air–sea interface. For the last four decades, ocean surface vector winds at synoptic scales are operationally being retrieved from spaceborne scatterometers. Such observations of ocean surface winds are assimilated in numerical models for improving operational forecasts at moderate resolution. Scatterometer-based observations are available with coarser spatial resolution in the range 12–50 km with wider data gaps in the coastal regions. However, wind intensity of cyclones computed using Ku-band scatterometer data tends to underestimate the actual scenario. Therefore, in extreme conditions like cyclones, backscattered power received by microwave scatterometers mainly

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6. Dugong day campaign 2020 and outreach materials

6.1 The 'Dugong Day' Celebration

Dugong, a globally vulnerable and an uncelebrated species, was dedicated with a day '**The Dugong Day**' for the first time in India on 28th May 2020. An initiative by Wildlife Institute of India to spread awareness about the importance and status of the species throughout the country. The species is protected under Schedule 1 of the Wild (Life) protection Act, 1972, India has signed a non-legally binding Memorandums of Understanding (MoU) with CMS on the conservation and management of Dugongs and their habitats in India on 28th May 2008.

To commemorate Dugong Day, a ten days long social media campaign was organized from 19th May 2020 to 28th May 2020, with the theme '**Save Dugong and Save Livelihood**'. The aim of the event was to the aware general public about Dugongs, their habitat, life cycle, distribution and the current status of the species in the country. The event was organized in collaboration with ENVIS resource partner "Wildlife and protected area", was channelized through different platforms like WII website, Facebook, Twitter and Instagram. Daily one infographic about Dugongs and their habitats were posted on all the social media platforms.

The event included online painting, slogan and quiz competition for all the people around the world. The Painting competition was organized under three categories, Category 1 for the age 6 -13 years, Category 2 for the age 14-18 years and, Category 3 for 19 years and above. Slogan competition was for all age groups in five languages English, Hindi, Tamil, Gujarati and Bengali and the quiz competition was also open for everyone.

The quiz competition was organized online for global reach. The link for the quiz was made available from midnight of 27th May 2020 and was closed on midnight of 28th May 2020. 2659 people participated in the quiz competition and were awarded the quiz participation certificate. Out of 2659 people 1310 were female participants and 1349 were male participants. 210 people participated in slogan competition and 227 participated in the painting competition. All the participants of the competition were awarded a participation certificate and the winners of the competition were awarded winning certificate along with dugong t-shirts, caps and awareness material. The total reach of this ten-day long campaign was around 10,000 from people across the globe.

Day 1

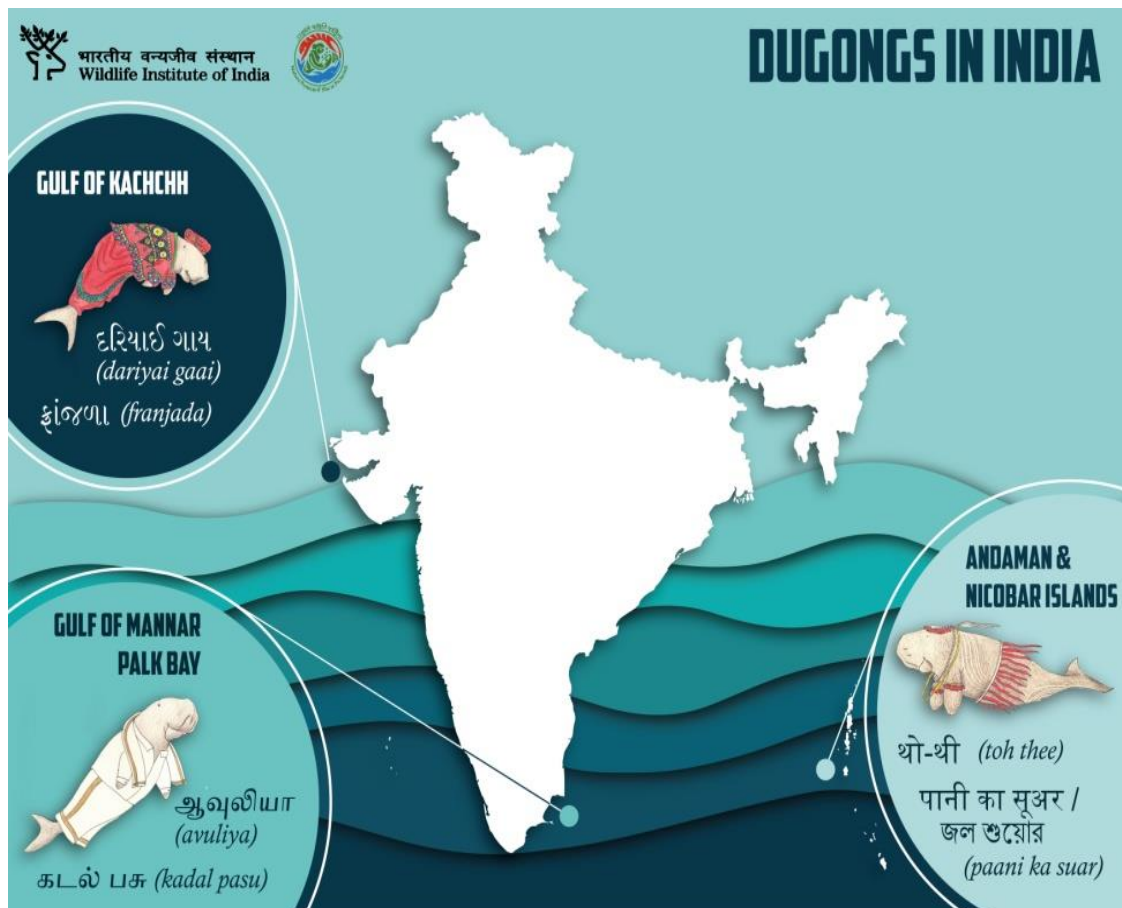
The first infographic was posted on 19th May 2020 with the basic information about Dugongs.



The infographic was captioned with multiple hashtags related to Dugong day celebration and pieces of information like celebration Dugong day on 28th May 2020, stay tuned for exciting updates.

Day 2

The second infographic was posted on 20th May 2020 with the information on the distribution of Dugongs in India

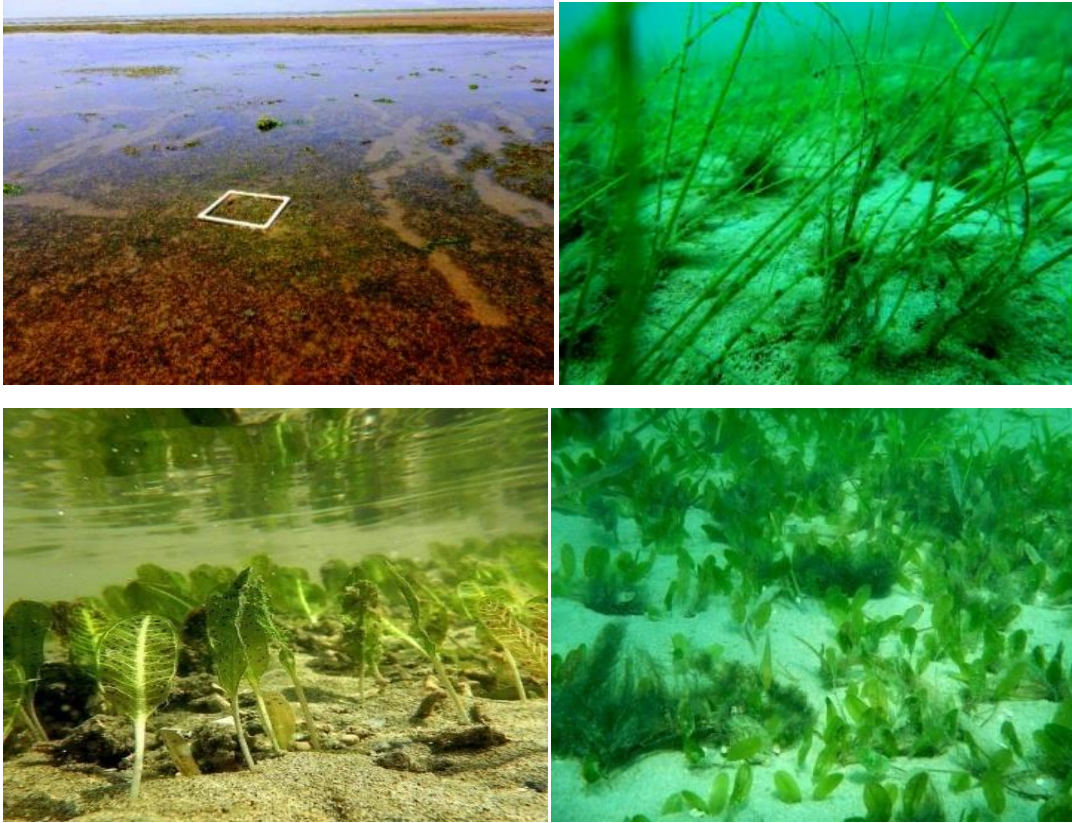


Caption: Known to cruise the waters off the coast of Gujarat, Tamil Nadu and Andaman and Nicobar Islands in India, dugongs are part of regional folklore, culture and mythology. According to the Hindu mythology, when Dwarka sank, Lord Krishna converted his cattle into dugongs a.k.a 'Sea Cows'. These gentle giants have got their own local names as well. The Karen tribes of North Andaman call them 'Tho-ti'.

Day 3

The third infographic was posted on 21st May 2020 with the information on Dugong habitat and feeding preferences.





Caption: Dugongs being a herbivorous marine mammal, their diet is highly specialized. They eat the marine flowering plants called ‘Seagrasses’ (what?! There are grasses under-water! And they flower too?!). This is why they are mostly referred to as ‘Sea Cows’. Though there is a wide variety of seagrasses, Dugongs generally prefer *Halophila* and *Halodule spp.* seagrasses, which are highly nutritious and easily digestible due to low fibre and high nitrogen content. (Yes, they too have a favourite dish!!). Dugongs have a specialized large upper lip which forms a muzzle like structure with which they ‘graze’ these delicate seagrasses. If the complete plant cannot be uprooted, they rip off the leaves leaving behind a feeding trail. It is critically important to conserve the feeding grounds of dugongs in the efforts to protect them from extinction.

Indian waters have 15 different species of seagrasses ranging from very small *Halophila* to large *Enhalus sp.* Tamil Nadu off-coast has all 15 species, while Andaman-Nicobar Islands have 12 seagrass species and Gujarat has 8 species that support the thriving population of Dugongs in the country. These lush meadows also support a variety of seafood including fish, crabs, and shrimps. But hey, dugongs are strictly vegetarian.

And these guys can grow up to 3-3.5m in length and weigh upto 400kg just by eating seagrass!!

Day 4

The fourth infographic was posted on 22nd May 2020 with the information on ecological importance of Dugongs.



Caption: Dugongs are known to be one of the primary consumers of seagrass. They prefer eating sparse seagrass meadows over the cluttered ones. While feeding with their strong lip, this grazing helps in the cycling of nutrients as they mix up different layers of sand; also allowing the seagrass to grow fresh leaves. Since they digest seagrass quite well, their poop is amazing for seagrass to regrow. Dugongs make their fertilizer for farming seagrasses!

Dugongs serve as an umbrella species in a seagrass ecosystem. They are critical in the conservation of seagrass habitats and its dependant fauna, maintaining a healthy dynamics of seagrass lifecycle. Protection for Dugong means protection seagrass and in turn green turtles, sea slugs, fish juveniles and other invertebrates.

The story of dugong in shallow water ecosystem is not just it! We are yet to unfold the many chapters encircling our *mermaids*.

Day 5

The fifth infographic was posted on 23rd May 2020 with the information on threats to dugongs



Caption: With few natural predators, dugongs are majorly threatened by the anthropogenic activities. For their effective conservation, it is imperative to regulate human activities in regions where dugongs thrive.

Dugongs are shy animal having few natural predators like the shark and salt-water crocodiles. Hence, anthropogenic activities are the major threat to dugongs.

Habitat loss: Primary habitat of dugongs are the seagrass meadows. Any damage to seagrass meadows has a direct effect on the dugong population. Trawl fishing is the major destroyers of seagrass meadows as they drag out everything from the seabed.

Fishing net entanglement: Dugongs get entangled in a fishing net which is placed in shallow waters or abandoned by fisher folks. These entanglements in fishing gear cause them to struggle and further tangling them into the net, if not rescued, it often leads to a stressful death.

Boat collisions: Since dugongs don't have gills, they have to surface regularly to breathe. Heavy boat traffic poses a significant threat to dugongs. While surfacing, they get hit by a boat or their propellers causing severe or lethal injuries.

Hunting for meat: Dugongs have been hunted since many centuries for its meat and oil (which is believed to have medicinal properties) by local and tribal communities. Hunting of dugongs

has become a grave point for the population decline of dugongs, with other threats hovering around them.

Pollution: Anthropogenic activities like constructions, waste disposal, dredging in the coastal shallow water environment damage the seagrass ecosystem thereby disturbing the feeding grounds of the dugong. Plastic pollution is a worldwide problem and like turtles, dugongs also ingest plastic on the sand while feeding.

Irresponsible tourism: Unregulated tourist boats and waste disposal in regions where dugong population survive alters the seagrass beds leaving lesser food for Dugongs.

For their effective conservation, it is imperative to regulate human activities in regions where dugongs thrive.

Day 6

The sixth infographic was posted on 24th May 2020 with the information on dugong strandings.

STRANDING /strænd.ɪŋ/

beaching of a live or dead marine organism

● **LIVE**

- FOREST DEPT. IS INFORMED
- BASIC INFORMATION AND LOCATION RECORDED
- IF NET ENTANGLEMENT, RESCUED AND RELEASED IMMEDIATELY

● **DEAD**

- MORPHOMETRIC DATA COLLECTED
- LOCATION RECORDED
- NECROPSY CONDUCTED
- GUT & TISSUE SAMPLE COLLECTED FOR ANALYSIS








विश्व वन्यजीव संशोधन संस्थान
Wildlife Institute of India

Caption: Stranding of marine organisms is a situation when they are out of their natural habitat, washed ashore on a beach or land either dead or alive.

Marine animals' stranding can happen for a variety of reasons including diseases, different human-induced threats etc. But these strandings provide a lot of information about biology, health and threats of the animal. Though stranding is sad, it allows researchers to observe the animal closely, collect samples (with proper government permissions and protocol) for further study. Especially when the organism is survived by very limited individuals and live catches are not the options, such as in case of dugongs.

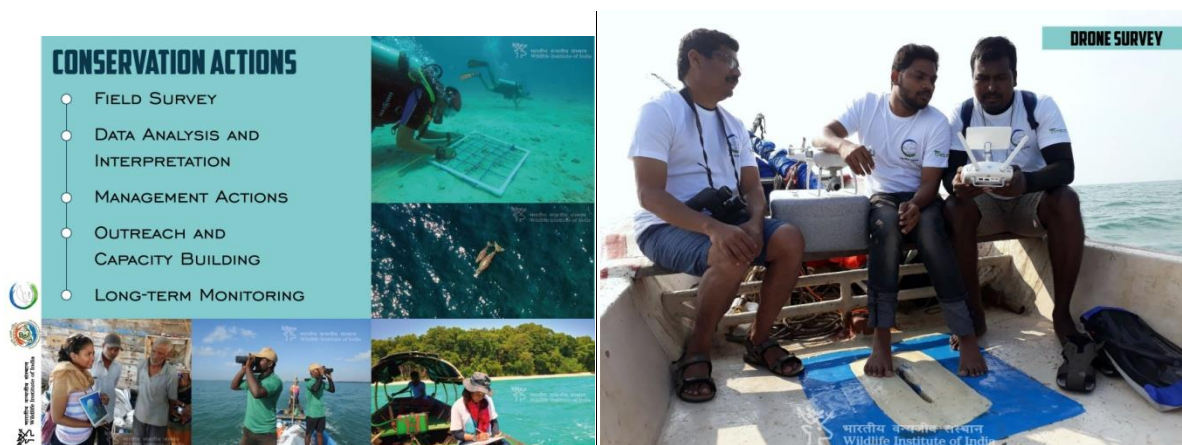
Managing Dugong stranding is a very skilful task whether its dead or alive. Handling alive stranding is even more difficult, as the animal is already in tremendous stress. If things are not handled carefully, there is a chance that we will harm the animal even more. Hence these stranding should be handled by professionals. In all live stranding, the breathing of animal should not be blocked at any cost till the animal is safely released back or rescued.

Over many years of collaborations, a Dugong Volunteer Network has been framed which consists of Fisherfolks, Forest Rangers, local people, and NGOs etc., which coordinate the stranding news and incidents.

When a dead dugong is found, its basic information such as location, sex, body measurements etc. is recorded. Necropsy, a surgical examination of the dead body is then performed. The animal is cut open to examine the cause of death and sample collection. Dead stranded dugongs are the source of valuable information like their health, diseases, infection etc. Gut content analysis of stranded dugongs has revealed information about their diet, digestive system, seagrass species preferences. These studies have also made us understand plastic consumption by these animals. Tissue samples collected from these dead animals are used for genetic studies. A genetic study conducted by our team has discovered that Indian dugongs along with ones from South Asia are genetically different than other Dugongs in the world.

DAY 7

The seventh infographic was posted on 25th May 2020 with the information on Protected under WPA(1972), Indian dugong populations need participatory approaches to assess their population, seagrass habitat quality and threats. Dugong Recovery Program combines these approaches with multiple stakeholders for Dugong conservation in India







Caption: Dugongs in India are protected under Schedule I of Wildlife Protection Act (1972), which means they have the protection equivalent to that of a Tiger. Dugongs are marine mammals with an estimated life expectancy similar to humans, of 75 years. They attain sexual maturity between 8-18 years age and give birth to one calf at a time. The calves remain under the care of the mother until they mature. With an estimated population of fewer than 200 individuals and with slow reproductive rate, conservation of the remaining Indian populations is needs of the hour to avoid local extinction of the species.

It is of utmost importance that there is an understanding of the species and its habitat to formulate effective conservation plans. Researchers implement a variety of methods such as sociological surveys to ascertain threats, population surveys using UAVs, boats, intertidal and

underwater surveys for seagrass habitat assessment, genetic analysis, diet analysis and pollution monitoring. These surveys enable us to understand the status of Dugong populations, their habitats and feeding grounds, their behaviour, and the threats posed to them. Field surveys are also significant in mapping seagrass meadows and regions of the high density of dugong populations.

All the data collected during such surveys are important in designing policies for the conservation of dugongs. This data aids forest managers to strategize the conservation action plans for Dugongs based on their status in different areas, the status of their feeding grounds, threats and needs of the local communities. Based on these data, awareness actions are planned to disseminate information and reduce threats. Further, these action plans serve as useful tools to conduct long-term conservation as well as safeguarding livelihoods of coastal communities.

Day 8

The eighth infographic was posted on 26th May 2020 with the information on the importance of awareness and capacity building for dugong conservation.

OUTREACH AND CAPACITY BUILDING

NATURE EDUCATION AND AWARENESS

- FISHERFOLK AWARENESS
- SCHOOL KIDS OUTREACH
- FRIENDS OF DUGONGS - SCHOLARSHIP PROGRAMME

INCENTIVES FOR CONSERVATION

- DUGONG RESCUE

TRAINING

- SCUBA DIVING
- MARINE BIODIVERSITY ASSESSMENT
- DRONE OPERATION TRAINING

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

SWIPE LEFT TO KNOW MORE



Caption: In India, Dugong conservation is possible with participatory approaches involving various strata of human society. To achieve effective conservation results, two major approaches are considered. A) awareness and Outreach and B) Capacity building of agencies and communities.

Awareness, education and outreach activities include fisherfolk, coastal communities, school and college students among other stakeholders such as the frontline agencies. Our flagship Dugong Scholarship Program creates 'Dugong Ambassadors' who contributing significantly by raising awareness at a local level. Their fisher parents form part of a network of volunteers called 'Friends of Dugongs'. Special incentive schemes are also made available to fisherfolk who release dugongs from net entanglements. With the help of Friends of Dugongs, we have successfully rescued several fishnet entangled Dugongs back to the sea.

Capacity building of state forest departments, marine police and fisherfolk for monitoring the health and population of dugongs and their seagrass habitats is being done at a large scale. Multiple workshops on SCUBA training and biodiversity assessments for forest rangers have been conducted to inculcate monitoring skillsets for surveillance and habitat analysis. Members of the forest department and Marine Police are also trained in Drone operations through workshops to aid them with surveillance.

In the last 3 years, these activities have reached more than 20000 people from coastal communities, frontline agencies and multiple other stakeholders such as tourism managers, dive schools etc. Our Friends of Dugong network has been effectively driving conservation of Dugong in its natural habitat.

Outreach and capacity building of local communities like fisherfolk and forest managers is essential for dugong conservation and to protect its vulnerable seagrass habitat.

Day 9

The ninth infographic was posted on 27th May 2020 with the information on agencies and communities working for the conservation of dugongs.





Caption: Dugongs are distributed on the coasts of Tamil Nadu, Gujarat and Andaman & Nicobar Islands. Multiple agencies and organizations working either in collaboration or independently in their respective capacities to conserve dugongs and their habitats. These agencies include State Forest Departments, Indian Navy, Indian Coast Guard and Police which patrol the waters where dugongs occur.

Fisher communities and local dive schools too form an integral part of the Dugong Volunteer Network which shares the data on sighting, stranding and illegal uptake of Dugongs. These data are crucial to develop a better understanding of the species' distribution, habitat use and population status. The conservation plan and policies to protect the organism and its habitat utilize these data. These agencies are further committed to protecting the species from hunting and poaching eventually supporting in their conservation.

There are independent NGOs and researchers who are also contributing to understanding the biology of the species and its conservation. Dr.Elrika D'souza from @ncf.india is engaged in studying dugongs and its habitats in the Andaman and Nicobar Islands for over a decade. OMCAR Foundation (<https://www.omcar.org>) from Palk Bay, Tamil Nadu is an NGO working towards the preservation and conservation of coastal habitats especially seagrass and mangroves.

Multilateral Environment 'Memorandum of Understanding on the Conservation and Management of Dugongs (Dugong dugon) and their Habitats throughout their Range' is an international collaboration of countries where Dugongs are found. This MoU was signed by India on 28th May 2008 abiding to protect the remaining population of Dugongs in India. Commemorating this day, on (28th May 2020) we celebrate Dugong Day, spreading awareness on the importance of this magnificent gentle giant of the sea. Salute to the agencies and communities working for the conservation of dugongs in India. It is a team effort.


 MOU ON
 CONSERVATION
 OF DUGONGS


TITLE	Memorandum of Understanding on the Conservation and Management of Dugongs (<i>Dugong dugon</i>) and their Habitats throughout their Range
TYPE	Article IV (4)
LEGAL STATUS	Multilateral Environmental Memorandum of Understanding
LANGUAGE	English (working language); unofficial courtesy translations available in Arabic, Chinese and French
DEPOSITARY	CMS Secretariat
COVERAGE	Dugong (<i>Dugong dugon</i>)
RANGE STATES/REIO*	46: AUSTRALIA, Bahrain, BANGLADESH, Brunei Darussalam, Cambodia, China, Comoros, DJIBOUTI, EGYPT, ERITREA, FRANCE (Mayotte and New Caledonia), INDIA , Indonesia, IRAN, IRAQ, ISRAEL, Japan, JORDAN, KENYA, Kuwait, MADAGASCAR, Malaysia, Maldives, MAURITIUS, MOZAMBIQUE, Myanmar, Oman, PAKISTAN, PALAU, Papua New Guinea, PHILIPPINES, Qatar, SAUDI ARABIA, SEYCHELLES, Singapore, Solomon Islands, SOMALIA, SRI LANKA, Sudan, Thailand, Timor-Leste, UNITED ARAB EMIRATES, UNITED REPUBLIC OF TANZANIA, Vanuatu, Vietnam, YEMEN.
FINAL ACT	Not applicable
SIGNATURE	27: Signed by 7 States on 31.10.2007 : AUSTRALIA, ERITREA, FRANCE (Mayotte and New Caledonia), MADAGASCAR, Myanmar, UNITED ARAB EMIRATES, UNITED REPUBLIC OF TANZANIA; 28.05.2008 : INDIA ; 19.08.2008 : Comoros, KENYA, PHILIPPINES; 09.09.2010 : Solomon Islands; 10.09.2010 : Papua New Guinea; 03.10.2010 : Bahrain, YEMEN; 04.10.2010 : PALAU, SEYCHELLES, Vanuatu; 18.04.2011 : MOZAMBIQUE; 30.06.2011 : Thailand; 31.01.2012 : SRI LANKA; 19.02.2013 : BANGLADESH, EGYPT, SOMALIA, Sudan; 03.03.2013 : SAUDI ARABIA; 10.09.2018 : Timor-Leste.
IN EFFECT	Immediately following signature; open for signature indefinitely.
ACTUALLY IN EFFECT	31 October 2007
RAT/ACP/APP/ACC	Not applicable
MEETINGS OF THE SIGNATORIES	Meetings convened every three years to assess implementation by or in consultation with the CMS Secretariat. First Meeting of the Signatories: Abu Dhabi, UAE, 4-6 October 2010. Second Meeting of the Signatories: Manila, Philippines, 19-20 February 2013. Third Meeting of the Signatories: Abu Dhabi, UAE, 13-14 March 2017.
SECRETARIAT	Secretariat at CMS Office - Abu Dhabi Tel: +971 2 6934 437, e-mail: cmsoffice.ae@cms.int , web: www.cms.int/dugong
FINANCING	None specified in the MOU; Signatory States are invited to contribute financial resources. Since 2009, the Secretariat has been supported by the Environment Agency - Abu Dhabi, on behalf of the Government of the United Arab Emirates.
RESERVATIONS	Not applicable
OTHER	Co-operating organizations: signed on 31.10.2007 by CMS Secretariat.

Day 10

The tenth infographic was posted on 28th May 2020.

Do you confuse dugongs with manatees? Check out our new infographic and find out the differences!! Go celebrate dugongs. **Happy Dugong Day!!**

DUGONGS' DOPPELGÄNGER

MANATEE (M)
V/S
DUGONG (D)

TAIL
TAIL (M) PADDLE SHAPED
TAIL (D) FLUKE-LIKE

FEEDS ON
ONLY SEAGRASSES (D)
SEAGRASS, SEAWEEDS, ALGAE ETC. (M)

SEXUAL MATURITY
4-17 YEARS (D)
5-9 YEARS (M)

FOUND IN
ATLANTIC OCEAN (M)
PACIFIC OCEAN, INDIAN OCEAN (D)

WEIGHT
250-400 KGS (D)
400-500 KGS (M)

HABITAT
EXCLUSIVELY MARINE (D)
MIGRATES BETWEEN MARINE AND FRESHWATER (M)

Wildlife Institute of India logo and text: भारतीय वन्यजीव संस्थान Wildlife Institute of India

HAPPY
DUGONG
DAY

CAMPA logo

Wildlife Institute of India logo and text: भारतीय वन्यजीव संस्थान Wildlife Institute of India

Two researchers of our project organized a Webinar on Dugong Day in regional language-Marathi

महा MTB facebook मुंबई तरुण भारत LIVE

गुपित समुद्री गायीचे..

२८ मे गुरुवार | संध्याकाळी ६ वाजता

छायाचित्र - वर्धन पाटणकर

फक्त 'महा MTB' च्या फेसबुक पेजवर facebook.com/MahaMTB

सागरी परिसंस्थेत अधिवास करणाऱ्या समुद्री गायीविषयी म्हणजेच 'डूगोंग' या जीवाबद्दल जाणून घेऊया 'WII'चे संशोधक सागर राजपूरकर आणि चिन्मया घाणेकर यांच्याकडून..

www.mahamtbt.com

Notification for all competitions of Dugong Day Celebration

भारतीय संघराज्य सरकार

राज्यीय वन्यजीव संरक्षण

WILDLIFE INSTITUTE OF INDIA

ENVIS RESOURCE PARTNER, "WILDLIFE AND PROTECTED AREAS"

WILDLIFE INSTITUTE OF INDIA, CHANDRABANI, DEHRADUN, UTTARAKHAND
EMAIL- wii@envis.nic.in; envis@wii.gov.in
WEBSITE- www.wiienvis.nic.in
www.wii.gov.in/campa-Dugong

DUGONG DAY | 28TH MAY, 2020
ONLINE PAINTING, SLOGAN & QUIZ COMPETITION

"CAMPA-RECOVERY OF DUGONGS AND THEIR HABITATS IN INDIA" TEAM OF WILDLIFE INSTITUTE OF INDIA, DEHRADUN, IN COLLABORATION WITH ENVIS RESOURCE PARTNER, "WILDLIFE AND PROTECTED AREAS" IS ORGANIZING AN ONLINE PAINTING, SLOGAN, AND QUIZ COMPETITION TO CELEBRATE "DUGONG DAY" ON 28TH MAY 2020. WINNERS WILL BE AWARDED EXCITING PRIZES AND E-CERTIFICATES FOR ALL PARTICIPANTS.

THEME FOR ALL COMPETITIONS "SAVE DUGONG, SAVE LIVELIHOOD"

1. ONLINE PAINTING COMPETITION
CATEGORY
CATEGORY I: 6-13 YEARS
CATEGORY II: 14-18 YEARS
CATEGORY III: 19 YEARS ABOVE

2. ONLINE SLOGAN COMPETITION
OPEN TO ALL AGE GROUPS IN ENGLISH, HINDI, TAMIL, GUJARATI AND BENGALI LANGUAGES.

3. ONLINE QUIZ COMPETITION (ON 27TH MAY, 2020)
LINK WILL BE UPDATED ON OUR OFFICIAL PAGES. FOLLOW US FOR MORE UPDATES.

LAST DATE OF SUBMISSION FOR PAINTING AND SLOGAN CONTEST
SUBMIT DIGITALLY ON OR BEFORE 26TH MAY 2020 TILL 1730 HRS.

HOW TO SEND YOUR ENTRIES
FILL THE REGISTRATION FORM AND UPLOAD A DIGITAL COPY OF YOUR SUBMISSION HERE: <https://forms.gle/wtxYwSH7oAd8hhoF7>
or [CLICK HERE](#)

*Please note: Only one entry per participant in each contest

@dugongsforever
@dugongsforever
@CAMPA_dugong_WII

DUGONG DAY 28TH MAY, 2020




ONLINE PAINTING,
SLOGAN & QUIZ
COMPETITION

HOW TO SEND YOUR ENTRIES

1ST METHOD:
FILL THE REGISTRATION FORM AND UPLOAD A DIGITAL COPY OF YOUR SUBMISSION
HERE: <https://forms.gle/wtxYwSH7oAd8hhoF7>


2ND METHOD

STEP 1: POST YOUR PAINTINGS OR SLOGANS ON SOCIAL MEDIA PLATFORMS AND TAG US.

 @dugongsforever  @dugongsforever  @CAMPAdugong_WII

STEP 2: USE HASHTAG #DUGONGDAY IN YOUR POST.
STEP 3: FOLLOW US. IT'S MANDATORY. LINK TO SOCIAL MEDIA PAGES IS GIVEN ABOVE.
STEP 4: MAIL YOUR ENTRY AT campadugong.events@gmail.com.

**Don't forget to mention your Name, Age, Contact no., Address and the Name of the competition you want to participate in the mail.*
**Please note: Only one entry per participant in each contest.*



Certificate of Quiz Competition

ORGANISERS



**DUGONG DAY
MAY 28, 2020**

CERTIFICATE OF PARTICIPATION

THIS IS TO CERTIFY THAT Ms. / Mr. / Dr. / Prof.

HAS SUCCESSFULLY PARTICIPATED IN THE ONLINE QUIZ COMPETITION
DURING "DUGONG DAY, 2020" CELEBRATION FROM 18-28 MAY 2020.



K. SIVAKUMAR, PH.D.
HEAD & COORDINATOR
WII ENVIS RESOURCE PARTNER
WILDLIFE INSTITUTE OF INDIA

Results of Slogan Competition



HAPPY DUGONG DAY

SLOGAN COMPETITION

ENGLISH
1ST : SUBASHINI. V, TIRUNELVELI
2ND : RAGHAV GUPTA, KANPUR
3RD: PRATHAMESH PAWAR, NASHIK

HINDI
PHALGUNI SARKAR, BILASPUR

GUJARATI
GAURAV VALAND, ANAND

BENGALI
SHYAMAL KUMAR BOSE,
PASCHIM MEDINIPUR

TAMIL
RAJU SARAVANAN, MANDAPAM

भारतीय वन्यजीव संस्थान
Wildlife Institute of India



ENGLISH

*"Grasses are green
I made it gleam
Myself, Ecosystem's bellwether
Stop making me feel bitter." - DUGONG*
- SUBASHINI.V, TIRUNELVELI

*Sustainable fishing will help oceans breathe free,
Our dugongs will protect coastal lives and the sea.*
- RAGHAV GUPTA, KANPUR

*We mermaids of sea at striving disguise
Hunting had Soaken tears from eyes
Do you wanna see our species demise?
It's your time to make a bold choice!*
- PRATHAMESH PAWAR, NASHIK

SPECIAL MENTION

Don't Make Zoology History!
- APURV CHHAVI, LUCKNOW

HAPPY DUGONG DAY

SLOGAN COMPETITION

TOP

SLOGANS

HINDI
समुद्री गाय, तैरते जाए।
घास फुस खाए, पर्यावरण को बचाए।।
- PHALGUNI SARKAR, BIASPUR

GUJARATI
મારા કદરૂપી દેખાવથી બીથો નહીં,
હું તો વનસ્પતિ ખાવ છું,
હું મનુષ્ય ! મને પણ બચાવ,
હું પણ તો સમુદ્ર "ગાય" છું.।।
- GAURAV VALAND, ANAND

BENGALI
"নীল আকাশের নিচে, নীল আলোর আলো...
আমরা ভূগর্ভে থাকি অশ্র আমলুসে।
আমাদের আসে বড়ো শক্তি।।।
মানুষের লাভে কখনো আমাদের সৎস্র।"
- SHYAMAL KUMAR BOSE, PASCHIM MEDINIPUR

TAMIL
பாலூட்டும் கடற்பசுவுக்கு பால் ஊற்றாதீர்கள்
- RAJU SARAVANAN, MANDAPAM CAMP

DUGON DAY
SLOGAN COMPETITION
TOP
SLOGANS

Results of painting competition

HAPPY
DUGON DAY

PAINTING COMPETITION

CATEGORY 1
1ST : RISHIT DHARA, NEW DELHI
2ND : KRISHIV BANSAL, GURGAON
3RD: AVANI TEJAS LAUD, MUMBAI

CATEGORY 2
1ST : TITLI GHOSH, KOLKATA
2ND : AVANTIKA GAWAI, MUMBAI
3RD: ATHARVA MUNDHE, MUMBAI

CATEGORY 3
1ST : NUSRA RIZWANA, KAVARATTI.
2ND : ABEL ARMAAN KHAN, TUMAKURU
3RD: PARESH VISHWANATH CHURI,
MUMBAI

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CATEGORY 1



CATEGORY 2

TITLI GHOSH, KOLKATA



DUGONG DAY
PAINTING COMPETITION
CATEGORY 2
TOP 3

AVANTIKA GAWAI, MUMBAI



DUGONG DAY
PAINTING COMPETITION
CATEGORY 2
TOP 3

ATHARVA MUNDHE, MUMBAI



DUGONG DAY
PAINTING COMPETITION
CATEGORY 2
TOP 3

CATEGORY 3

NUSRA RIZWANA, KAVARATTI




DUGONG DAY
PAINTING COMPETITION
CATEGORY 3
TOP 3

ABEL ARMAAN KHAN, TUMAKURU



DUGONG DAY
PAINTING COMPETITION
CATEGORY 3
TOP 3

PARESH VISHWANATH CHURI, MUMBAI



DUGONG DAY
PAINTING COMPETITION
CATEGORY 3
TOP 3

6.1.2 Media reports and coverage

<https://www.downtoearth.org.in/news/wildlife-biodiversity/world-dugong-day-2020-marine-mammal-fighting-for-survival-in-indian-waters-71413>

<https://www.facebook.com/103515107969704/posts/140281020959779/>

<https://www.youtube.com/watch?v=wxdgKKowN1Q&feature=youtu.be> May 27, 2020, Devbhumi Gujarat News

<https://www.youtube.com/watch?v=87ZoPUplKgw&feature=youtu.beokha> Today News channel 28 May 2020

<https://www.youtube.com/watch?v=GSP2jfVFosk&feature=youtu.be>

Loksamnanews Channel 28 May 2020

<https://www.youtube.com/watch?v=S14-jdQ6ZQ4&feature=youtu.be> City News 27th May 2020

<https://www.facebook.com/332291960529888/posts/903073796785032/> Dwarka Today 27th May 2020

<https://www.saamana.com/dugong-day-celebration-wild-life-institute-india/?fbclid=IwAR0ujV5Gsnux2pfoBONytFKsDPKteYEsoFyk5Ghl2xjENAvhXVRp-1MjDmQ> SamanaNews paper 22nd May 2020

<https://twitter.com/mymahanagar/status/1265918419632656385> My Mahanagar 28th May 2020

<https://youtu.be/7qt5R301Cis> Okha Today News channel 6th June 2020

My Mahanagar
@mymahanagar

२८ मे रोजी 'डुगॉन दिन' साजरा केला जातो. पर्यावरणाच्या दृष्टीने अतिशय उपयुक्त घटक असलेल्या या जीवांचे संवर्धन करणे गरजेचे असल्याने आणि सामान्य नागरिकांपर्यंत या प्राण्यांचे महत्त्व पोहोचवून म्हणून हा दिवस साजरा केला जातो.

Translate Tweet



दर . आजचा घडामोडी . दुगॉन दिन विशेष : समुद्री गाय 'डुगॉन' या सस्तन प्राण्यांविषयी संवेदनशील व्हा!

डुगॉन दिन विशेष : समुद्री गाय 'डुगॉन' या सस्तन प्राण्यांविषयी संवेदनशील व्हा!

पर्यावरणाच्या दृष्टीने अतिशय उपयुक्त घटक असलेल्या या जीवांचे संवर्धन करणे गरजेचे असल्याने आणि सामान्य नागरिकांपर्यंत या प्राण्यांचे महत्त्व पोहोचवून म्हणून हा दिवस साजरा केला जातो.

By My Mahanagar Team - May 28, 2020 12:57 pm Mumbai



MONGABAY
NEWS & INSPIRATION FROM NATURE'S FRONTLINE

FORESTS ANIMALS OCEANS PEOPLE RIVERS OPPORTUNITIES MONGABAY GLOBAL WILDTech ABOUT

To search, type and hit enter. Q

Mongabay Series: Almost Famous Species, Eco Hope

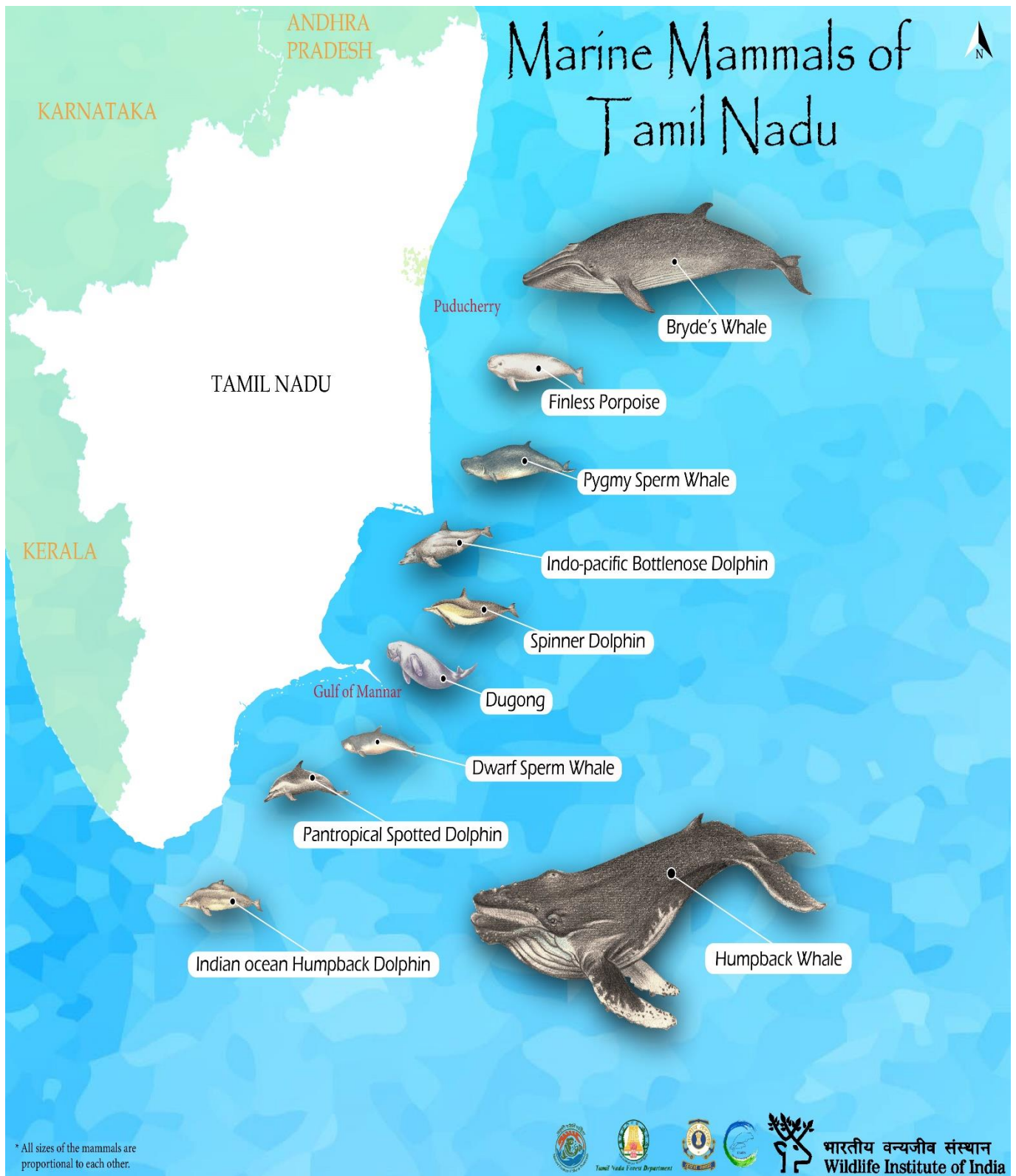
Why India needs its fishers to save dugongs and their seagrass habitat

by Catherine Gilon on 4 March 2020

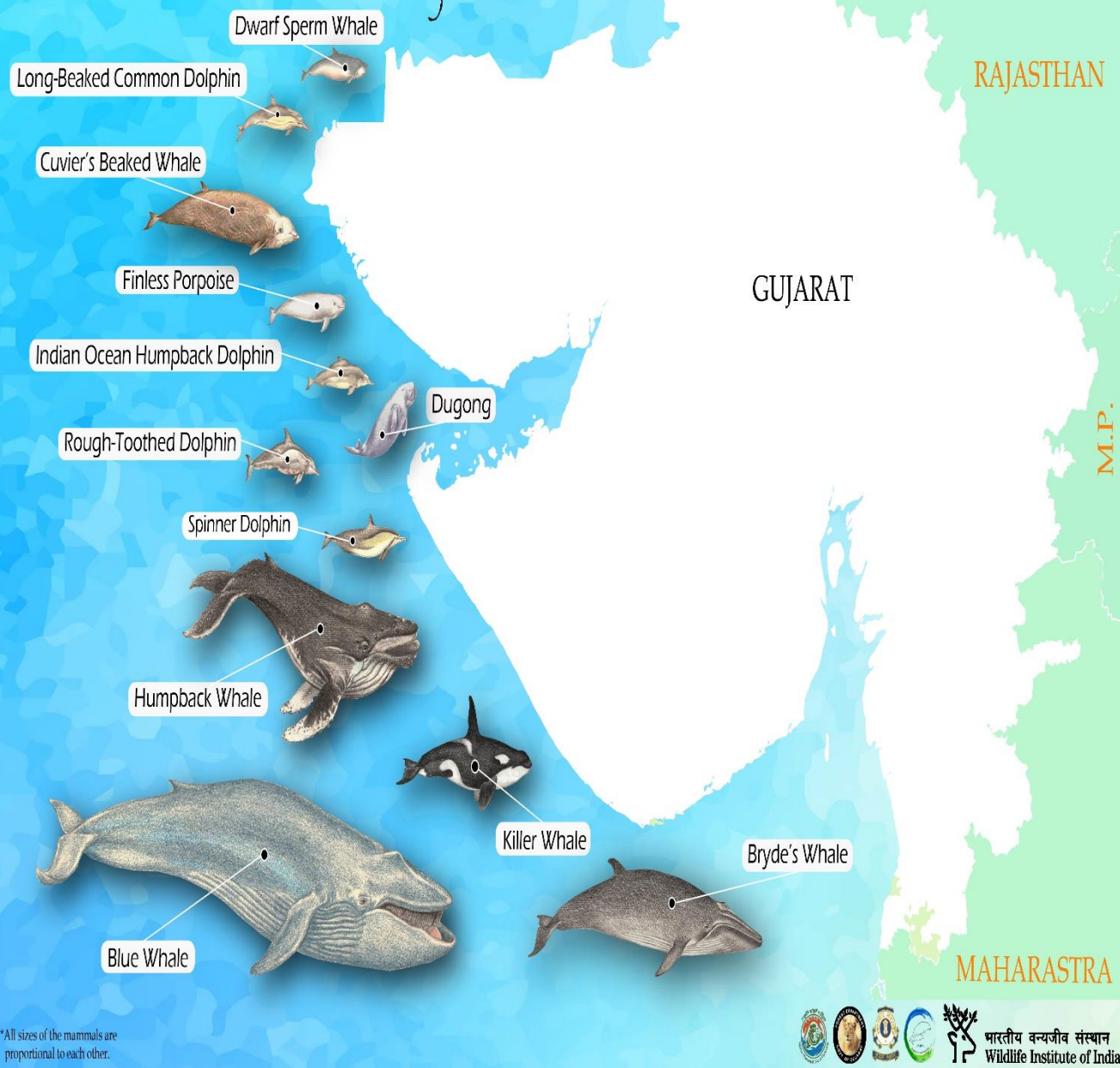
f t in l e m



6.2 Outreach materials for public awareness



Marine Mammals of Gujarat



*All sizes of the mammals are proportional to each other.



Marine Mammals of Andaman & Nicobar Islands



*All sizes of the mammals are proportional to each other.






















A FIELD GUIDE TO
SEAGRASSES
OF INDIA AND
ASSOCIATED FAUNA


sea grass






















7. DUGONG AMBASSADORS 2019-2020**Table 1: Dugong Ambassadors of Tamil Nadu**










Sr. No.	Photo	Name	Gender	Standard	School
1		S. Deebika	Female	11 th	Govt. Girls Hr. Sec. School, Adiramapattinam
2		S. Prathana	Female	9 th	Govt. Girls Hr. Sec. School, Adiramapattinam
3		P. Kamali	Female	11 th	Govt. Girls Hr. Sec. School, Adiramapattinam
4		N. Nageshwari	Female	11 th	Govt. Hr. Sec. School, Rajamadam
5		E. Nasrin Banu	Female	11 th	Govt. Hr. Sec. School, Mallipattinam
6		B. Mohamed Paisul	Male	11 th	Govt. Hr. Sec. School, Mallipattinam
7		J. Aseera	Female	9 th	Govt. Hr. Sec. School, Mallipattinam
8		S. Shabhurrusha	Female	9 th	Govt. High School, Sethuma Chathiram
9		M. Sarumathi	Female	9 th	Govt. High School, Sethuma Chathiram











Sr. No.	Photo	Name	Gender	Standard	School
10		B. Riyana	Female	9 th	Govt. High School, Sethuma Chathiram
11		P. Pavithra	Female	9 th	Govt. High School, Puduthuru
12		K. Sundareswari	Female	11 th	Govt. Hr. Sec. School, Kattumavadi
13		P. Karthika	Female	11 th	Govt. Hr. Sec. School, Kattumavadi
14		M. Kaviyarasan	Male	11 th	Govt. Boys Hr. Sec. School, Manamelkudi
15		B. Chitralakshmi	Female	11 th	Govt. Girls Hr. Sec. School, Manamelkudi
16		M. Aruna Devi	Female	11 th	Govt. Girls Hr. Sec. School, Manamelkudi
17		C. Sugitha	Female	9 th	Govt. Hr. Sec. School, Jagathapattinam
18		R. Thaslima Banu	Female	11 th	Govt. Hr. Sec. School, Kottaipattinam
19		R. Nanthini	Female	11 th	Govt. Hr. Sec. School, Gopalapattinam



Sr. No.	Photo	Name	Gender	Standard	School
20		M. Murugeswari	Female	11 th	Govt. Hr. Sec. School, Mimisal
21		R. Saminathan	Male	11 th	Govt. Hr. Sec. School, Mimisal
22		U. Pavithra	Female	9 th	Govt. High School, Vattanam
23		S. Megaran Beevi	Female	9 th	Govt. Hr. Sec. School, S. P. Pattinam
24		G. Munishwaran	Male	11 th	S. M. Govt. Hr. Sec. School, Thondi
25		R. Kerishtoper	Male	9 th	S. M. Govt. Hr. Sec. School, Thondi
26		M. Malaiyarasi	Female	11 th	Govt. Girls Hr. Sec. School, Thondi
27		V. Bagampriyal	Female	9 th	Govt. Girls Hr. Sec. School, Thondi
28		B. Nagasoundarya	Female	9 th	Govt. High School, Nambuthalai
29		M. Manotha	Female	9 th	Govt. High School, Nambuthalai

Sr. No.	Photo	Name	Gender	Standard	School
30		K. Kavinesh Kumar	Male	9 th	Amala Annai Hr. Sec. School, Karangkadu
31		S. Sandosh	Male	9 th	Amala Annai Hr. Sec. School, Karangkadu
32		S. Sivaranjani	Female	11 th	Amala Annai Hr. Sec. School, Karangkadu
33		T. Vimalthasan	Male	11 th	Govt. Hr. Sec. School, Uppoor
34		M. Achitha	Female	11 th	Govt. Hr. Sec. School, Uppoor
35		S. Dhivya	Female	11 th	Govt. Hr. Sec. School, Uppoor
36		K. Kali Karthika	Female	9 th	Govt. Hr. Sec. School, Tiruppalaikudi
37		N. Durkka	Female	9 th	Govt. Hr. Sec. School, Tiruppalaikudi
38		S. Bowmiya Begam	Female	9 th	Govt. Hr. Sec. School, Tiruppalaikudi
39		S. Logesh Raj	Male	9 th	Govt. High School, Sambai

Sr. No.	Photo	Name	Gender	Standard	School
40		S. Karthigadevi	Female	9 th	Govt. Hr. Sec. School, Devipattinam
41		N. Jeyapratha	Female	11 th	Mohamedia Hr. Sec. School, Chittar Kottai
42		K. Savithiri	Female	11 th	Mohamedia Hr. Sec. School, Chittar Kottai
43		N. Gowtham	Male	9 th	Govt. High School, Palanivalasai
44		K. Ritheesh	Male	9 th	Arabi Oliyullah High School, Puduvalasai
45		G. Vijaya	Female	11 th	Govt. Girls Hr. Sec. School, Panaikulam
46		P. Kaviya	Female	9 th	Govt. Girls Hr. Sec. School, Panaikulam
47		B. Vikram	Male	11 th	Bahrudin Govt. Boys High School, Panaikulam
48		K. Viji	Female	11 th	Govt. Hr. Sec. School, Alagankulam
49		B. Umeshvithya	Female	11 th	Govt. Hr. Sec. School, Alagankulam

Sr. No.	Photo	Name	Gender	Standard	School
50		R. Sheeba	Female	9 th	Govt. Hr. Sec. School, Uchipulli
51		M. Jansi	Female	9 th	Govt. Hr. Sec. School, Uchipulli
52		V. Santhiya	Female	9 th	Govt. Hr. Sec. School, Uchipulli
53		U. Udayabrunda	Female	9 th	Govt. Hr. Sec. School, Irumeni
54		M. Harris Jayaraj	Male	9 th	Govt. Hr. Sec. School, Irumeni
55		S. Al Shiba Fathima	Female	9 th	Govt. Hr. Sec. School, Vedalai
56		S. Tharshika	Female	9 th	Govt. Hr. Sec. School, Vedalai
57		S. Afritha Banu	Female	11 th	Govt. Hr. Sec. School, Vedalai
58		J. Banu Priya	Female	11 th	Govt. Hr. Sec. School, Vedalai
59		A. Babyrani	Female	11 th	Govt. Hr. Sec. School, Vedalai

Sr. No.	Photo	Name	Gender	Standard	School
60		R. Asmiya	Female	11 th	Govt. Hr. Sec. School, Mandapam Camp
61		A. Farsiya Fathima	Female	9 th	Govt. Girls Hr. Sec. School, Mandapam
62		N. Durga	Female	9 th	Govt. Girls Hr. Sec. School, Mandapam
63		M. Arrahilthifa	Female	9 th	Govt. Girls Hr. Sec. School, Mandapam
64		A. R. Harimathi	Female	11 th	Govt. Girls Hr. Sec. School, Mandapam
65		J. Jerolin Santhiya	Female	11 th	Govt. Hr. Sec. School, Pamban
66		M. Abirami	Female	11 th	Govt. Hr. Sec. School, Thangachimadam
67		A. Mariya Renipa	Female	11 th	Govt. Hr. Sec. School, Thangachimadam
68		S. Jemil	Female	9 th	Govt. Hr. Sec. School, Thangachimadam
69		M. Anthony Benosh	Male	9 th	Punitha Yagappan Hr. Sec. School, Thangachimadam

Sr. No.	Photo	Name	Gender	Standard	School
70		L. Zionraj	Male	9 th	Punitha Yagappar Hr. Sec. School, Thangachimadam
71		S. Sahaya Sweetlin	Female	11 th	Punitha Yagappar Hr. Sec. School, Thangachimadam
72		M. Ageciya Nilodika	Female	9 th	Punitha Yagappar Hr. Sec. School, Thangachimadam
73		S. Babu	Male	9 th	Govt. Hr. Sec. School, Rameswaram
74		T. Palanimurugan	Male	9 th	Govt. Hr. Sec. School, Rameswaram
75		M. Thavamurugan	Male	11 th	Govt. Hr. Sec. School, Rameswaram
76		I. M. Ramkumar	Male	9 th	Govt. Hr. Sec. School, Rameswaram
77		A. Arul Ebineesh	Male	11 th	Govt. Hr. Sec. School, Rameswaram
78		N. John Pethuro	Male	9 th	Govt. Hr. Sec. School, Rameswaram
79		P. Rathish Kumar	Male	9 th	Govt. High School, Karaiyur

Sr. No.	Photo	Name	Gender	Standard	School
80		N. Nambu Priyadharshini	Female	9 th	Govt. High School, Karaiyur
81		S. Thurgesh Raja	Male	9 th	Govt. Hr. Sec. School, Pudumadam
82		M. Jaheedeem	Male	9 th	Govt. Hr. Sec. School, Pudumadam
83		A. Nasrin Begam	Female	9 th	Govt. Girls Hr. Sec. School, Pudumadam
84		K. Jeya	Female	9 th	Govt. High School, Thamaraiikulam
85		S. Mohammedu Shihar	Male	9 th	Govt. Hr. Sec. School, Periyapattinam
86		S. Jaisha	Female	9 th	Govt. Hr. Sec. School, Periyapattinam
87		M. Saktheeswaran	Male	9 th	Govt. high School, Kalimankundu
88		R. Jeya Surya	Male	9 th	Govt. Hr. Sec. School, Thinaikulam
89		M. Muthu Kumar	Male	9 th	Govt. Hr. Sec. School, Thirupullani

Sr. No.	Photo	Name	Gender	Standard	School
90		S. Segu Bakurudeen	Male	9 th	Mahdhoomia Hr. Sec. School, Kilakarai
91		Y. Anthony Akshab	Male	9 th	Islamiah High School, Kilakarai
92		A. Mohana Soundhari	Female	9 th	Hameediah Girls Hr. Sec. School, Kilakarai
93		K. Kaviya	Female	11 th	Hameediah Girls Hr. Sec. School, Kilakarai
94		R. Mugesh Kunnan	Male	9 th	Hameediah Boys Hr. Sec. School, Kilakarai
95		M. Vinitha	Female	9 th	Govt. Hr. Sec. School, Ervadi
96		C. Panu Priya	Female	11 th	Govt. Hr. Sec. School, Ervadi
97		M. Nandini	Female	11 th	Govt. Hr. Sec. School, Ervadi
98		G. Durga Devi	Female	11 th	Govt. Hr. Sec. School, Ervadi
99		N. Thilochana	Female	11 th	Govt. Hr. Sec. School, Ervadi





































Sr. No.	Photo	Name	Gender	Standard	School
100		P. Iswarya	Female	9 th	Govt. Hr. Sec. School, Ervadi







Table 2: Dugong Ambassadors of Andaman & Nicobar Island









Sr. No.	Photo	Name	Gender	Standard	School
1		Snigdha Sikder	Female	11 th	Govt. Sr. Sec School Havelock-3
2		Anisha Dhali	Female	12 th	Govt. Sr. Sec School Havelock-3
3		Seema Chowdhury	Female	12 th	Govt. Sr. Sec School Havelock-3
4		G. Shiva	Male	12 th	Govt. Sr. Sec School Havelock-3
5		Abhijeet Mazumder	Male	12 th	Govt. Sr. Sec School Havelock-3
7		M. Neha	Female	First year graduation	Govt. Sr. Sec School Havelock-3
8		Abhay Halder	Male	11 th	Govt. Sr. Sec School Havelock-3
9		Chanchal Sarkar	Male	12 th	Govt. Sr. Sec School Havelock-3








10		Rohit Samma ddar	Male	12 th	Govt. Sr. Sec School Havelock-3
11		Ashit Halder	Male	12 th	Govt. Sr. Sec School Havelock-3
12		Rohit Mondal	Male	12 th	Govt. Sr. Sec School Havelock-3
13		Ranjeet Mondal	Male	12 th	Govt. Sr. Sec School Havelock-3
14		Payal Bala	Female	12 th	Govt. Sr. Sec School Havelock-3
15		Tanushr ee Mondal	Female	12 th	Govt. Sr. Sec School Havelock-3
16		Srishti Gharam i	Female	12 th	Govt. Sr. Sec School Havelock-3
17		Nibedita Mondal	Female	11 th	Govt. Sr. Sec School Havelock-3
18		Sunita Roy	Female	10 th	Govt. Sr. Sec School Havelock-3

19		Deepti Mondal	Female	12 th	Govt. Sr. Sec School Havelock-3
20		Rupsha Biswas	Female	First year graduation	Govt. Sr. Sec School Havelock-3
21		Shilpi Bala	Female	First year graduation	Govt. Sr. Sec School Havelock-3
22		Priyanka Biswas	Female	12 th	Govt. Sr. Sec School Havelock-3
23		Smriti Mondal	Female	11 th	Govt. Sr. Sec School Havelock-3
24		R. Priya	Female	12 th	Govt. Sr. Sec School Neil Island
25		Rekha Roy	Female	11 th	Govt. Sr. Sec School Neil Island
26		Pinky Podder	Female	11 th	Govt. Sr. Sec School Neil Island
27		Sumit Das	Male	10 th	Govt. Sr. Sec School Neil Island

28		Rohit Kumar Das	Male	10 th	Govt. Sr. Sec School Neil Island
29		Abinash Mondal	Male	10 th	Govt. Sr. Sec School Neil Island
30		Vishnu Bairagi	Male	12 th	Govt. Sr. Sec School Neil Island
31		Kajal Roy	Female	12 th	Govt. Sr. Sec School Neil Island
32		Prasant a Roy	Male	11 th	Govt. Sr. Sec School Neil Island
33		Rajesh Shill	Male	First Year graduation	Govt. Sr. Sec School Neil Island
34		Samare sh Gain	Male	12 th	Govt. Sr. Sec School Neil Island
35		Sushmit a Das	Female	12th	Govt. Sr. Sec School Neil Island
36		Nitish Biswas	Male	First Year graduation	Govt. Sr. Sec School Neil Island

37		Pritish Biswas	Male	First Year graduation	Govt. Sr. Sec School Neil Island
38		Avay Das	Male	11 th	Govt. Sr. Sec School Neil Island
39		Baishaki Das	Female	9 th	Govt. Middle School Neil Island
40		Sadhan a Das	Female	9 th	Govt. Middle School Neil Island
41		Dev Kumar Biswas	Male	11 th	Govt. Middle School Neil Island
42		Rajdeep Ghose	Male	8 th	Govt middle school Guptapara
43		Sangita Das	Female	11 th	Govt middle school Guptapara
44		Tapan Biswas	Male	11 th	Govt middle school Guptapara
45		Rani Roy	Female	11 th	Govt middle school Guptapara

46		Sudeep Mondal	Male	9 th	Govt middle school Guptapara
47		Nisha Roy	Female	11 th	Govt middle school Guptapara
48		Ajay Biswas	Male	10 th	Govt middle school Guptapara
49		Pasanjit Mondal	Male	11 th	Govt middle school Guptapara
50		Bijoy Sutradhar	Male	11 th	Govt middle school Guptapara
51		Sakshi Das	Female	11 th	Govt middle school Guptapara
52		Beuty Biswas	Female	8 th	Govt Middle School Wandoor
53		Tarun Mondal	Male	10 th	Govt Middle School Wandoor
54		Subankar Sardar	Male	10 th	Govt Middle School Wandoor

55		Uday Bairagi	Male	9th	Govt Middle School Wandoor
56		Mitali Mondal	Female	10th	Govt Middle School Wandoor
57		Sania Adhikari	Female	11th	Govt Middle School Wandoor
58		Manas Biswas	Male	11th	Govt Middle School Wandoor
59		Sumit Mondal	Male	11th	Govt Middle School Wandoor
60		Madhari Mondal	Female	11 th	Govt Middle School Wandoor
61		Aysha Toppo	Female	7 th	Government Senior Sec. school Rangachang
62		T. Zaira Banu	Female	7 th	Government Senior Sec. school Rangachang
63		Manju	Female	7 th	Government Senior Sec. school Rangachang

64		Priyanka Tirkey	Female	7 th	Government Senior Sec. school Rangachang
65		T. Rukshar Begum	Female	10 th	Government Senior Sec. school Rangachang
66		M. Jaya Praveen	Female	10 th	Government Senior Sec. school Rangachang
67		Avishek Minj	Male	11 th	Government Senior Sec. school Rangachang
68		Amit Minj	Male	11 th	Government Senior Sec. school Rangachang
69		Sumit Kujur	Male	12 th	Government Senior Sec. school Rangachang
70		S. Rajkumar	Male	12 th	Government Senior Sec. school Rangachang
71		Abishek Tirkey	Male	12 th	Government Senior Sec. school Rangachang
72		J. Omakshi	Female	10 th	Government Senior Sec school Bambooflat.

73		K. Kavita	Female	10 th	Government Senior Sec school Bambooflat
74		P. Dharma Rao	Male	10 th	Government Senior Sec school Bambooflat
75		K. Madhav Rao	Male	10 th	Government Senior Sec school Bambooflat
76	 <small>A. KALPANA 07/10/2018</small>	A. Kalpana	Female	10 th	Government Senior Sec school Bambooflat
77		V. Banuwathi	Female	10 th	Government Senior Sec school Bambooflat
78		B. Kalavathi	Female	10 th	Government Senior Sec school Bambooflat
79		L. Kurma Rao	Male	10 th	Government Senior Sec school Bambooflat
80		J. Swathi	Female	11 th	Government Senior Sec school Bambooflat
81		M. Shana Bibi	Female	11 th	Government Senior Sec school Bambooflat



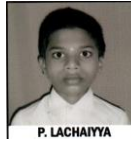


























82		N. Kumari	Female	11 th	Government Senior Sec school Bambooflat
83		B. Joyothi	Female	11 th	Government Senior Sec school Bambooflat
84	 P. LACHAIYYA	P. Lachaiya	Male	11 th	Government Senior Sec school Bambooflat
85	 P. UHA	P. Uha	Female	12 th	Government Senior Sec school Bambooflat
86	 J. KAVITHA	J. Kavitha	Female	12 th	Government Senior Sec school Bambooflat
87		Mahesh Dass	Male	11 th	Government Senior Sec school Bambooflat









Table 3: Dugong Ambassadors of Gujarat








SN	Photo	Name	Gender	Standard	School
1		Payal Jasrajbha Manek	Female	9 th	RMSA Government Highschool Vasai
2		Paruben Devubha Manek	Female	9 th	RMSA Government Highschool Vasai
3		Namrata Madhav Rathod	Female	9 th	RMSA Government Highschool Vasai
4		Thaim Ashmabanu Sulemanbhai	Female	10 th	PVM Girls HighSchool and Higher Secondary School
5		Manek Bharti Gagabha	Female	10 th	PVM Girls HighSchool and Higher Secondary School
6		Mahinur Jusabbhai Karar	Female	11 th	PVM Girls HighSchool and Higher Secondary School
7		Simran Firojkhan Khatak	Female	11 th	PVM Girls HighSchool and Higher Secondary School
8		Shaniyabanu Ajimbhai Malek	Female	9 th	PVM Girls HighSchool and Higher Secondary School








SN	Photo	Name	Gender	Standard	School
9		Roshan Khamisha Bhikhalani	Female	11 th	PVM Girls HighSchool and Higher Secondary School
10		Shabari Salim shaikh Bismillah	Female	9 th	PVM Girls HighSchool and Higher Secondary School
11		Vaghela Indrakumar	Male	9 th	Shree Karmayog Highschool
12		Rinuben Rameshbhai Chauhan	Male	9 th	Shree Karmayog Highschool
13		Sahil Vinodbhai Kasta	Female	10 th	Shree Karmayog Highschool
14		Kinjal P Chanpa	Male	9 th	Shree Karmayog Highschool
15		Arti Lakhabhai Vaghela	Female	10 th	Shree Karmayog Highschool
16		Rajabhai Jivabhai Vaghela	Female	9 th	Shree Karmayog Highschool





SN	Photo	Name	Gender	Standard	School
17		Baraiya Hiteshbhai Pragna	Female	7 th	Shree Dwarka Taluka School 1
18		Arjan Jiva Chauhan	Male	7 th	Shree Varvala Wadi Primary School
19		Arjunbhai Jivabhai Chauhan	Male	7 th	Shree Varvala Wadi Primary School
20		Shantiben Pratapbhai Vaghela	Female	7 th	Shree Varvala Wadi Primary School
21		Payal Vaghela	Female	7 th	Shree Varvala Wadi Primary School
22		Varshibhai Vaghela	Male	7 th	Shree Varvala Wadi Primary School
23		Karan Kanabhai Chauhan	Male	6 th	Shree Varvala Wadi Primary School
24		Lakhman Vaghela	Male	7 th	Shree Varvala Wadi Primary School









SN	Photo	Name	Gender	Standard	School
25		Mamta Mavjibhai Chauhan	Female	6 th	Shree Varvala Wadi Primary School
26		Nagita Bhikhubhai Vaghela	Female	7 th	Shree Varvala Wadi Primary School
27		Sumaribai Parmar	Female	6 th	Shree Varvala Wadi Primary School
28		Ramabhai Ajunbhai Chauhan	Male	6 th	Shree Varvala Wadi Primary School
29		Abbas Faruk Bolim	Male	7 th	Nagar Palika Sanchalit Okha Primary School
30		Jigar Balubhai Dhayani	Male	7 th	Nagar Palika Sanchalit Okha Primary School
31		Saniya Sap	Female	7 th	Nagar Palika Sanchalit Okha Primary School
32		Rayazada Muskan Munaf	Female	8 th	Nagar Palika Sanchalit Okha Primary School








SN	Photo	Name	Gender	Standard	School
33		Rafik Adam Bandri	Male	7 th	Nagar Palika Sanchalit Okha Primary School
34		Ayub Junus Bandri	Male	7 th	Nagar Palika Sanchalit Okha Primary School
35		Aksha Aasif Chauhan	Female	8 th	Nagar Palika Sanchalit Okha Primary School
36		Komalaben Harjibhai Gohel	Female	8 th	Nagar Palika Sanchalit Okha Primary School
37		Shirinbanu Rafikbhai Betara	Female	8 th	Nagar Palika Sanchalit Okha Primary School
38		Ashraf Rajha Betara	Male	8 th	Nagar Palika Sanchalit Okha Primary School
39		Komal Kamalan Mrugesh	Male	8 th	Nagar Palika Sanchalit Okha Primary School
40		Bolim Aezaz	Male	8 th	Nagar Palika Sanchalit Okha Primary School



SN	Photo	Name	Gender	Standard	School
41		Sodha Riyaz	Male	8 th	Nagar Palika Sanchalit Okha Primary School
42		Ravina Vijaybhai Parmar	Male	8 th	Shree Varvala Primary School
43		Ravina Vaghela	Female	7 th	Shree Varvala Primary School
44		Jasmin Harun Bloch	Female	8 th	Shree Varvala Primary School
45		Manek Gani Sorathiya	Female	8 th	Shree Varvala Primary School
46		Krupali Anilbhai Tavdi	Female	7 th	Shree Varvala Primary School
47		Divya Rupadiya	Female	7 th	Shree Varvala Primary School

SN	Photo	Name	Gender	Standard	School
48		Manisha Vaghela	Female	8 th	Shree Vavala Primary School
49		Julekhanu Janibhai Pateliya	Female	7 th	Shree Rupen Bandar Primary School
50		Mantasa Gafur Beladiya	Female	7 th	Shree Rupen Bandar Primary School
51		Sumera Juma Thaiyam	Female	7 th	Shree Rupen Bandar Primary School
52		Hina Hanif Bhesaliya	Female	7 th	Shree Rupen Bandar Primary School
53		Nazmin Kasambhai Bhesaliya	Female	7 th	Shree Rupen Bandar Primary School
54		Sanvovar Jusubhai Mer	Female	8 th	Shree Rupen Bandar Primary School

SN	Photo	Name	Gender	Standard	School
55		Shabnam Shabirbhai Ishbani	Female	7 th	Shree Rupen Bandar Primary School
56		Sikandar Salim Pateliya	Male	8 th	Shree Rupen Bandar Primary School
57		Nurjaha Yunus Pateliya	Female	7 th	Shree Rupen Bandar Primary School
58		Sharifan Munasha Jalali	Female	8 th	Shree Rupen Bandar Primary School
59		Sanambanu Rafikbhai Betai	Female	7 th	Shree Rupen Bandar Primary School
60		Subhaniya Rijavan	Male	10 th	Shri Swaminarayan Highschool
61		Modi Sahil	Male	10 th	Shri Swaminarayan Highschool
62		Nariya Sahid	Male	10 th	Shri Swaminarayan Highschool

SN	Photo	Name	Gender	Standard	School
63		Vadha Latif	Male	10 th	Shri Swaminarayan Highschool
64		Jagatiya Mohamad Mohyunudin	Male	10 th	Shri Swaminarayan Highschool
65		Subhaniya Mohmad	Male	9 th	Shri Swaminarayan Highschool
66		Ruknani Soyab	Male	9 th	Shri Swaminarayan Highschool
67		Sap Navaz Jumabhai	Male	11 th	Mithapur HighSchool and Higher Secondary School
68		Kureshi Ashiyabanu Sattarbhai	Female	9 th	Mithapur HighSchool and Higher Secondary School
69		Chaki Sahid	Male	10 th	Mithapur HighSchool and Higher Secondary School
70		Chaki Tasneem Mahammad bhai	Female	11 th	Mithapur HighSchool and Higher Secondary School

SN	Photo	Name	Gender	Standard	School
71		Dhayani Kapil Sureshbhai	Male	10 th	Okha Grampanchayat HighSchool and Higher Secondary School
72		Koshar Shabir Kureshi	Female	10 th	Okha Grampanchayat HighSchool and Higher Secondary School
73		Nariya Femida Faridbhai	Female	10 th	Okha Grampanchayat HighSchool and Higher Secondary School
74		Kasta Mansi Harishbhai	Female	12 th	Okha Grampanchayat HighSchool and Higher Secondary School
75		Sodha Satar Idrushbhai	Male	10 th	Okha Grampanchayat HighSchool and Higher Secondary School
76		Mokha Jahidhusain Jafarbhai	Male	10 th	Okha Grampanchayat HighSchool and Higher Secondary School
77		Nijam Jushab Modi	Male	10 th	Okha Grampanchayat HighSchool and Higher Secondary School

SN	Photo	Name	Gender	Standard	School
78		Amjad Gudhani	Male	10 th	Okha Grampanchayat HighSchool and Higher Secondary School
79		Rahul Harajibhai Gohel	Male	12 th	Okha Grampanchayat HighSchool and Higher Secondary School

**RECOVERY OF DUGONGS AND THEIR HABITATS IN INDIA AN INTEGRATED PARTICIPATORY APPROACH
RECEIPT & PAYMENT
FOR THE PERIOD OF 01 APRIL 2019 TO 31 MARCH 2020**

RECEIPT	AMOUNT (Rs.)	PAYMENT	AMOUNT (Rs.)
Opening Balance	14,94,791.32	Manpower Engagement	78,07,586.00
Grant Received	2,40,54,000.00	Capacity Building & Awareness	42,55,602.00
Advances for Expenses	76,48,715.00	Research Monitoring Species and Habitat	1,35,53,620.00
Advance For Expenses from D/WII A/c No. 55701	2,50,000.00	Participatory Management	10,42,000.00
Bank Interest	65,526.00	Marine Mammal Rescue and Rehab	1,50,167.00
Interest on FDR	35,06,535.00		
FDR Withdrawal	1,25,00,000.00	Total Expenditure	2,68,08,975.00
		Outstanding :	
		Forest Advance	11,42,938.00
		Tour Advance	3,65,758.00
		Outstanding Loan from A/c No.-55701	2,50,000.00
		Balance as on 31.03.2020 A/C No. 55294	2,09,51,896.32
Grand Total	4,95,19,567.32	Grand Total	4,95,19,567.32



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

