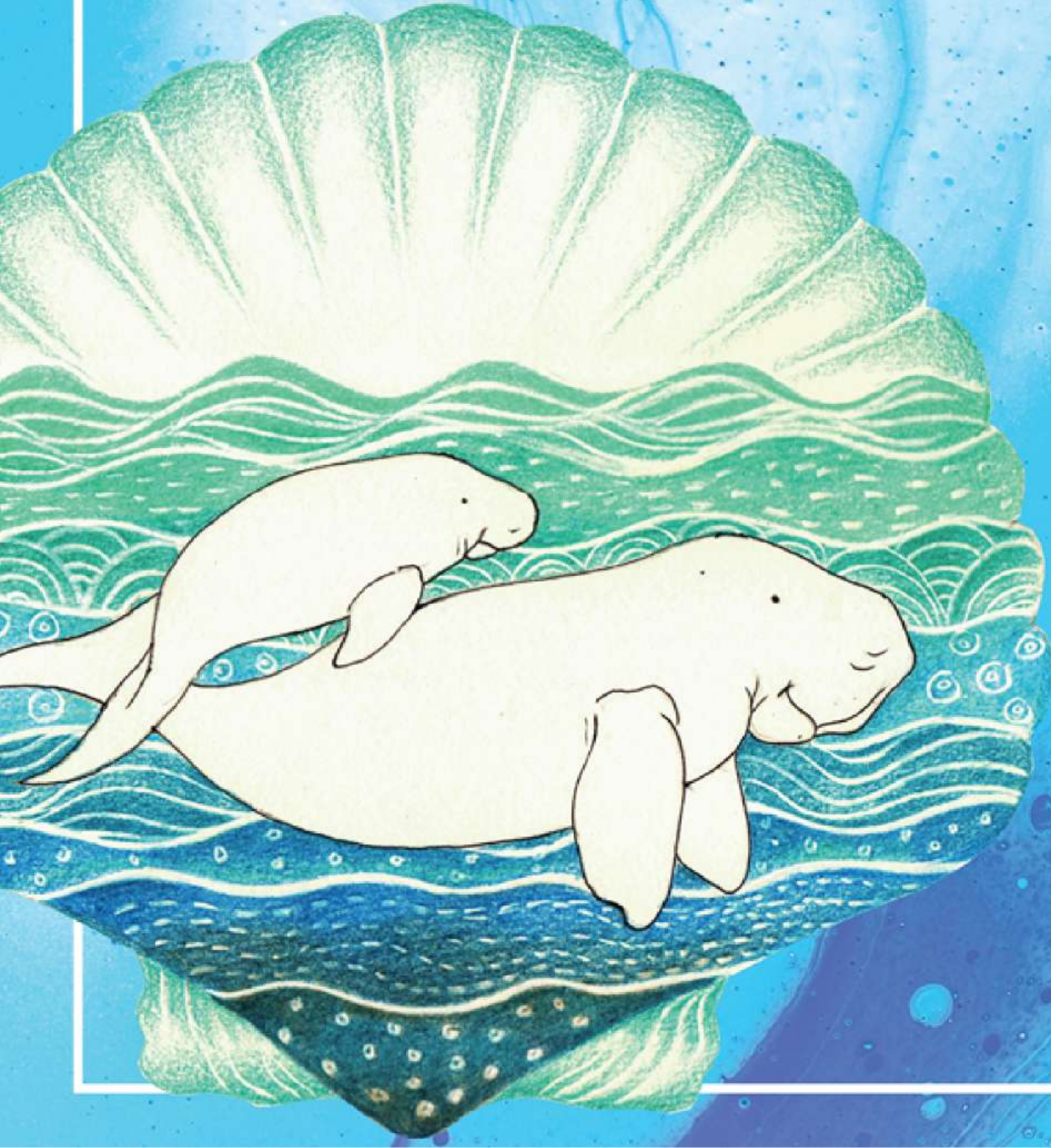
Quarterly Progress report

January - March 2021

Recovery of Dugongs and Their Habitats in India

An Integrated Participatory Approach



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

Project Duration:	5 years (2016 – 2020)
Total Budget (5-year):	23.58 crore INR
Year 1 release:	5.17 crore INR
Year 2 release:	2.4054 crore INR
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Implementing agencies:	Tamil Nadu Forest Department (TNFD) Department of Environment & Forest, Andaman & Nicobar (ANFD) Gujarat Forest Department (GFD) Indian Coast Guards (ICGS) Indian Navy
National Partners:	Zoological Survey of India (ZSI) Indian Institute of Science, Education and Research, Kolkata (IISER-K) National Centre for Sustainable Coastal Management (NCSCM), Central Marine Fisheries Research Institute (CMFRI), Kochi Bombay Natural History Society, Mumbai
Regional Partners:	State Fisheries Department GEER Foundation Centre for Environment Education (CEE) Wildlife Trust of India (WTI) OMCAR Foundation Suganthi Devadasan Marine Research Institute (SDMRI) Andaman Nicobar Environment Team (ANET)

	Marine Police
International Partner:	Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats (Dugong MoU) Signatories
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2.1 RESEARCH AND MONITORING

***2*.1.1 Seagrass surveys** - Seasonal changes in seagrass meadows of the south-western Gulf of Kutch,Gujarat

Intertidal meadows- A monthly visit to three topographically different meadows was done to study the seasonal changes in the seagrass community. Seagrass and sediment samples were sampled using random quadrats in a fixed plot on each site. The plot area was fixed; approximately 300 m^2. With the consultation and permission of the Gujarat Forest department, HOBO temperature and light loggers were carefully set near meadows on each site. The logger was cleaned off crustose algae and dust every month and data was off-loaded every two months.

All seagrass species were observed to grow at a rapid pace after February. Although the growth rates amongst the four species, i.e., *Halophila ovalis*, *Halophila decipiens*, *Halophila beccarii,* and *Halodule uninervis*, differed across the winter to transitional summer months. Increments in seagrass covers at each site seem to have a temperature cue (Figure 2.1, 2.4, 2.6). Although the overall algal growth changed across the reefs, the algal cover substantially remained limited to the rocky reef area. It did not seem to have caused any spatial disturbance to the seagrasses. Epiphytic cover on seagrasses remained limited to the early winter months and only showed a dramatic decrease on Patthiwadi reef-top (JHW-MHQ in Fig 2.8)

A meadow can be patchy and still have high cover 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 that relates to the seasonal patterns in seagrasses. This may further reveal the movement patterns of dugongs across these meadows.

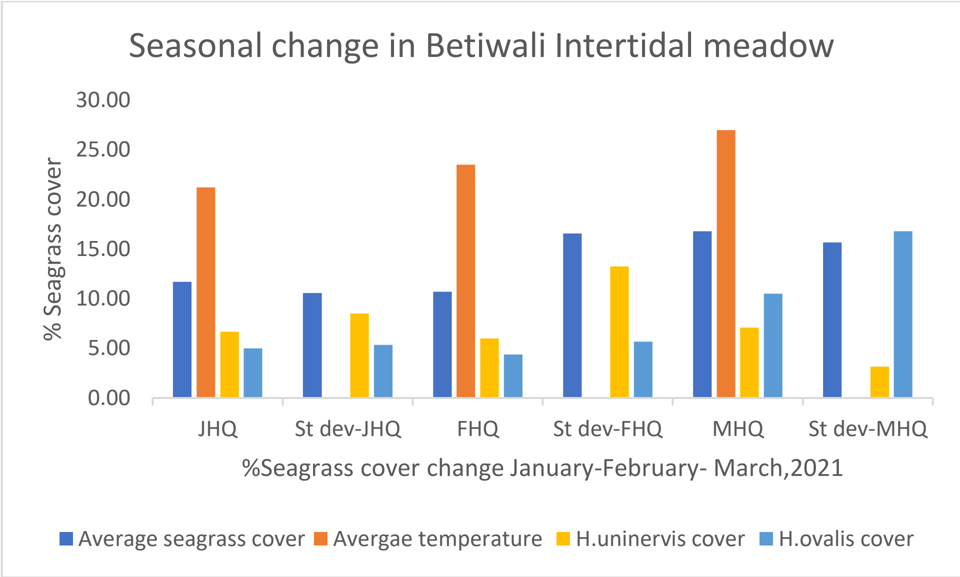

Figure 2.1: Seasonal change of % seagrass cover in Betiwali region of Paga reef (HQ-Betiwala reef, BH- Bhaidar reef, TAM- Taam reef) in Gulf of Kutch, Gujarat

Figure 2.2: Seagrass monitoring on Taam reef, 2021. (a) Quadrat showing Epiphytic load of seagrasses in January. (b) Researcher standing at the bank of an exposed channel during the low tide period. (c) Bryopsis sp. of macroalgae growing along the Taam meadow, which is dominated by *Halophila decipiens* and *Halophila ovalis* in the Gulf of Kutch, Gujarat

Figure 2.3: (a) Quadrat showing growth of *Halophila beccarii* on Bhaidar reef, (b)Researcher during exploratory surveys at Noru reef, (c) Dugongs feeding trail on monitoring site at Bhaidar reef in February.

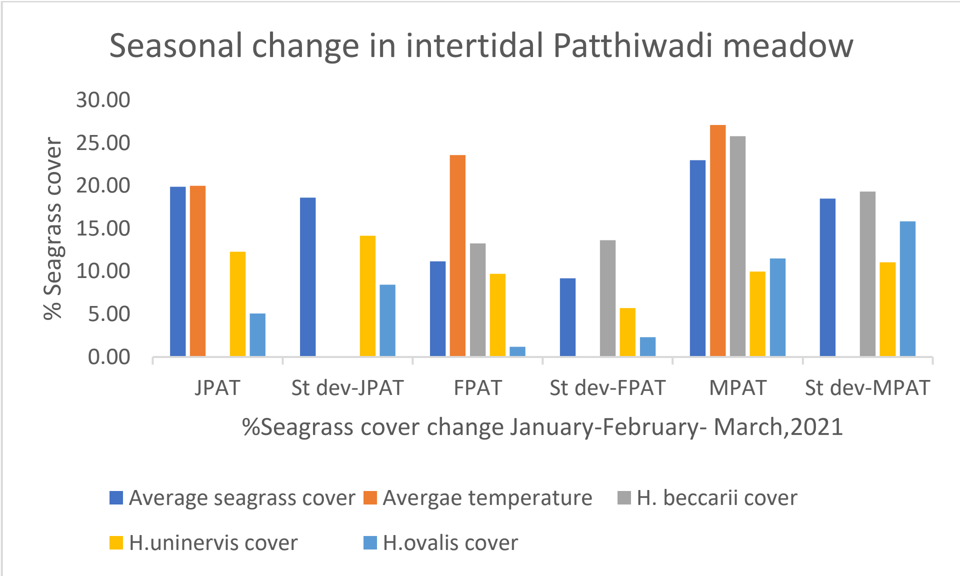

Figure 2.4: Seasonal change of % seagrass cover in Patthiwadi region of Bhaidar's reef (HQ- Betiwala, BH- Bhaidar reef, TAM- Taam reef) in Gulf of Kutch, Gujarat

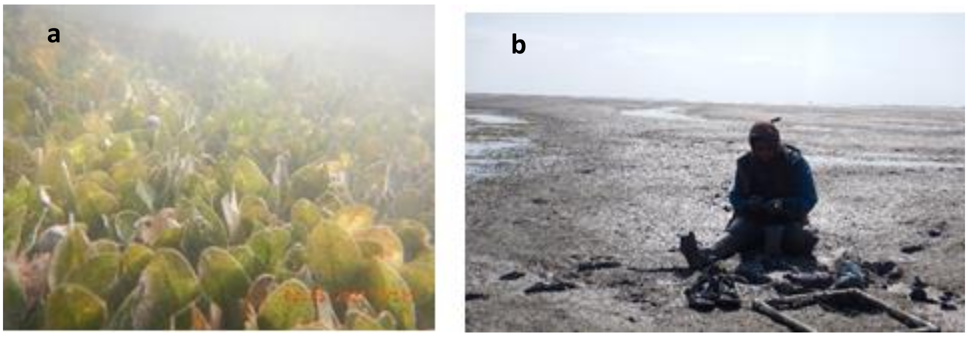

Figure 2.5: (a) High Halophila cover on Paga reef. (b) Field researcher sampling seagrass and sediment samples from mud-flats in Gulf of Kutch, Gujarat

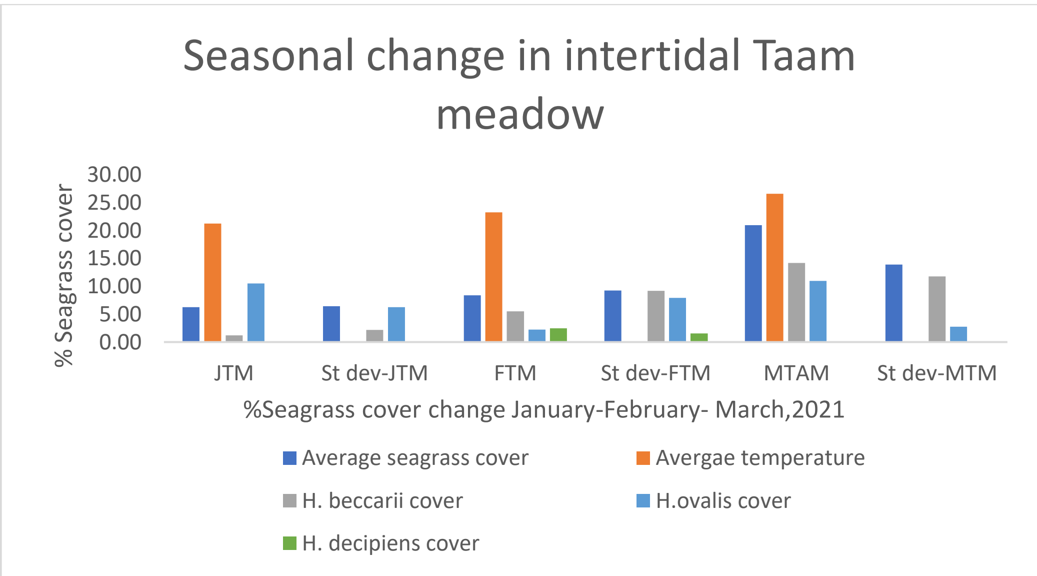

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Figure 2.7: (a) Researchers cleaning seagrass samples, (b) Researchers working during flooding tide on Taam reef in Gulf of Kutch, Gujarat

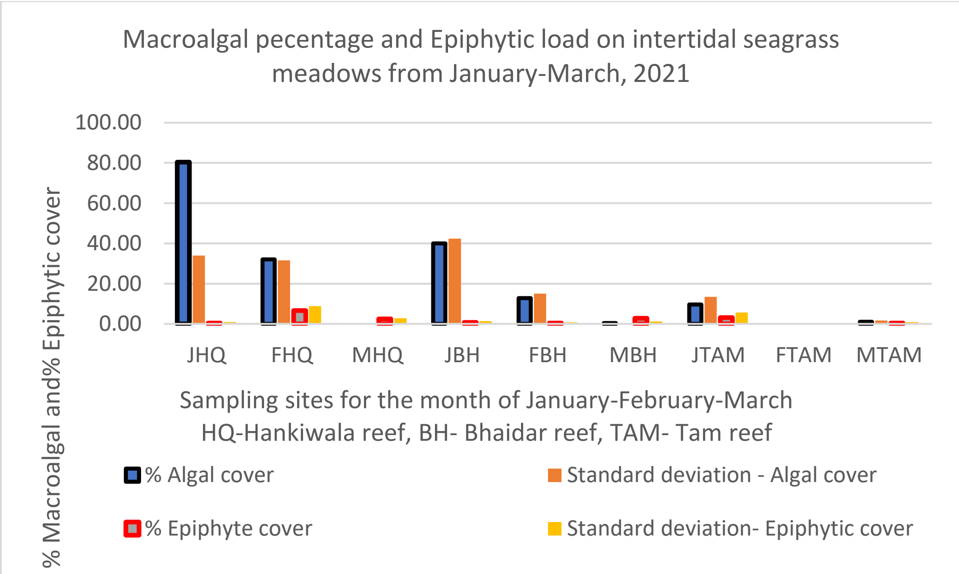

Figure 2.8: Macroalgal percentage and Epiphytic cover across the three monitoring sites (HQ- Betiwala reef, BH- Bhaidar reef, TAM- Taam reef) in Gulf of Kutch, Gujarat

Figure 2.9: Microalgal epiphytic load on seagrasses is more common during the winter months

Seagrass mapping in subtidal zones of Paga reef and Bhaidar Island

To map the extent of seagrasses in the subtidal zone a Van Veen grab was used to check for seagrass' presence and absence. Before mapping, regional knowledge became a substantial prerequisite. A small 12 ft dinghy was used for mapping smaller coves. Associated data; depth, temperature, salinity was taken.

It was observed that; 11 out of 22 sampling points were seagrass-absent points in Paga's subtidal zone for an area of 393.4 hectares and 10 out of 22 sampling points were seagrass absent points in Bhaidar Island's southern cove of a total survey area of 86 hectares. Seagrass *Halophila decipiens* was the only species observed so far to be dominating these shallow subtidal meadows.

Subtidal mapping efforts were stopped after a rough sea state due to the arrival of southwestern tropical winds.

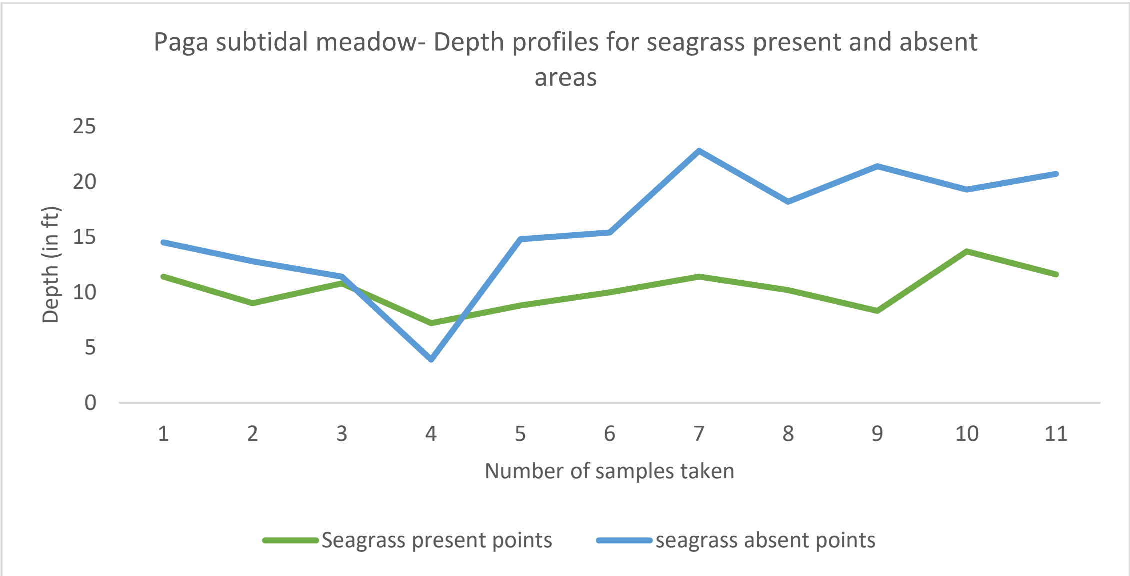

Figure 2.10: Depth profile of a typical subtidal seagrass meadow in Gulf of Kutch, Gujarat

As observed from the above (Figure 2.10), seagrass colonizes low tide shallower zones in the subtidal waters of southwestern GoK. The average depth for colonization of seagrasses is 15 feet (water depth during high water period).

2.1.2 Ecological surveys for estimating seagrass-associated benthic macrofauna

The organisms inhabiting the sediment are referred to as benthos. Depending upon their size, benthic animals are divided into macrofauna, microfauna, and meiofauna and macrofauna. Benthic community responses to environmental perturbations are useful in assessing the impact of anthropogenic perturbations on environmental quality. Macrobenthic organisms which are considered for the present study are animals with body size larger than 0.5 mm. The presence of benthic species in a given assemblage and population density depend on numerous factors, both biotic and abiotic.

A rich community of infaunal organisms directly or indirectly contributes 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), affecting 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 January 2021 to March 2021.

Study areas

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 a foot shape) is 5 km away from the coast. It is an excellent reef with high diversity of corals and coral associates and remains submerged during high tides. Earlier workers reported pearl oyster beds from these reefs. It is totally devoid of mangroves because of its total submergence during high tides. 654 ha area is covered by reef vegetation. A total of 591 ha of reefs with corals are found in this island. This island was leased in the past by the fisheries department for collection of shells and pearls

Bhaidar island is located between 22~7 .9'N - 22°-28.2'N and 69'°17.6' E - 69°19.5' E stands 3rd with an area of 3660 hectares and situated 11 km away from the coast (Venkataraman, et al., 2004). This island stands 6th in the coverage of mangroves. The mangroves cover an area of 416 hectares. *Avicennia*, *Ceriops,* and *Rhizophora* are the dominant mangroves found on this island. It is recorded as a nesting site for Indian Reef Heron, Darter, Grey Heron, and large Egret. Mudflats cover an area of 134 hectares, Sandy beach is found on the western side of the island and the total sandy area on this island is recorded as 31 hectares. Island proper has a coral reef with degraded corals in patches. as well-known as a nesting site for Sea turtles. Fishermen, carry out fishing on the reef and stay on the island, especially during rough weather conditions.

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.

Devdi, Dhabdhaba, Lefa are rocky islands located between 22°22.0'N 22°23.0'N and 69°11.1 'E 69°12.0'E. Close to Poshitra point and was connected to the mainland in the past. They are all rocky islands with scrub forests composed of *Aloe*, *Euphorbia* Goral, etc., similar to the scrub forests on the coast of Poshitra. They are almost devoid of mangroves and coral formations when some *Avicennia* patches are found on Dhabdhaba. Rocks sprinkled at high tide were supported by small scattered colonies of few coral species. Rich windowpane oyster beds attract fishermen. Local people also occasionally visit these areas for recreation and fishing around these islands is also not ruled out.

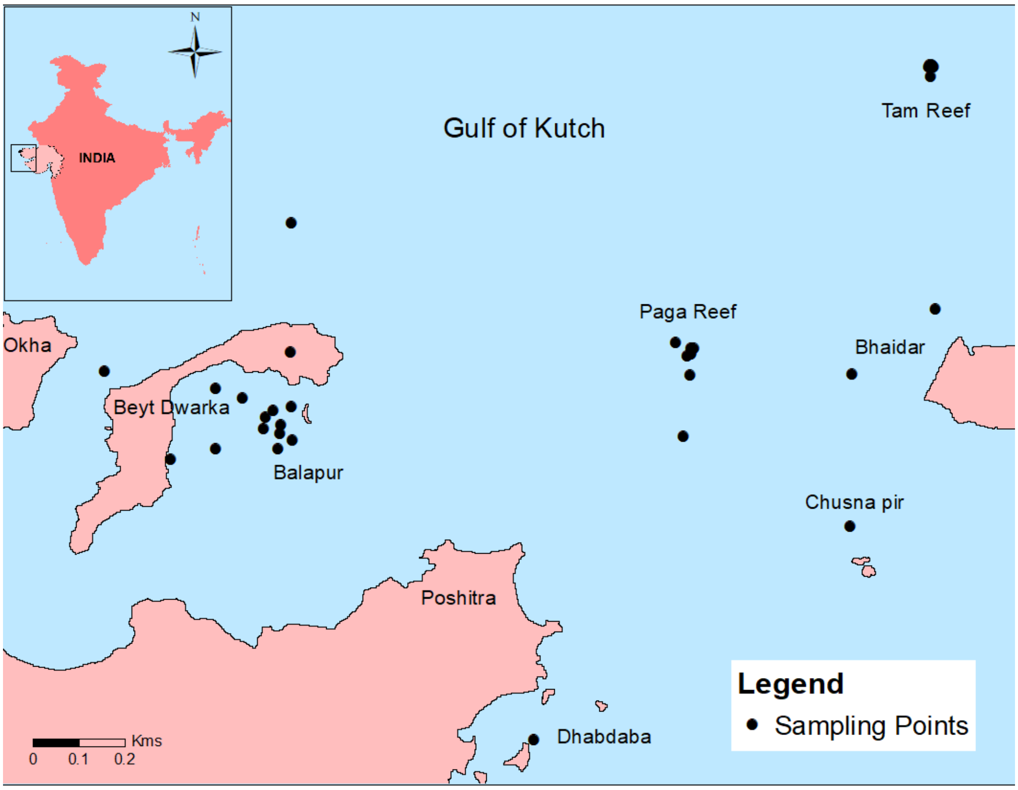

Figure 2.11: Sampling locations for Macrobenthic fauna associated with seagrass in GoK, Gujarat

Methodology

Seagrass-associated invertebrates were collected during the low tide in the pre-monsoon season from January 2021- March 2021.

Natural Geography inshore areas (NAGISA) sampling protocol for seagrass and macroalgae coastal areas was followed for intertidal macrobenthos collection. GPS Garmin eTrex 30 was used for making waypoints. The intertidal seagrass meadows were exposed during low tide. In intertidal seagrass meadows, quadrats were randomly placed. Macrobenthic samples were collected from quadrates of 25x25 Cm in high, mid, and low tide intertidal zones, which were 100 meters spaced apart. Quadrates are the square sampling plots of fixed length and width generally used to study sedentary or slow-moving animals. Approximately six quadrates were placed. Five replicates were taken from each quadrat, and a depth of 5-10 cm of sediment was collected in seagrass present and absent areas each. Samples were sieved and preserved in 5%, formalin and stained with Rose-Bengal. The benthos in the sediment sample was recorded after sieving through 500 mesh size sieves on board. The total population was estimated as the number of animals in 1 meter and biomass on a wet weight basis.

Upon receipt in the laboratory, samples were washed and transferred to a preservative. The washed and preserved sediment with benthic invertebrates were poured into a white enamel tray. The organisms were sorted with the help of a stereomicroscope and arranged into different groups in separate vials and preserved in 70% Ethanol. The preserved animals were later identified to their lowest taxonomic group under a stereomicroscope using relevant identification guides and counted. For further identification, will be carried out with Annamalai University, Tamil Nadu.

Subtidal faunal collection

Van Veen grabs with an area $0.04m^2$ were used to collect subtidal benthic samples. The Van Veen grab is easily operated by a rope. Once on the boat, the grab was opened above a plastic bucket and the sample was gently removed. Samples were sieved to remove fine sediments and any other extraneous material. Depth was measured onboard using the DEPTHTRAX 1H handheld depth finder with the inbuilt temperature sensor. Dissolved oxygen (DO), Salinity, pH was measured with the help of recalibrated portable Dissolved Oxygen meter, salinity, and pH meter. Seagrass cover could not be estimated due to turbidity. Seagrass composition and shoot density were estimated post-field trip.

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 were 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. The Rose Bengal dye at the strength of 0.1% selectivity coloured all the living organisms in the sample.

Figure 2.12: Macrobenthic faunal collection and post-processing

Results

Total 91 samples were collected from Paga Reef, Taam reef, Dabdaba Island, Balapur, Bhaidar, and Chusna Pir during the pre-monsoon period of January 2021- March 2021. Total 23 groups viz Gastropods, Pelecypod, Crustaceans such as Tanaidceans, Cumceans, Amphipods, Isopods, Polychaetes, Foraminiferans, Holothuroidea, Echinoids, Ophiuroidea, Crinoids, Scaphopoda, Polyplacophora, Marine insects, etc. For further taxonomic level identification samples were sent to the Centre of Advanced Study in Marine Biology, Annamalai University, and Tamil Nadu institute. The status and validity of all taxa were checked and updated using the World Register of Marine Species (WoRMS Editorial Board 2016).

The highest wet weight biomass and groups were found at Paga reef. Average biomass varied from 2.11 – 85.12 gm/m^2 wet weight). Density is one of the simplest analysis factors (the number of individuals per unit area or volume) highest density was observed in Taam reef average population varied 64.58-1054.35 nos/m^2) and the highest number of groups was observed in Tam reef average number of faunal groups 3-9 during the study period.

The standing stock of macrobenthic fauna in terms of population and biomass varied widely during the present study (Table 2.1). The range and average faunal standing stock and composition of macrobenthos are given below.

Table 2.1: The range and average faunal standing stock and composition of macrobenthos associated with seagrass meadows in Gulf of Kutch, Gujarat

Locations	Parameter					
	Population (no/m^2)		Biomass (g/m^2; wet weight)		Groups (no.)	
	Range	Average	Range	Average	Range	Average
Paga Reef	16-1936	534.7	0.0-2727.6	85.12	1-8	8
Tam Reef	16-576	148	0.0-18.72	10.56	3-9	5
Bhaidar Island	16-1728	593.22	0.0-990.20	21.14	3-6	4
Balapur Island	25-1325	207.95	0.0-57.25	6.07	1-2	2
Chusana Pir	50-1275	383.33	0.0-13	8.77	4-6	5
Dabdaba Island	25-225	64.58	0.0-15.75	2.11	4-4	4

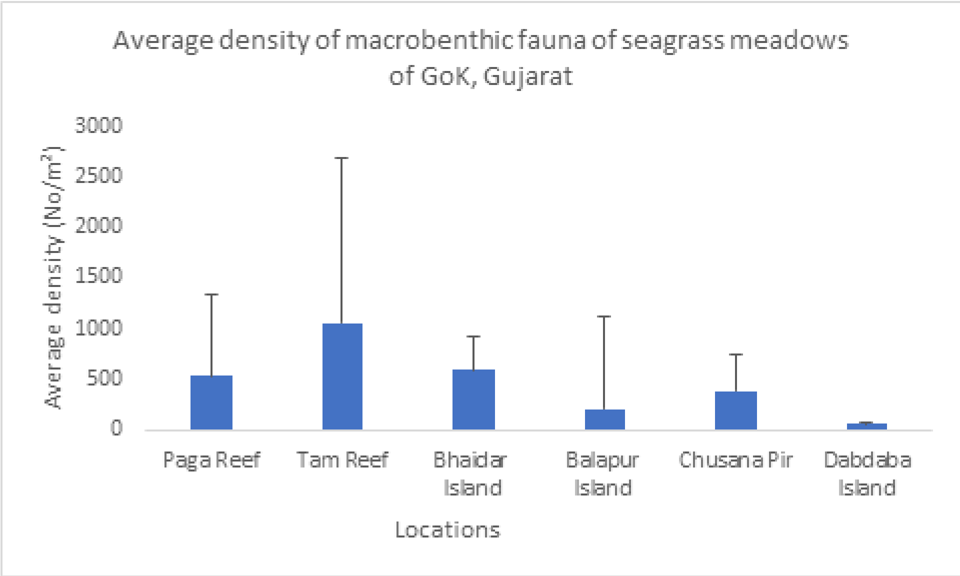

Figure 2.13: Average density (no/m^2) of macrobenthos associated with seagrass during January - March 2021 of GoK, Gujarat

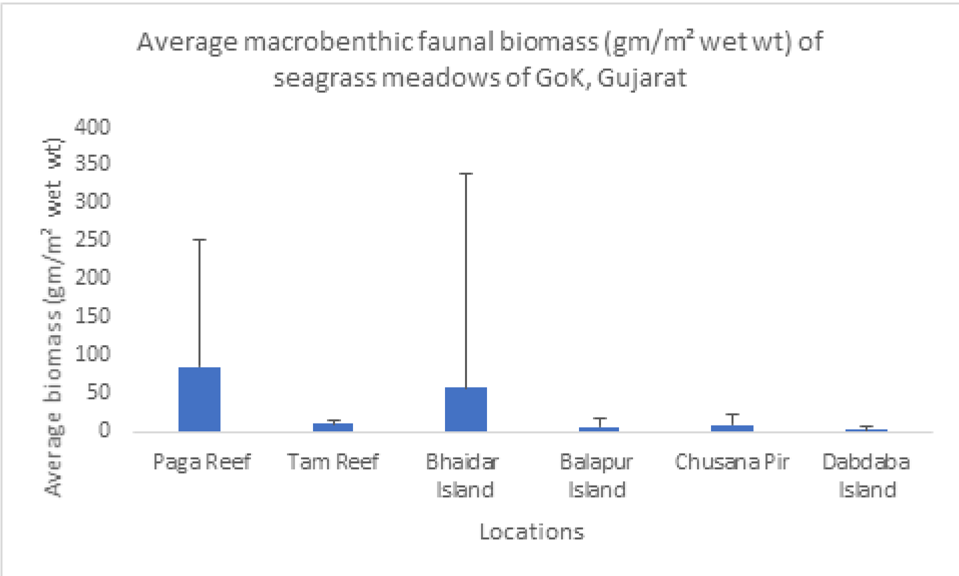

Figure 2.14: Average biomass (g/m^2) of macrobenthos associated with seagrass during January 2021 -March 2021 of GoK, Gujarat

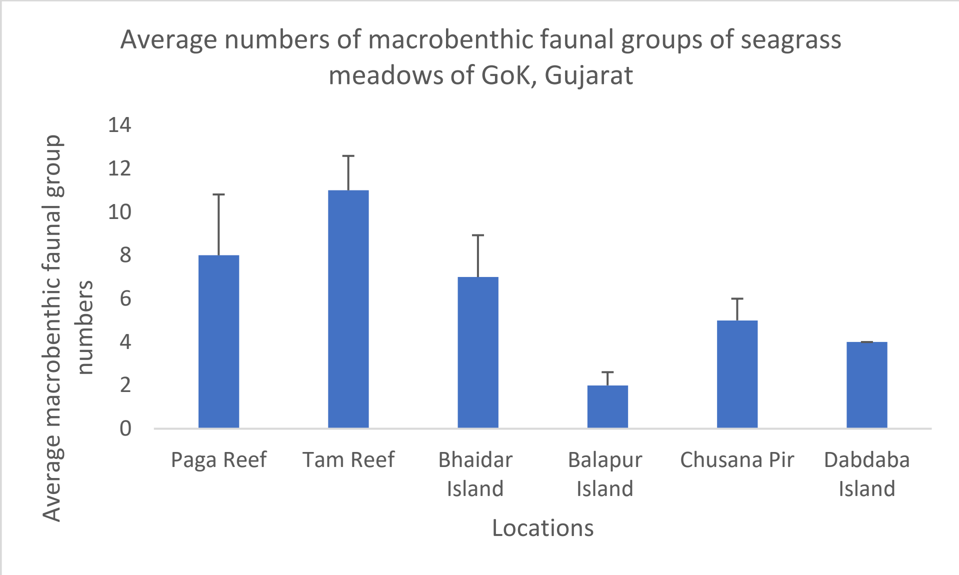

Figure 2.15: Average numbers of faunal groups of macrobenthos during January - March 2021 of GoK, Gujarat

In Bhaidar Island, a total of 14 polychaetes, 14 gastropods, 3 bivalves, and 11 Amphipod, One Isopod species have been identified.

The Paga reef, site shows highest abundance and richness, whereas Tam and Balapur showed lowest abundance during January to March 2021 as shown in (Figure 2.16-2.17).

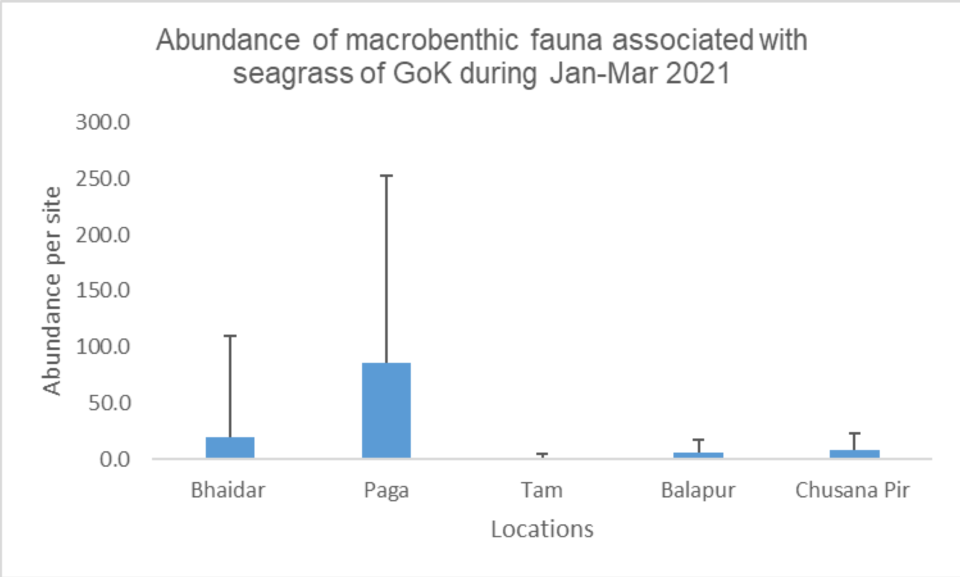

Figure 2.16: Abundance of macrobenthic faunal groups associated with seagrass of Gulf of Kutch, Gujarat during January-March 2021

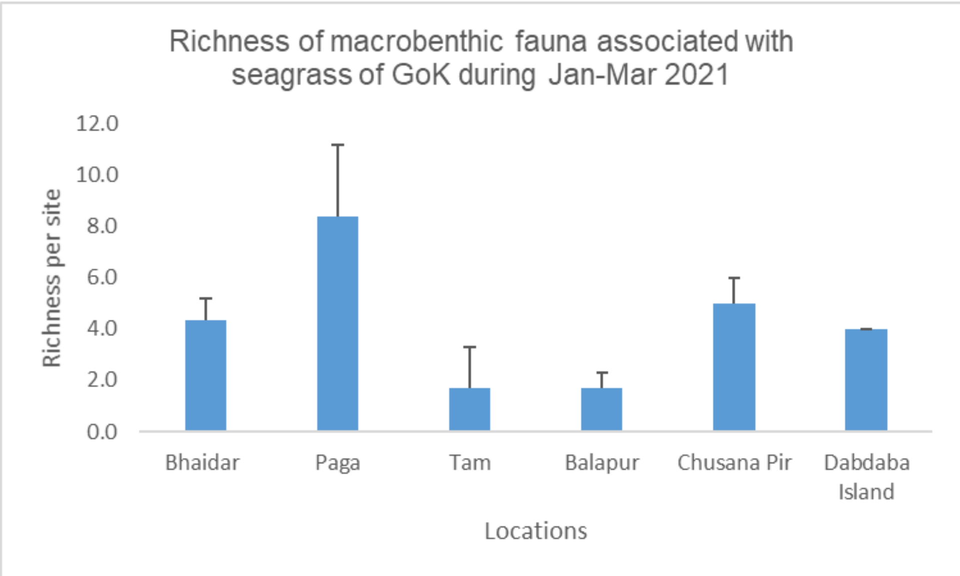

Figure 2.17: Richness of macrobenthic faunal groups associated with seagrass of Gulf of Kutch, Gujarat during January-March 2021

Table 2.2: List of Polychaetes found during a survey of Gulf of Kutch, Gujarat

SN	List of Polychaetes	Family
1	*Perinereis cultrifera* (Grube, 1840)	Nereididae
2	*Phyllodoce mucosa* Örsted, 1843	Phyllodocidae
3	*Perinereis capensis* (Kinberg, 1865)	Nereididae
4	*Platynereis sp.*	Nereididae
5	*Eunice indica* Kinberg, 1865	Eunicidae
6	*Prionospio cirrifera* Wirén, 1883	Spionidae
7	*Pterocirrus macroceros* (Grube, 1860)	Phyllodocidae
8	*Spiophanes bombyx* (Claparède, 1870)	Spionidae
9	*Scalibregma capensis*	Scalibregmidae
10	*Exogone heterosetosa* McIntosh, 1885	Syllidae
11	*Glycinde capensis* Day, 1960	Goniadidae
12	*Syllis gracilis* Grube, 1840	Syllidae
13	*Ophelina longicaudata* (Caullery, 1944)	Opheliidae
14	*Polychaete larvae*	

Table 2.3: List of Mollusc found during survey at Gulf of Kutch, Gujarat

SN	*Mollusc*	Family
Gastropod		
1	*Pirenella cingulata (Gmelin, 1791)*	Potamididae
2	*Turritella acutangula (Linnaeus, 1758)*	Turritellidae
3	*Turritella attenuata Reeve, 1849*	Turritellidae
4	*Bullia vittata (Linnaeus, 1767)*	Nassariidae
5	*Umbonium vestiarium (Linnaeus, 1758)*	Trochidae
6	*Nassarius conoidalis* (Deshayes, 1833)	Nassariidae
7	*Nassarius castus (Gould, 1850)*	Nassariidae
8	*Oliva sp.*	Olividae
9	*Littoraria scabra* (Linnaeus, 1758)	Littorinidae
10	*Euplica scripta* (Lamarck, 1822)	Columbellidae
11	*Calistoma sp.*	Calliostomatidae
12	*Mitrella blanda* (G. B. Sowerby I, 1844)	Columbellidae
13	*Clypeomorus bifasciata* (G. B. Sowerby II, 1855)	Cerithiidae
14	*Trochus kotschyi Philippi, 1849*	Trochidae
Scaphalopoda		
1	*Dentalium elephantinum Linnaeus, 1758*	Dentaliidae
	Pelecypod or Bivalve	
1	*Mesocibota bistrigata* (Dunker, 1866)	Arcidae
2	*Solen* sp.	Solenidae
3	*Donax sp.*	Donacidae

Table 2.4: List of crustaceans found at Gulf of Kutch, Gujarat

SN	List of Amphipods	Family
1	*Gammarus locusta* (Linnaeus, 1758)	Gammaridae
2	*Birubius rostratus* (Dana, 1853)	Phoxocephalidae
3	*Caprella mutica* Schurin, 1935	Caprellidae
4	*Caprella linearis* (Linnaeus, 1767)	Caprellidae
5	*Phoxocephalus holbolli* (Krøyer, 1842)	Phoxocephalidae
6	*Ampithoe ramondi* Audouin, 1826	Ampithoidae
7	*Orchestia gammarellus* (Pallas, 1766)	Talitridae
8	*Harpinia laevis* Sars, 1891	Phoxocephalidae
Isopod		
1	*Anthura gracilis* (Montagu, 1808)	Anthuridae

Figure 2.18: Macrobenthic groups found during a survey in the Gulf of Kutch, Gujarat 1. Isopods 2. Brachyurans (Crab) 3. Sea spider 4. Sponge 5. Gastropod (*Turricula javana*) 6. Brittle star (Ophiuroids) 7. Polychaete 8. Pelecypod (Bivalve) 9. Amphineurans (Chiton) 10. Tube anemone (order Ceriantharia) 11. Sipuncula (Peanut worm) 12. Holothurian (Sea cucumber) 13). Bivalve (Solen sp.) 14. Sergestidae (Prawn) 15. Isopoda (Anthuridae family)

Table 2.5: Diversity of macrobenthic faunal group associated with seagrass meadows in Gulf of Kutch during January- March 2021

SN	Faunal Groups	Bhaidar Island	Balapur	Tam Reef	Paga Reef	Chusana Pir	Dabdaba
1	Amphipods	+	+	+	+	+	+
2	Anomuran (Hermit crab)	-	-	-	+	-	-
3	Asteroidea	-	-	-	-	-	-
4	Brachyuran (Crab)	-	+	+	-	-	-
5	Crinoides	-	-	-	-	+	-
6	Cumaceans	+	-	+	+	-	-
7	Decapod (Unid)	+	-	+	+	-	-

SN	Faunal Groups	Bhaidar Island	Bala pur	Tam Reef	Paga Reef	Chusana Pir	Dabdaba
8	Echinoids	+	-	-	-	+	-
9	Foraminiferans	-	-	+	+	-	-
10	Gastropods	+	+	+	+	+	+
11	Holothuroidea	+	-	+	+	-	-
12	Isopod	-	-	+	+	+	-
13	Marine Insect	-	-	+	-	-	-
14	Oligochaete	+	-	+	+	+	+
15	Ophiuroids	+	-	+	+	-	-
16	Opisthobranchs	+	-	+	-	-	-
17	Pycnogonida (Sea spider)	-	-	+	+	-	-
18	Pelecypods	+	+	+	+	+	+
19	Polychaetes	+	-	+	+	+	+
20	Polyplacoplacophora	-	-	-	+	-	-
21	Porifera	+	-	+	-	-	-
22	Scaphalopod	+	+	-	+	-	-
23	Sipuncula	-	-	-	-	+	+
23	Tanaidaceans	+	-	+	+	-	-
Note: + : Present , -: Absent							

2.1.3 Threat mapping of Critical Dugong Habitats

Study area

The present study was carried out across critical dugong habitats of marine national parks and marine sanctuary areas situated in the southwestern part of the Gulf of Kutch, Gujarat. Around 604 square km area from 22°24'55.04" N - 69°15'17.87"E has been covered.

Methodology

A grid-based distance sampling approach was used, where grids of 2X2 km were divided as near and offshore grids. At each point in the selected grid, a 360º point count method was followed, by scanning an area of 1 km for 10 minutes, to document threats in terms of boat traffic, plastic pollution, and animal activities. A total of 108 grids were randomly sampled from January -March 2021. Parameters like distance of the subject (boat, Marine megafauna, marine litter, etc.) from the observer's boat, angle of spots, types of the boat (fishing/ ferry/ cargo vessels), and size (in case of plastic litter) was recorded along with GPS location. Additionally, variables like the depth of the water column and environmental variables (pH, Dissolved Oxygen, Temperature, and Salinity) were also recorded. A Van-Veen grab was used to confirm the presence and absence of seagrasses with sediment collection. Total 61 samples of sediments and 10 samples of seagrasses were taken for nutrient and pollutant analysis that will be analysed in the future.

Results and discussion

Varied nature of boat traffic was observed; 75% of the boat traffic detected was of fishing boats either actively fishing or anchored, followed by 21% ferry boats, 3% of cargo vessels, and 1% boats of defense bodies (Indian Coast Guard) (Figure 2.18). It was observed that plastic bags/ wrappers composed the most frequently found floating litter (40%), followed by buoys, ghost nets, and ropes (29%). The percentage of other plastic waste materials was 23% and plastic bottles/boxes were very low at 8% only. (Figure 2.20).

Small to medium-sized fishing vessels majorly operate in these areas. Fishing techniques involved the utilization of gill nets, longlines, bottom-set nets, trawl nets. Lobster fishing was observed to be predominantly operational in channels.

Fisheries by-catch and ghost nets pose a direct threat to the survival of marine megafauna in the Gulf of Kutch, Gujarat.

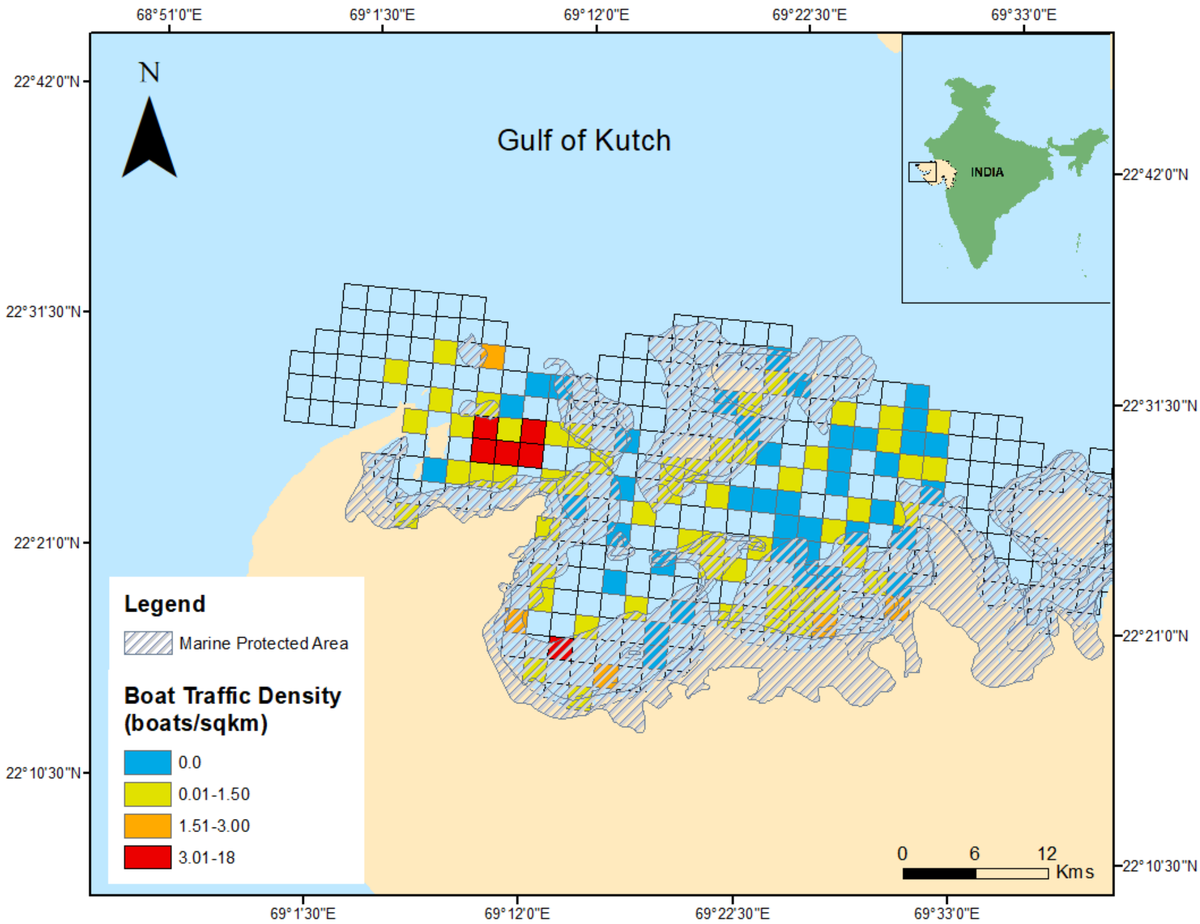

Figure 2.19: Density of boat traffic in and around Gulf of Kutch Marine National Park, Gujarat from January -March 2021

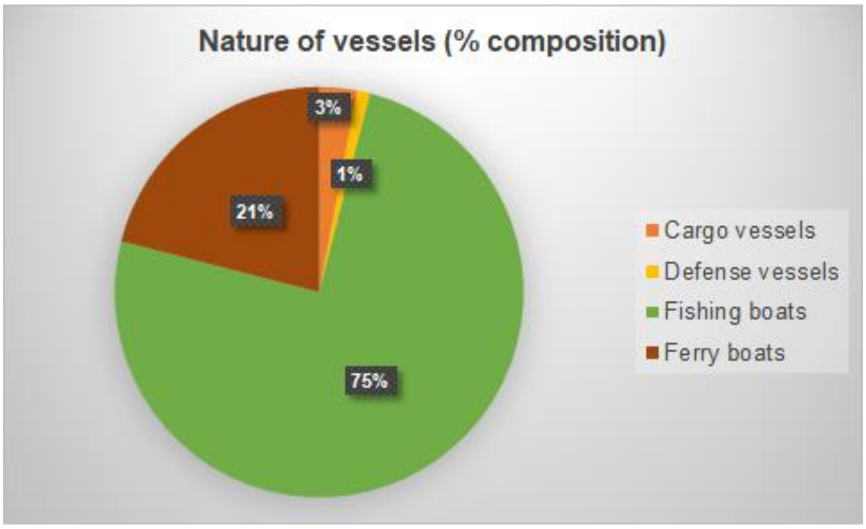

Figure 2.20: Composition of vessels found across the Gulf of Kutch Marine National Park Gujarat from January -March 2021

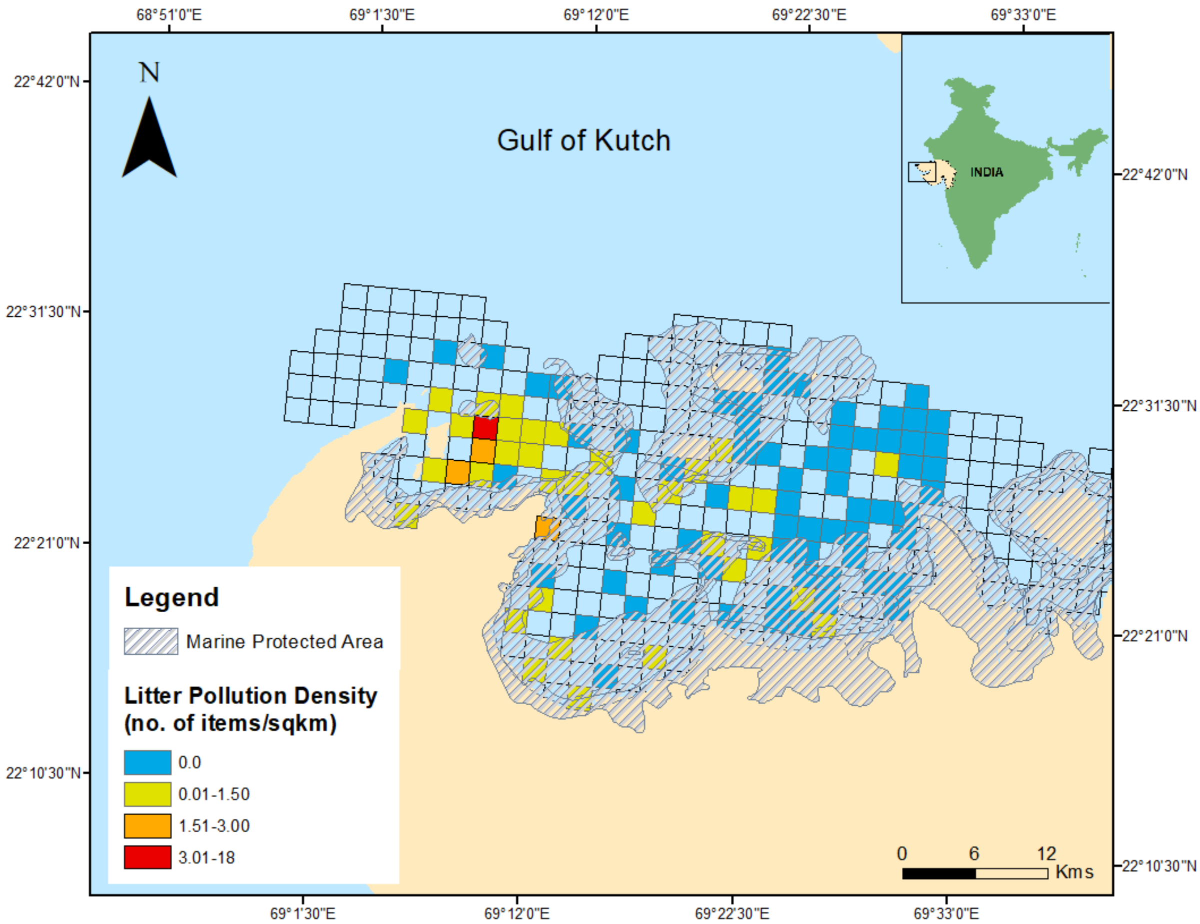

Figure 2.21: Density of macro-litter pollution found in and around Gulf of Kutch Marine National Park, Gujarat for the period of January -March 2021

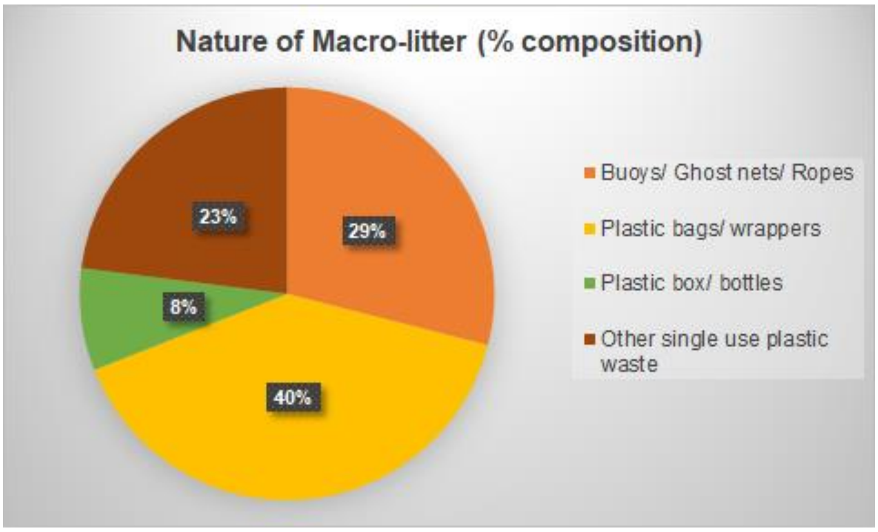

Figure 2.22: Composition of floating macro litter pollution across the Gulf of Kutch Marine National Park, Gujarat from January -March 2021

Figure 2.23:Interview surveys at Dalda Bandar- Fish landing site: Tuna, seer fish, sailfish, unicorn leather jacket, blacktip shark, etc.

Figure 2.24: Threat mapping and sample collection with grab at centroids

Figure 2.25: Ghost net entangled with bleached corals and Styrofoam container stranded at Paga reef. The ghost net was removed and the container was collected

Figure 2.26: Ajad island– Murex, Sea fans entangled in ghost net stuck with mangroves

Figure 2.27: Ghost net removed from the Mithapur reef

Figure 2.28: Line of trawlers docked on the Balapur area where seagrass meadow present

Figure 2.29: Plastic pipe caught in grab while taking seagrass and sediment samples from Balapur, Beyt Dwarka

2.1.4 Underwater pilot survey at Mithapur- Arambada area for the assessment of seagrass meadows

Seagrass meadows and associated faunal diversity were documented at Mithapur and Arambada region while underwater diving survey with our regional partner Wildlife Trust of India, Mithapur field research team. A total of 15 exploratory dives have been done to locate seagrass meadows of the Mithapur and Arambada area. *Halophila decipiens*, *Halophila ovalis,* and *Halodule uninervis* meadows have been documented.

Figure 2.30: (a) *Halophila decipiens* (b) *Halodule uninervis* meadows at the depth of 6 meters

Figure 2.31: Recording environmental parameters and associated fauna at Mithapur seagrass meadow

2.1.5 Interview surveys

Due to the current pandemic, the team, for the first time resorted to on-field interview surveys which were opportunistic. Fishing boats docked near survey sites were approached for interviews. All necessary precautions were taken before the interviews. A semi-structured questionnaire survey was thus carried during the season.

Fishing hot spots seem to shift with season with the availability of seasonal fish, as a consequence so do the fishing gears (Longline fishing for mackerels in winters to trawling for silver pomfrets in summers). Off-shore islands; Chank and Nor seemingly have lesser fishing pressure around their reef as compared to islands near the coastline; Ajad. Dabdaba etc. Fishermen from the Salaya region, owning small gillnetters dominate the fishing areas. Trawlers are limited to the channels near Okha. Rare accidental by-catch included a range of animals, from the protected Hammer-headed sharks to green sea turtles. All animals were reportedly released immediately after. The implication of seasonal fishing pressure on dugong habitat and movement will be studied in depth in the upcoming season.

Figure 2.32: (a,b) Fishermen during interview surveys, (e,f) Researcher interviewing a trawler fisher, Researcher interviewing a small-scale fisher from Salaya, old hook and line on the boat. This practice mostly prevails during the calmer winter waters in the channels of GoK, Gujarat.

2.2 OUTREACH & AWARENESS

1. Total of 20 students of 6th to 8th std. of Saraswati Shishumandir Primary School at Okha were sensitized about Dugongs and their habitat, other marine mammals, plastic pollution, and other threats to marine life. Outreach material, Notebooks, and storybooks have been given to students on 22nd February 2021.

Figure 2.33: Awareness program at Saraswati Shishumandir Primary School

2. Webinar on “Conservation of Dugongs and their habitats in Gulf of Kutch, Gujarat” with Fisheries college of Veraval, Junagadh Agriculture University. Total 85 participants were registered and e-certificates were given to those participants on 24th February 2021.

3. Total of 25 students of the 8th std. of Okha Nagarpalika School were sensitized about Sea birds, plastic pollution, and other threats to marine birds. Outreach material, Notebooks, and storybooks have been given to students on 25th February , 2021.

Figure 2.34: Awareness program at Okha Nagar Palika Sanchalit High school

4. Total of 19 students of 6th std. of Bansi School of Okha were sensitized about Dugongs and their habitat, other marine mammals, plastic pollution, and other threats to marine life. Outreach material, Notebooks, and storybooks have been given to students on 26th February 2021.

Figure 2.35: Awareness program at Bansi School, Okha

5. Live webinar on the Facebook page about Marine mammals: Dugong in collaboration with Wildlife Awareness Network on 26th February 2021. A total of 683 viewers have seen the webinar till now.

Figure 2.36: Flyer for the live webinar

6. Total of 22 fishermen of Bhimrana village were sensitized about Dugongs and seagrass ecosystem, clues for Dugong's feeding trials to detect their presence and threats to marine mammals on 14th March 2021. We distributed masks, t-shirts along with awareness pamphlets. Few of the fishermen told us about the past records of seagrass location near Bhimrana.

Figure 2.37: Community workshop at Bhimarana village

6. Webinar on “Conservation of Dugongs and their habitats in Gulf of Kutch, Gujarat” with Sardar Patel University, Aanand. The session was attended by graduates, postgraduates, and faculty members. A total of 58 participants were registered and e-certificates were given to those participants on 19th March 2021.

2.3 CAPACITY BUILDING

1. Five marine commando officers of Okha Marine Police were trained for sightings and recording marine mammals. Logbooks and other outreach materials were distributed in January 2021.

Figure 2.38: Capacity building training program for Okha marine police

2. Training sessions for identification of seagrass and threats to marine mammals were given to 4 marine police officers and two Indian Navy officers on the field at Chushnapir Island on 8th March 2021. Dugong monitoring Logbooks were distributed among them

Figure 2.39: Capacity building training program for Marine Police and Navy officers

GULF OF MANNAR AND PALK BAY, TAMIL NADU
January - March 2021

Team Members: Rukmini Shekar (Project Fellow), Madhu Magesh K (Project Fellow), Chinmaya Ghanekar (INSPIRE Fellow), Noah Shinde (Field Assistant), T Andrews (Field Assistant), G Thangapandi (Field Assistant), M Rajeshwaran (Field Assistant)

Volunteers: Akila P, Vanmathi B, Sathiya Jothi A, Tharshini S, Anes Jerina J K, Keerthiga M, Arthi G, Mangala Gowri V

Acknowledgment: Thiru T. P. Raghunath IFS (Principal Chief Conservator of Forests and Chief Wildlife Warden, Tamil Nadu Forest Department), Dr. Sanjay Kumar Srivatsava IFS (Additional Principal Chief Conservator of Forest (Wildlife), Tamil Nadu Forest Department), Thiru. A. S. Marimuthu (Wildlife Warden, Gulf of Mannar Marine National Park, Ramanathapuram and District Forest Officer, Ramanathapuram), Thiru. Anand Kumar IFS (District Forest Officer, Pudukottai District), Thiru. Ilayaraja (District Forest Officer, Thanjavur District), Thiru. T. K. Ashok Kumar (District Forest Officer, Kanyakumari District), Thiru. Nagendran (Commanding Officer, Indian Coast Guard Station, Mandapam), Thiru. Ilamvazhudi (District Director of Fisheries, Tamil Nadu Fisheries Department, Ramanathapuram District), Thiru. V. Abdul Kadhar Jailani (Assistant Director of Fisheries, Mandapam), Thiru. Satish Nirmal (Range Forest Officer, Ramanathapuram), Thiru. Palanikumar (Range Forest Officer, Kilakarai, Ramanathapuram), Thiru. Venkatesh (Range Forest Officer, Mandapam, Ramanathapuram), Thiru. Kumar (Range Forest Officer, Thanjavur District), Smt. Manjula (Inspector of Police, Coastal Security Group, Pattukottai, Thanjavur), Thiru. Rajkumar (Sub-Inspector of Police, Coastal Security Group, Pattukottai, Thanjavur), Dr. V. Balaji (Director, OMCAR Foundation, Velivayal, Thanjavur District), Dr. Sesh Serebiah (Director, Jehovah Shamma Centre for Marine and Wildlife Research, Mudiveeranpattinam, Ramanathapuram District), Mr. S. B. Aravind (Dive Instructor and Director, Temple Adventures, Pondicherry), Dr. C. Stella (Head of the Department, Department of Oceanography and Coastal Area Studies, Alagappa University, Karaikudi)

3.1 RESEARCH AND MONITORING

As part of the research and monitoring component, in Tamil Nadu, we conducted seagrass meadow assessment in South Palk Bay and off the Gulf of Mannar coast of Rameshwaram, marine mammal assessment survey of Thanjavur coast in North Palk Bay and seagrass associated fish surveys in parts of Palk Bay and Gulf of Mannar. We also had an M.Sc. Marine Science student from Bharatidasan University, who finished her dissertation project entitled 'Pollution Assessment on the Habitat of Dugongs (*Dugong dugon*) in the Palk Bay and Gulf of Mannar, Southeast coast of India' in collaboration with our team.

Figure 3.1: Sampling locations for seagrass meadow assessment in South Palk Bay

3.1.1 Seagrass Surveys

South Palk Bay and a part of the insular coast of Rameshwaram island facing towards Gulf of Mannar Biosphere Reserve were chosen for the seagrass meadow assessment from January to March, 2021. Nine parallel transects extending up to 9 kilometres from the coast were surveyed for seagrass meadow characteristics such as seagrass cover, seagrass diversity (genus level) and shoot density. Quadrats were placed at half-kilometre intervals on each transect (n=135 quadrats). Five locations were chosen in South Palk Bay in such a manner that each transect was parallel to each other with a distance of 5 kilometres between each transect (Figure. 3.1).

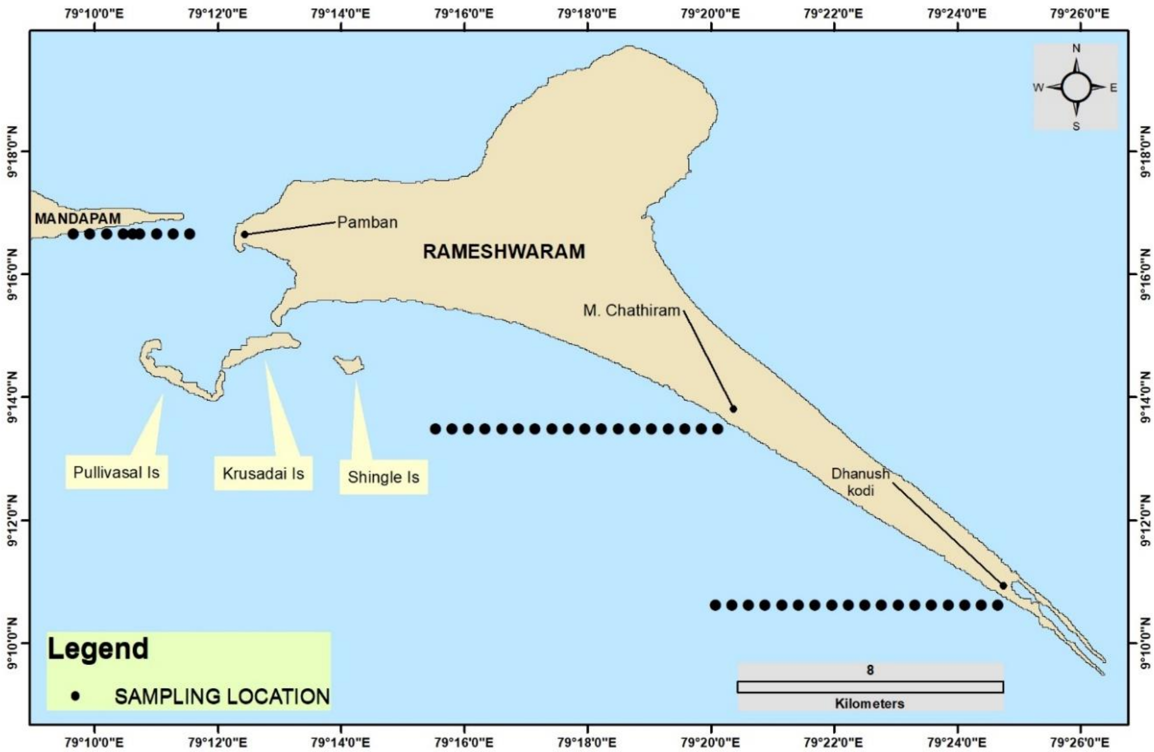

Figure 3.2: Sampling locations for seagrass meadow assessment off Gulf of Mannar Coast of Rameshwaram Island

Three westward transects parallel to each other were chosen off Rameshwaram coast. Each transect was 5 kilometre away from each other (Figure. 3.2).

The methodology used included on-board deployment of drop-down quadrat of 0.5 x 0.5 m (Figure 3.6), a Van Veen grab (Figure 3.4), and a water sampler (Figure 3.5) from trawl or traditional fishing vessels.

Figure 3.3: Water clarity determination using Sechchi Disc

Environmental parameters were recorded using a thermometer, depth meter, Secchi disc (Figure 3.3), and a hand-held refractometer for air and water temperature, water depth, water clarity and water salinity, respectively.

Figure 3.4: (Right): Collection of seagrass and sediment sample using a Van-veen grab

Figure 3.5: (Bottom right) Deployment of a drop-down quadrat fitted with a camera to obtain quadrat data

Figure 3.6: (Bottom left) Deployment of Water sampler to collect water samples from seagrass meadows

Seagrass Cover:

Overall, a seagrass cover of 10.61% (± 21.51) was observed from all locations sampled. *Cymodocea* spp. was the most dominant genera of species present (7.65 ± 18.16% cover). The second most common genera were that of *Halophila* spp. at 1.47% cover (± 8.43%). (Figure. 3.7)

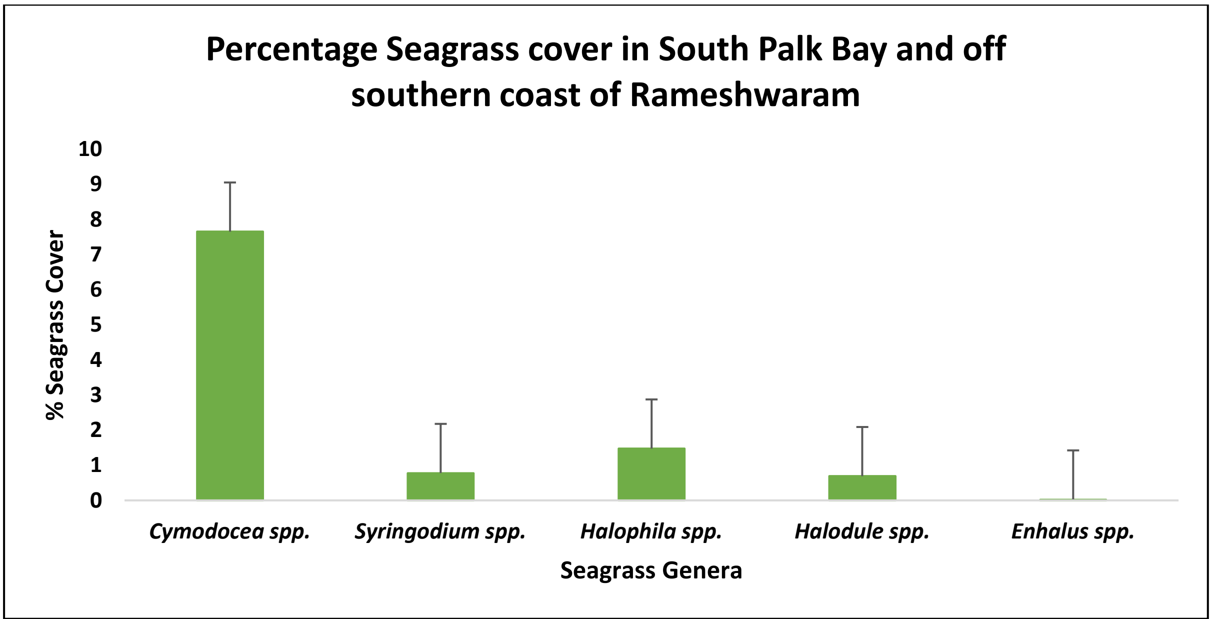

Figure 3.7: Percentage Seagrass cover in South Palk Bay and off southern coast of Rameshwaram, Tamil Nadu

Seagrass presence was not recorded in 3 out of 9 transects. Two of these transects were off Rameshwaram Island (Mukundaraiyar Chathiram and Dhanushkodi). Of the one transect that showed presence of seagrass off Rameshwaram Island (Rameshwaram), seagrass were recorded at only one point at 1km off the coast. *Cymodocea* spp. was the only species recorded, with a cover of 0.56% (± 3.69).

The transect off Padanendal showed highest cover (36.89% ± 26.41) and diversity of seagrass (n = 5 species). One transect in South Palk Bay (Uchipulli) showed no presence of seagrass. The transect off Azhagankulam in South Palk Bay had seagrass only at one location at 2 km off the coast. In South Palk Bay, *Cymodocea* spp. showed the highest cover (11.2% ± 21.22) and *Enhalus* spp. showed lowest cover (0.03% ± 0.31). The overall seagrass cover of South

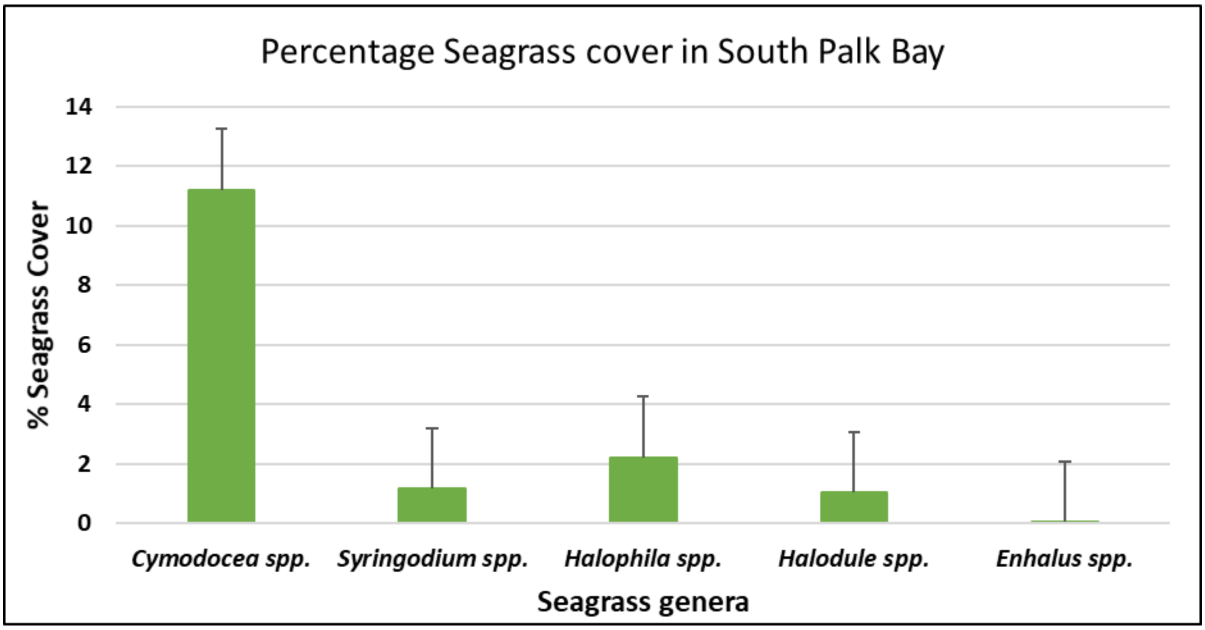

Figure 3.8: Percentage Seagrass cover in South Palk Bay, Tamil Nadu

Palk Bay was at 15.64% (± 24.73). Five genera of seagrasses were recorded from the region (Figure 3.8).

Seagrass Shoot Density:

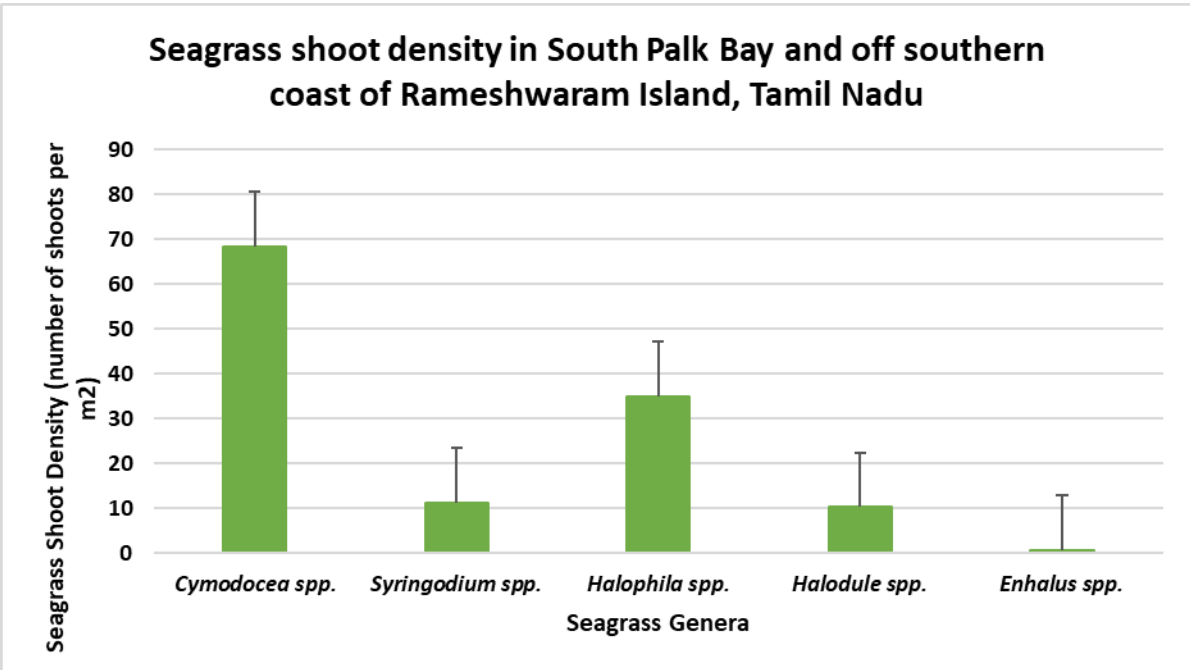

Figure 3.9: Shoot density of seagrass genera in South Palk Bay and off the southern coast of Rameshwaram Island, Tamil Nadu

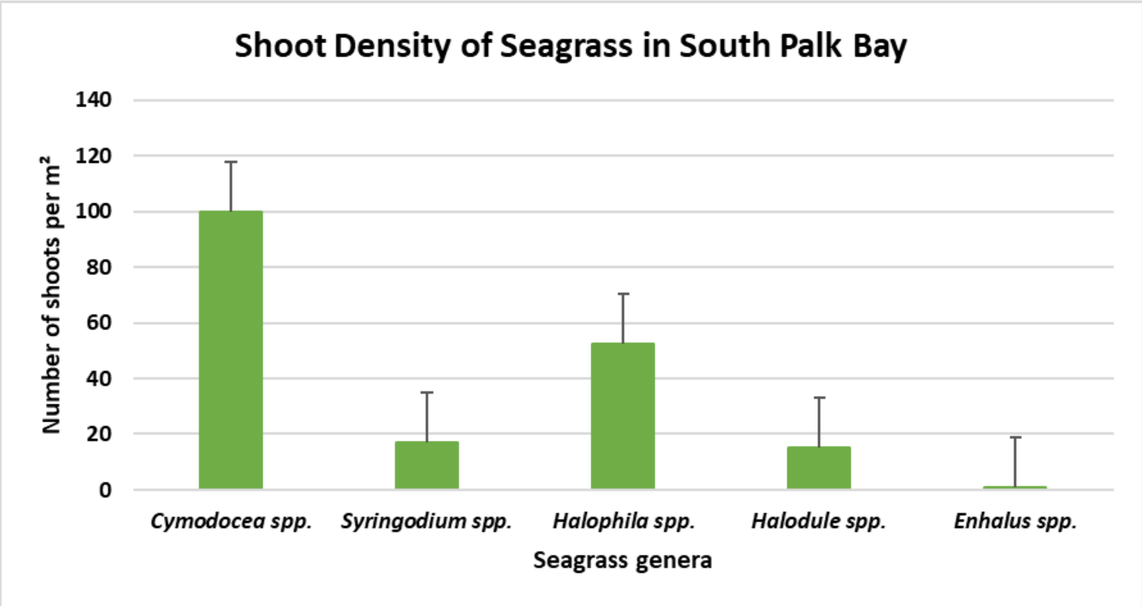

Figure 3.10: Shoot density of seagrass genera in South Palk Bay

Shoot density of *Cymodocea* spp. was found to be highest (68.44 ± 152.52 shoots per m^2) compared to all other genera of seagrass in South Palk Bay and off southern coast of Rameshwaram island. *Enhalus* spp. was seen to have least shoot density (0.74 ± 7.06 shoots per m^2). *Halophila* spp. was found in dense meadows and exhibited the second highest shoot density of 34.96 ± 193.26 shoots per m^2) in the region. (Figure 3.9).

As no seagrass genera were recorded from the southern coast of Rameshwaram Island, except for a small patch of *Cymodocea* spp. from only one location, data of shoot density of seagrasses from South Palk Bay was analyzed separately. (Figure 3.10).

In South Palk Bay alone, *Cymodocea* spp. and *Halophila* spp. showed highest shoot densities with 100 (± 176.86) shoots per m^2 and 52.44 (± 234.75) shoots per m^2, respectively. *Halodule* spp. and *Syringodium* spp. have similar shoot densities at 15.33 (±72.48) shoots per m^2 and 16.89 (± 110.79) shoots per m^2, respectively.

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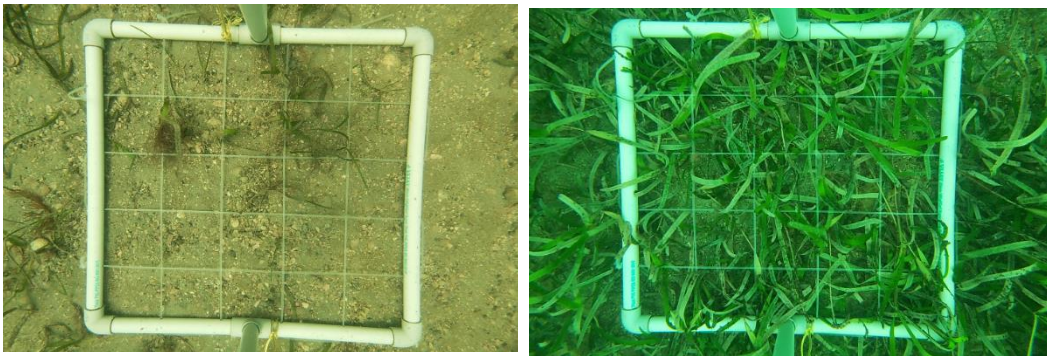


Figure 3 11: (a) Left. Seagrass bed with very low (4%) seagrass cover; (b) Right. Seagrass bed with 50% seagrass cover

3.1.2 Marine Mammal Survey

Five traditional fishing boats were used to survey a 105 km^2 area off Thanjavur coast in the proposed North Palk Bay Conservation Reserve area, to record presence of dugongs, other marine fauna, litter, and fishing activity in the region.

All boats started simultaneously from Sethubavachathiram coast in Thanjavur district on predefined parallel transects 5 km in length and 1km apart from each other. Each boat had at least two observers and 2 boatmen who were local fishermen.

Figure 3.12: Briefing by team member before commencement of Marine Mammal and Litter Survey

Total of 12 fishermen and 7 Student volunteers from Alagappa University, Karaikudi and Bharatidasan University, Trichy took part in the survey. The event ensured community involvement and we distributed T-shirts to all participants before-hand. A briefing

Figure 3.13: Marine Mammal and Litter Survey team at Sethubavachathiram, Thanjavur district, North Palk Bay

was conducted before commencement of the survey to explain the importance of conserving marine life, importance of dugongs and seagrasses and method in which the survey would be conducted.

Marine organisms observed were jellyfish, rays, fishes like reef needle and half-beaks, and shore birds. There were 23 live organisms recorded, of which, 14 were of jellyfish, 3 were of shore birds and one was of a ray. (Figure 3.16).

Figure 3.14: Marine Mammal and Litter Survey being

Figure 3.15: Marine Mammal and Litter Survey team on one boat

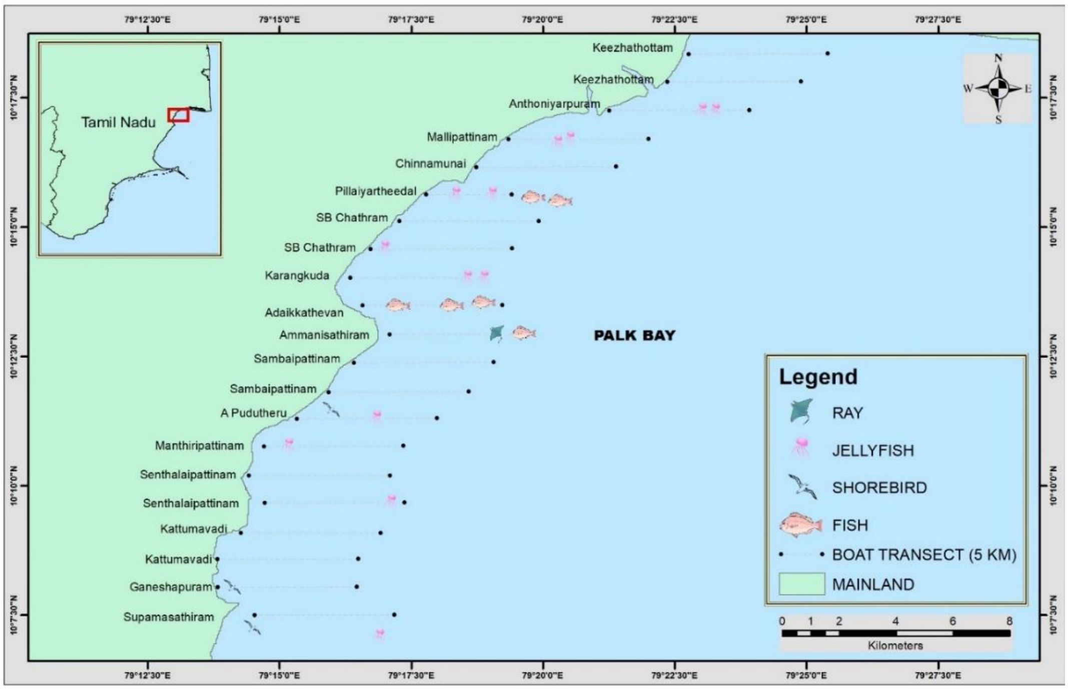


Figure 3.16: Map of marine life recorded along transects of boat survey

82 records of thermocol and plastic litter were recorded during the survey. 37 records of plastic waste in the form of plastic covers, milk packets, polyvinylchloride pipes, nylon ropes, water bottles and cans, and 45 records of thermocol and foam buoys and foam pieces were made during the surveys. (Figure 3.17).

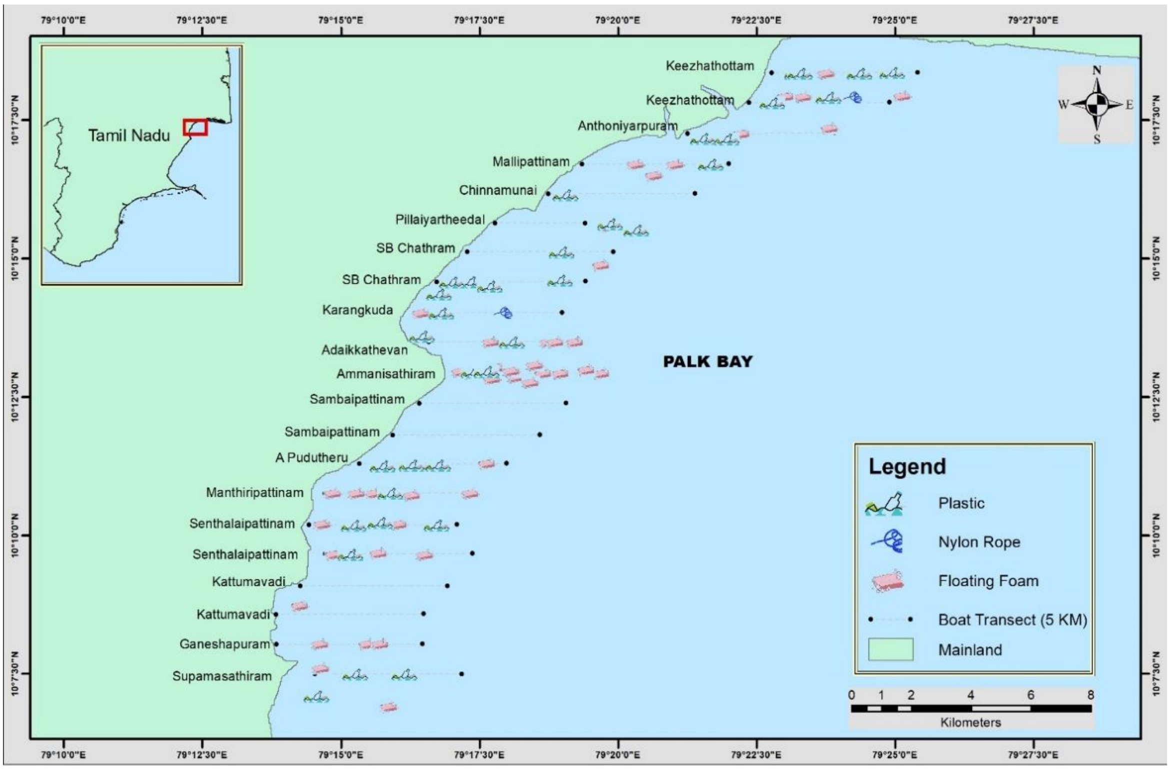


Figure 3.17: Map of litter recorded along transects of boat survey

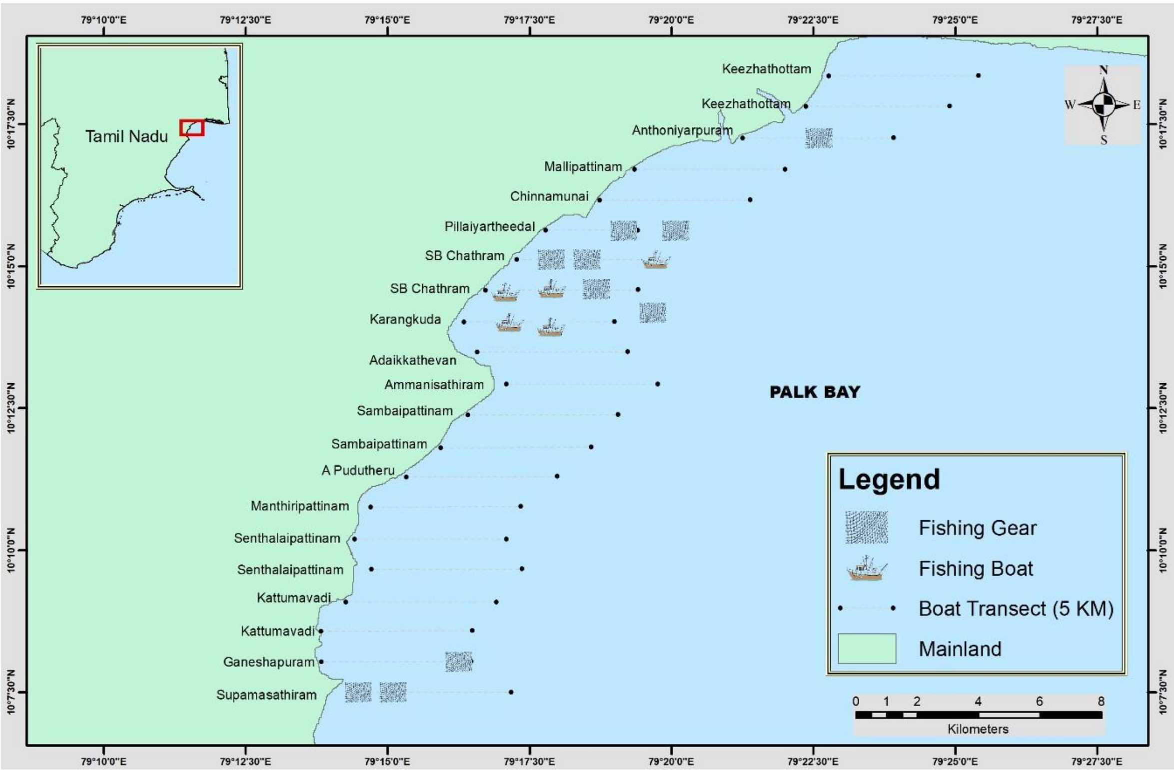


Figure 3.18: Map of fishing activity recorded along transects of boat survey

There were 9 records of set gill nets in the region. 4 traditional boats actively carrying out fishing were taken note of. 2 anchored trawl boats were also recorded. (Figure. 3.18).

Figure 3.19: Marine Mammal and Litter Survey team conducting the survey

Figure 3.20: (a) Left. Thermocol floating (b) Right. Fishing boat at sea

3.1.3 Seagrass Associated Fish Survey

Study Area

The study is conducted in Mandapam group of islands of Gulf of Mannar and Palk Bay. Fourteen manual point counts were conducted near four islands for fish diversity and density assessment. Three fish market surveys were conducted at Morapannai, Tamaraipattinam and Tiruppalaikudi situated along Palk Bay coast which all are small markets in the area.

Fish Market Survey

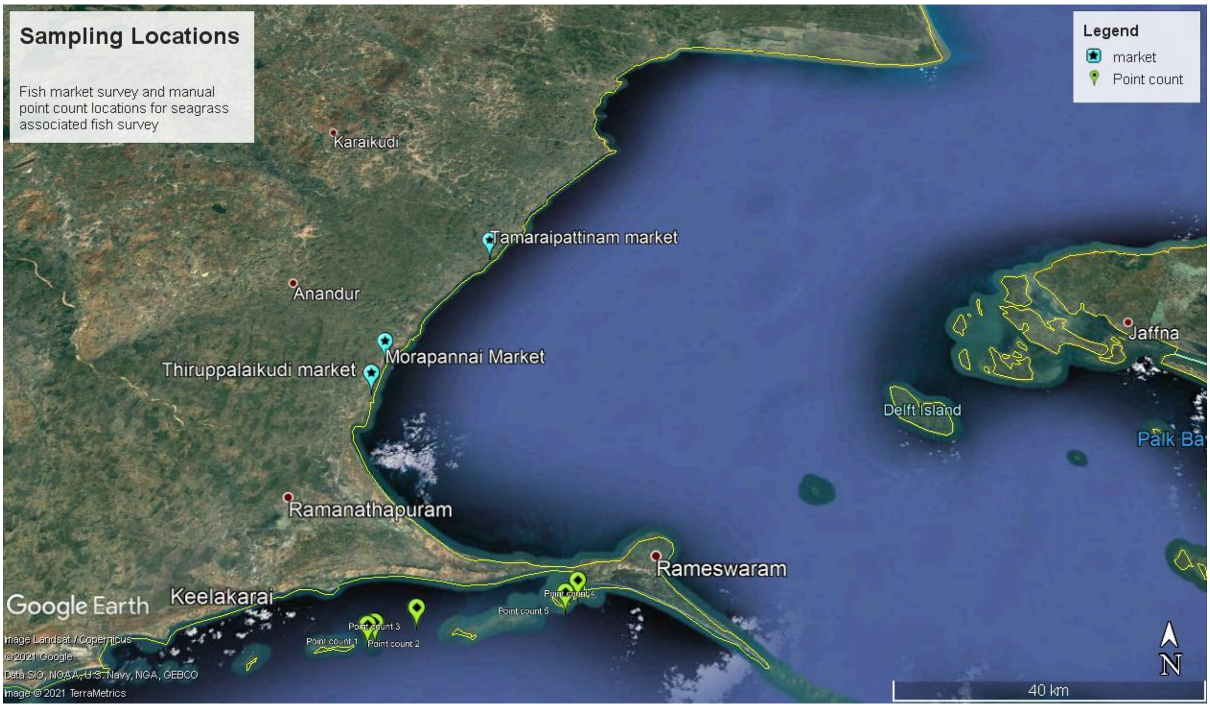


Figure 3.21: Sampling Locations for seagrass associated fish

Methodology:

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

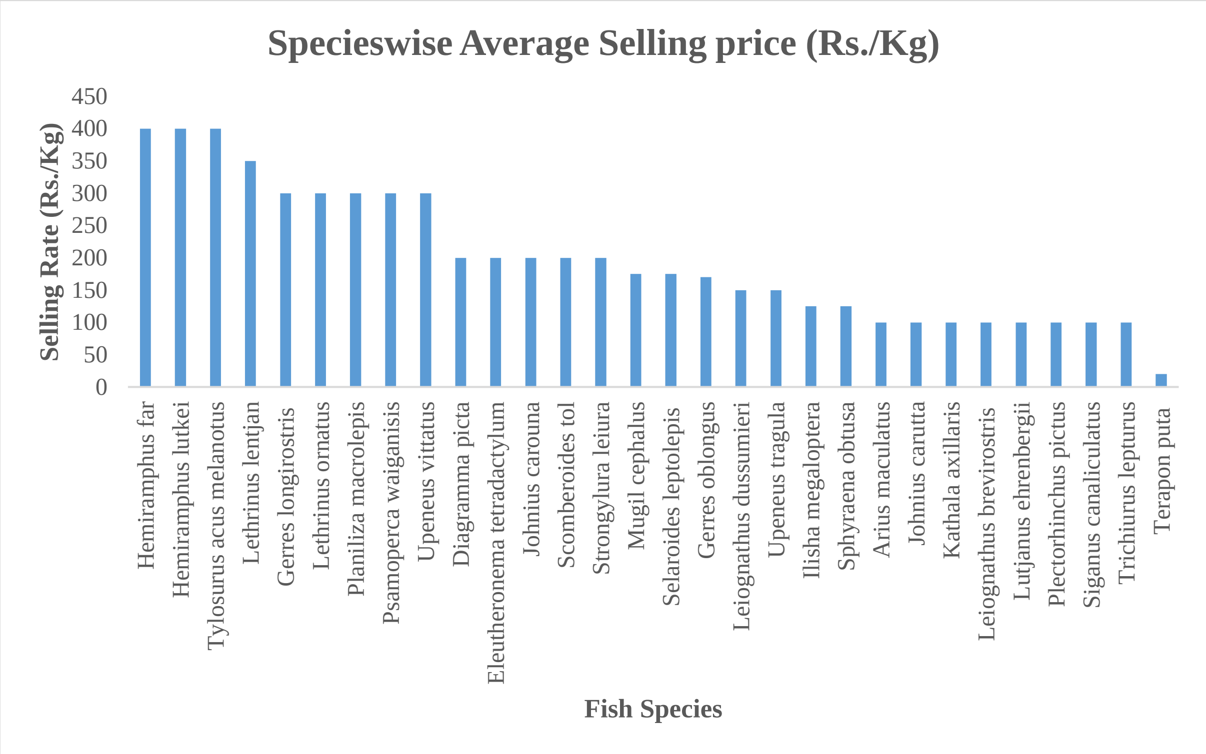


Figure 3.22: Species wise fish selling price in Palk Bay

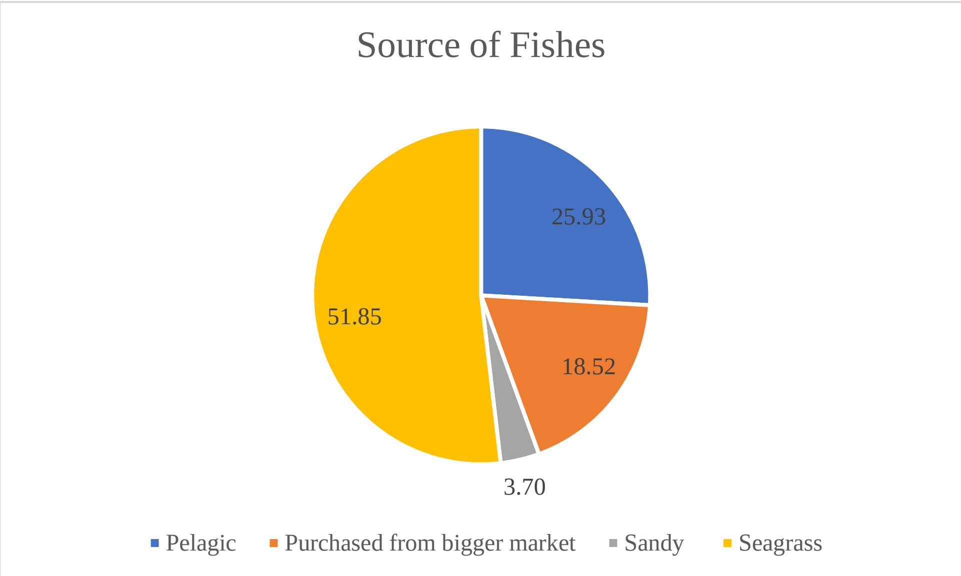


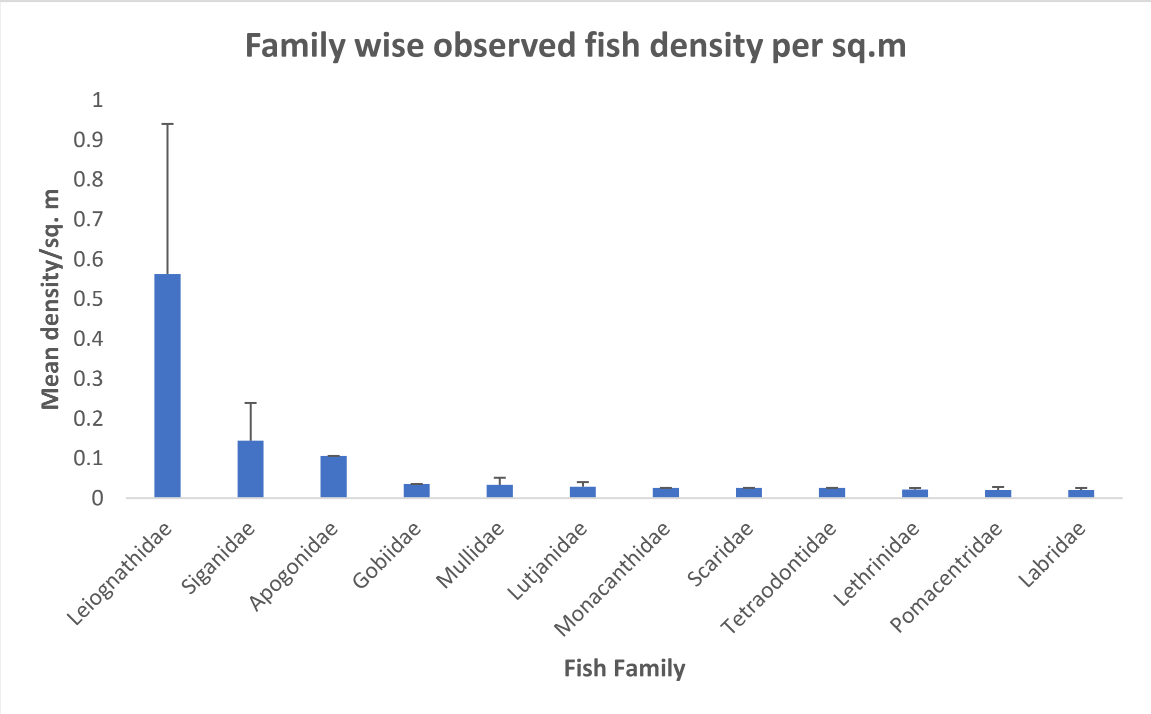
Figure 3.23: Sources of fish sold in markets of Palk Bay

Result: Thirty fish species belonging to 19 families were observed in these fish market surveys. Price for *Hemiramphus far*, *Hemiramphus lutkei* and *Tylosurus acus melanotus* was the highest at Rs. 400/kg whereas it was the lowest for *Terapon puta* at Rs. 20/kg (Figure 3.22). In Palk Bay, 51.85% of fishes were caught from seagrass beds followed by 25.9% caught in Pelagic area (Figure 3.23). Around 18% of fishes were also sourced from bigger wholesale indicating existence a chain of sellers in the area (Figure 3.23).

Density of Seagrass associated Fish

Methodology:

To understand diversity and usage of seagrass meadows by fish, random point counts were conducted at Gulf of Mannar (n=14). Variable radius point counts were performed by noting down each fish sighting in the point count. Observer hovered not more than 2 meters above centre of the point for 10 minutes. The activity within every minute of every fish species individual or shoal was noted along with seagrass characteristics. 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 meters.



Results

Figure 3.24: Family wise average fish density observed in sampled area in 2021

Fish Density in seagrass meadows of Gulf of Mannar

Family-wise average fish densities were calculated for the sampled area by Distance software version 7.3 (Thomas et al., 2010). Models were selected based on minimum values of Akaike's Information Criterion (AIC). The uniform simple polynomial model was selected for fish density estimation (AIC=142.3457) over Negative exponential, half normal, and hazard rate models. The average fish density was found to be 0.28/sq.m (Table 3.1). As the coefficient of variation is high, further sampling is required to understand actual fish densities in the area.

In the Gulf of Mannar, Family Leiognathidae (Ponyfish) has the highest density in the sampled area as these fish are found in huge shoals (Figure 3.24). Fish belonging to families such as Labridae, Mullidae, Lethrinidae are found in lower densities because they are either solitary or form small shoals.

Table 3.1: Fish density and cluster size estimates

	Estimate	%CV	df	95% confidence interval	
Average cluster size	1.8367	16.06	48.00	1.3326	2.5317
DS	0.20028	25.03	12.43	0.11728	0.34200
D (Density)	0.28263	26.96	16.60	0.16147	0.49471

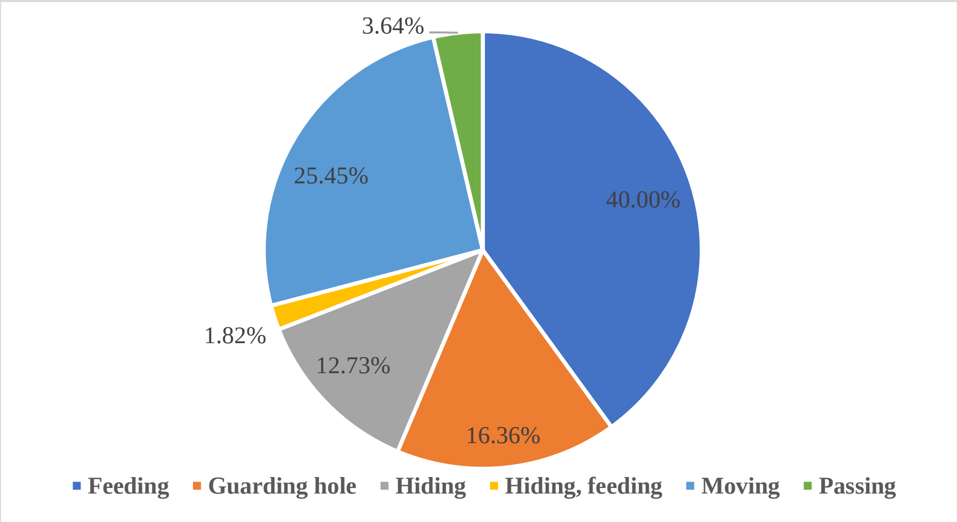


Figure 3.25: Percentage of fish activities observed in seagrass meadows

Fish Behavior

Observed fish behaviour in seagrass meadows was categorized into four major categories: 1. moving in the meadow, 2. passing by, 3. feeding, and 4. hiding between leaves. A total of 56 observations of fish behaviour were recorded in 14 random point counts. In 40% of observations, feeding behaviour was recorded, suggesting the importance of seagrass meadows as feeding grounds for fishes. 25.45% observations were of fish moving in seagrass meadows, whereas 3.64% observations were of fish passing by the meadow. Observations of fishes hiding in seagrass canopy were 12.73%, signifying seagrass meadows as a shelter for fish species in the Gulf of Mannar. 16.36% of observations were specific to the behaviour of

Shrimp-gobies as they guard the shrimp holes. Complex fish behaviour such as hiding followed by feeding was also observed (Figure 3.25).

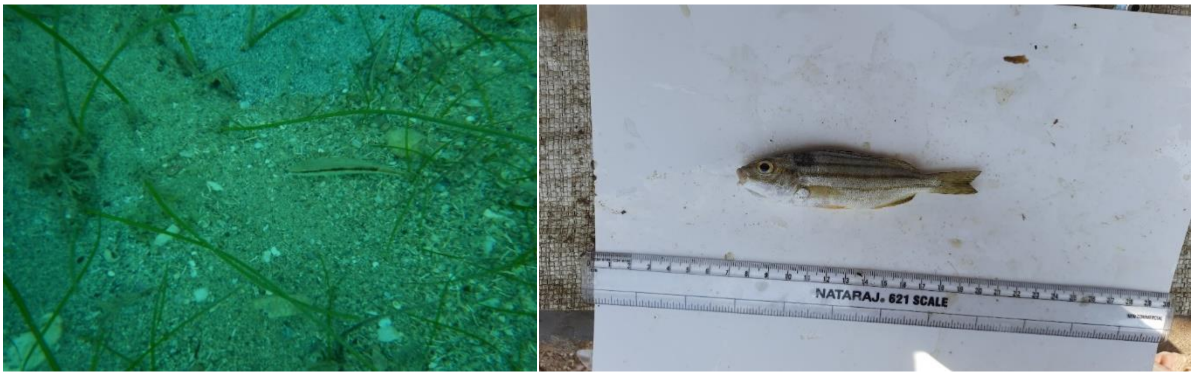


Figure 3.26: (a) Left. Goatfish in seagrass meadow; (b) Right. *Terapon puta* caught from seagrass meadow

Figure 3.27: Fish vendor at a fish market in Nambuthalai, Middle Palk Bay

3.1.4 Dissertation Project

Ms. V. Mangala Gowri, an M.Sc. Marine Science student from Bharatidasan University, collaborated with our field team to carry out her dissertation project entitled '**Pollution Assessment on the Habitat of Dugongs (*Dugong dugon*) in the Palk Bay and Gulf of Mannar, Southeast coast of India'**. Her work aimed at estimating physico-chemical parameters of water, pollution indicating parameters in sediments, heavy metal concentrations in sediment using Atomic Absorption Spectrophotometry (AAS).

Seagrass, water and sediment samples were collected from six sites (Figure 3.28) chosen based on site characteristics like estuaries, and seaweed farming areas. Samples were collected from 3 locations at each site. The sampling was conducted in March 2021. Sites were compared for levels of pollution. Site A and F had interference of fresh water runoff, Site B and C were seaweed farming sites, Site D was a site of litter accumulation, and Site E had no disturbance, and was considered as a control site.

Samples were collected using snorkeling and SCUBA diving as tools. Water samples were collected 1 litre polyethylene-terephthalate (PET) bottles for physico-chemical analyses. Sediment and seagrass samples were collected in polythene bags, sealed and stored. All samples were frozen until further analysis.

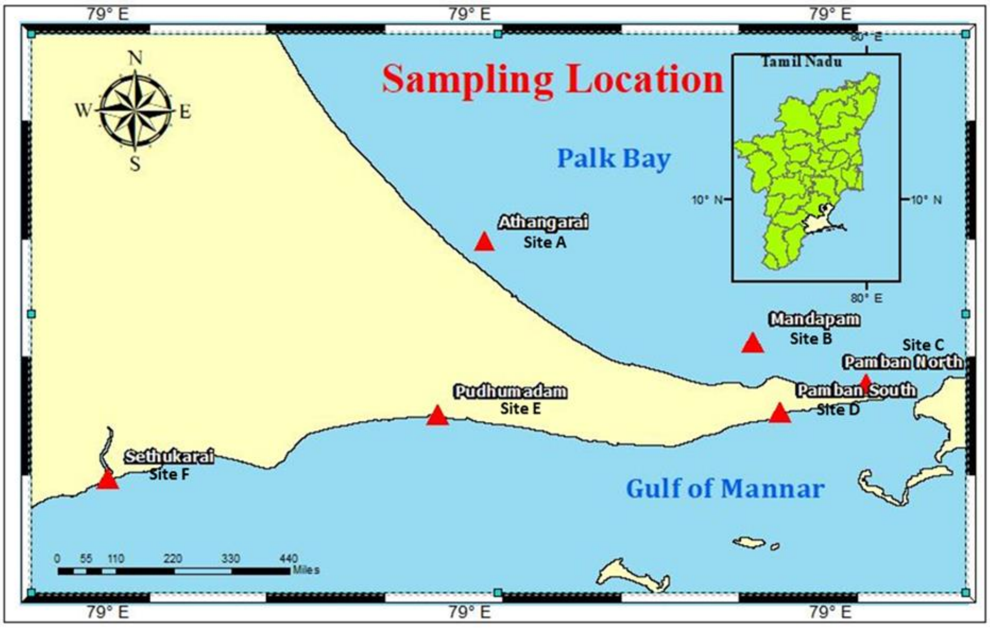


Figure 3.28: Sampling sites for contaminant analysis from Palk Bay, Tamil Nadu

a) Results of Physico-chemical Parameters Water samples showed high amounts of magnesium and phosphates where human interference was more (Site D). (Figure 3.29).

b) Enumeration of Pollution Indicators:

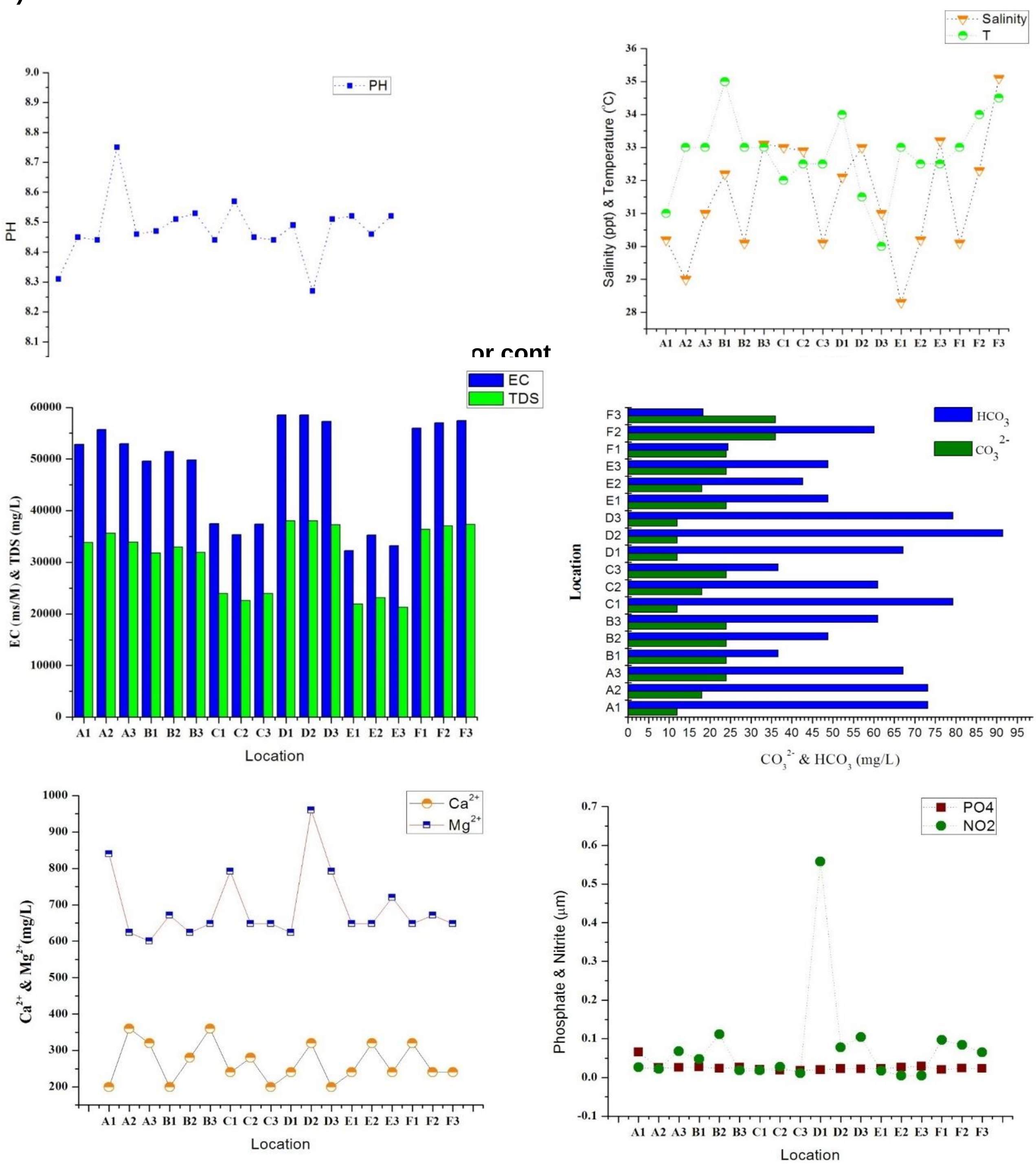


Figure 3.29: Graphs depicting temperature and salinity differences (top left), pH variation (top right), electrical conductivity and total dissolved solids (middle left), carbonate and bicarbonate contents (middle right), Calcium and magnesium ion concentration (bottom left), and, Phosphate and nitrate content variation in water samples collected at each sampling location.

Bacteriological analyses of water were the pollution indicator chosen for the study. The results indicate that water is polluted by fecal contamination to an extent that it is unsuitable for recreational activities. The total viable counts (TVC) were an order of magnitude above $10^4 mL^{-1}$ for all sites, which is substantially high. The mean TVC ranged from 23.8–41[$\times 10^4$] $mL^{-1;}$ 20 - 25[$\times 10^4$] mL^{-1}; 1.3–2.1[$\times 10^4$] mL^{-1};2.7 –6.2[$\times 10^3$] mL^{-1}; 1.9–2.0 [$\times 10^3$] $mL^{-1}$and 2.0 – 2.8[$\times 10^3$] mL^{-1} at Site D, F, A, B, C and E, respectively. Variations in total viable counts (TVC) were large in Site D. Similar to TVC, the Total Coliforms, *Faecal Coliforms, and Faecal Streptococci* ranges were higher in Sites D and F. All sites were found to have high TVC and the values were relatively higher in most of the places which may be due to the presence of populations residing in these coastal areas. (Figure 3.30).

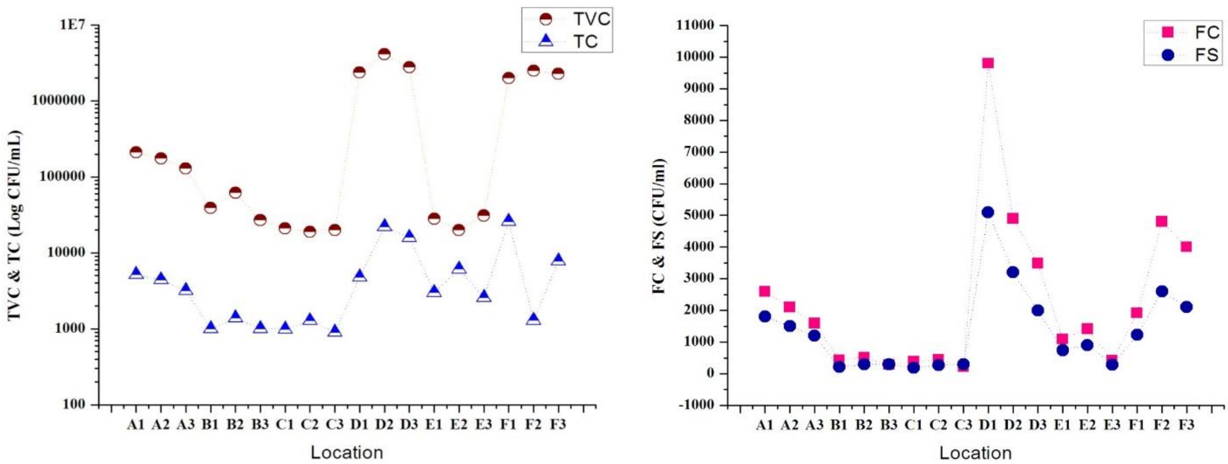


Figure 3.30: Graphs depicting total viable counts and Total coliforms (left), and, faecal *coliforms* and faecal *streptococci* (right) presence across sampling locations

High *Fecal coliforms* (40%) present in water samples are explained by a lack of sewage treatment in inhabited areas as well as by storm water drains or seepage running into adjacent nearshore areas. (Figure 3.30).

The counts of *Salmonella* sp (SA) ranges from 0 - 400 mL^{-1} respectively. During the monsoon season discharges including sewage waste from dumping sites contaminated groundwater sources additionally increasing bacterial loads compared to other seasons. Results of the bacteriological parameters revealed that coastal samples were highly affected with high bacterial populations at all locations. In conclusion, our study gives an indication of the high extent of microbial pollution and hence any further addition of wastes containing microbes may deteriorate the existing hygienic quality of the study area. (Figure 3.31)

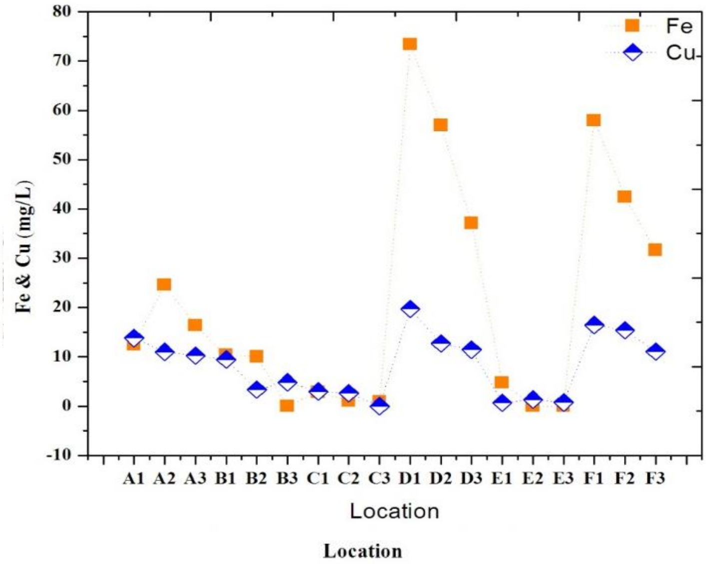


Figure 3.31: Graph depicting presence of *Salmonella/Shigella* spp. across sampling locations

c) Heavy Metals:

Heavy metal concentrations were relatively high and the average metal concentration were in the range for Fe (0 to 73.4 mg/L), the maximum concentration of Copper (Cu) was observed in Site D and the minimum was in the Site F (Figure 3.32). The higher concentrations at these sites might be due to domestic sewage from industrial/shipping activities and fishing communities dotted along the study area. The presence of Cu in the seawater/aquifer could be attributed to the urban and industrial runoff as well as traffic emission/fossil fuel paints and agrochemicals. The continuous increase in heavy metal contamination of coastal water is a cause of concern as these metals have the ability to bioaccumulate in the tissues of various biota.

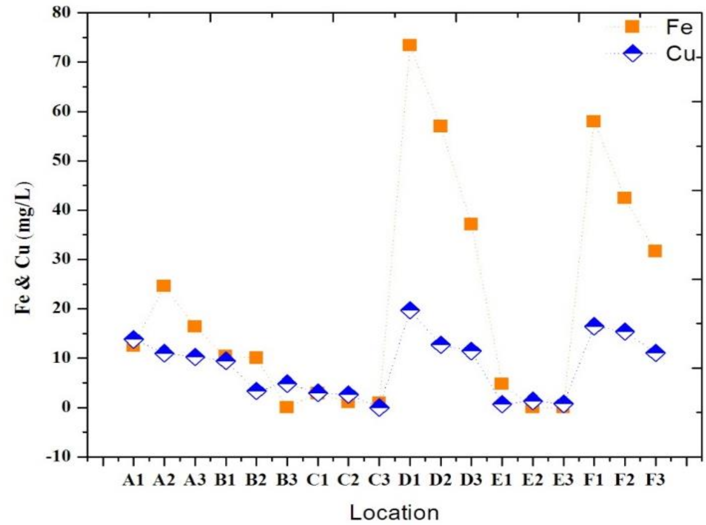


Figure 3.32: Graph depicting heavy metals- Iron and Copper presence across sampling locations

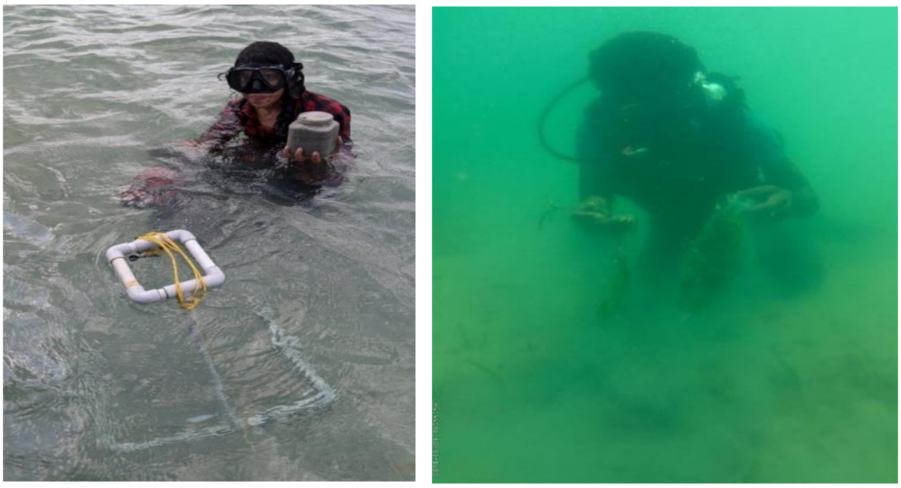


Figure 3.33: Sample collection-seagrass, sediment and water

3.1.5 Dugong Stranding

A total of 3 dugong strandings were recorded in the month of January alone. There were no stranding events in February and March. As March has been observed to be a month of the year when maximum dugongs have stranded, it is unusual that the number of strandings was zero in March, 2021. Morphometric measurements and tissue samples were collected from the stranded dugongs.

(i) One stranded dugong was found on 06th January, 2021 on Valinokkam beach of Gulf of Mannar Biosphere Reserve. The cause of death was unknown. The individual was a female sub-adult. (Figure 3.34).

(ii) On 15th January, 2021, an adult male dugong was found stranded on the beach of Manamelkudi, North Palk Bay. (Figure 3.35 a)

(iii) On 29th January, 2021, a female sub-adult dugong was found washed ashore on Sanguthoppu Beach, Manamelkudi, North Palk Bay. (Figure. 3.35 b*)*

Figure 3.34: Dugong carcass stranding at Valinokkam, Gulf of Mannar, Tamil Nadu

Figure 3.35: (a) Left. Dugong carcass at Manamelkudi, Palk Bay
(b) Right. Dugong carcass at Sanguthoppu, Manamelkudi, Palk Bay

3.2 Outreach and Awareness

Date: 25th January 2021

Venue: District Forest Officer, Thanjavur

The Dugong team from TN met the District Forest Officer of Thanjavur at Thanjavur Forest Office, to discuss on how to introduce the concept of North Palk Bay Conservation Reserve to the locals, potential alternate livelihood options for the community and the required documents to prepare the initial official reports to declare the area as a Conservation reserve.

Date: 05th February 2021

Venue: Temple Adventure, Pondicherry

We met the Director, Temple Adventure regarding our next biodiversity monitoring training programme with SCUBA diving course**.**

Date: 08th February 2021 to 11th February 2021

Venue: Verified Dugong ambassadors' details

The team Visited 66 schools from Thanjavur, Puthukkottai, Ramanathapuram and Tuticorin district, verify the bank details of 100 dugong ambassadors who were getting Dugong scholarship instalment on regular basis.

Date: 26th February 2021

Venue: Wildlife Warden, Gulf of Mannar, Ramanathapuram

A meeting with Wildlife Warden and Rangers, Gulf of Mannar was conducted to obtain permission for preservation of marine mammal carcass to be used for the Marine Mammal stranding workshop.

Date: 03th March 2021

Venue: Mohamed Sathak Dasthagir B.Ed College, Ramnathapuram

Discussed with Dr. S. Somasundaram, Principal, Mohamed Sathak Dasthagir B.Ed College, Ramnathapuram for finalising the result for Phase IV Dugong ambassadors.

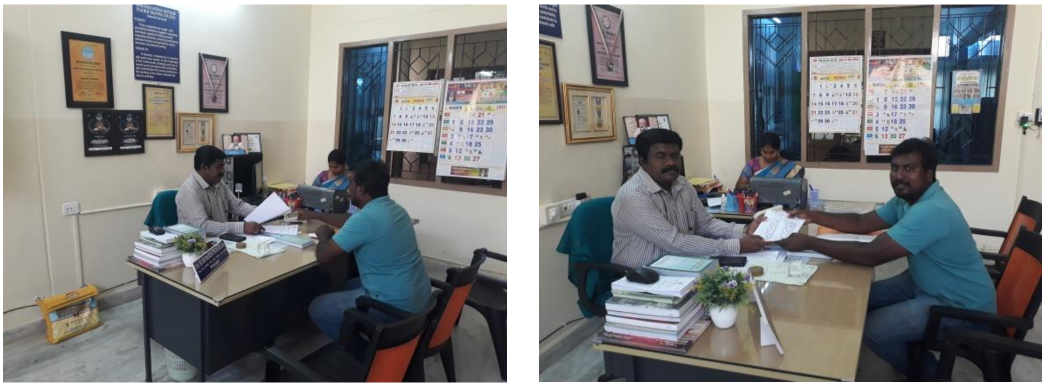


Figure 3.36: Receiving the final dugong ambassador's result

Date: 05th March 2021

Venue: Zoom Meeting with the DFO, Thanjavur

We discussed and finalized the subject expert list for conservation reserve at north Palk bay with Mr. Ilayaraja, DFO, Thanjavur via Zoom Meeting.

Date: 22th March 2021

Venue: Forest Day celebration at Ramanathapuram

We celebrated Forest day on 22nd march 2021, with Forest department and School students from Mohamed Sathak Kabeer School, Ramanathapuram

Figure 3.37: Awareness program and plantation on Forest day 2021

Date: 24th March 2021

Venue: Alagappa University at Thondi campus

Alagappa University invited CAMPA-Dugong Tamil Nadu team to take a training session on Dugong recovery programme presentation along with SCUBA diving and biodiversity & monitoring training for Marine biology and Oceanography students of Alagappa University at Thondi campus.

Figure 3.38: Awareness and Training program at Alagappa University, Thondi

ANDAMAN AND NICOBAR ISLANDS
January- March 2021

Team Members:

Swapnali Gole, Project Fellow, Sagar Rajpurkar, Project Fellow, Sohom Seal, UGC Research Fellow, Sumit Prajapati, Project Assistant, Esha Gokhale, Field Assistant, Aashish Gokhale, Field Assistant, Ajay Kumar (Local Volunteer), Saw Tapori (Local Volunteer)

Acknowledgment:

Department of Environment and Forest

Sh. Tarun Coomar (PCCF- ANI), Sh. D M Shukla (PCCF- Wildlife), Sh. Shaji Abrahim (DFO-Havelock Division), Smt. Nabanita Ganguly (DFO- DCF, Wildlife Division), Sh. K. G. Rassogi (DFO- Mayabunder Wildlife Division), Smt. Deep Shikha Sharma (DFO-Mayabunder Territorial Division), Sh. Kuldeep Sharma (DFO-Diglipur Territorial Division, North Andaman), Sh. A. K. Paul (ACF, Wildlife), Sh. Ajith John (ACF- Diglipur Territorial division, North Andaman), Sh. K. P. Abdul Rasheed (Range officer, Kalara Range-Mayabunder Wildlife Division), Sh. Bipul Chandra Roy (Range officer, Aerial Bay Range-Diglipur Territorial division), Sh, Pratap Singh (Range officer, Karmatang Range- Mayabunder Territorial Division), Sh. Alagar Gopi (Forest Guard, Mayabunder Wildlife Division), Sh. Raghu (Forest Guard, Mayabunder Territorial Division), Sh. Mohammad Hussain (Forester, Wildlife Division, Wandoor), Sh. C. Rammaya (Forest guard, Wildlife Division, Wandoor), Sh. Pradeep Karmakar (Camp Officer Havelock Division), Sh. M Syed Hussain (Forest guard, Havelock Division), Sh. K. Kumar Swami (Forest guard, Diglipur division)

DRM (Forest Department)

Sh. Justin (Boat Master, Mahatma Gandhi Marine National Park, Wandoor), Sh. Nikunju (DRM, South Andaman), Saw Emuyi (DRM, Mayabunder, N&M Andaman), Saw Darius (DRM-Boat Master, Mayabunder, N&M Andaman), Sh. Pratap (DRM- Boat Master, Mayabunder, N&M Andaman), Saw Keybow and Crew (Boat-Master, Karmatang range, N&M Andaman), Sh. Surojit Das and Crew (DRM- Boat Master, Aerial Bay, Diglipur, North Andaman), Sh. Parimal and Crew (DRM- Boat Master, Radhanagar, Diglipur, North Andaman)

Indian Navy

Captain Vishal Roy (Commanding Officer, INS Utkrosh), Lieutenant Commander. Vivek Tamilmani (INS Utkrosh, South Andaman), Lieutenant Commander. Prafful Itape (INS Utkrosh, South Andaman), Commander Manas R Moharana (Commanding Officer, INS Kohassa) Surg Lt. Cdr.Vinod Chavan (INS Kohassa, Shibpur)

Indian Coast Guard

DIG Ashish Sinha (Port Blair Headquarters), Comdt. Rishab Saxena (Port Blair Headquarters), Sh. S. M. Singh (DHQ-9, Aerial Bay), Comdt. P. R. Lochan (DHQ-9, Rampur), Deputy Commandant Manmohan Singh (DHQ-9, Rampur), Assistant Commandant Shubham Sharma (DHQ-9, Aerial Bay)

Police Marine Force

Sh. Amit Singh (PCR, Headquarters Port Blair), Sh. Arun Kumar Rai (North and Middle Andaman). Sh. Rajendran (North Andaman)

Directorate of Fisheries, Port Blair,

Fishers Community, Andaman,

SCUBA Divers Community, Andaman, Life guards, South and North Andaman

4.1. RESEARCH AND MONITORING

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

Understanding dugong distribution is primary in managing the extant population on the island, especially in the wake of growing anthropogenic pressures on dugong habitats.
Further, the inaccessibility of sites due to geographical vastness and limitations to conducting boat-based surveys collectively affects our understanding of dugong distribution in the islands. To fill this gap, a citizen science-based approach called the dugong monitoring program was initiated in 2017 and has been successfully expanded throughout the North Andaman this season.

For this field season (January to March 2021), the dugong monitoring network was expanded to South Andaman, Mayabunder, and Diglipur.

Methodology:

The program was expanded geographically to the previously identified stakeholders viz; fishers, tourism allied sectors, Forest department, Indian Navy, Indian Coast guards, and marine police, with the latter being a new stakeholder.

All the included stakeholders in the dugong monitoring network were followed up monthly via phone call to collect the data regarding dugong sightings. Inventory of number, age class, time, location, photographs, and video of sighted dugongs was recorded and maintained to understand the movement patterns and distribution of dugongs in the islands.

Results

A total of 32 sightings were recorded throughout the Andaman Islands from January- March 2021, out of which three were of mother and calf (Figure 4.1).

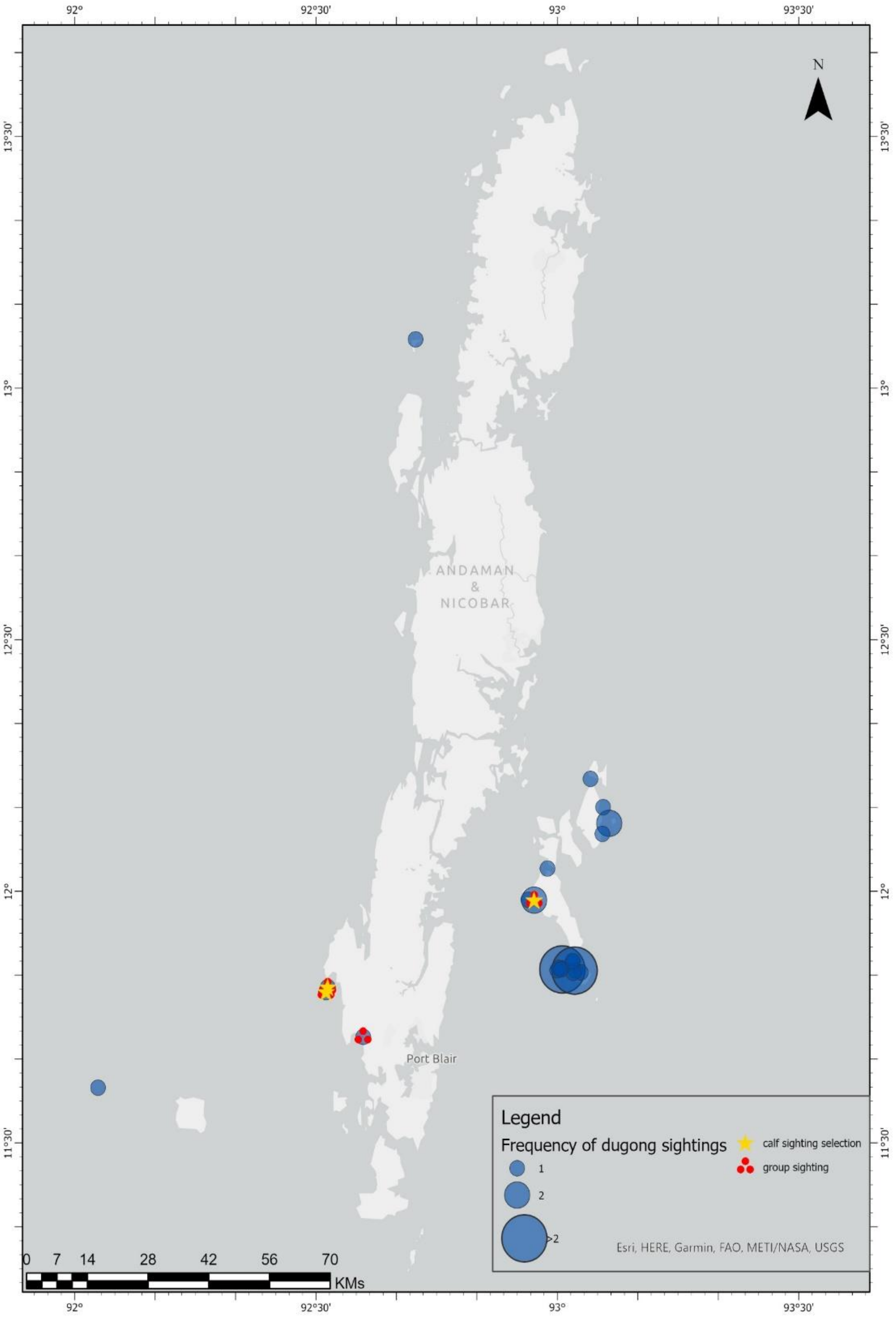


Figure 4.1. Distribution of dugongs across islands through citizen science initiative

4.1.2 Quantifying and mapping threats to 'Critical Dugong Habitatats in the Andaman Islands in terms of boat traffic and plastic litter

Background and Objective:

Dugongs are threatened majorly by net entanglement, habitat destruction, and fishing pressure in their habitats (Marsh et al., 2012). Despite knowing these threats, there is a lack of studies to quantify these threats for understanding the intensity of pressure. A threat Mapping survey was carried out in the North Andaman to quantify and characterize threats to dugongs and their habitats in terms of boat traffic and floating macro-litter

Study area:

The present surveys were carried out in the identified critical dugong habitats of North and Middle Andaman, namely Mayabunder and Diglipur.

Methodology:

A grid-based sampling method was used for the survey, where 2*2 km of grids were divided as near and offshore grids (approximately 20km offshore) from the island. The nearshore grids were selected based on the distribution of seagrass habitats, dugong sightings from literature, ground sampling, and interview surveys, whereas equal no. Offshore grids were randomly selected to represent the area spatially. At each point of the chosen grid, a 360-degree point count method was used by scanning the area upto1km for 15 minutes to document the floating macro-litter and boat traffic.

Data variables like; Litter-type, boat-type, angle of the sighting, the distance of object was recorded. Environmental parameters like sea state, cloud cover, pH, salinity, temperature, and GPS location of boat position were also taken down. For this study, we considered marine-litter only from anthropogenic sources, which we classified as "plastic bottles/caps", "plastics bags" (i.e., wrappers, sheets, films, packaging sheets), "Styrofoam" and "buoys" and nature of boats (fishing, cargo, defense, and inter-island ferries).

A total of 29 grids were sampled during the study period collectively from Mayabunder and Diglipur.

Results:

29 grids were sampled from Mayabunder (n=18) and Diglipur (n=11) during the study period. Boat traffic was majorly contributed by fishing boats (70.83%) which were either actively fishing or in transit, followed by passenger boats (20.83%) used for inter-island movement and lastly by cargo and defense ships (Figure 4.2)

Macro-litter observed it included plastic bottles, bags, thermocol, and buoys in which plastic bottles contributed to 4.44% followed by plastic bags (37%), thermocol (15%), and buoys (3.7%) (Figure 4.3)

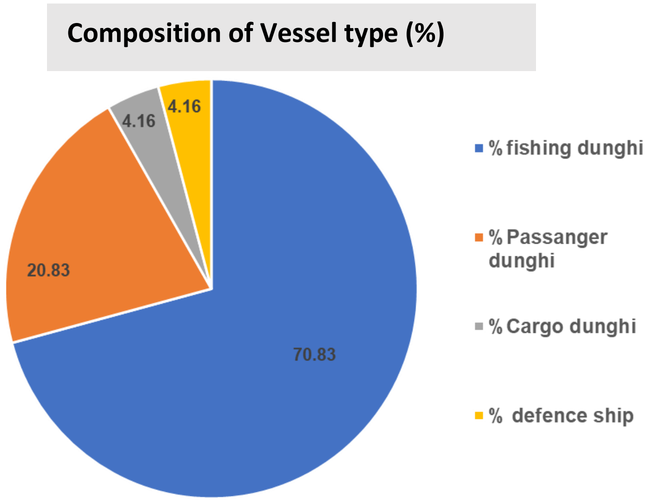


Figure 4.2: Composition of boat-traffic found during threat-mapping survey in north and middle Andaman

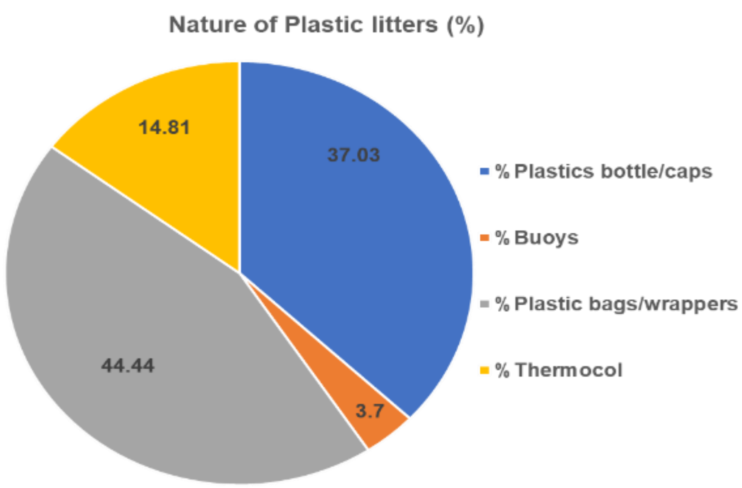
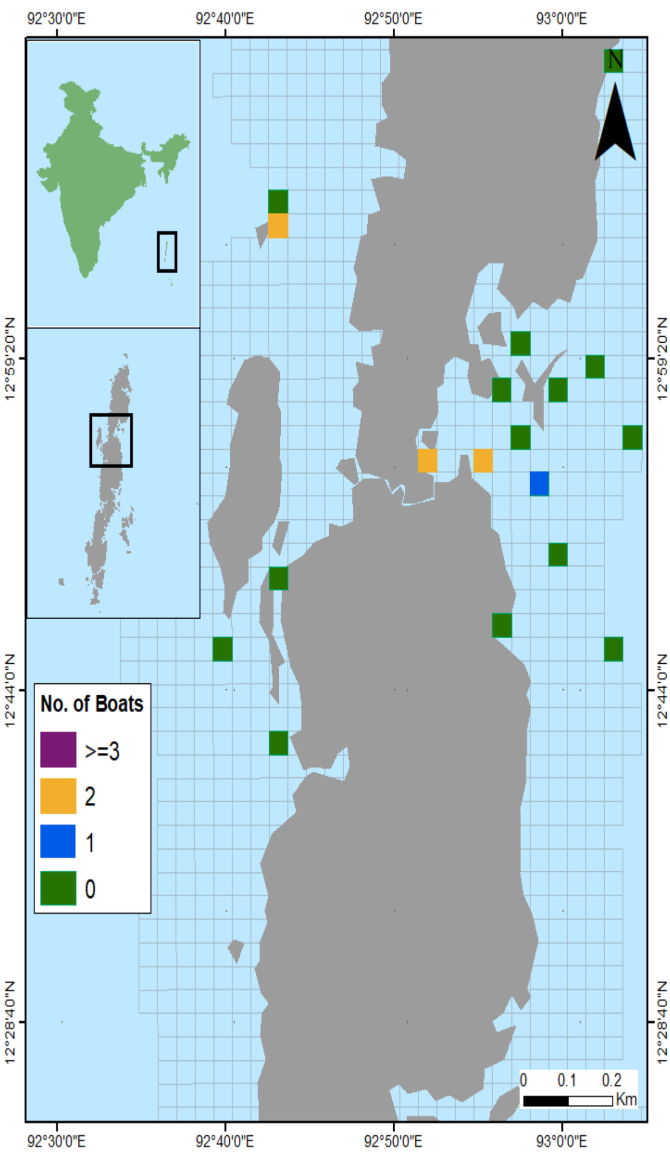


Figure 4.3: Composition of floating macro-litter found in north and middle Andaman

Mayabunder

Total 18 grids were sampled during the survey on the East and West coast of the Mayabunder. Low to moderate level of boat traffic observed. Only two grids showed an average level of boat traffic nearshore, whereas the rest of the grids showed zero boat traffic level. Illegal fishing was observed during the survey. Very low to moderate levels of floating macro-litter were observed during the survey. Only two grids showed a slightly high level of floating macro-litter in the map. Some of the offshore grids could not be covered due to unfavorable weather conditions (Figure 4.4)



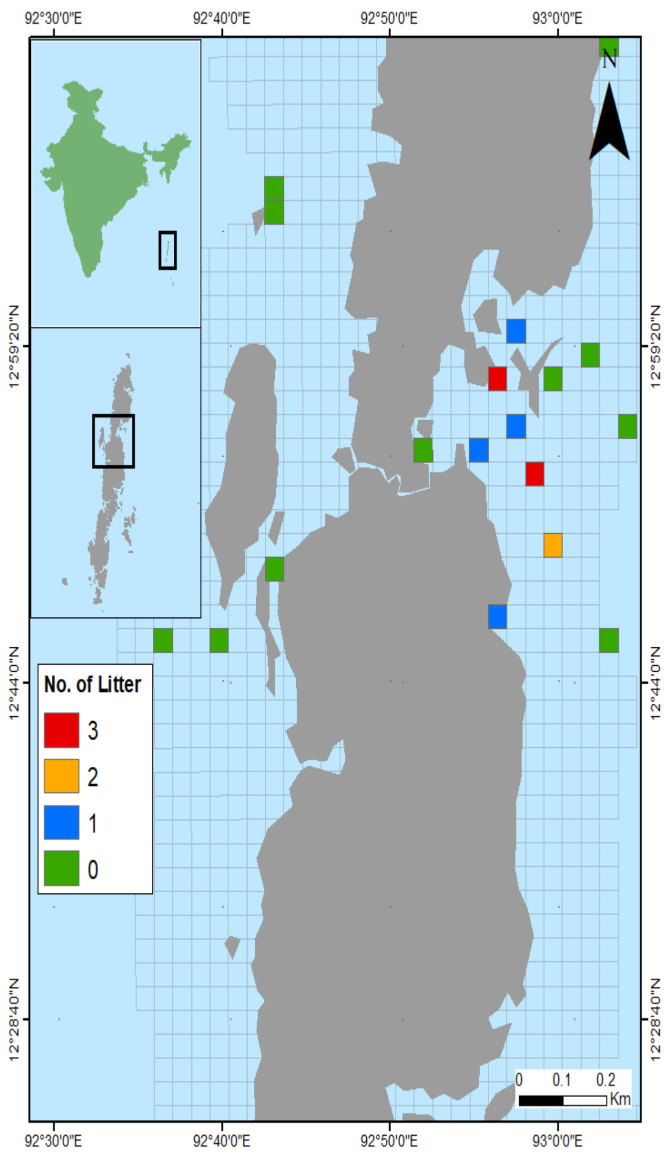


Figure 4.4: Boat-traffic (left) and floating macro-litter (right) in Mayabunder from January to march 2021

Diglipur

Total 11 grids were sampled during the survey on the East and West coast of Diglipur. Low to nil levels of boat traffic and floating macro-litter were observed during the survey. Only two grids showed a high level of boat traffic near the shore because boats were either anchored in the jetty or moving. One grid showed a slightly high level of floating macro-litter. (Figure 4.5)

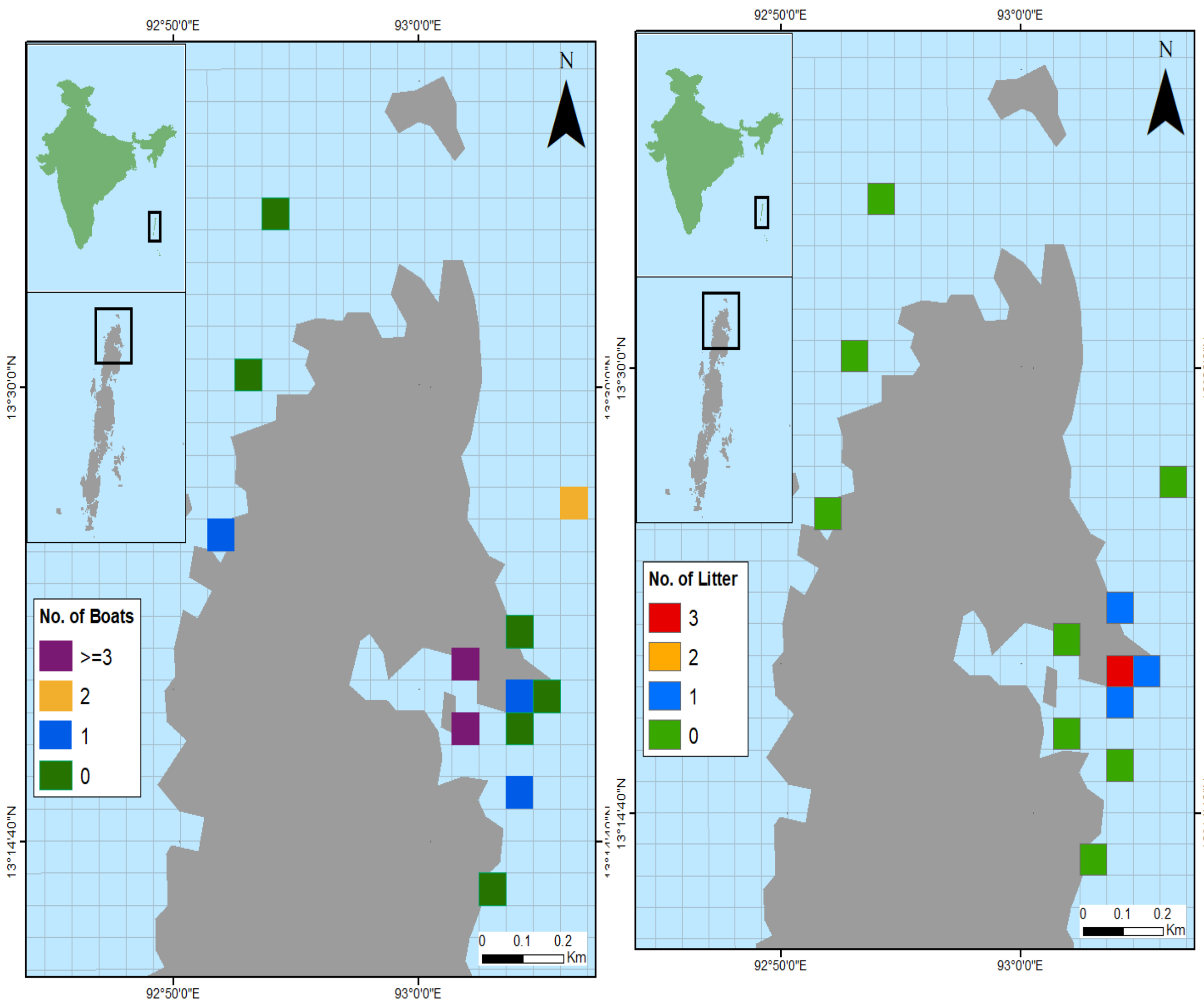


Figure 4.5: Map showing boat-traffic (left) and floating macro-litter (right) in diglipur from January to march 2021

Figure 4.6: Fishing boats were observed during threat-mapping survey

Figure 4.7: Threat-mapping survey in North and Middle Andaman from January to March 2021

4.1.3 Habitat characterization of seagrass habitats in 'Critical Dugong Habitats'

Intensive Seagrass exploratory surveys: Intertidal (on foot) and subtidal (using SCUBA)

Seagrass meadows provide critical habitats for various faunal groups (Jones et al. 2020) and serve as the only feeding ground for threatened species like dugong, distributed in pockets throughout Andaman and Nicobar Islands. Several studies have been carried out on seagrasses that suggest these habitats are threatened by anthropogenic activities such as coastal development, boat anchorage, increasing tourism activity, and natural calamities (tsunami, cyclones), which directly hampers the associated fauna, including dugongs. Thus, it is crucial to understand these seagrass habitats, which will aid in the management and conservation of dugongs.

In the present study, we aimed to understand the distribution of seagrasses in critical dugong habitats.

Study area:

The present study was carried out in 14 sites from South, North, and Middle Andaman: Craggy, Shibpur, Smith Island, Temple, Excelsior, Delgarno, Radhanagar channel, Paget, Reef, North Reef, Pokkadera, Shaheed Dweep, Swaraj Dweep, and Burmanallah.

Methodology:

After exploration and locating the seagrass meadow, a Line Intercept Transect (LIT) methodology was used to understand the depth-wise seagrass distribution, species composition, and seagrass cover.

A 50m long LIT'S were laid perpendicular to shore, and at each site, three replicates were taken spaced apart 150-200m. On this line, at every 5m, a 50X50 cm quadrat was used to record the 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 6 species belonging to 4 genera were recorded from the present study viz; *Halophila ovalis, Halophila decipiens, Halodule uninervis, Halodule pinifolia, Thalassia hemprichii, Enhalus acoroides.*

The highest number of species (n=4) were recorded from 2 islands of the northern most part, namely; Radhanagar channel and Smith Island (see figure 9), whereas a single monospecific seagrass meadow was found in 5 islands, namely Burmunallah, Shaheed Dweep, Delgarno island, Paget Island and North Reef Island (Table 4.1).

Depth

Thalassia hemprichii and *Enhalus acoroides* were distributed in intertidal regions, while four species belonging to 2 genera, *Halodule spp.* and *Halophila spp.,* were distributed in the sub-tidal area (up to 5.5 m) (Figure 4.8).

Substratum

Seagrass meadow substratum compositions were mainly characterised by Sand (sn), Sand and Rubble (sn & ru), deal coral (dc), live coral(lc), and rock(rc) and rubble (ru) substratum. All the seagrass preferred either a sand with rubbles and rock or complete fine sediment substratum. All the intertidal habitats were found in either coarse or fine sediment mixed with rocks and rubbles. Substratum composition was also changed with respect to depth observed during the study period.

In Intertidal habitats, two species of seagrass, namely *Thalassia hemprichii* and *Enhalus acoroides,* were recorded in these regions of 4 sampled islands of Andaman. Both the species were found in mixed substratum in coarse substratum along with rocks and rubbles.

Sub-tidal regions were mainly characterised by fine sand sediment to live coral substratum. These regions were mainly composed of delicate and less fibroid species which can be easily uprooted, like *Halophila ovalis, Halophila decipiens, Halodule pinifolia, Halodule uninervis* which are mainly observed in these habitats. Both genera of seagrasses were also recorded in muddy substratum near mangroves habitats.

During the study period dugong feeding trails were also found in two islands of northernmost islands of Andaman part namely smith island and Excelsior Island. Delicate species like Halophila spp. and Halodule species were mostly abundant and dominated in these islands in fine sediment to muddy texture substratum.

In addition to that, fruiting and flowering seasons of *Thalassia hemprichii*, *Enhalus acoroides* , and *Halophila decipiens* were also observed during the study period.

Table 4.1: Distribution of seagrass species from each sampled islands of Andaman

SN.	District	Site Name	Species composition
1	South Andaman	Burmunallah	*Thalassia hemprichii*
2	South Andaman	Shaheed Dweep	*Thalassia hemprichii*
3	South Andaman	Swaraj Dweep	*Enhalus acoroides, Thalassia hemprichii*
4	North and Middle Andaman	Pokkadera	*Thalassia hemprichii, Enhalus acoroides*
5	North and Middle Andaman	North Reef Island	*Halodule uninervis*
6	North Andaman	Craggy Island	*Halophila ovalis, Halodule pinifolia*
7	North Andaman	Shibpur	*Halophila ovalis, Halodule pinifolia*
8	North Andaman	Smith Island	*Halophila decipiens, Halophila ovalis, Halodule uninervis, Halodule pinifolia*
9	North Andaman	Excelsior Island	*Halophila ovalis, Halodule pinifolia*
10	North Andaman	Delgarno Island	*Halophila ovalis*
11	North Andaman	Temple Island	*Halophila ovalis, Halodule pinifolia*
12	North Andaman	Radhanagar channel	*Halophila ovalis, Halophila decipiens, Halodule pinifolia, Halodule uninervis*
13	North Andaman	Paget island	*Halophila decipiens*
14	North Andaman	Reef Island	*Halophila decipiens, Halophila ovalis, Halodule uninervis*

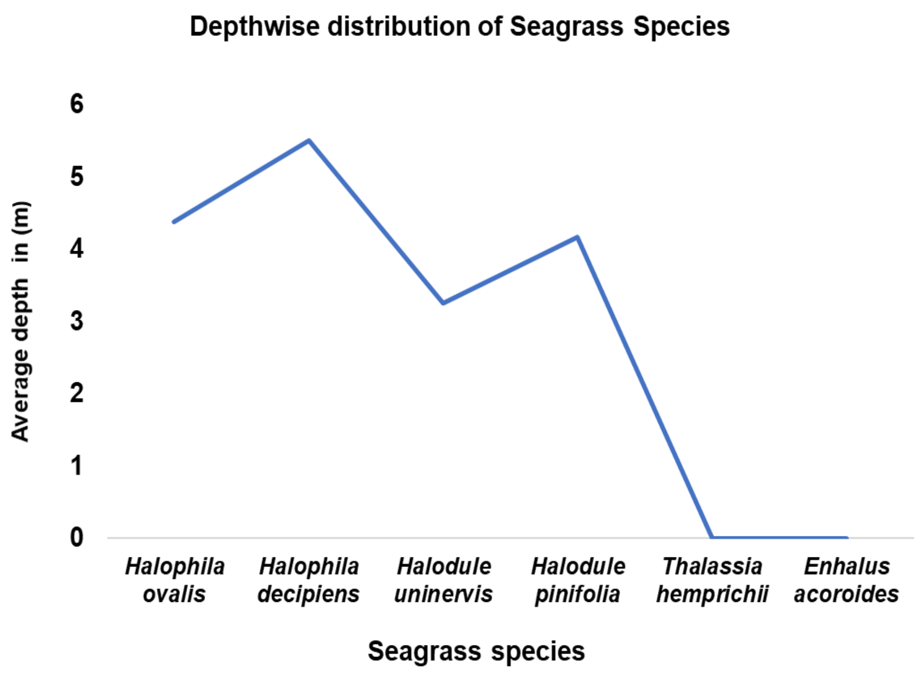


Figure 4.8: Depthwise distribution of seagrass species from each sampled islands of Andaman

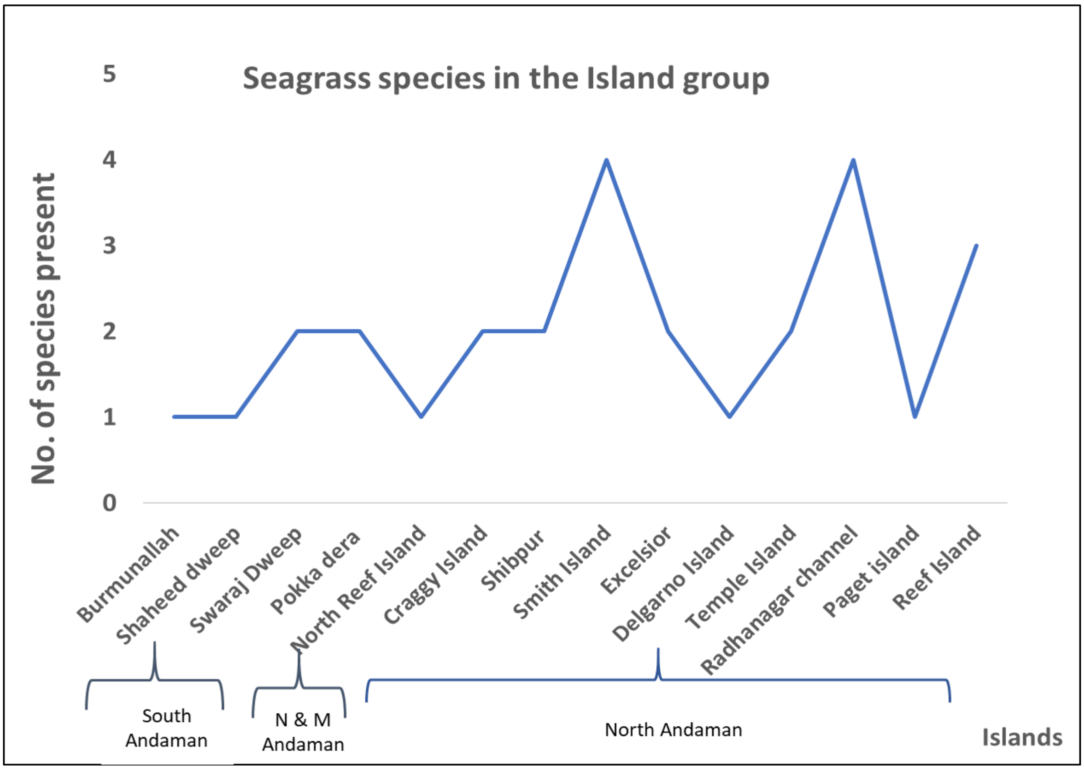


Figure 4.9: Seagrass species richness from each sampled islands of Andaman

Discussion

In this present study, we recorded only two seagrass species; Thalassia hemprichii and *Enhalus acoroides,* from the intertidal region. Both the species are more fibroid in structure and have a strong-rooted system and difficult to uproot, which can stand in heavy wave action and tidal fluctuations in coarse sediment. Only species which are delicate in structure and have less fibroid genera, and have a weaker rooted system that can be easily uprooted, such as Halodule spp. and Halophila spp., were found in sub-tidal regions in fine sediments and muddy substratum.

Observation of dugong feeding trails in two sampled islands of North Andaman; Smith island and Excelsior island, which are identified as critical dugong habitats (Sivakumar et al. 2020). These islands are mainly dominated by two genera of seagrasses, such as *Halophila* spp. and *Halodule* spp., which are primarily preferred species by dugongs (Preen 1995; Marsh et al. 2018). Grazing on seagrass meadows by dugong is beneficial in the biotic dispersal of seagrass propagules and seeds in the islands, which will aid in enhancing the connectivity and resilience among seagrass meadows and helps in seagrass to grow after loss (Tol et al., 2020). More observations and frequent monitoring of these meadows will also aid in understanding the movement and feeding patterns of dugong which will be helpful in the management and conservation of dugong and seagrass habitats.

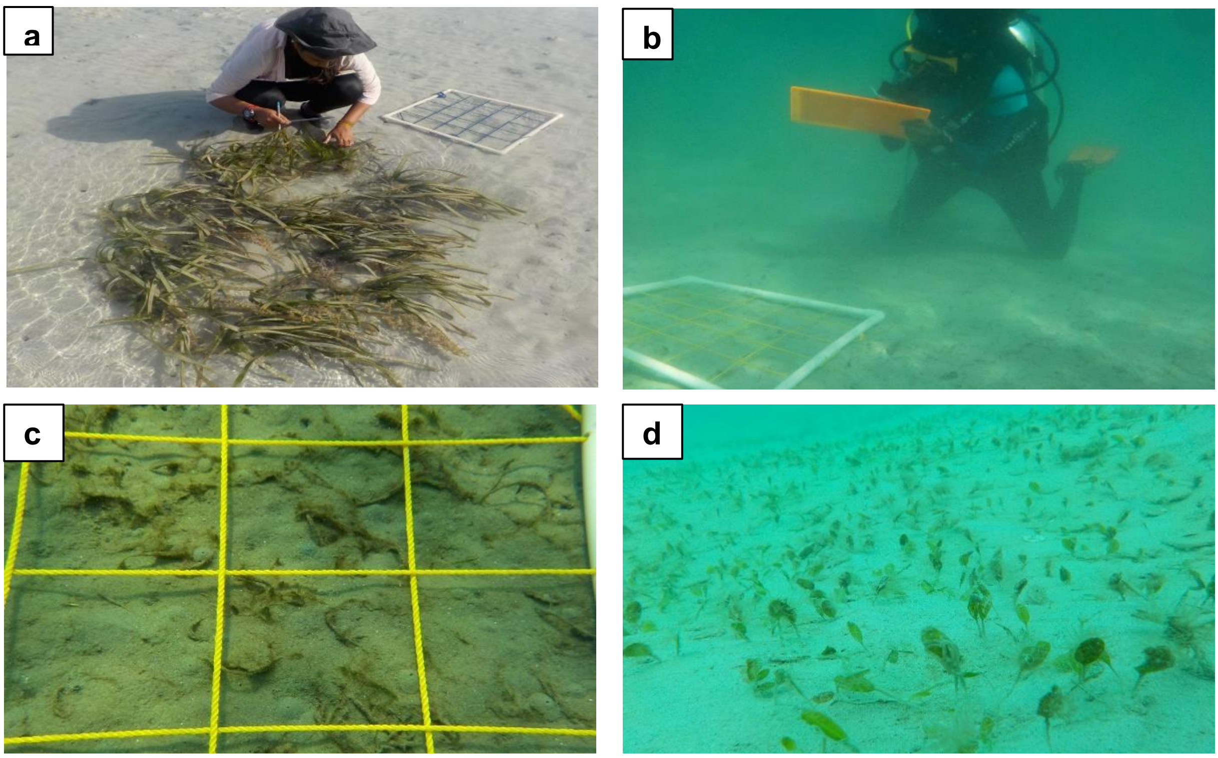


Figure 4.10: Seagrass habitat assessment survey from January to Mach 2021 across Andaman Islands: a) Intertidal seagrass survey in Swaraj dweep island b) Sub-tidal seagrass survey in Smith Island, North Andaman c) Habitat characterization of sub-tidal seagrass meadow in Paget Island, North Andaman d) *Halophila ovalis* Meadow at sub-tidal region of Reef Island, North Andaman

4.1.4 Extensive surveys using remote sensing and GIS technology

Background and objective:

Understanding the dynamics of change in seagrass ecosystems over time and space provides the basis for developing and assessing seagrass management strategies. Any such study of ecology and environmental management requires extensive data for various seagrass properties over suitable extant and temporal scales. Conventional survey methods are labor-intensive and time-consuming due to the constraints in working in the marine environment (Nobi and Thangaradjou, 2012). Hence, remote sensing provides a handy tool for seagrass distribution and change detection studies with Geographic Information System (GIS) techniques (Kendrick *et al.,* 2002; Dekker *et al*., 2005; Gullstrom et al., 2006; Wabnitz *et al.,* 2008).

Mapping of seagrasses distribution started long back in 1871, where Ascherson and Beccari (1871) made the first attempt to map the geographical distribution of seagrasses. Since then, various attempts have been made to map seagrass meadows at national and global levels. In India, satellite imaging for seagrass detection and mapping studies has been very few (Table 4.2).

Table 4. 2: Studies related to the mapping of seagrasses from India

SN	Imageries Used	Spatial Resolution	Study area	Accuracy (%)	Citation
1	IRS LISS III	23.5 m	Lakshadweep	67.5	Nobi E. P. & Thangaradjou T. (2012)
2	Landsat 8 OLI	30 m	(i) Palk Bay (ii) Gulf of Mannar (Tamil Nadu) (iii) Gulf of Kachchh (Gujarat) (iv) Chilika Lake (Odisha) (v) Islands of Andaman & Nicobar and (vi) lagoons of Lakshadweep Islands	64 to 83.5	Geevarghese G.A. *et al*., 2017)

SN	Imageries Used	Spatial Resolution	Study area	Accuracy (%)	Citation
3	IRS-1D, LISS III	23.5 m	Gulf of Mannar		Umamaheswari *et al*., 2009)
4	IRS P6 LISS IV	5.8 m	Lakshadweep Islands	73.16	Nobi *et al*.,2012)
5	LANDSAT ETM+	30 m	i. Gulf of Mannar	85.19	Gunasekara and Mishra (2014)
			ii. Palk Bay	92.59	
6	IRS P6 LISS III	23.5 m	Andaman and Nicobar Islands	40	Paulose *et al.,* 2013)

Though seagrasses are reported to provide 28 ecosystem services, and several of these services vary across genera and bioregions, there is no report on seagrass ecosystem service values (Nordlund *et al.,* 2016). India stands 16th regarding the number of publications on seagrasses (York *et al*., 2017), whereas countries with a much lesser coastal extent and EEZ are in the lead. Therefore, in India, seagrass ecosystems have hardly gained attention from the scientific fraternity in terms of management and conservation (Thangaradjou & Bhatt, 2018) despite their sharp decline worldwide at a rate of ~7% annually since 1980 (Waycott *et al*., 2009, Fourqurean *et al.,* 2012; Duarte *et al.,* 2013), hence, globally, 24% of seagrass species are now classified as either threatened or near-threatened on the IUCN's Red List (Short *et al.,* 2011). Moreover, regular mapping of seagrasses is also neglected. In India, unlike mangroves (mapped at every two years' interval) and corals (mapped at decadal interval), there is no such regular mapping scheme available for seagrasses (Thangaradjou and Bhatt, 2018). In connection to bridge this gap and to provide a regular mapping schema for seagrass monitoring, we try to map seagrass habitats using satellite imageries (Sentinel-2).

Study area:

South Andaman: Mahatma Gandhi Marine National Park (MGMNP)- Tarmugli (east coast), Boat, Belle, Snob, Chester, Grub, Alexandra, Red Skin, Malay, Hobday, Pluto, Jolly Buoy Islands.

North Andaman: Mayabunder, Karmatang

Duration: December 06, 2020 – till date.

Methodology:

Field surveys were carried out at the Andaman Islands from December 06, 2020, to date and collecting ground truth data on the presence and absence of seagrasses and their coverage. Surveys were conducted in intertidal and subtidal areas:

1. **Intertidal survey:**
    1. Line intercept transects (LITs) were used in intertidal areas of seagrass surveys.
    2. For intertidal surveys, straight transects were walked from high tide line (HTL) to low tide line (LTL) during low tide, and point locations were recorded at an interval of 50m. Distance between the two transects was kept as 100m.
    3. Intertidal surveys were conducted in the Burmunallah region. The number of points locations collected: 35 (thirty-five). Species recorded: Dense patch of *Cymodocea spp.* is recorded.
2. **Subtidal survey:**
    1. Boat-based surveys were also conducted in sub-tidal areas.
    2. Quadrats were laid with a drop-down camera to estimate the percentage of seagrass cover. For boat-based surveys, point locations were noted at a minimum distance of 50meters from each other at different depths.
        1. South Andaman
            1. A reconnaissance survey was conducted at Mahatma Gandhi Marine National Park (MGMNP), Wandoor, to run the quadrat's drop-down camera and proper functioning.
            2. On finalizing the methodology, boat-based surveys were conducted from January 28, 2021, to February 02, 2021, in the Wandoor region. The number of point locations collected: 38 (thirty-eight). Species recorded: Halophila sp. was recorded from 01 (one) point.
        2. North Andaman
            1. Visited Mayabunder, North Andaman, from February 23 till date. Areas covered so far: Sound, Steward, Avis Islands. The number of point locations collected so far: 07 (seven). Species recorded: Halophila sp. is recorded from 01 (one) location, on the east coast of Sound Island.

Results:

During boat surveys in the subtidal region, 97-point locations were surveyed, of which 10 locations were recorded with seagrass presence. The depth of all ten present locations has a shallow depth, ranging from 1.0 - 2.5 m; two locations were recorded with moderate to high depth, one with 9.7m and another with 16.1m. Therefore, it proves the fact that seagrasses as photosynthetic plants majorly grow in the photic zone. The transparency of all 10 points ranges from 1.0 - 14m.

Intertidal areas were explored by walking as a line intercept transect method. Of 53-point locations, 37 points had seagrasses of varied density. Photographs were analyzed for seagrass percentage cover in the sampled point locations.

Figure 4.11: Survey locations of South Andaman with their respective seagrass percentage cover

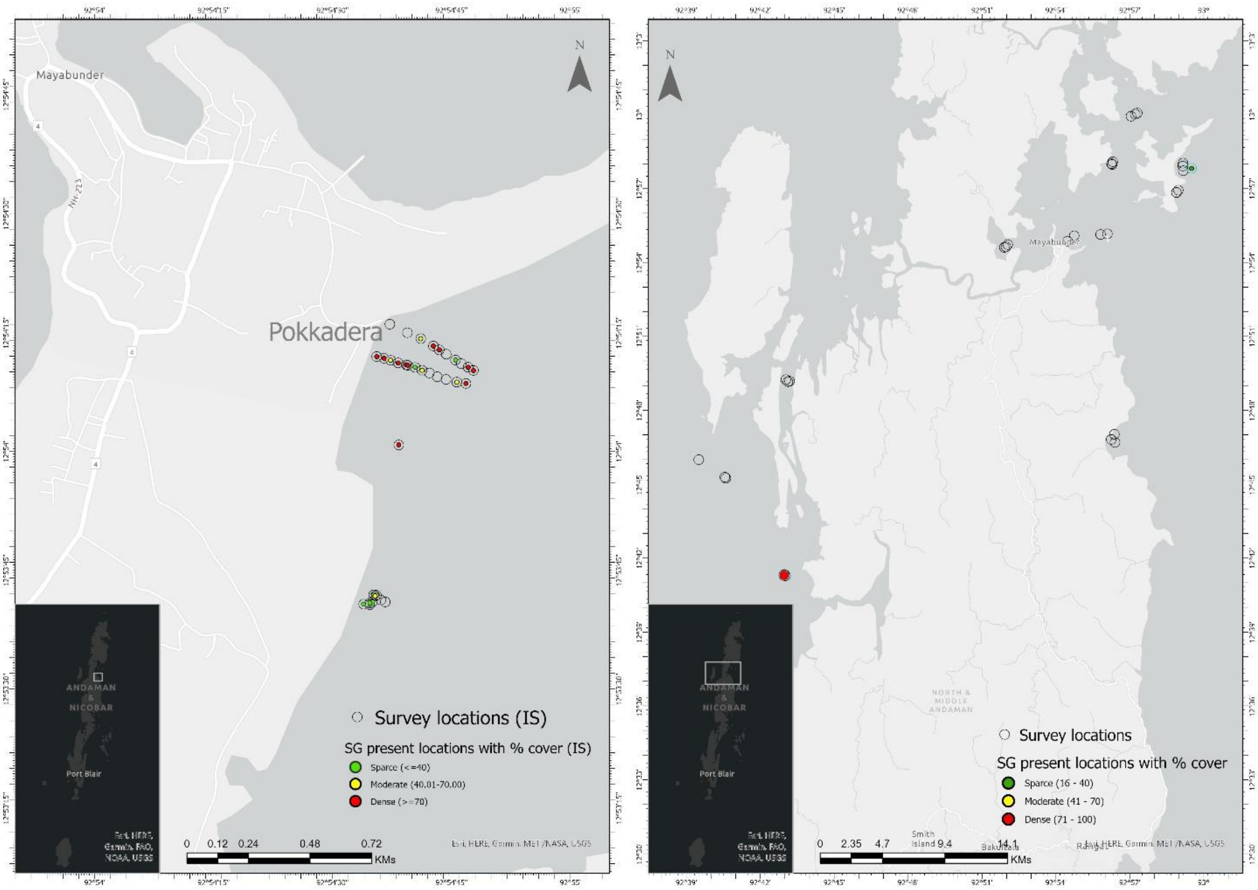


Figure 4.12: Survey locations of North Andaman with their respective seagrass percentage cover

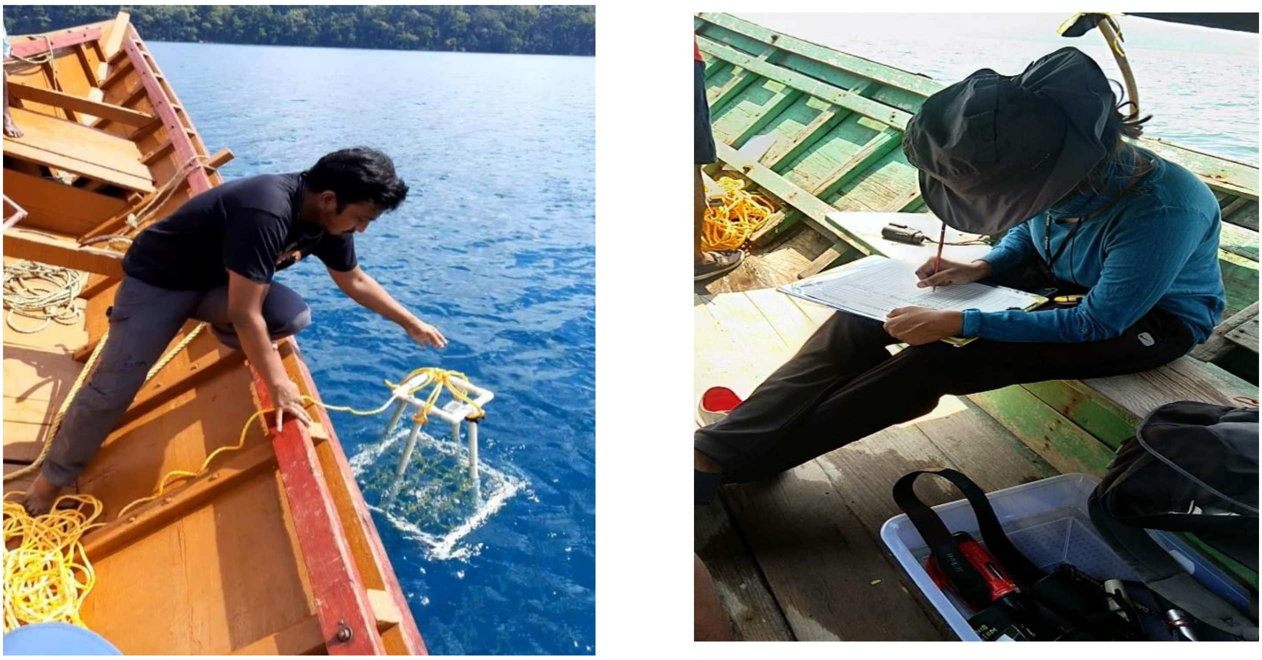


Figure 4.13: Quadrate with attached camera used for survey to check presence-absence of seagrass (in left), environmental parameters recording dugong seagrass survey (in right)

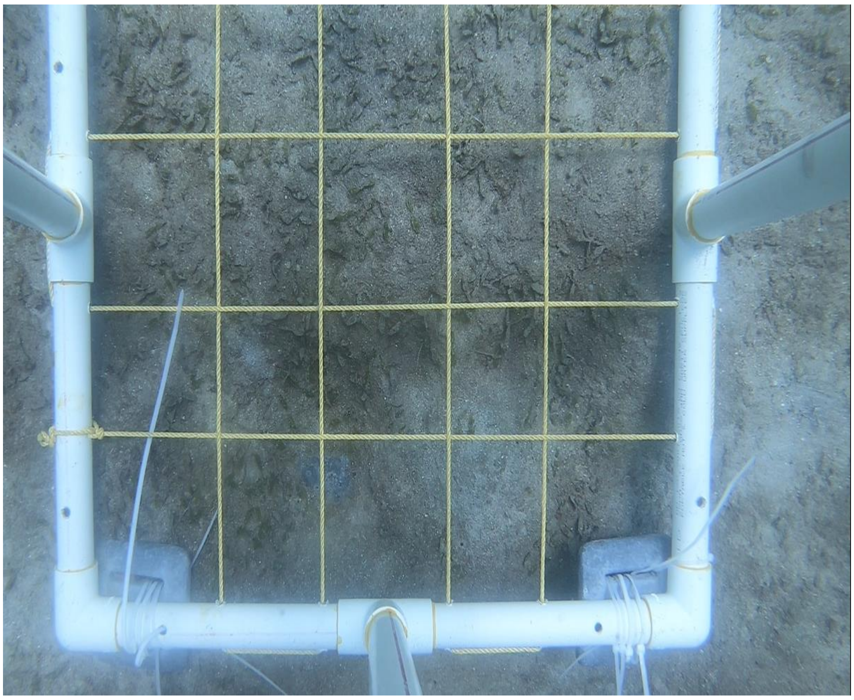


Figure 4.14: ***Halophila spp.*** **meadow covered in sediments from North and Middle Andaman during seagrass survey**

4.2 Outreach, Awareness, and Capacity Building Programme

Involving different types of stakeholders in the monitoring program will aid in understanding distribution patterns of dugongs in the islands and help strengthen species monitoring and rescue and release operation in case of strandings by training through workshops and training programs.

In this field season of the project, from January to March, we conducted 14 outreach, awareness, and capacity-building programs across the Andaman Islands to raise awareness about the importance of dugongs and their habitats and need for conservation (Table 3). Out of 14 events, 3 were awareness programs with fishing communities identified as 'Important Dugong Areas' through interview surveys and citizen science approach. One Programme with School Children and the general public to raise awareness about their state animal of the islands. Three were Capacity Building Programme with frontline forest staff. They were trained on the rapid emergency response of dugongs and other marine mammal handlings. New Patrolling agencies, i.e., "Marine Police," were involved in the 'Dugong Monitoring Network' to obtain the dugong's sightings. The rest of the events were followup programs and expansion of the 'Dugong Monitoring Network' in the other areas of the islands with other patrolling agencies.

Table 4.3: Details of Outreach Awareness and Capacity Building Programme Conducted from January to March 2021 across Andaman Islands

SN	District	Location	Name of the event	Type of stakeholders	The total no, of people who attended	Type of event
1	South Andaman	Manjery	Awareness program with the fishing community of Manjery village	Fisherman	15	Outreach and awareness
2	South Andaman	Mini Bay, Port Blair	Dugong Awareness program with school children of navy children school, 11th grade	School children	60	Outreach and Awareness

SN	District	Location	Name of the event	Type of stakeholders	The total no, of people who attended	Type of event
3	South Andaman	Flag Point, Marina Park	Mass sensitization dugong awareness for the general public of islands	General Public	300-400	Outreach and Awareness
4	South Andaman	Port Blair	Dugong Monitoring follow-up programme with INS Utkrosh, Indian Navy	Indian Navy	50	Capacity Building Programme
5	South Andaman	Wimberlygunj	Dugong Monitoring Programme conducted with frontline forest staff of south Andaman territorial division, Wimberlygunj	Forest Department	40	Capacity Building Programme
6	South Andaman	Port Blair	Follow-up dugong monitoring program conducted with Indian Coast Guard	Indian Coast Guard	10	Capacity Building Programme
7	South Andaman	Port Blair	Dugong Monitoring Programme conducted with Marine Police of Port Blair	Marine Police	35	Capacity Building Programme
8	North and	Karmatang, Mayabunder	Dugong Awareness Programme	Fishing Community	200	Outreach and Awareness

SN	District	Location	Name of the event	Type of stakeholders	The total no, of people who attended	Type of event
	Middle Andaman		conducted with the fishing community of Karmatang village			
9	North and Middle Andaman	Interview island, Mayabunder	Dugong Monitoring Programme conducted with frontline forest staff and Police staff posted at interview island	Forest department and Police department	30	Capacity Building Programme
10	North and Middle Andaman	Mayabunder	Dugong Monitoring Programme conducted with Marine Police	Marine Police	06	Capacity Building Programme
11	North and Middle Andaman	Rampur, Mayabunder	Dugong Monitoring Programme conducted with Indian Coast Guard, Mayabunder	Indian Coast Guard	20	Capacity Building Programme
12	North and Middle Andaman	Mayabunder	Dugong Monitoring Programme conducted with Forest Department of Mayabunder	Forest Department	25	Capacity Building Programme

SN	District	Location	Name of the event	Type of stakeholders	The total no, of people who attended	Type of event
13	North and Middle Andaman	Mayabunder Fishing Colony	Dugong Awareness Programme conducted with the fishing community of Mayabunder fishing colony	Fishing Community	10	Outreach and Awareness

Figure 4.15: Pictures showing Outreach and Capacity Building Programmes held from January- March 2021 in Andaman Islands:
A) Awareness Programme conducted for fishing community of Manjery Village, South Andaman B) Capacity Building Programme Conducted in Wimberlygunj Forest Division for Frontline Forest Staff, South Andaman C) Dugong Monitoring Programme conducted for Marine Police of Port Blair, South Andaman D) Awareness Programme conducted for Fishing Communities of Karmatang Village, Mayabunder E) Capacity Building Programme Conducted for Frontline Forest and Police Staff Posted in Interview island, Mayabunder F) Dugong Monitoring Programme Conducted for Marine Police in Mayabunder

5.1 EX-SITU ANALYSIS FOR DUGONG CONSERVATION

5.1.1 Aerial Surveys using UAVs in Gulf of Kutch Marine National Park, Gujarat

Situated in Devbhoomi Dwarka district of Gujarat, Gulf of Kutch Marine National Park has been assessed as a critical habitat for dugongs and seagrasses. The waters in the region are highly turbid and boat surveys to detect and study dugongs in the region have not been successful, thus Unmanned Aerial Vehicles (UAVs) were used to detect dugongs in the region. Small unmanned aerial drones have been proven effective to study marine mega-fauna like dugongs, thus in this premise, UAVs were used to detect study dugongs in the region. The main objective of the study was to survey seagrass habitats aerially using drones for detecting dugongs and other marine megafauna.

Study Area-

The Gulf of Kutch Marine National Park and Marine Sanctuary was selected as a study area. The present study was carried out across critical dugong habitats of marine national parks and marine sanctuary areas situated in the southwestern. Aerial surveys were undertaken from Bet Dwarka, Ajad Island, Paga Reef, Bhaidar Island and Chusna Peer.

Methodology-

Aerial surveys were undertaken using the DJI Mavic 2 Pro UAV manufactured by SZ DJI Technology Co, China. It is a micro quadcopter with 4 rotors weighing 907 g. The flight paths were designed in order to cover maximum areas over known seagrass meadow locations. The flights were planned using the DJI Go 4 and Litchi Hub applications. Random scan sampling and Transect sampling was undertaken according to the standard methodology suggested by Raoult et al. 2020 for studying sirenians. The altitude of the flight was kept constant at 100 meters with a speed of 35 km/hr. The width of the survey strip was 75 meters. Continuous video was recorded during each flight and was stored and saved in hard drive for analysis.

Results-

A total of 22 flights were undertaken during these surveys during the pre-monsoon period from Jan 01 to Jan 15, 2021. During the surveys, seagrass meadows were detected, aerially confirming presence of seagrasses. No dugongs were observed during the surveys. Sea turtles were observed during the survey in high numbers. Other fauna detected during the surveys were Indian Ocean Humpback Dolphins, birds etc. Fishing boats, mainly trawlers were also observed during the survey effort. Fishing nets, ghost nets etc. were the threats that were observed to dugongs during the study. A total of 24 sea turtles were observed during a single 17 min flight from Chusna Peer. Turtles were seen congregating over the seagrass meadows there probably for grazing.

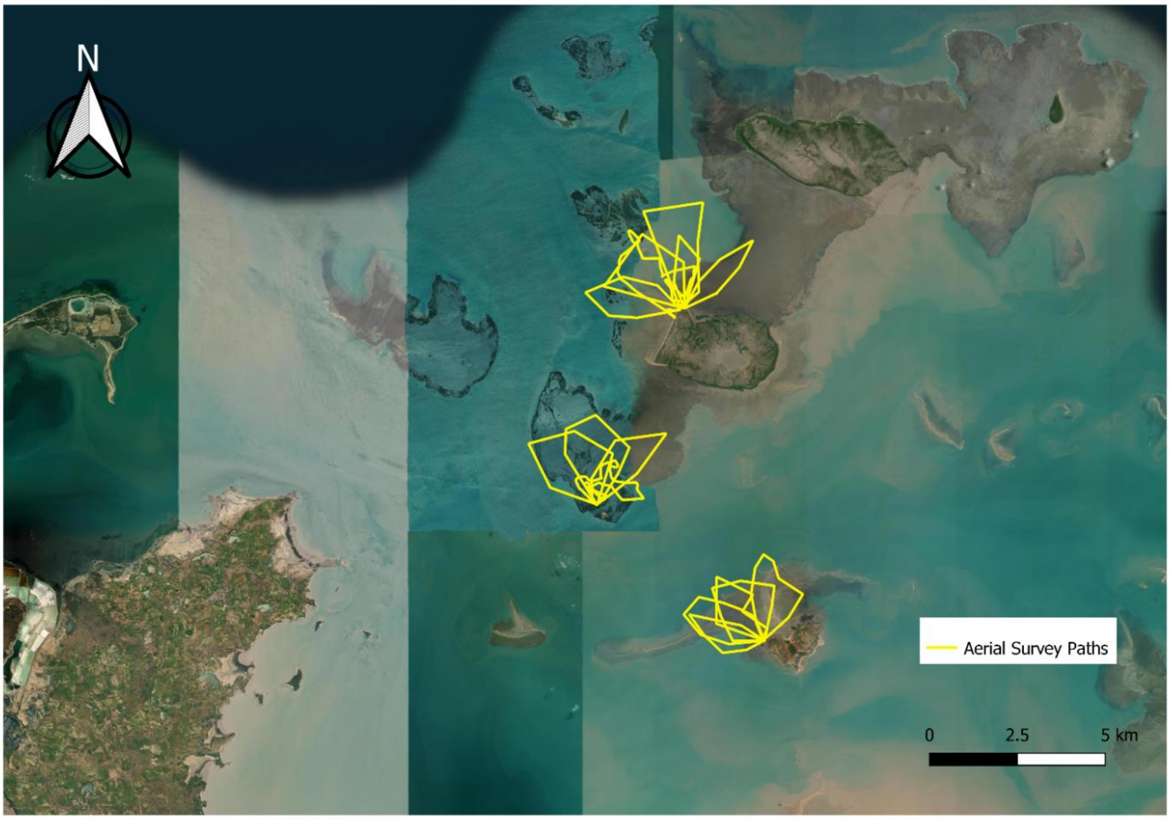


Figure 5.1: Gulf of Kutch Aerial Survey Map

5.1.2 Aerial Surveys using UAVs in Mahatma Gandhi Marine National Park, South Andaman Islands

Background and Objective-

Situated in South Andaman Islands near Port Blair, Mahatma Gandhi Marine National Park has been assessed as a critical habitat for dugongs. Aerial surveys were conducted here in 2019, and we were successful in detecting dugongs within the boundaries of the Marine National Park. Small unmanned aerial drones have been proven effective to study marine mega-fauna like dugongs, thus in this premise, UAVs were used to detect study dugongs and other megafauna in the region.

The main objective of the study was to systematically survey the Marine Protected Area, aerially using drones for detecting dugongs and other marine megafauna.

Study Area-

Mahatma Gandhi Marine National Park was selected as the study area. The area of the Marine National Park is about 281sq km. The study areas surveyed included Wandoor, North Wandoor, Grub Island, Red Skin Island, Alexandria Island, Tarmugli Island, Boat Island, Jolly Buoy Island, Chester Island, Snob Island, Rutland, Twins and Cinque Islands.

Methodology-

Aerial surveys were undertaken using the DJI Mavic 2 Pro UAV manufactured by SZ DJI Technology Co, China. It is a micro quadcopter with 4 rotors weighing 907 g. The area was divided using grids. The grid size was fixed at 2x2km. The flights were planned using the DJI Go 4 and Litchi Hub applications. Random scan sampling and Fixed width transect sampling was undertaken according to the standard methodology suggested by Raoult et al. 2020 for studying sirenians. The altitude of the flight was kept constant at 100 meters with a speed of 35 km/hr. The width of the survey strip was 75 meters. The surveys were conducted along with the patrolling staff of Forest Department, covering maximum possible grids using fixed width aerial transects. The maximum length of the transect was 1.5 km. Continuous video was recorded during each flight during grid based transect sampling as well as random scan sampling. The videos were then saved in external hard drives for further analysis.

Results-

A total of 112 transects covering 25 grids, were undertaken during the study. The list of transects undertaken and grids covered is given below. (Table 2.2.1) The study spanned from February to March 2021. Random scan sampling was also undertaken from each survey site.

The list of areas surveyed is given below. The video analysis is ongoing for the same.

Table 5.1: Areas surveyed using Fixed Width Aerial Transects.

SN	Survey Area	No of Transects	No of Grids
1	Boat Island	16	4
2	Jolly Buoy	8	2
3	Cinque	8	2
4	Red Skin	18	3
5	Tarmugli	16	4
6	Twins	10	2
7	Wandoor	12	2
8	Chester	6	1
9	Rutland	4	1
10	Snob	4	1
11	North Wandoor	4	1
12	Pungi Balu	6	2

During the surveys, marine megafauna like Bottlenose Dolphins (Tursiops sps), Manta Rays (Mobula sps), Spotted eagle rays (Aetobatus sps), unidentified shark species, marine turtles and shoals of fish were observed. No dugongs were observed during the initial phases of the analysis.

Figure 5.2: Pod of Bottlenose Dolphins

Figure 5.3: Manta Ray observed during surveys at Twins Islands of Andaman Islands

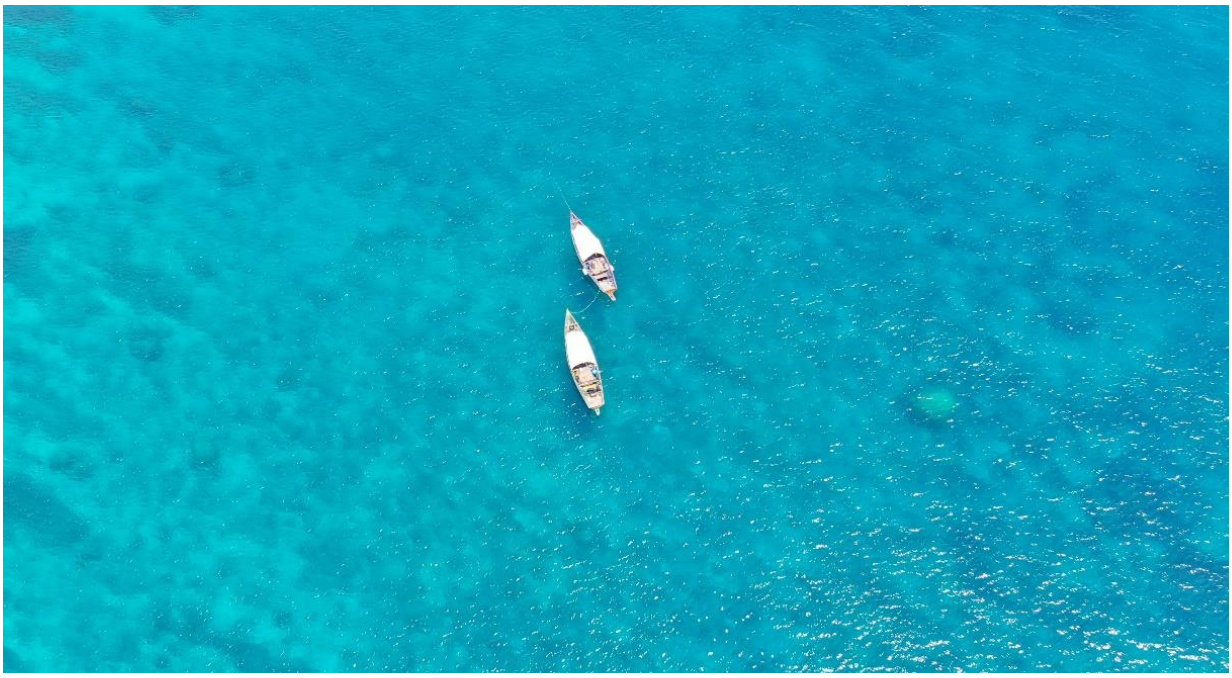


Figure 5.4: Anchored fishing boats observed off North Cinque Island of Andaman Islands

Figure 5.5: Shoal of fish observed off Jahaji Beach, Rutland Island of Andaman Islands

Figure 5.6: Researcher surveying in Mahatma Gandhi Marine National Park of Andaman Islands

5.1.3 Capacity building

A three-day Capacity Building workshops for Hands on Drone Training for marine megafauna monitoring was undertaken at Chidyatapu, Biological Park from 2nd to 4th March 2021. A total of 5 frontline forest staff were trained during the workshop. The flights were undertaken from Chidyatapu Biological Park, Mundapahar Beach and Forest Department Guest House. Skill like drone maneuvering, waypoint flight missions, transect sampling and focal follow missions were undertaken independently by each participant. The main aim of the workshop was to train the staff of the South Andaman division to operate the drone in order to monitor marine megafauna in critical habitats.

Table 5.2: Participants trained for Hands on UAV training Workshop

Field Site	Forest Division	Location	Name	Designation
Andaman & Nicobar	South Andaman	Chidya Tapu	Mohommed Hussain	Forester
Andaman & Nicobar	South Andaman	Chidya Tapu	Mohommed Basheer	Forest Guard
Andaman & Nicobar	South Andaman	Chidya Tapu	Jaykumar	Forest Guard
Andaman & Nicobar	South Andaman	Chidya Tapu	K Netaji	Forest Guard
Andaman & Nicobar	South Andaman	Chidya Tapu	C Ramayya	Forest Guard

Figure 5.7: Theory session during UAV training workshop, Chidyatapu, Andaman Islands

Figure 5.8: Participants flying the UAV during the workshop at Andaman Islands

5.1.2. Sediment and Seagrass Sample Analysis

Introduction

Seagrasses have been reported as a source of nutrient, nursery area and habitat for fishes, benthic organisms and marine mammals in many studies. Seagrass habitats are highly dynamic but a decrease in its extent due to human disturbance has been documented over the last centuries in many studies (Cambridge et al. 1986; Morris and Viknstein, 2004 and Waycott et al. 2005). Seagrasses are able to change their own environment by fixing sediment and enhancing sediment and organic matter trapping (Moriarty and Boon, 1989). This benefits seagrass by stimulating its growth and decreasing the chances of mortality from erosion (Cardoso et al. 2004). The study of effect of sediment and seagrass on each other could be helpful in understanding the seagrass distribution and associated faunal species (Fonseca et al. 1983; Healey and Hovel, 2004).

Study points, collection, processing and analysis of samples

For the year 2020, samples were received during the month of December from the two study sites i.e. Gulf of Kutch, Gujarat and Andaman Islands. 200 sediment samples were received from Gujarat and 33 seagrass and 43 sediment samples from Andaman Islands for the nutrient analysis (Table 5.3).

Table 5.3. Sampling points and observed species in the study sites.

Site	Number of sampling points	Seagrass species observed
Gulf of Kutch, Gujarat	3	*Halophila ovalis, Halophila decipiens Halodule uninervis*
Andaman Islands	3	*Halodule pinifolia, Thalassia hemprichii, Enhalus acoroides, Halodule uninervis, Syringodium isoetifolium, Halophila ovalis, Cymodocea rotundata, Halophila decipiens*

Seagrass samples were collected using stratified random sampling method. Quadrats of size 50x50 cm^2 were plotted randomly on a meadow. Seagrass samples were collected from 20x20 cm^2 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 60ºC 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 cm^2 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 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, 2016). Nitrogen was determined using Micro-Kjeldahl method (Miller and Houghton, 1945). Sodium and Potassium was determined using Flame Photometer method (Barnes et al. 1945). 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 March 2021 (Figure 5.9).

 1.Organic Carbon estimation in sediment samples	 2. Ash content estimation in seagrass samples	 3. Nitrogen estimation in sediment and seagrass samples

Figure 5.9: Laboratory analysis of the sediment samples

Result

The concentration of sodium, organic carbon and organic matter varied among the study points in the sediment samples of Andaman Island (Figure 5.10).

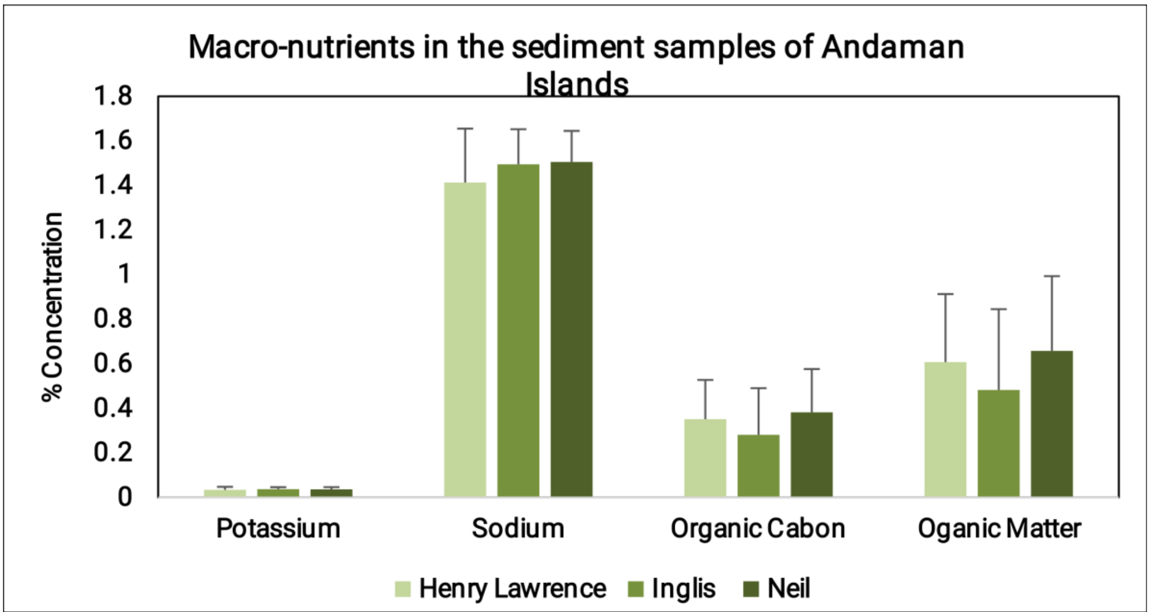


Figure 5.10: Concentration of nutrients in the sediment samples of Andaman Islands

Variation was also observed in the concentration of macro-nutrients in the seagrass samples. Highest concentration of sodium, organic carbon and organic matter was observed in the samples of Henry Lawrence (Figure 5.11).

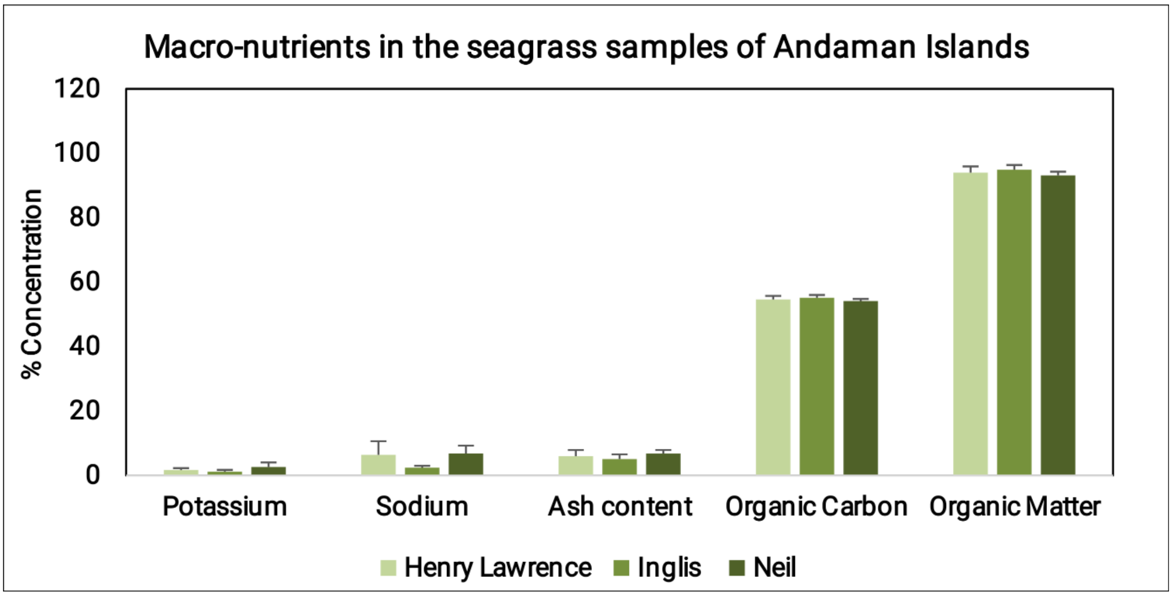


Figure 5.11: Concentration of nutrients in the seagrass samples of Andaman Islands

In the site Gujarat, the concentration of nutrients in the sediment samples also varied. Highest nitrogen content was observed in the samples of Manmarudi. Whereas, organic carbon and organic matter in the samples of Nor Reef (Figure 5 12).

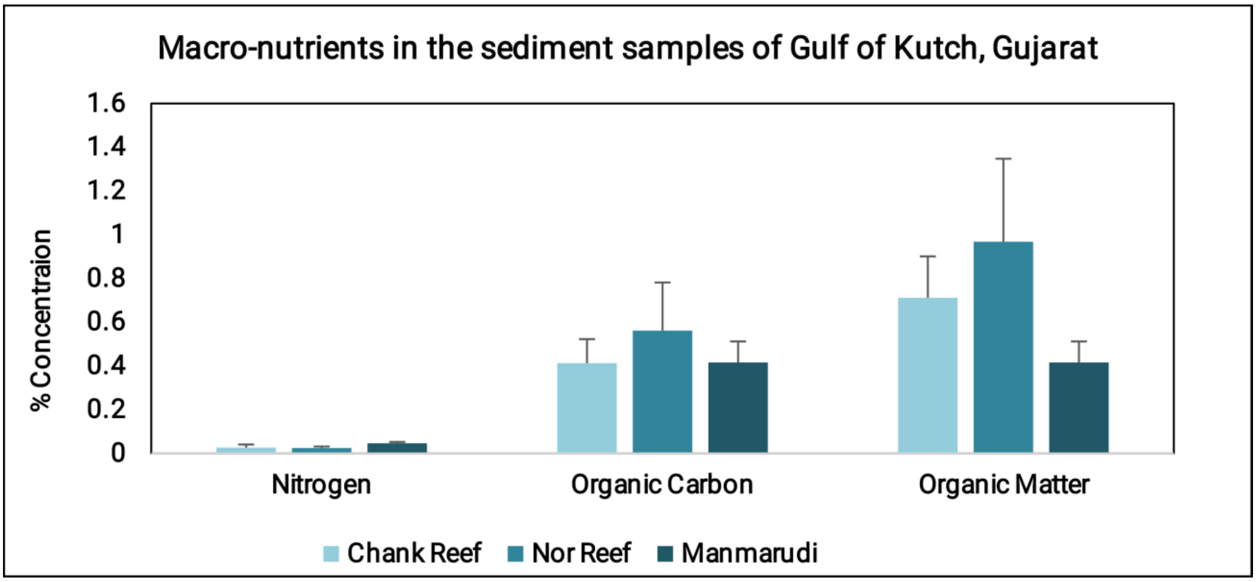


Figure 5.12: Concentration of nutrients in the sediment samples of Gulf of Kutch, Gujarat

Way Forward

1. Factors influencing the concentration of nutrients in the sediments and seagrasses are being analyzed and observed. Samples collected for this season will be analyzed and for next season the collection is in process. On receiving, they will be analyzed for the same.

5.1.3 Seagrass- associated infaunal benthic macrofauna from seagrass meadows of Andaman Islands (Ritchie's Archipelago)

Introduction

Seagrass beds are an important part in the coastal and estuarine ecosystem which influences a number of ecosystem services (Bos, *et al.,* 2007). Seagrasses are represented by 72 species belonging to 12 genera and 6 families (Short *et al.,* 2011). Seagrass habitat supports macrofauna species diversity, abundance and biomass than adjacent unvegetated habitats. Due to their sensitivity to adjust in water and habitat for immoderate biodiversity, they are comprehended as important indicator species that replicate the general health of coastal ecosystems (Thayer *et al.,* 1978).

Macrobenthos, are invertebrates that live on or in sediment or attached to a hard substrate. Annelid worms, bivalves, gastropods, crustaceans, tunicates, and insect' larvae are the most commonly encountered Macrofauna in an estuarine or freshwater environment. Macrofauna can be retained using 500 μm sieve. When macrofauna lives within the substrate it is called infauna and when macrofauna lives on or just above the substrate it is called epifauna (Lenihan & Micheli 2001).

Macrofauna communities are known to play an important role for ecosystem & ecosystem services like they help in bioturbation and bio-irrigation in areas where physical disturbance is low (Kristensen & Kostka 2005, Meysman *et al*., 2006). In process of search for food these organisms actively help in rework and irrigate the sediment. As a result, it helps to 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 suspension feeding activities (Yingst & Rhoads 1980, Aller & Yingst, 1985, Blackburn 1988, Mermillod-Blondin *et al*., 2004).

This study focuses on infaunal community of seagrass beds for the health assessment of seagrass habitat.

Study Area

For the study of macrobenthic fauna of seagrass meadows, the samples have been collected from 9 transect 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.

Shaheed Dweep , formally known as Neil island is located in Ritchie's Archipelago, South Andaman. The total area of the island is 13.77 Km^2 with a coastline of 19.4 Km^2.

Rani Jhansi Marine National Park is located in the Ritchie's Archipelago Andaman and Nicobar Islands in the Bay of Bengal. It was founded in 1996, and covers 256 km².

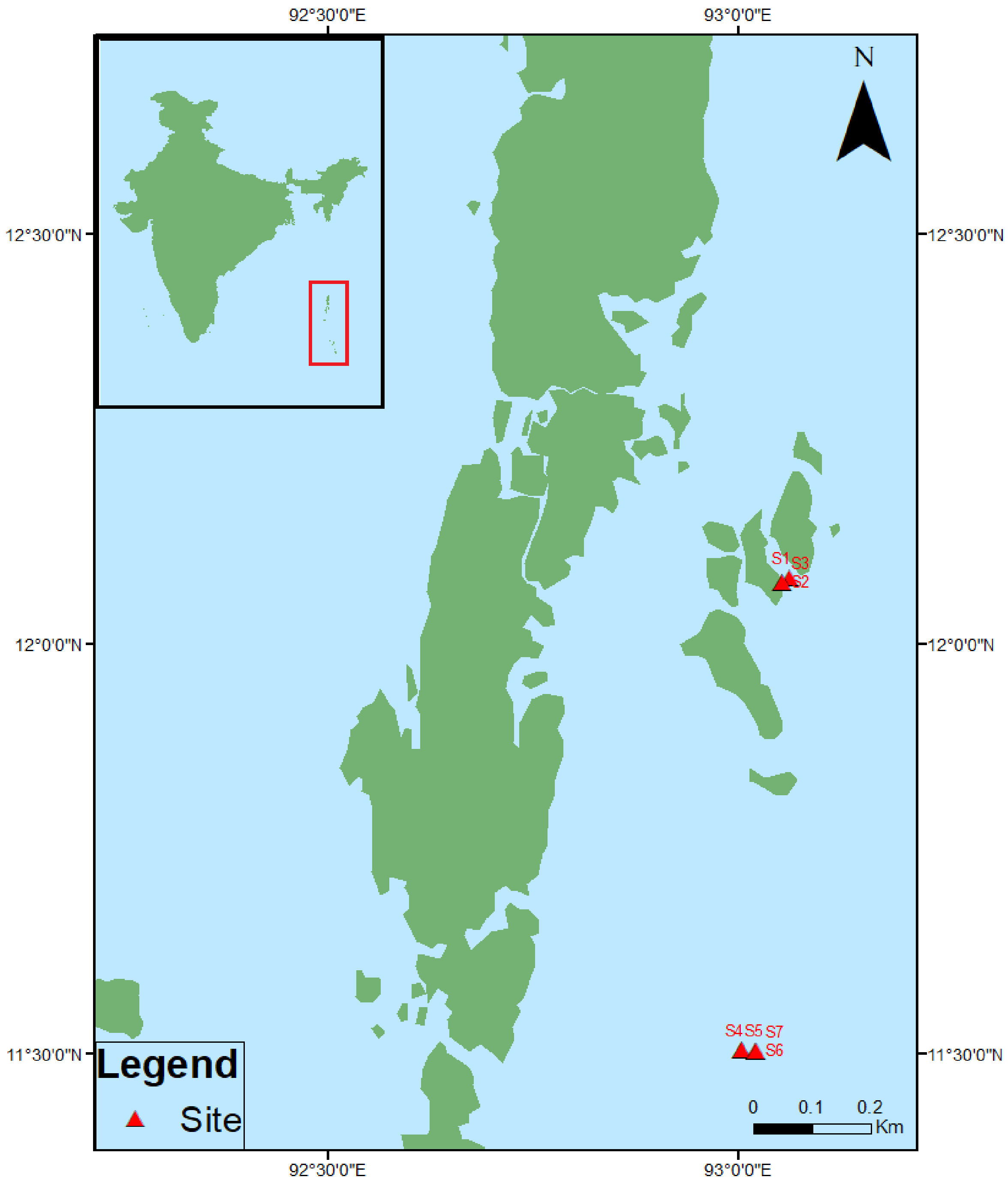


Figure 5.13: Sampling locations for seagrass associated macrobenthic fauna at Andaman Islands (Ritchie's Archipelago)

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 500µ 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 identification.

Identification and analysis

The individuals have been identified and sorted till group level and its diversity has been analyzed per m^2.

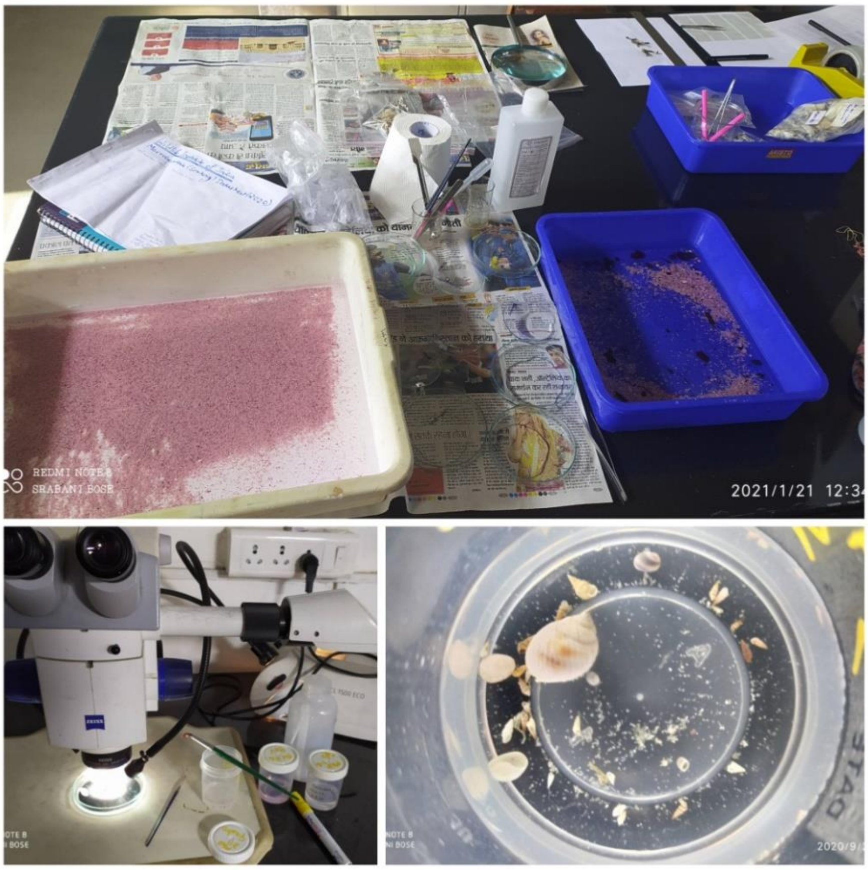


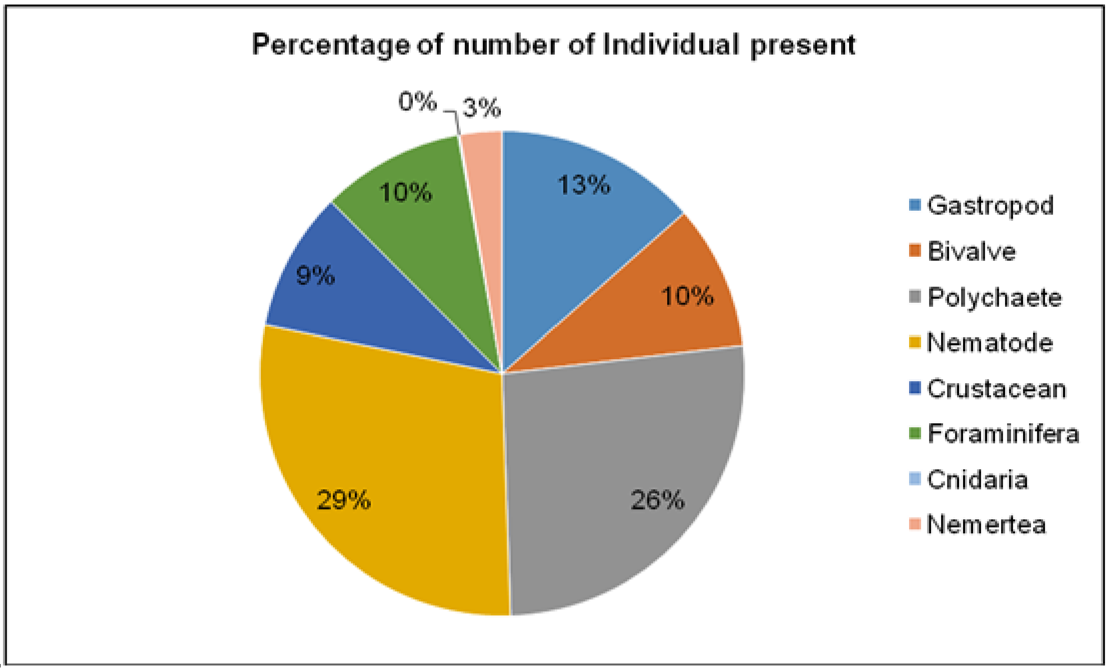
Figure 5.14: Process of sorting and identification till group level

Results

A Total of 30 samples has been collected from Henry Lawrence Island (n=13), Shaheed island (n=9) and Rani Jhansi Marine National Park (n=8) during December to March 2020. Al the sorting of the samples are done. Number of Individual from each group and its biomass has been calculated of about 21samples, rest is needed to be done.

The Individual has been sorted and classified in 8 groups viz. Gastropod (GS), Bivalve(BV), Polychaete (PL), Nematode(NM), Foraminifera(FM), Crustacean (CR), Cnidaria(CN) and Nemertea(NT).

The overall biomass of organisms varied from 0.18-110 gm/m² and number of individuals vary from 25-6175 no./m².



.

Figure 5.15: Macrobenthic faunal percentage compositions of Andaman Islands

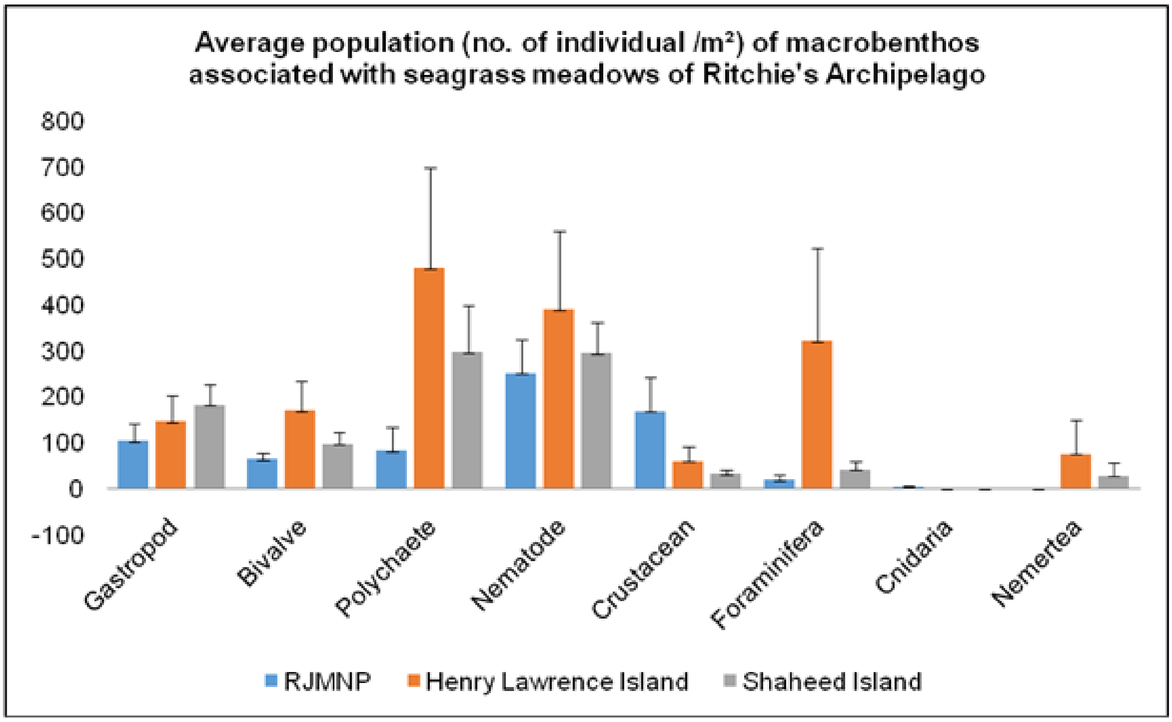


Figure 5.16: Average population (no. of individual /m²) of seagrass associated macrobenthos of Ritchie's Archipelago

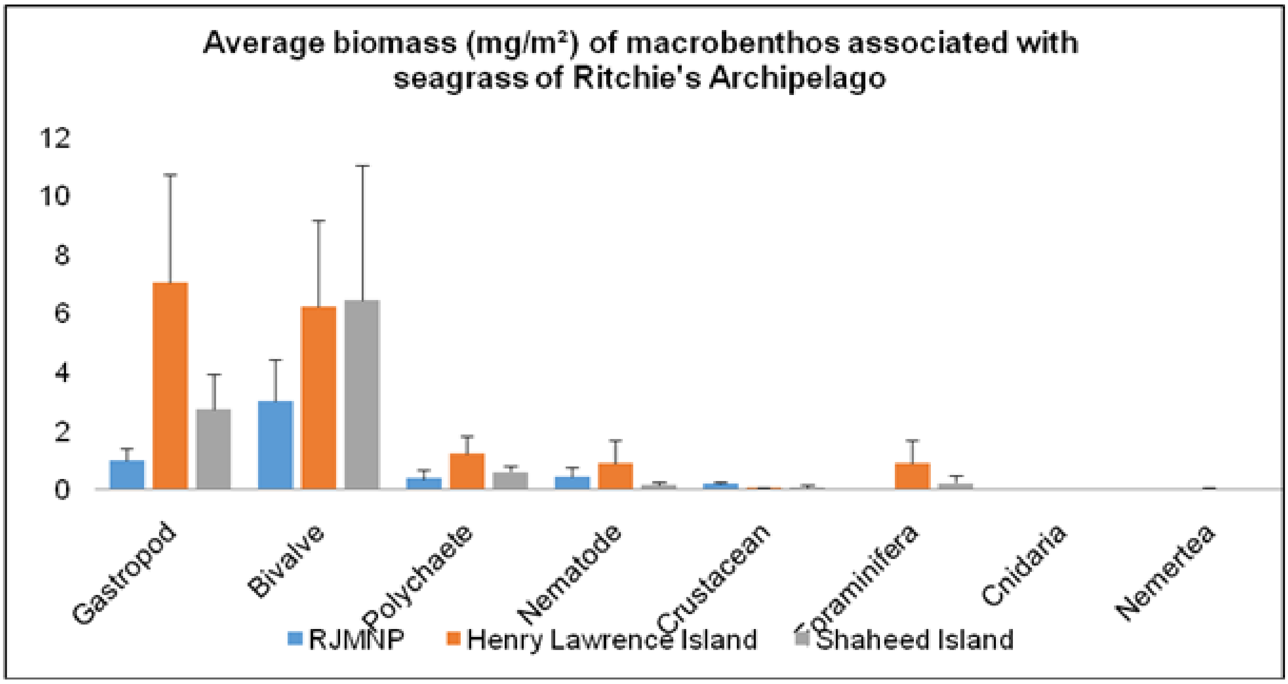


Figure 5.17: Average biomass (g/m²) of *seagrass associated* macrobenthos of Ritchie's Archipelago

Rani Jhansi Marine National Park (RJMNP)

Total 8 quadrats {3 transect} were laid. The seagrass composition in the area was dominated by *Halophila pinifolia.* Total 8 samples from this area constituted of 6 groups viz. Gastropod (15%; 0-275 individual/m², N=8; Avg 103.57; SE±37.96), Bivalve(9.33%; 0-100 indi/m², N=7; Av 64..28; SE±14.28), Polychaete (12%; 0-350 indi/m², N=8 ; Avg 82.14 indi/m²; SE± 52.53), Nematode (36.26%; 0-500 indi./m², N=8; Avg 250; SE±73.39), Crustacean (24.35%; 0-450 indi./m², N=8; Avg 167.8; SE±74.6), Foraminifera (2.59 %; 0-75indi,/m², N=8; Avg 17.8; SE±2.6) and Cnidaria (0.51%; 0-25indi,/m², N=8; Avg 3.57; SE±3.6)

Though Nematode community (36.26%) is dominant, the biomass of Bivalve (62.54%) is highest in Rani Jhansi Marine National Park.

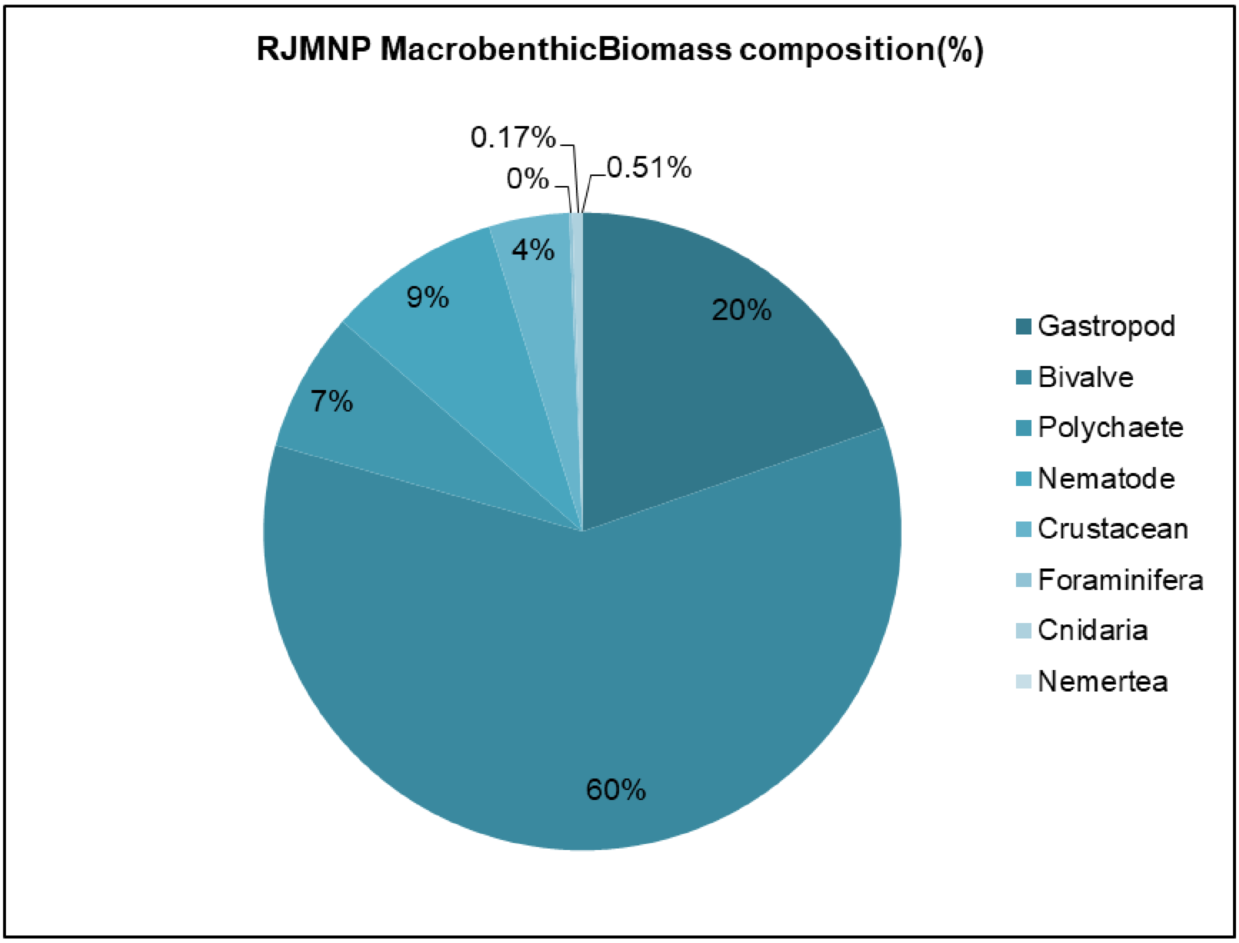


Figure 5.18: Percentage abundanceof various benthic taxonomic groups in RJMNP

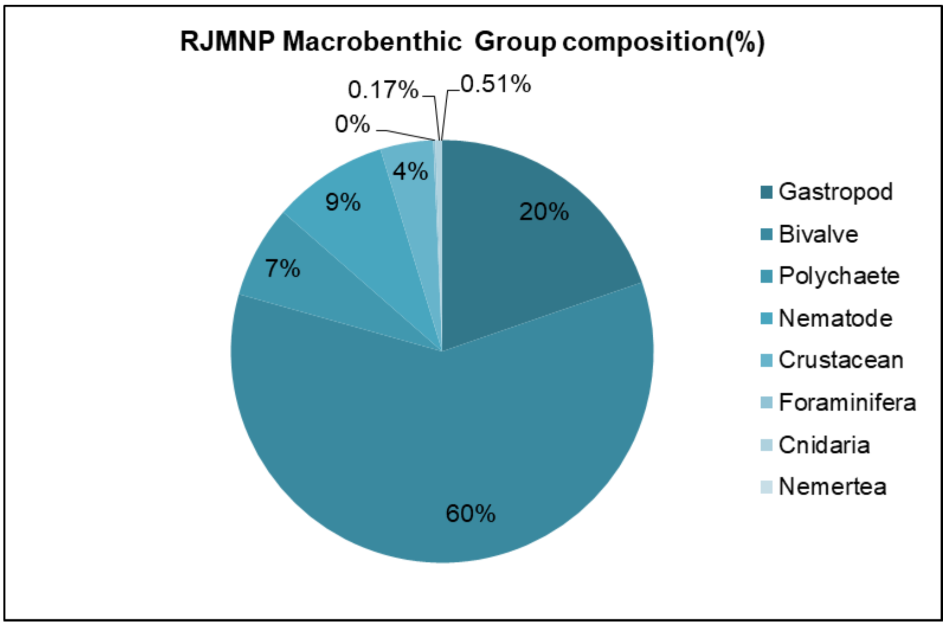


Figure 5.19: Percentage biomass of various benthic taxonomic groups in RJMNP

Henry Lawrence

Total 13 quadrats {5 transect} were laid. The seagrass composition in the area was dominated by *Halophila pinifolia.* Total 13 samples from this area constituted of 7 groups but only 5 samples individual and biomass count has been done. Hence the found groups are viz. Gastropod (8.84%; 0-350 individual/m², N=5; Avg 145; SE±57.2), Bivalve(10.4%; 0-375 indi/m², N=5; Av 170; SE±63.4), Polychaete (29%; 0-1300 indi/m², N=5 ; Avg 480 indi/m²; SE± 217), Nematode (23.8%; 0-1000 indi./m², N=5; Avg 390; SE±171), Crustacean (3.65%; 0-175 indi./m², N=5; Avg 60; SE±30.2) , Foraminifera (19.5 %; 0-975 indi,/m², N=5; Avg 320; SE±204) and Nemertea (4.6%; 0-375 indi,/m², N=5; Avg 75; SE±4.6).

Here Polycheate community (29%) is dominant, the biomass of Gastropod (42.87%) is highest in Henry Lawrence.

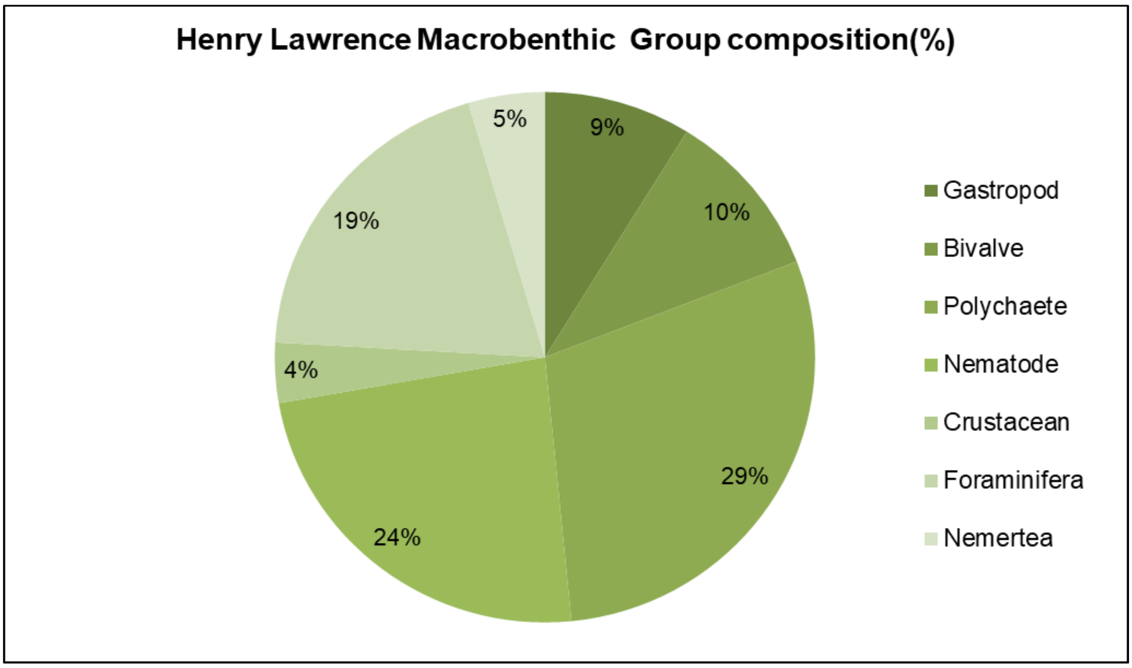


Figure 5.20: Percentage biomass of various benthic taxonomic groups in Henry Lawrence

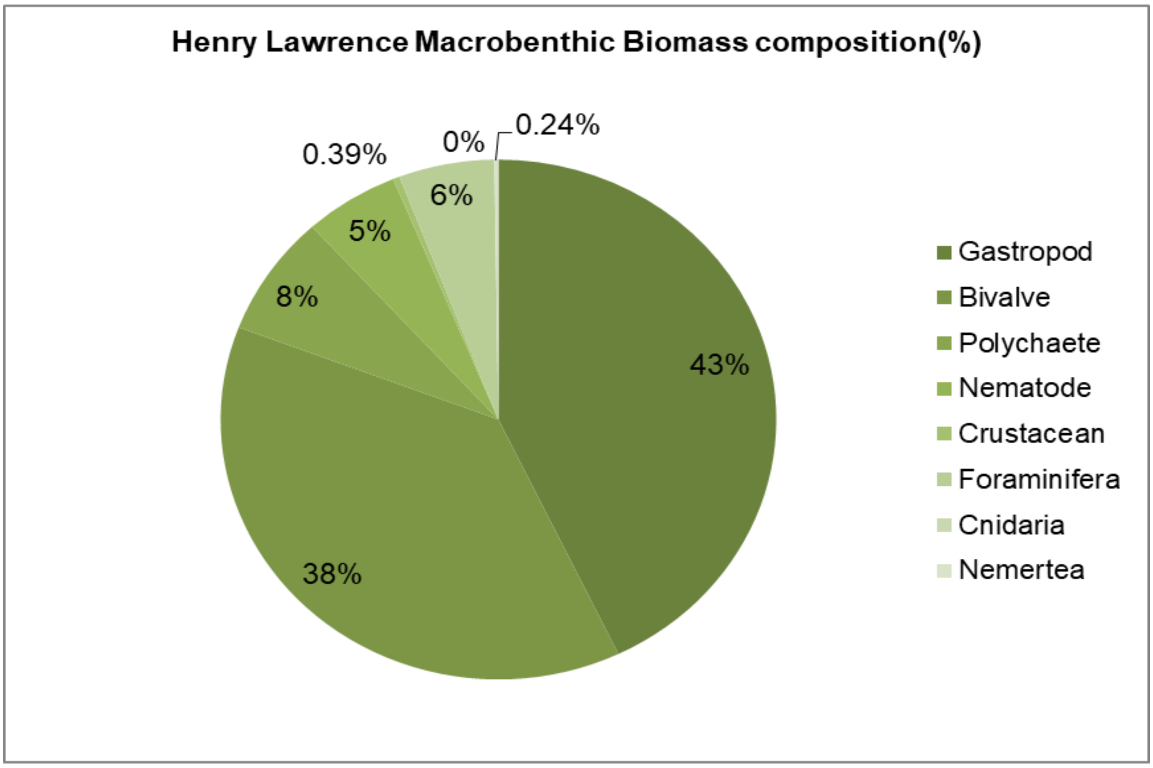


Figure 5.21: Percentage biomass of various benthic taxonomic groups in Henry Lawrence

Shaheed Dweep Island

Total 9 quadrats {4 transect} were laid. The seagrass composition in the area was dominated by *Halodule ovalis*, *Thalasia Hempirchii* and *Halophila pinifolia.* Total 9 samples constituted of 7 groups but only 5 samples individual and biomass count has been done. Hence the found groups are viz. Gastropod (17.16%; 0-300 individual/m², N=9; Avg 161.3; SE±57.2), Bivalve (9.17%; 0-225 indi/m², N=9; Avg 86.11; SE±27.64), Polychaete (31%; 0-900 indi/m², N=9 ; Avg 297.2 indi/m²; SE± 94), Nematode (29.3%; 25-525 indi./m², N=9; Avg 58; SE±30), Crustacean (6.2%; 0-275 indi./m², N=9; Avg 58; SE±30) , Foraminifera (3.9 %; 0-150 indi,/m², N=9; Avg 36.1; SE±18.8) and Nemertea (2.66%; 0-225 indi,/m², N=9; Avg 25; SE±26.5).
Here Polycheate community (31%) is dominant, the biomass of Bivalve (62.5%) is highest in Shaheed Dweep Island.

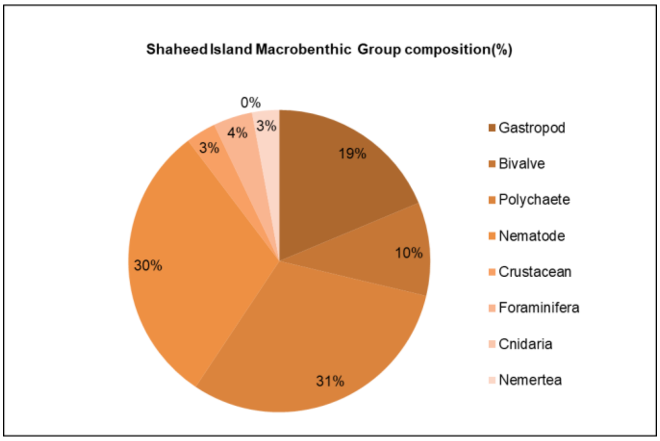


Figure 5.22: Percentage abundance of various benthic taxonomic groups in Shaheed Island

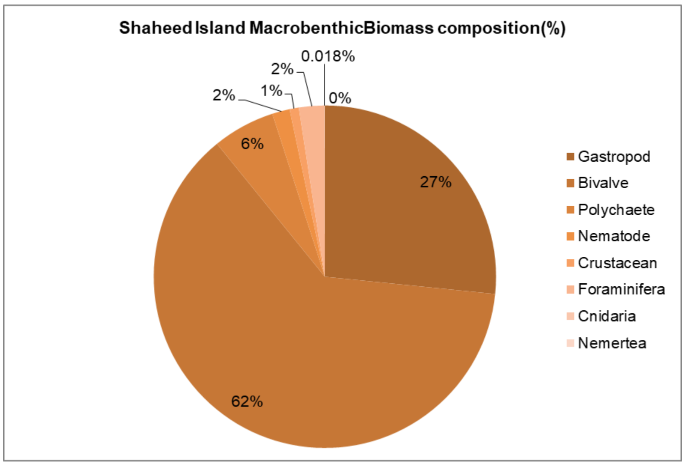


Figure 5.23: Percentage abundance of the biomass of various benthic taxonomic groups in Shaheed Dweep Island

Table 5.4: Distribution of macrobenthic faunal group in Andaman Islands [GS-Gastropod, BV-Bivalve, PL-Polychaetes, NM-Nematode, CR-Crustacean, FM-Foraminifera,CN-Cnidaria, NT-Nemertea, UN- Unknown]

Sample ID	GS	BV	PL	NM	CR	FM	CN	NT	UN
ING 1.1	-	+	-	+	+	-	-	-	-
ING 1.6	+	+	+	-	-	+	-	-	+
ING 1.11	+	+	-	-	-	+	-	-	+
ING 2.1	+	+	-	+	+	-	-	-	+
ING 2.11	+	-	+	+	+	-	-	-	+
ING 3.1	+	+	-	+	+	-	-	-	+
ING 3.6	+	+	+	+	+	-	-	-	-
ING 3.11	+	+	+	+	-	-	+	-	+
JT 1.6	+	+	+	+	+	-	-	-	-
JT 1.11	+	+	-	+	-	-	-		+
JT 2.1	-	+	+	+	+	-	-	+	+
JT 2.6	-	+	+	+	-	-	-	-	+
JT 2.11	+	+	+	+	+	-	-	-	+
LX 1.1	-	-	+	+	+	-	-	-	+
LX 2.1	-	+	+	+	-	-	-	+	-
LX 2.6	+	+	+	+	-	-	-	-	-
BHA 1.1	+	+	+	+	+	-	-	-	-
BHA 1.6	+	+	+	+	+	+	-	-	-
BHA 1.11	+	-	+	+	+	-	-	-	-
BHA 2.1	+	+	+	+	+	+	-	-	-
BHA 2.6	+	+	+	+	+	-	-	-	+
BHA 2.11	+	+	-	+	+	+	-	-	-
IMD1.1	+	+	+	+	-	-	-	-	+
IMD 1.6	+	+	+	+	-	+	-	-	+
IMD3.6	+	+	+	+	-	+	-	-	+
IMD1.11	+	+	+	+	-	-	-	-	+
IMD 3.1	+	+	+	+	+	+	-	-	+
IMD2.6	+	+	+	+	+	-	-	-	+
IMD 2.1	+	+	+	+	+	+	-	+	-
IMD 3.11	+	+	+	-	+	+	-	-	+

Figure 5.24: Seagrass assosiated Macrobenthic fauna: 1)Sipuncula 2) Acantholaimus Sp.(Nematode) 3) Laevidentalium sps. 4) Pyrinidae (Anachis Sp.) 5) Neritidae 6)Sipuncula 7) Mactra Sps.(Bivalve) 8) Clavatulidae (Gastropod) 9) Fissurilidae (Gastropod)

5.1.4. Mapping Seagrass distribution using satellite imageries

Introduction

Space-borne technologies like Remote sensing (RS) and Geographic information system (GIS) are actively used for underwater mapping using moderate and high-resolution satellite products with high efficiency. High-resolution satellite images can be processed to study the distribution of seagrass beds and detect the dugong feeding trails (Mizuno *et al*., 2017). The primary and secondary range distribution of Dugongs in the Indo-Pacific region is shown in Figure 1. Primary sites are areas where dugongs are frequently reported, and secondary sites are areas where a single dugong or a calf is occasionally reported.

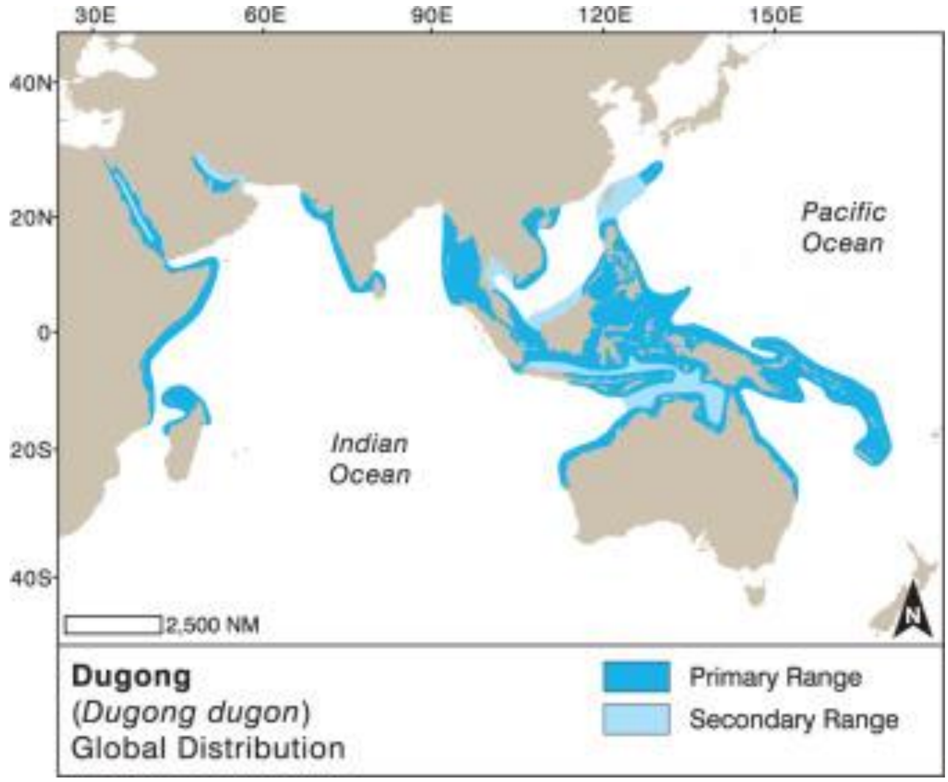


Figure 5. 25: Primary and secondary range distributions of Dugong in the Indo-Pacific region. Source (Jefferson et al., 2015).

Objective

To map seagrass distribution using machine learning algorithms on Google Earth Engine (GEE) from high-resolution satellite imageries.

Study Area

1. Parts of Andaman group of Islands
2. Palk Bay, Tamil Nadu
3. Gulf of Kutch, Gujarat

Datasets

European Space Agency (ESA) provides a high-resolution data repository of the Sentinel-2 image series. The products are being extensively used for land monitoring and climate change activities. It also supports the assessment of biogeophysical parameters such as Leaf Area Index (LAI), Leaf Chlorophyll Content (LCC), and Leaf Cover (LC). This research aims to classify Sentinel-2 multi-temporal series data at 10m resolution for the period of Apr 2015 to Apr 2020 to analyze the seagrass beds in the study area. Sentinel-2 Level 1C (Top-of-Atmosphere reflectance) and Sentinel-2 Level 2A (Bottom of Atmosphere reflectance) will be used for further analysis. Google Earth Engine has a free data repository of Sentinel 2 data for public access and can be easily extracted using Earth Engine API. Table 5.3 specifies the metadata with bands description of Sentinel-2 data product.

Table 5.5: Metadata for Sentinel-2 product

METADATA	
Satellite	Sentinel-2
Sensor	Multispectral Instrument (MSI)
Bands	Band 1 Aerosol (443.9 nm-S2A/ 442.3 nm-S2B) Band 2 Blue (496.6 nm-S2A/ 492.1 nm-S2B) Band 3 Green (560 nm-S2A/ 559 nm-S2B) Band 4 Red (664.5 nm-S2A/ 665nm-S2B) Band 8 NIR (835.1 nm-S2A/ 833 nm-S2B) Band 11 Shortwave Infrared 1 (1613.7 nm-S2A/ 1610.4 nm-S2B) Band 12 Shortwave Infrared 2 (2202.4nm-S2A/ 2185.7 nm-S2B)
Spatial Resolution	10 m
Temporal Resolution	5 days at equator with twin satellites (Sentinel 2A and Sentinel 2B) under cloud-free conditions
Date of capture	Apr 2015 –till date

Methodology

The overall methodology is briefly described in Figure 5.26, where the whole process is executed in GEE using JavaScript. Certain parts of statistical processing will be performed on R programming. Also, using very high-resolution spectral profiling, an attempt would be made to detect dugongs.

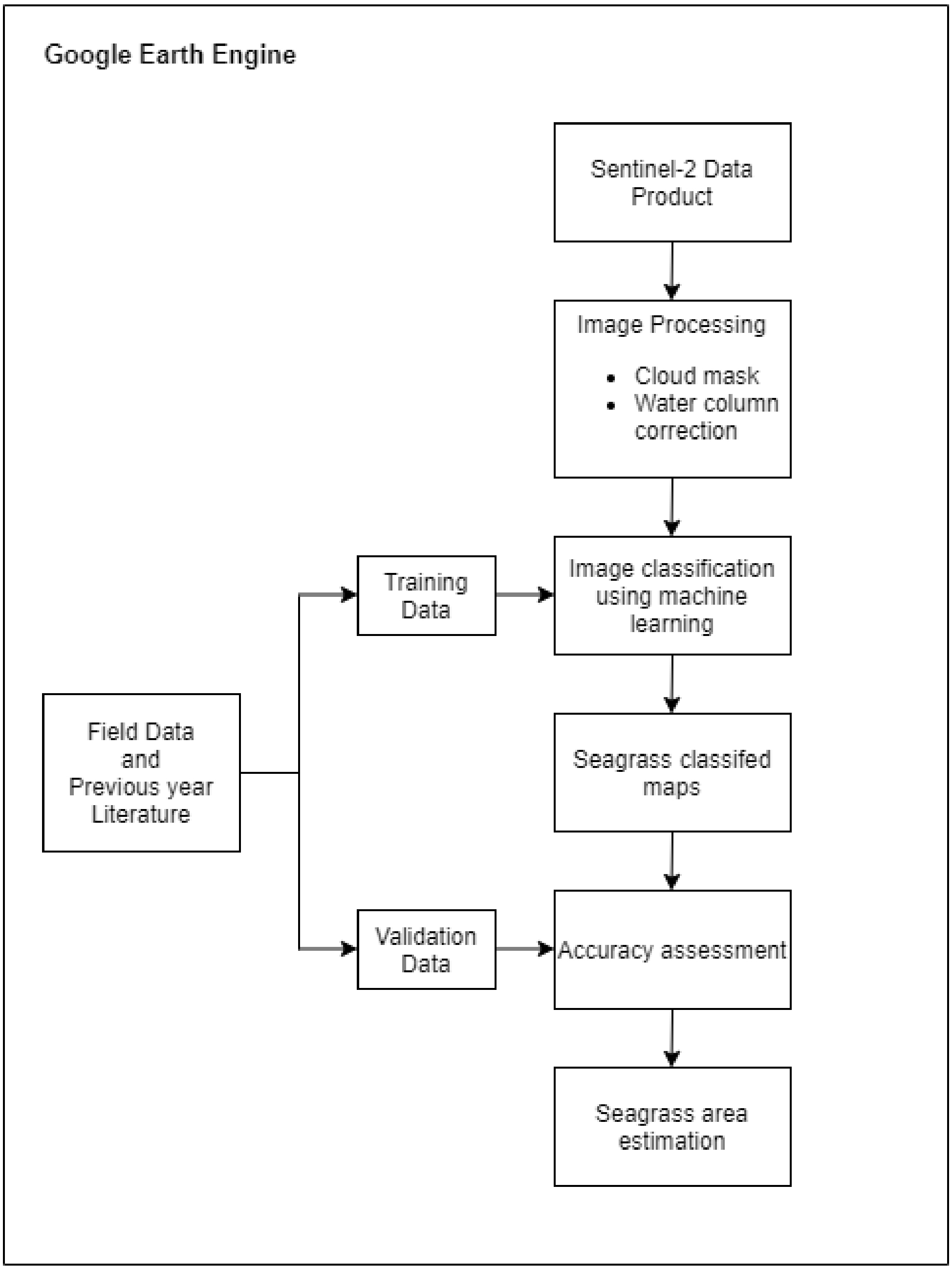


Figure 5.26: Overall methodology

Results

Seagrass classification is performed using the pixel-based image classification method. GEE in-built machine learning classifier, Random Forest (RF), is tested for different sites. The RF model was analyzed on Sentinel-2 surface reflectance level-2 product, an atmospherically corrected data providing radiometrically and geometrically corrected cloud-free images for all the study sites. Temporal data for the period of April 2015 to date satellite images are used for different sites depending upon the low tide and cloud cover. The field data acquired for Andaman & Nicobar Island was from 2018 to 2021. The data was segregated into four classes as seagrass, sand rubble, water, and mixed pixels. Andaman & Nicobar Islands support a rich underwater habitat, including various seagrass species and corals reefs. These habitats were observed to exist in diverse culture, as shown in Figure 5.27, Figure 5.28, and Figure 5.29. Also, the Palk Bay in Tamil Nadu consists of a dense patch of seagrass. The field data obtained from Palk Bay is from 2018-2019. Based on seagrass percentage cover, the satellite image is classified into four classes: dense seagrass, sparse seagrass, sand, and water, as shown in Figure 5.30. Whereas in the low tide regions of the Gulf of Kutch, Gujarat, only two classes were observed, namely seagrass and non-seagrass. The seagrass classification for Gujarat is shown in Figure 5.31.

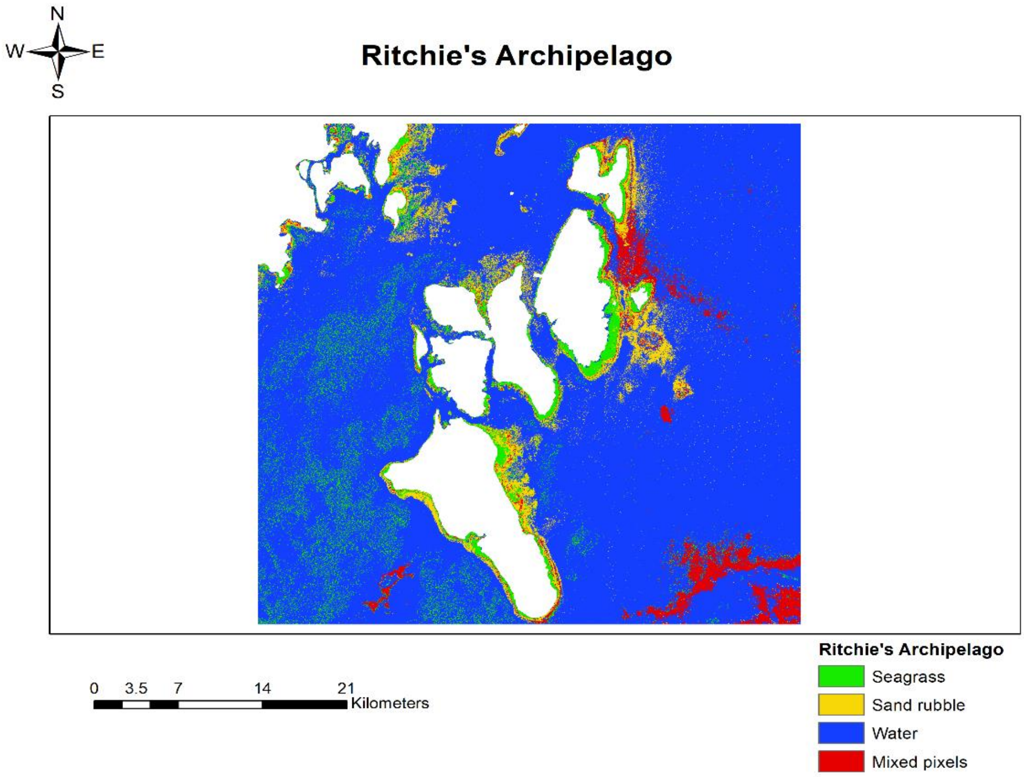


Figure 5.27 Seagrass classification for Ritchie's Archipelago, Andaman Nicobar Island

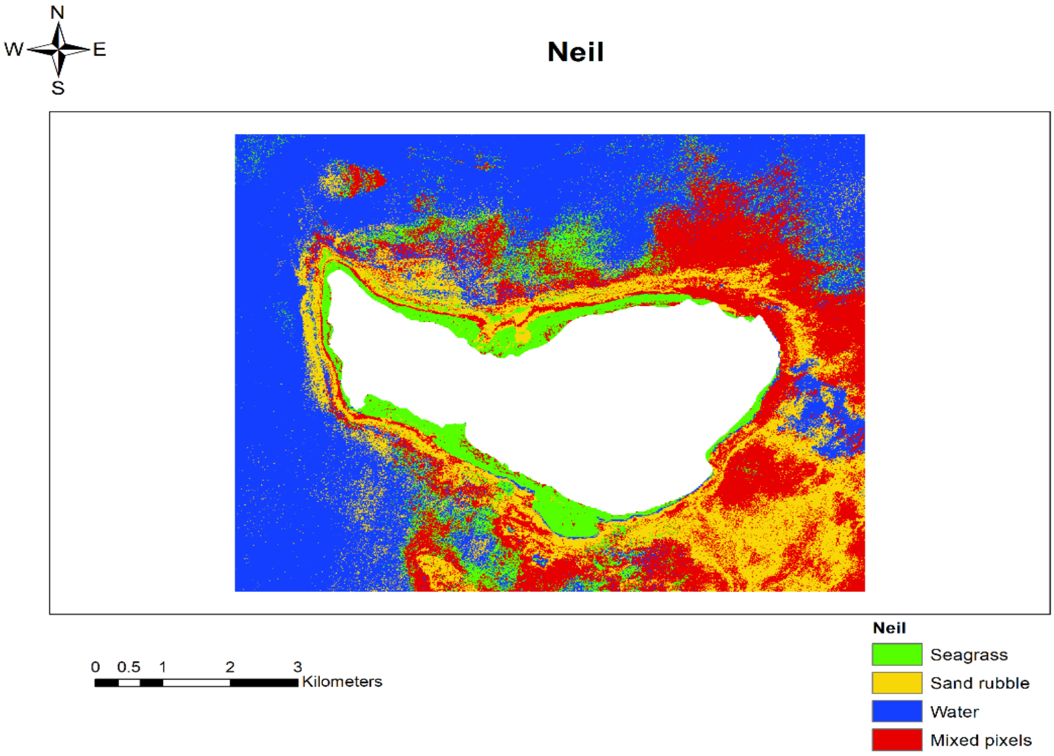


Figure 5.28: Seagrass classification for Neil Island, Andaman and Nicobar Islands

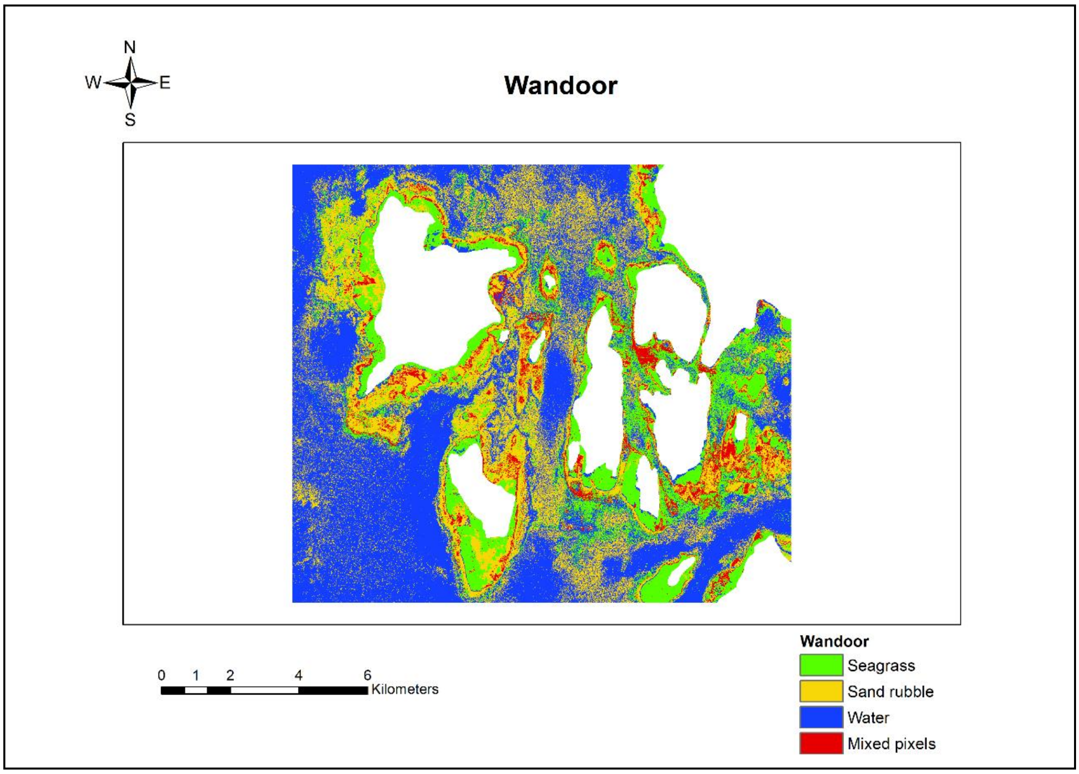


Figure 5.29:Seagrass classification for Wandoor, Andaman and Nicobar Islands

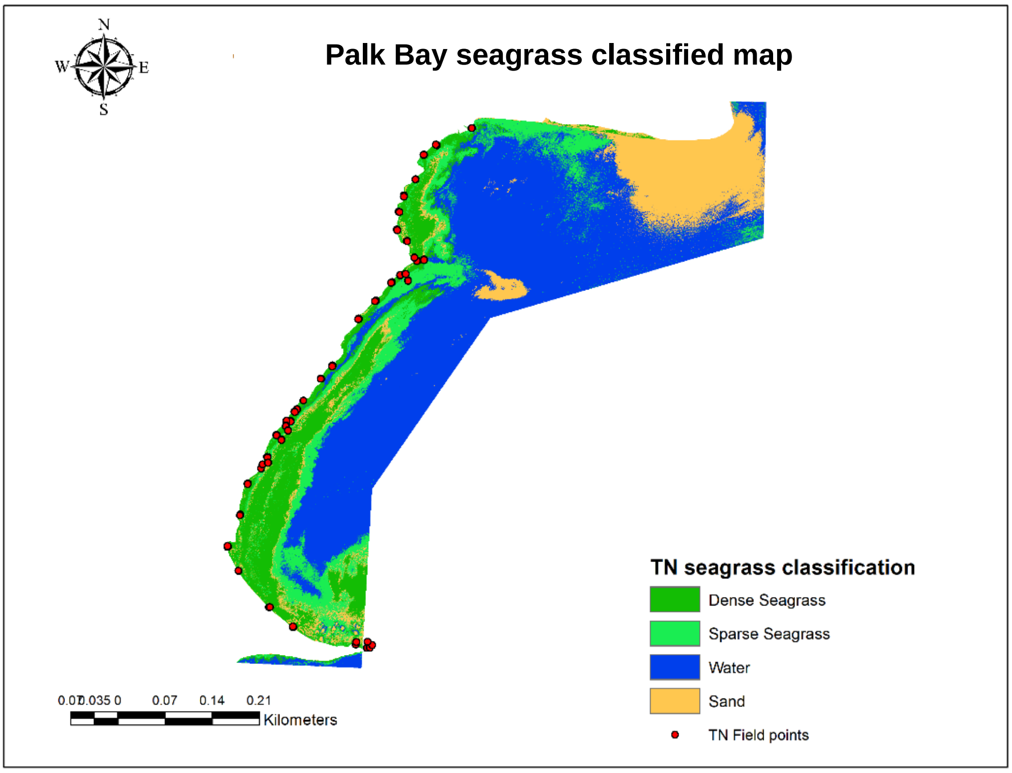


Figure 5.30: Seagrass classification for Palk Bay, Tamil Nadu

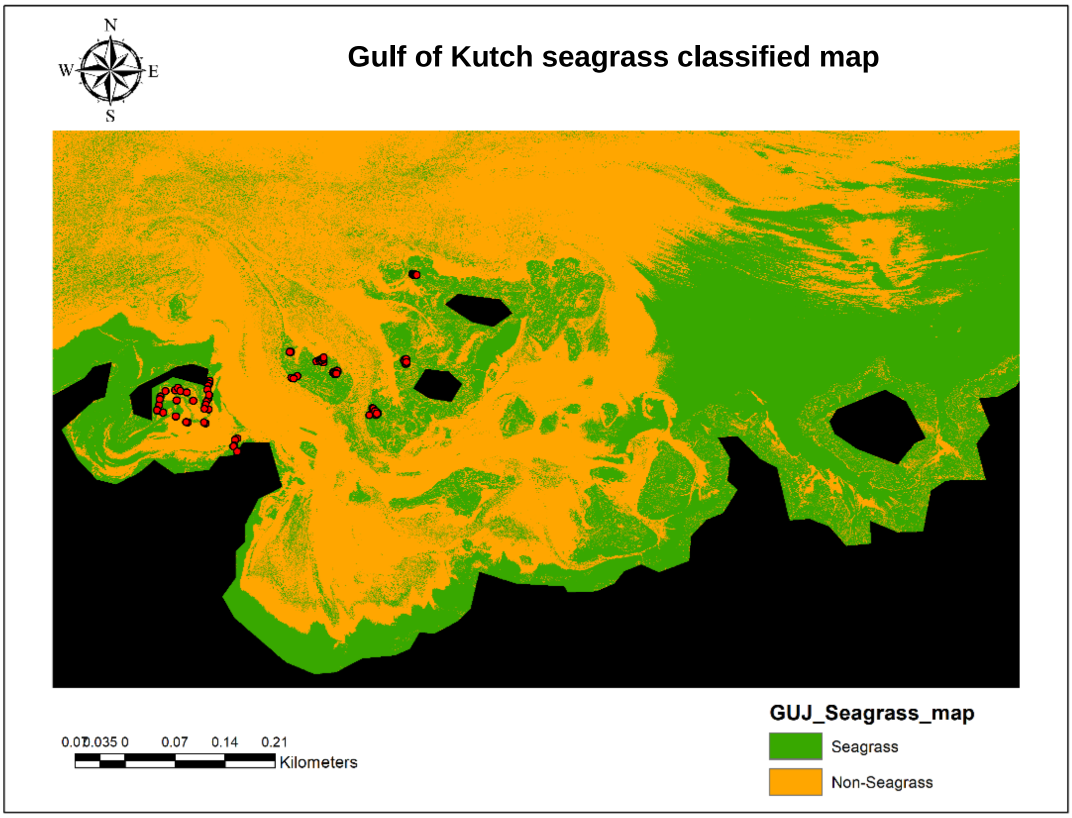


Figure 5.31: Seagrass classification for Gulf of Kutch, Gujarat

5.1.5 Study of Dugong population in Indian sea waters using microsatellite and mitochondrial markers

Introduction

Conservation is best done when we get a snapshot of the species population structure in the past and the present. This gives us how time, any anthropological or natural event has affected the population to recent structure.

Microsatellites are short tandemly arrayed di-, tri-, or tetranucleotide repeat sequences with repeat size of 1–6 bp repeated several times flanked by regions of nonrepetitive unique DNA sequences, which are distributed throughout the genomes of most eukaryotic species (Tautz, D., 1989). The very high levels of variability associated with microsatellites, speed of processing, and the potential to isolate large number of loci provide a marker system capable of detecting differences among closely related populations of a species (Muneer, P. A., 2009). Free of natural selection pressure, short size range, uninterrupted stretches of identical repeat units and high proportion of polymorphisms are some of the properties that make microsatellites ideal genetic markers for conservation genetics and population structure analysis by giving an insight in understanding mutational processes (Abdul-Muneer, P. M. 2014).

The control region of the mitochondrial DNA (mtDNA) due to its elevated mutation rate, lack of recombination and maternal inheritance serve as a biomarker in phylogenetic studies and ancestry. Mitochondrial DNA (mtDNA) has strictly maternal inheritance which means mtDNA haplotypes should be shared by all individuals within a maternal family line hence giving a picture of ancient geneflow.

Method

Microsatellite markers were used for amplification of dugong nuclear DNA. The reactions were performed in panels consisting of four different microsatellite markers of varied amplicon size and labelling dye. Details of the primers are mentioned in Table 5.4. The samples were amplified panel-wise.

Table 5.6: Panels used for microsatellite analysis along with the primers used, their annealing temperature and corresponding dyes.

SN.	Panels	Primers	Dye	Temperature
1	Panel_1	Ddu B01	Fam	58
2		Ddu C05	Pet	58
3		Ddu B02	Ned	58
4		Ddu E04	Vic	58
5	Panel_2	Ddu G12	Fam	58
6		Ddu D08	Pet	58
7		Ddu C11	Ned	58
8		Ddu G11	Vic	58
9	Panel_3	Ddu E09	Fam	58
10		Ddu F07	Pet	58
11		Ddu H02	Ned	58
12		Ddu C09	Vic	58
13	Panel_4	Tma A02	Fam	54
14		Tma E08	Pet	54
15		Tma A09	Ned	54
16		Tma A04	Vic	54

Microsatellite markers were amplified using Qiagen Hotstart mastermix (Qiagen Inc., Hilden, Germany) and genotyped in ABI 3500XL Genetic Analyzer (Applied Biosystems, California, United States). Allele sizes for each locus were scored manually using GENEMARKER v2.6.7 (SOFTGENETICS INC., USA).

Mitochondrial DNA (mtDNA) control region was amplified using a universal mammalian primer- A24 (Kocher et al., 1989) and dugong-specific primers A58, A77 and A80 (Blair, D. et al., 1997).The amplified PCR products were cleaned using Exonuclease-Shrimp Alkaline Phosphatase (Exo-SAP) mixture (New England Biolabs, Ipswich, Massachusetts) and sequenced bidirectionally using BigDye v3.1 Terminator kit in ABI 3500XL Genetic Analyzer (Applied Biosystems, California, United States).

Analysis

The alleles were manually called therefore any error in calling of these microsatellite loci were checked in GIMLET v1.3.3 (Valière, N., 2002). All the calls with frequency less than ten percent were re-called. The microsatellite data thus generated was used to look for the genetic variability in the four-sampling site by implementing Bayesian iterative algorithm using the software STRUCTURE v2.3.4. (Porras-Hurtado, *et al.,* 2013).

The mitochondrial DNA fragment of dugongs generated was aligned with already submitted sequences of Dugongs (Srinivas *et al*., 2019) in MEGA v.7 (Kumar, S., 2016) and cleaned for further analysis. We looked for common haplotypes in DnaSP v5.10(Librado, *et al*., 2005) and determined if there was any structuring between the Dugong sequences obtained from various field sites using Bayesian Analysis for Population Structure (BAPS) v6.2 (Corander *et al.,* 2007). A haplotype network, using PopArt v1.7 (Leigh,. *et al*., 2015), containing all the haplotypes was made to get a picture of the variability amongst the population.

Results

Out of the 44 dugong samples that we acquired we have generated microsatellite data for 37 individuals and mitochondrial data for all 44 individuals. Both the data are being analyzed for deeper demographic understanding. Here we talk about some basic analysis that gives a baseline outlook.

The mitochondrial analysis showed there are 10 distinct haplotypes with one to 10 base-pair differences between the sequences. This variability was spread out across the population i.e., the haplotypes were found in most of the sampling sites (Figure 5.24)

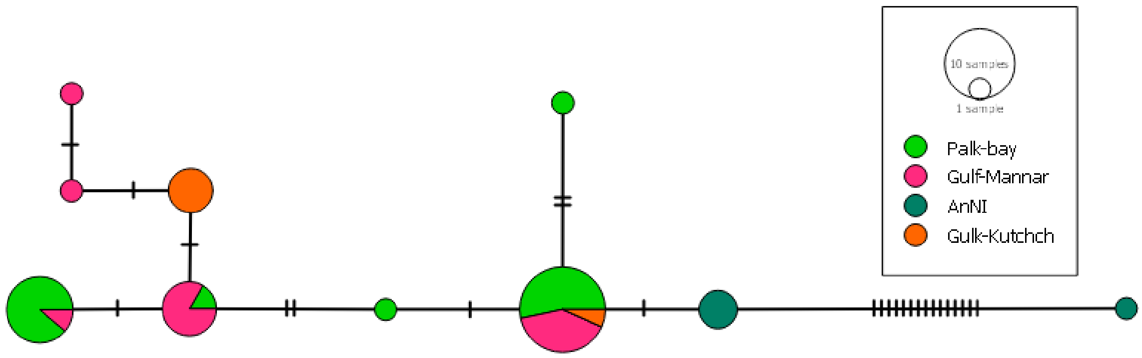


Figure 5.32: Each circle depicts a haplotype and the colors within shows the places it is shared in. The dashes depict the number of base-pair differences between each haplotype.

The Bayesian Analysis for Population Structure (BAPS) using mitochondrial gene showed that there are two distinct maternal lineages in the Indian dugong population again shared between the four sites (Fig. 5.33).

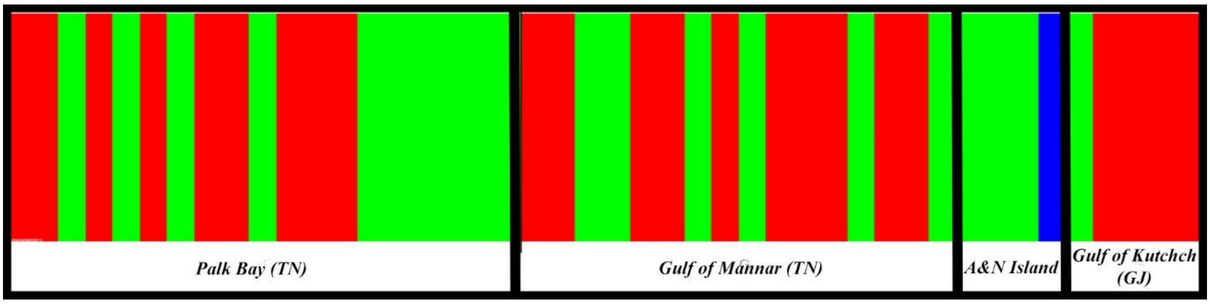


Figure 5.33: The BAPS analysis showed two maternal lineages, depicted by different colors, shared between all the sampling sites

In either of the analysis above, it appears like Andaman & Nicobar Islands appears to have a distinct line apart from the forementioned two, however the samples acquired from the place is relatively less to speculate anything.

The population structure analysis using microsatellite brings out a similar picture for recent time, where in there is no segregation in populations from the sites. It can be said that the populations are intermixing however further analysis on the same needs to be done. Such a result can also be a result of loci not being efficient in picking up the distinction (Fig 5.34).

Figure 5.34: Structure population genetic analysis depicts there is no distinction in population and the variability is equally distributed across the sampling sites. The bars show the probability of an individual being in each lineage which in this case ranges between 40-60 per cent (Srinivas et al., unpublished data)

Both mitochondrial and microsatellite analysis points towards populations mixing and being connected. For a deeper understanding and a precise picture, we need to look into migration rates, any bottleneck event and inbreeding signatures to comment about how well the populations are connected with each other. However, the baseline analysis does point towards the importance of conserving sea-grass patches between these sampling sites since they play major role in sustaining the dugong habitat.

References

1. Apte Deepak (2012) Field guide to the marine life of India, BNHS India 502 pp.
2. Apte Deepak, (2014).Seashells of India: An illustrated guide to common gastropods BNHS India 197pp
3. Ascherson, P. and Beccari, O., 1871. *Plantae phanerogamae marinae, quas cl.* Australia between 1967 and 1999. *Aquatic Botany,* 73(1): 75-87.
4. Chakraborty, S., Bhattacharya, T., Singh, G., & Maity, J. P. (2014). Benthic macroalgae as biological indicators of heavy metal pollution in the marine environments: A biomonitoring approach for pollution assessment. Ecotoxicology and environmental safety, *100*, 61-68.
5. Chester, Roy, and M. J. Hughes. "A chemical technique for the separation of ferromanganese minerals, carbonate minerals and adsorbed trace elements from pelagic sediments." Chemical Geology 2 (1967): 249-262.
6. Duarte, C. M. Kennedy, H. Marbà, N. and Hendriks, I. 2013. Assessing the capacity of seagrass meadows for carbon burial: current limitations and future strategies.Ocean & coastal management, 83: 32-38
7. Fourqurean, J. W. Duarte, C. M. Kennedy, H. Marbà, N. Holmer, M. Mateo, M. A.G. Pellas. Duarte, C. M. Kennedy, H. Marbà, N. and Hendriks, I. 2013. Assessing the capacity of seagrass meadows for carbon burial: current limitations and future strategies. *Ocean & coastal management,* 83: 32-38.
8. Geevarghese, G.A., Akhil, B., Magesh, G., Krishnan, P., Purvaja, R. and Ramesh, R.,2018. A comprehensive geospatial assessment of seagrass distribution in India. *Ocean & Coastal Management*, *159*, pp.16-25.
9. Govindasamy, C., Arulpriya, M., Ruban, P., Jenifer, F. L., & Ilayaraja, A. (2011). Concentration of heavy metals in seagrasses tissue of the Palk Strait, Bay of Bengal. *International journal of environmental sciences*, *2*(1), 145.
10. Gullström, M. Lundén, B. Bodin, M. Kangwe, J. Öhman, M. C. Mtolera, M. S. and Björk,M. 2006. Assessment of changes in the seagrass-dominated submerged vegetation of tropical Chwaka Bay (Zanzibar) using satellite remote sensing. *Estuarine, Coastal and Shelf Science,* 67(3): 399-408.
11. Gunasekara, S.S. and Mishra, A.K., 2014. Mapping the coverage of seagrass
12. http://www.marinespecies.org/index.php
13. Jones, B. L., Nordlund, L. M., Unsworth, R. K., Jiddawi, N. S., & Eklöf, J. S. (2021). Seagrass structural traits drive fish assemblages in small-scale fisheries. *Frontiers in Marine Science*, *8*, 354.
14. Kamboj R.D., Joshi D. and Parmar H. (2019). Common Marine Mollusc of Gujarat, Gujarat Ecological Education and Research (GEER) Foundation, Gandhinagar. 220pp.
15. Kendrick, G. A. Aylward, M. J. Hegge, B. J. Cambridge, M. L. Hillman, K. Wyllie, A.
16. Kumar, G., Kumar, M., & Ramanathan, A. L. (2015). Assessment of heavy metal contamination in the surface sediments in the mangrove ecosystem of Gulf of Kachchh, West Coast of India. *Environmental Earth Sciences*, 74(1), 545-556.

17. Marsh, H., Grech, A., & McMahon, K. (2018). Dugongs: seagrass community specialists. In *Seagrasses of Australia* (pp. 629-661). Springer, Cham.
18. Marsh, H., O'Shea, T. J., Reynolds, J. E., & Reynolds III, J. E. (2012). Ecology and conservation of the Sirenia: dugongs and manatees (Vol. 18). Cambridge University Press.

19. McKenzie, L. J., & Yoshida, R. L. (2012). Seagrass-Watch: Proceedings of a Workshop for Monitoring Seagrass Habitats in the Mackay Whitsunday Region, Queensland, Australia. QPWS Whitsunday Information Centre, Jubilee Pocket, Airlie Beach, 13-14.
20. Nobi, E.P. and Thangaradjou, T., 2012. Evaluation of the spatial changes in seagrass cover in the lagoons of Lakshadweep islands, India, using IRS LISS III satellite images. *Geocarto International*, *27*(8), pp.647-660.
21. Nobi, E.P., Dilipan, E., Thangaradjou, T. and Kumar, P.D., 2013. Restoration scaling of seagrass habitats in the oceanic islands of Lakshadweep, India using geospatial technology. *Applied Geomatics*, *5*(2), pp.167-175
22. Nordlund, M.L. Koch, E.W. Barbier, E.B. and Creed, J.C. 2016. Seagrass ecosystem services and their variability across genera and geographical regions. *PLoS One,*11(10): e0163091.
23. P.A., 2008. Regional-scale seagrass habitat mapping in the Wider Caribbean region
24. Panseriya, Haresh Z., et al. "Distribution, speciation, and risk assessment of heavy metals: a geochemical exploration of Gulf of Kachchh, Gujarat, India." Environmental Earth Sciences 79 (2020): 1-10.
25. Paulose, N.E., Dilipan, E. and Thangaradjou, T., 2013. Integrating Indian remote
26. Pilcher, N. J., & Kwan, D. (2012). Dugong questionnaire survey project manual. *CMS-UNEP Abu Dhabi Office). Available online at: http://www. cms. int/dugong/en/document/standardised-dugong-questionnaire-project-manual*.
27. Preen, A. (1995). Diet of dugongs: are they omnivores? *Journal of Mammalogy*, *76*(1), 163-171. https://doi.org/10.2307/1382325
28. Say, P. J., Burrows, I. G., & Whitton, B. A. (1990). Enteromorpha as a monitor of heavy metals in estuaries. In *North Sea—Estuaries Interactions* (pp. 119-126). Springer, Dordrecht.
29. and Lord, D. A. 2002. Changes in seagrass coverage in Cockburn Sound, Western seagrass meadows of Gulf of Mannar Biosphere Reserve, India using IRS ID satellite imagery. *International Journal of Biodiversity and Conservation*, *1*(5), pp.187-193. sensing multi-spectral satellite and field data to estimate seagrass cover change in the Andaman and Nicobar Islands, India. *Ocean Science Journal*, *48*(2), pp.173-181. services and their variability across genera and geographical regions. *PLoS One,*
30. Shaaban, M. T., Ibrahim, H. A., Abouhend, A. S., & El-Moselhy, K. M. (2015). Removal of heavy metals from aqueous solutions using multi-metals and antibiotics resistant bacterium isolated from the Red Sea, Egypt. *American* Journal of Microbiological Research, *3*(3), 93-106.
31. Short, F.T., Polidoro, B., Livingstone, S.R., Carpenter, K.E., Bandeira, S., Bujang, J.S., Calumpong, H.P., Carruthers, T.J., Coles, R.G., Dennison, W.C. and Erftemeijer, P.L., 2011. Extinction risk assessment of the world's seagrass species. *Biological Conservation*, *144*(7), pp.1961-1971.
32. Sivakumar K., Johnson J. A., Pande A., Gole S., Dudhat S., Shekar S., Pathan S., Ghanekar C., Dikshit D., Magesh M. K., Rajpurkar S., Seal S., Bayyana S., Patel S.,

Saini H., Prajapati S., Hatkar P., Mehta D., Bose S., Tripura V., Christian G., Yellapu S., Sharma S., Semwal R., Pacha, A. (2020). Annual Progress Report IV (2019-20), CAMPA- Recovery of dugongs and their habitats in India: An integrated participatory approach, Wildlife Institute of India (Ministry of Environment, Forest & Climate Change), Dehradun, pp 313.

33. Subbba Rao, N.V. (2003) Indian Seashells (Part I): Polyplacophora and Gastropoda Rec. Zoo. Surv. India, Occ. Paper No. 192: i-ix, 1-416. (Published, Director, Zool. Surv. India, Kolkata) technology. *Applied Geomatics*, *5*(2), pp.167-175.
34. Thangaradjou, T. and Bhatt, J.R., 2018. Status of seagrass ecosystems in India. *Ocean & Coastal Management*, *159*, pp.7-15.
35. Tol, S. J., Jarvis, J. C., York, P. H., Grech, A., Congdon, B. C., & Coles, R. G. (2017). Long distance biotic dispersal of tropical seagrass seeds by marine mega-herbivores. *Scientific Reports*, *7*(1), 1-8.
36. Umamaheswari, R., Ramach, S. and Nobi, E.P., 2009. Mapping the extend of using Landsat sensors: Applications to conservation and ecology. *Remote Sensing of Environment*, *112*(8), pp.3455-3467.
37. Venkataraman, K., Jeyabaskaran, R., Raghuram, K. P., and Alfred, J. R. B., (2004). *Bibliography and checklist of corals and coral reef associated organisms of India* (Vol. 226). Zoological Survey of India.
38. Wabnitz, C.C., Andréfouët, S., Torres-Pulliza, D., Müller-Karger, F.E. and Kramer, Waycott, M. Duarte, C.M. Carruthers, T.J. Orth, R.J., Dennison, W.C. Olyarnik, S. 11(10): e0163091.
39. Kristensen, E., & Kostka, J. E. (2005). Macrofaunal burrows and irrigation in marine sediment: Microbiological and biogeochemical. *Interactions between Macro–and Microorganisms in Marine Sediments. Washington, DC: American Geophysical Union*, 125-157.
40. Meysman, F. J., Middelburg, J. J., & Heip, C. H. (2006). Bioturbation: a fresh look at Darwin's last idea. *Trends in Ecology & Evolution*, *21*(12), 688-695.
41. Mermillod-Blondin, F., Rosenberg, R., François-Carcaillet, F., Norling, K., & Mauclaire, L. (2004). Influence of bioturbation by three benthic infaunal species on microbial communities and biogeochemical processes in marine sediment. *Aquatic Microbial Ecology*, *36*(3), 271-284.
42. Blackburn, T. H. (1988). Benthic mineralization and bacterial production. *Nitrogen cycling in coastal marine environments*, *33*, 175-190.
43. Ingst, J. Y., & Rhoads, D. C. (1980). The role of bioturbation in the enhancement of bacterial growth rates in marine sediments. *Marine benthic dynamics*, *11*(1), 407-421.Bos, A. R., Bouma, T. J., de Kort, G. L., & van Katwijk, M. M. (2007). Ecosystem engineering by annual intertidal seagrass beds: sediment accretion and modification. *Estuarine, Coastal and Shelf Science*, *74*(1-2), 344-348.
44. Short, F. T., Polidoro, B., Livingstone, S. R., Carpenter, K. E., Bandeira, S., Bujang, J. S., & Zieman, J. C. (2011). Extinction risk assessment of the world's seagrass species. *Biological Conservation*, *144*(7), 1961-1971.
45. Thayer, G. W., Parker, P. L., LaCroix, M. W., & Fry, B. (1978). The stable carbon isotope ratio of some components of an eelgrass, Zostera marina, bed. *Oecologia*, *35*(1), 1-12.
46. Lenihan, H. S., & Micheli, F. (2001). Soft-sediment communities. *Marine community ecology*, 253-287.

47. Barnes, R. B., Richardson, D., Berry, J. W., & Hood, R. L. (1945). Flame photometry a rapid analytical procedure. *Industrial & Engineering Chemistry Analytical Edition*, *17*(10), 605-611.
48. Bojko, O., & Kabała, C. (2016). Loss-on-ignition as an estimate of total organic carbon in the mountain soils. *Polish Journal of Soil Science*, *47*(2), 71.
49. Cambridge, M. L., Chiffings, A. W., Brittan, C., Moore, L., & McComb, A. J. (1986). The loss of seagrass in Cockburn Sound, Western Australia. II. Possible causes of seagrass decline. *Aquatic Botany*, *24*(3), 269-285.
50. Cardoso, P. G., Pardal, M. A., Lillebø, A. I., Ferreira, S. M., Raffaelli, D., & Marques, J. C. (2004). Dynamic changes in seagrass assemblages under eutrophication and implications for recovery. *Journal of Experimental Marine Biology and Ecology*, *302*(2), 233-248.
51. Dugong | Species | WWF. (2020). Retrieved October 9, 2020, from https://www.worldwildlife.org/species/dugong
52. Jefferson, T. A., Webber, M. A., & Pitman, R. L. (2015). Sirenians. *Marine Mammals of the World*, 523–534. https://doi.org/10.1016/b978-0-12-409542-7.50006-8
53. Mizuno, K., Asada, A., Matsumoto, Y., Sugimoto, K., Fujii, T., Yamamuro, M.,Jimenez, L. A. (2017). A simple and efficient method for making a high-resolution seagrass map and quantification of dugong feeding trail distribution A field test at Mayo Bay, Philippines. *Ecological Informatics*, *38*, 89–94. https://doi.org/10.1016/j.ecoinf.2017.02.003
54. Padilla, J. E., & Hudson, A. (2019). United Nations development programme (UNDP) perspectives on Asian Large Marine Ecosystems. *Deep-Sea Research Part II: Topical Studies in Oceanography*, *163*, 127–129. https://doi.org/10.1016/j.dsr2.2019.05.011
55. Unsworth, R. K. F., McKenzie, L. J., Collier, C. J., Cullen-Unsworth, L. C., Duarte, C. M., Eklöf, J. S. Nordlund, L. M. (2019). Global challenges for seagrass conservation. *Ambio*, *48*(8), 801–815. https://doi.org/10.1007/s13280-018-1115-y
56. Ascherson, P. and Beccari, O., 1871. *Plantae phanerogamae marinae, quas cl.Eduardus Beccari in Archipelago Indico annis 1866 et 1867, et in Mari Rubro anno 1870 collegit, enumeratae*. G. Pellas.
57. Duarte, C. M. Kennedy, H. Marbà, N. and Hendriks, I. 2013. Assessing the capacity of seagrass meadows for carbon burial: current limitations and future strategies.*Ocean & coastal management,* 83: 32-38.
58. Fourqurean, J. W. Duarte, C. M. Kennedy, H. Marbà, N. Holmer, M. Mateo, M. A. and Serrano, O. 2012. Seagrass ecosystems as a globally significant carbon stock.*Nature geoscience,* 5(7): 505-509.
59. Geevarghese, G.A., Akhil, B., Magesh, G., Krishnan, P., Purvaja, R. and Ramesh, R.,2018. A comprehensive geospatial assessment of seagrass distribution in India.*Ocean & Coastal Management*, *159*, pp.16-25.
60. Gullström, M. Lundén, B. Bodin, M. Kangwe, J. Öhman, M. C. Mtolera, M. S. and Björk,
61. M. 2006. Assessment of changes in the seagrass-dominated submerged vegetation of tropical Chwaka Bay (Zanzibar) using satellite remote sensing. *Estuarine, Coastal and Shelf Science,* 67(3): 399-408.
62. Gunasekara, S.S. and Mishra, A.K., 2014. Mapping the coverage of seagrass meadows of Gulf of Mannar and Palk Bay (India) using Landsat ETM+ data.

63. Kendrick, G. A. Aylward, M. J. Hegge, B. J. Cambridge, M. L. Hillman, K. Wyllie, A. and Lord, D. A. 2002. Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999. *Aquatic Botany,* 73(1): 75-87.
64. Jones, B. L., Nordlund, L. M., Unsworth, R. K., Jiddawi, N. S., & Eklöf, J. S. (2021). Seagrass structural traits drive fish assemblages in small-scale fisheries. *Frontiers in Marine Science*, *8*, 354.
65. Marsh, H., O'Shea, T. J., Reynolds, J. E., & Reynolds III, J. E. (2012). Ecology and conservation of the Sirenia: dugongs and manatees (Vol. 18). Cambridge University Press.
66. Marsh, H., Grech, A., & McMahon, K. (2018). Dugongs: seagrass community specialists. In *Seagrasses of Australia* (pp. 629-661). Springer, Cham.
67. McKenzie, L. J., & Yoshida, R. L. (2012). Seagrass-Watch: Proceedings of a Workshop for Monitoring Seagrass Habitats in the Mackay Whitsunday Region, Queensland, Australia. QPWS Whitsunday Information Centre, Jubilee Pocket, Airlie Beach, 13-14.
68. Nobi, E.P. and Thangaradjou, T., 2012. Evaluation of the spatial changes in seagrass cover in the lagoons of Lakshadweep islands, India, using IRS LISS III satellite images. *Geocarto International*, *27*(8), pp.647-660.
69. Nobi, E.P., Dilipan, E., Thangaradjou, T. and Kumar, P.D., 2013. Restoration scaling of seagrass habitats in the oceanic islands of Lakshadweep, India using geospatial technology. *Applied Geomatics*, *5*(2), pp.167-175.
70. Nordlund, M.L. Koch, E.W. Barbier, E.B. and Creed, J.C. 2016. Seagrass ecosystem services and their variability across genera and geographical regions. *PLoS One,*11(10): e0163091.
71. Paulose, N.E., Dilipan, E. and Thangaradjou, T., 2013. Integrating Indian remote sensing multi-spectral satellite and field data to estimate seagrass cover change in the Andaman and Nicobar Islands, India. *Ocean Science Journal*, *48*(2), pp.173-181.
72. Pilcher, N. J., & Kwan, D. (2012). Dugong questionnaire survey project manual. *CMS-UNEP Abu Dhabi Office). Available online at: http://www. cms. int/dugong/en/document/standardised-dugong-questionnaire-project-manual*.
73. Preen, A. (1995). Diet of dugongs: are they omnivores? *Journal of Mammalogy*, *76*(1), 163-171. https://doi.org/10.2307/1382325
74. Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14. DOI: 10.1111/j.1365-2664.2009.01737.x
75. Short, F.T., Polidoro, B., Livingstone, S.R., Carpenter, K.E., Bandeira, S., Bujang, J.S., Calumpong, H.P., Carruthers, T.J., Coles, R.G., Dennison, W.C. and Erftemeijer, P.L., 2011. Extinction risk assessment of the world's seagrass species. *Biological Conservation*, *144*(7), pp.1961-1971.
76. Sivakumar K., Johnson J. A., Pande A., Gole S., Dudhat S., Shekar S., Pathan S., Ghanekar C., Dikshit D., Magesh M. K., Rajpurkar S., Seal S., Bayyana S., Patel S., Saini H., Prajapati S., Hatkar P., Mehta D., Bose S., Tripura V., Christian G., Yellapu S., Sharma S., Semwal R., Pacha, A. (2020). Annual Progress Report IV (2019-20), CAMPA- Recovery of dugongs and their habitats in India: An integrated participatory approach, Wildlife Institute of India (Ministry of Environment, Forest & Climate Change), Dehradun, pp 313.

77. Thangaradjou, T. and Bhatt, J.R., 2018. Status of seagrass ecosystems in India. *Ocean & Coastal Management*, *159*, pp.7-15.
78. Tol, S. J., Jarvis, J. C., York, P. H., Grech, A., Congdon, B. C., & Coles, R. G. (2017). Long distance biotic dispersal of tropical seagrass seeds by marine mega-herbivores. *Scientific Reports*, *7*(1), 1-8.
79. Umamaheswari, R., Ramach, S. and Nobi, E.P., 2009. Mapping the extend of seagrass meadows of Gulf of Mannar Biosphere Reserve, India using IRS ID satellite imagery. *International Journal of Biodiversity and Conservation*, *1*(5), pp.187-193.
80. Wabnitz, C.C., Andréfouët, S., Torres-Pulliza, D., Müller-Karger, F.E. and Kramer, P.A., 2008. Regional-scale seagrass habitat mapping in the Wider Caribbean region using Landsat sensors: Applications to conservation and ecology. *Remote Sensing of Environment*, *112*(8), pp.3455-3467.
81. Waycott, M. Duarte, C.M. Carruthers, T.J. Orth, R.J., Dennison, W.C. Olyarnik, S.and Kendrick, G.A. 2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the national academy of sciences,* 106(30):12377-12381.

Annexure I Media reports and Coverage

JSK Gujarati News coverage:

RNI NO. : DELHIN 2015/64915

JSK News ગુજરાતી જે.કે.એસ.ન્યુઝ

નિડર, નિષ્પક્ષ, સત્ય એટલે આમ જનતાનો બુલંદ અવાજ

FRANCHISE OF LEAD INDIA NATIONAL NEWS AGENCY & NEWS

BREAKING NEWS Social Media

UDYAM-GJ-02-0000039

ઓફિસ : HDFC બેંક સામે, જયસરદાર કોમ્પ્લેક્ષ, માણેકપરા, અમરેલી.

વિજ્ઞાન દિવસ અંતર્ગત ઓ. એન. પી પ્રાયમરી સ્કૂલ મા વિદ્યાર્થીઓ માટે અવેરનેસ પ્રોગ્રામ નું આયોજન

દેવભુમી દ્વારકા તા.૨૭/૦૨/૨૦૨૧,

વિજ્ઞાન દિવસ અંતર્ગત ઓ. એન. પી પ્રાયમરી સ્કૂલ મા વિદ્યાર્થીઓ માટે અવેરનેસ પ્રોગ્રામ નું આયોજન થયું હતું, જેમાં પક્ષી, પર્યાવરણ, પ્લાસ્ટિક, દરિયાઈ ગાય વગેરે જેવા વિષયો ઉપર સમજાવવા મા આવ્યું હતું. અને ઓફલાઈન વેબિનાર નું આયોજન કર્યું હતું. જેમાં શાળા ના શિક્ષિકા પૂજાબેન દવે એ પણ વિજ્ઞાન વિશે મહત્વ નું વિસ્તૃત માર્ગદર્શન આપ્યું હતું, આચાર્ય શ્રી જાડેજા સર એ વિજ્ઞાન ની વિશેષતા સમજાવી હતી. , ભારતીય વન્ય જીવન સંસ્થાન માંથી પ્રાચી બેન અને રોનક ભાઈ પણ આવેલ હતા.

રીપોટરઃ- વીતલ પીસાવાડીયા

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ઓખામાં દરિયાઈ ગાયના રક્ષણ માટે તાલીમ

કચ્છમાં દરિયાઈ ગાય એટલે કે ડુગોંગના સંરક્ષણ માટે કામ કરતી વાઇલ્ડલાઇફ ઇન્સ્ટિટ્યૂટ ઈન્ડિયાની ગુજરાતની ટીમે દરિયાની અંદર ગુજરાત ઓખા મરીન પોલીસ સ્ટેશનના પીએસઆઈ આર. એમ. મુંધવાના માર્ગદર્શન હેઠળ એક કાર્યક્રમનું આયોજન કર્યુ હતું. આ કાર્યક્રમમાં મરીન કમાન્ડો હાજર રહ્યા હતા. તેમને દરિયાઇ સસ્તન પ્રાણી જોવા અને નોંધ કરવા માટે તાલીમ આપવામાં આવી હતી. સાથે સાથે દરિયાઇ ગાયની નોંધણી કરવા માટે નોંધપોથીનું વિતરણ પણ કર્યું હતું.

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હર કદમ આપકે સાથ

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વિજ્ઞાન દિવસ અંતર્ગત ઓ. એન. પી પ્રાયમરી સ્કૂલ મા વિદ્યાર્થીઓ માટે અવેરનેસ પ્રોગ્રામ નું આયોજન થયું હતું, જેમાં પક્ષી, પર્યાવરણ, પ્લાસ્ટિક, દરિયાઈ ગાય વગેરે જેવા વિષયો ઉપર સમજાવવા મા આવ્યું હતું. અને ઓફલાઈન વેબિનાર નું આયોજન કર્યું હતું. જેમાં શાળા ના શિક્ષિકા પૂજાબેન દવે એ પણ વિજ્ઞાન વિશે મહત્વ નું વિસ્તૃત માર્ગદર્શન આપ્યું હતું , આચાર્ય શ્રી જાડેજા સર એ વિજ્ઞાન ની વિશેષતા સમજાવી હતી. , ભારતીય વન્ય જીવન સંસ્થાન માંથી પ્રાચી બેન અને રોનક ભાઈ પણ આવેલ હતા.

દેવભૂમિ દ્વારકા થી વિતલ પિસાવાડિયા

સંતોષ ટી & દુધ ડેરી
મો.૯૮૨૪૮ ૨૦૯૧૮
મો.૯૯૦૪૧ ૨૯૩૨૩
ન્યુ બસ્ટેન્ડ સામે માંગરોળ ૩૬૨૨૨૫

Andaman Chronicle: http://www.andamanchronicle.net/index.php/20559-when-dugong-meets-the-islanders-a-republic-day-to-remember

When Dugong Meets the Islanders: A Republic Day to Remember!

Denis Giles – 27 January 2021

Port Blair, Jan 27: On the auspicious occasion of the 72nd Republic Day of India, the CAMPA_Dugong team of the Wildlife Institute of India (WII) took their dugong awareness program, a step ahead. This time neither the stakeholders were chosen, nor did the program happened in a close knit setup with limited participants, as the dugong researchers took it by the Sea! And which place would have been ideal, other than the Flag Poin at Marina Park-Port Blair, where our tri-color proudly sways with the wind!

Dugong researchers from the Wildlife Institute of India, Dehradun have been sensitizing different

सत्यमेव जयते

भारतीय वन्यजीव संस्थान
Wildlife Institute of India