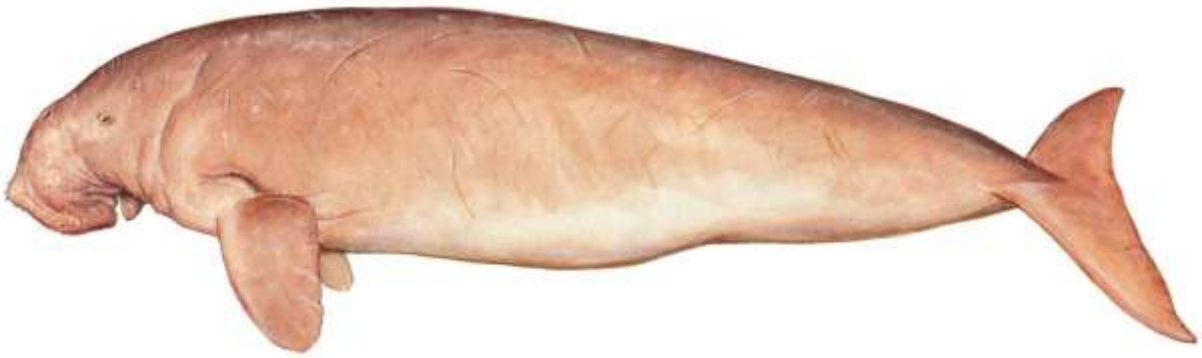

REPORT ON THE SURVEY OF
DUGONGS AND SEAGRASS
OF GULF OF MANNAR
2016 -2018

ORCA

The document is an expanded version of the final report of the Dugong and Sea grass survey carried out In the Palk Bay and Gulf of Mannar area- Sri Lanka, "Increasing knowledge on sea grass habitats and dugong distribution at selected sites in North Western Sri Lanka" (project LK6) Implemented by Ocean Resources Conservation Association (ORCA) under the The GEF DUGONG & SEAGRASS CONSERVATION PROJECT 2015 to 2018

ORCA
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RESOURCES
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ASSOCIATION

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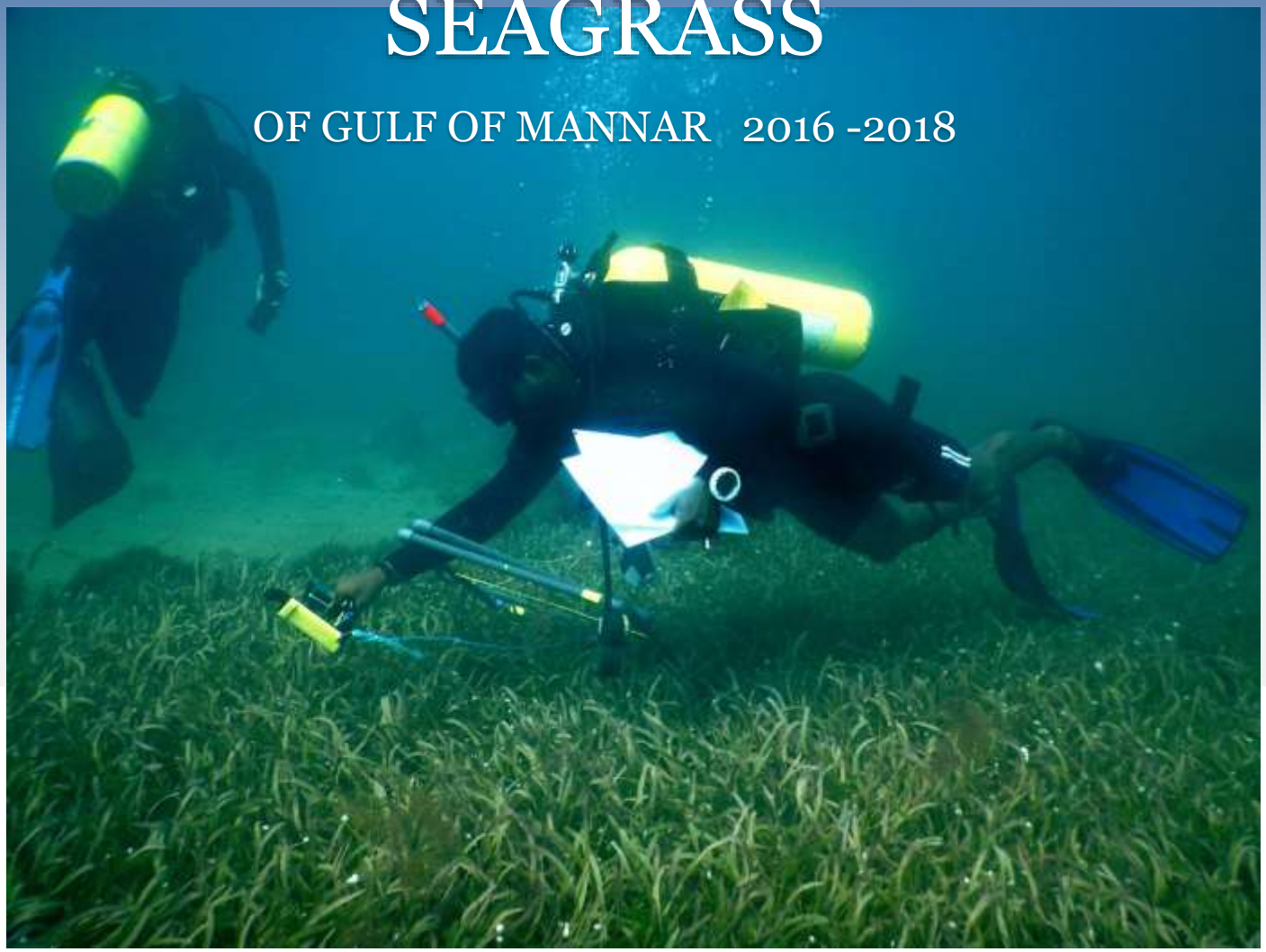

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OCEAN RESOURCES CONSERVATION ASSOCIATION-ORCA

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The GEF DUGONG & SEAGRASS CONSERVATION PROJECT

Enhancing the Conservation Effectiveness of Seagrass Ecosystems Supporting Globally Significant Populations of Dugongs Across the Indian and Pacific Ocean Basins

Funded by GEF/UNEP/ CMS/ Mohamed bin Zayed Species Conservation Fund"

*** Released to public as an ORCA E-Publication in 2026 ***

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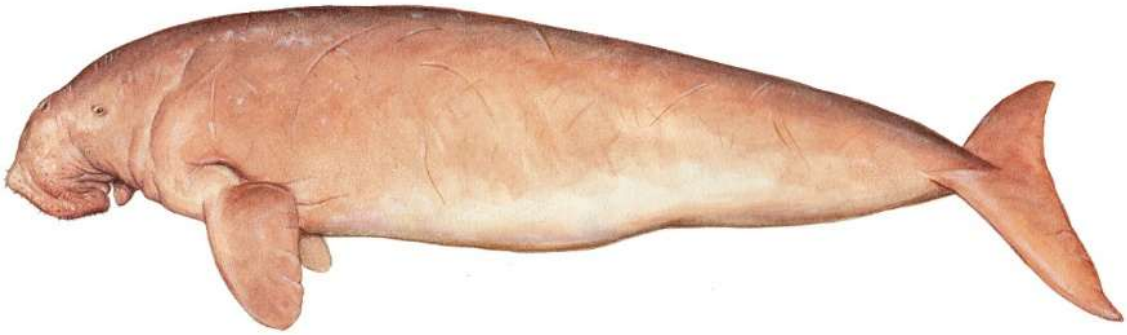

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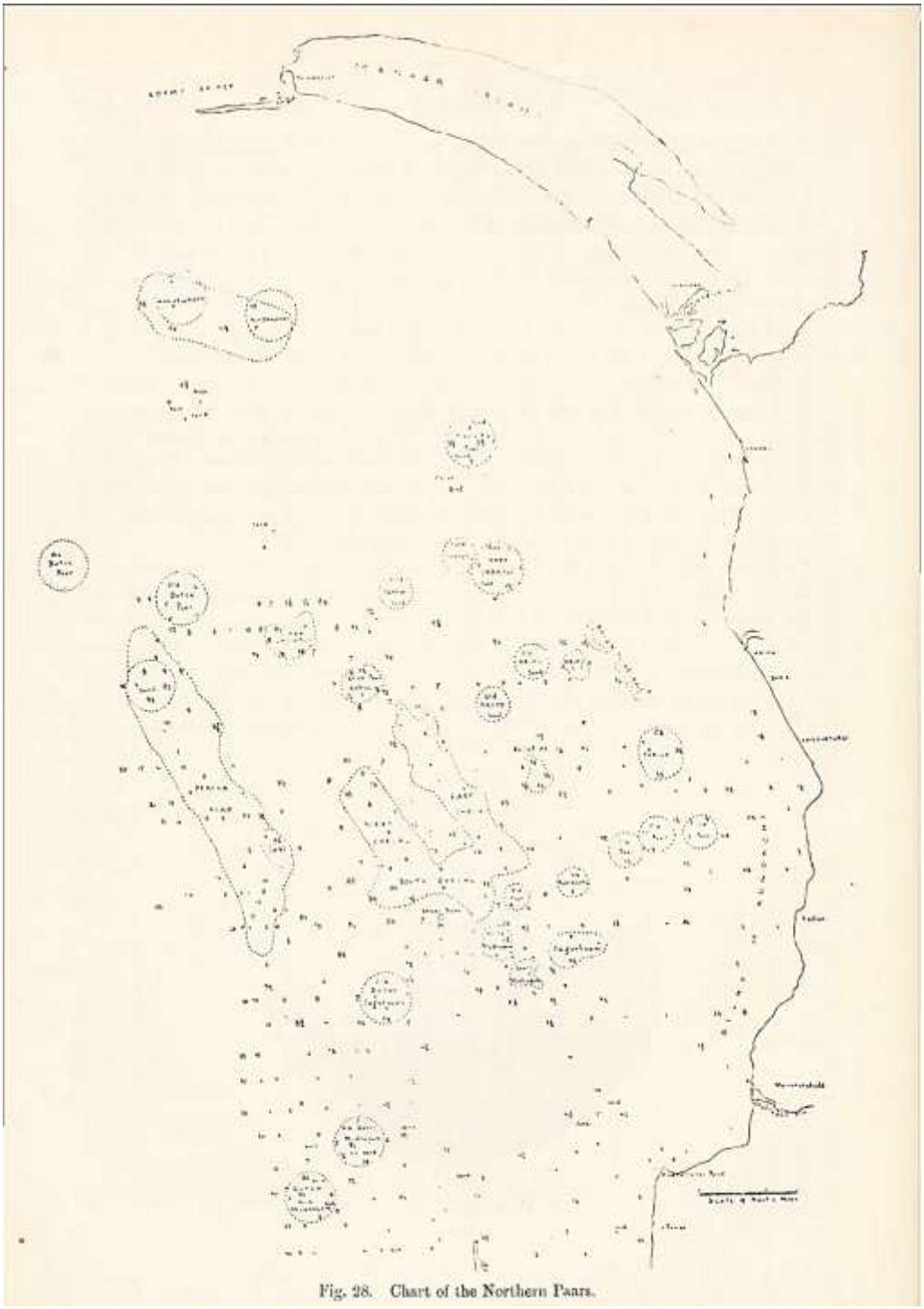


Fig. 28. Chart of the Northern Paars.

Historic map of the Northern Paars from Kudiramale pt. to Arippu from the "Report to the government of Ceylon on the pearl oyster fisheries of the gulf of Manaar" 1903

REPORT ON THE SURVEY OF DUGONGS AND SEAGRASS OF GULF OF MANNAR-ORCA-2016-2018

Prasanna Weerakkody, Samantha Suranjan Fernando, K.Lakmal , Sajith Subhashana, Nuwan Peduru-arachchi

Increasing knowledge on sea grass habitats and dugong distribution at selected sites in North Western Sri Lanka

Introduction

The Dugong is the most highly threatened large mammal in Sri Lanka. It is also the least known and understood of Sri Lankan large mammals. the primary records indicated that the North-western Sea board between Kalpitiya and Jaffna and stretching over the wide continental shelf that connects Sri Lanka and India through the Palk Bay and Gulf of Mannar is the last known habitat for the now scattered remnant Dugong herds that seem to have travelled these seas in herds of over 200 in the mid 1970's

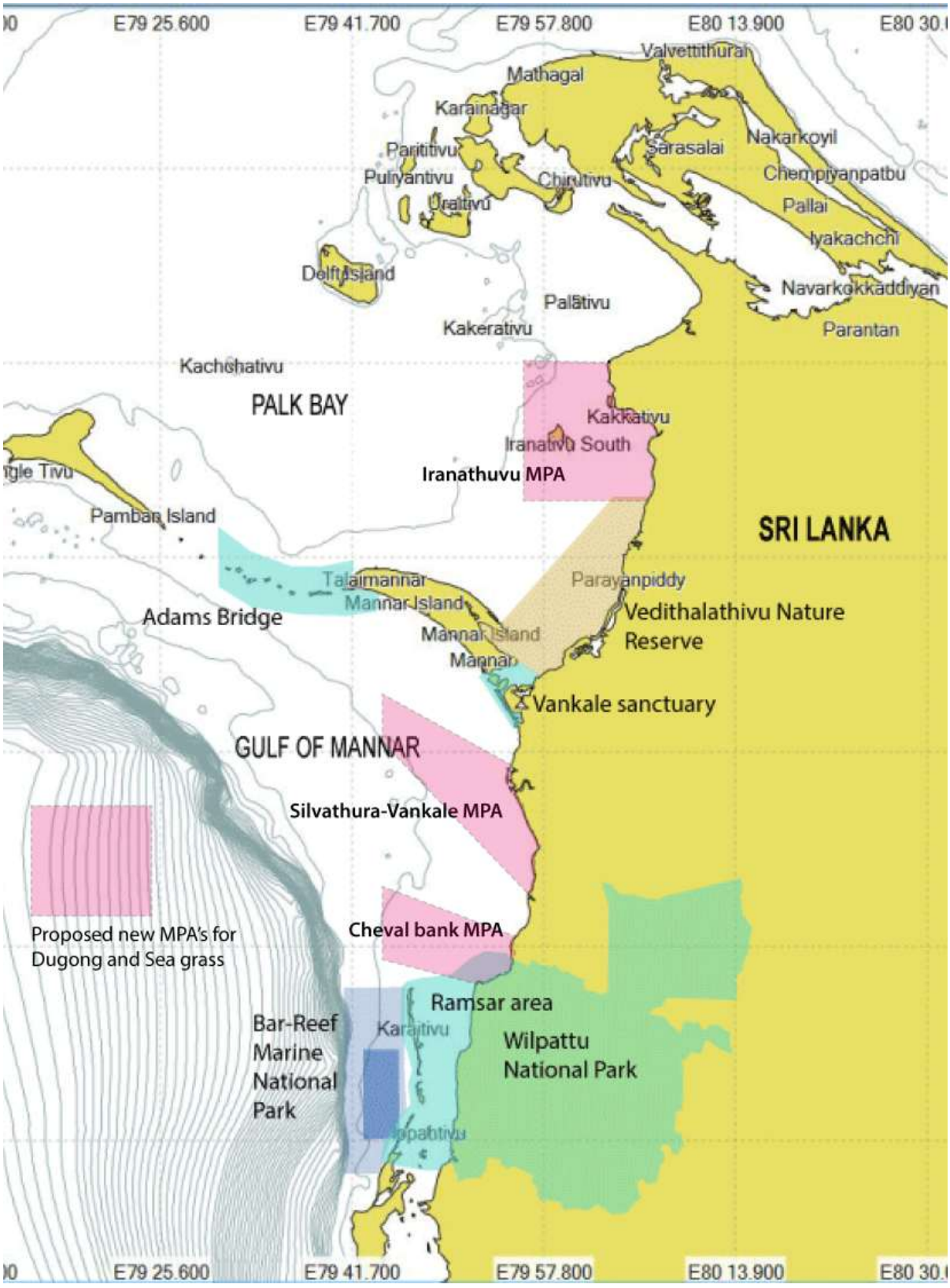
The 30-year war had made this zone un-accessible to all but the military activities; limiting fisheries activities to coastal areas. The War situation was a blessing for most marine species including the Dugong and coral reefs etc. as it had created an un-official sanctuary where they would grow breed and prolifer with minimal human impacts.

Few incidental records of Dugongs being caught and brought ashore or few records from sources within the armed forces was all that was known of these animals during this period.

In the post war era, the area is increasingly coming under human pressure as all fishing restrictions that were in place has been lifted and major development activities from tourism to increased agricultural runoff to Oil drilling activities are threatening the regions bio-diversity. The re-settling of the coastal communities who had sought refuge in the south during the war and expansion of fishing activities including destructive fishing practices including Bottom set gill nets, Blast fishing, modified illegal purse seine net operations and Bottom trawling have become major threats to the recovering population of Dugong among other marine species.

The Dugong when encountered is still considered a valuable commodity as its meat is highly priced which would lead to high number of kills of the encountered animals.

The Palk-bay/ Gulf of Mannar region contains the most extensive areas of Sea grass habitats in Sri Lanka. the sea grasses are important foraging grounds for the Dugong and sea turtles and a host of other organisms including many fishery important fin fish species. the Sea grass meadows are also important nursery grounds for animals and also contribute significantly in stabilizing the substrates and preventing erosion during the rough seas during the Monsoon periods. They are also important as carbon sinks and as a major source of primary production.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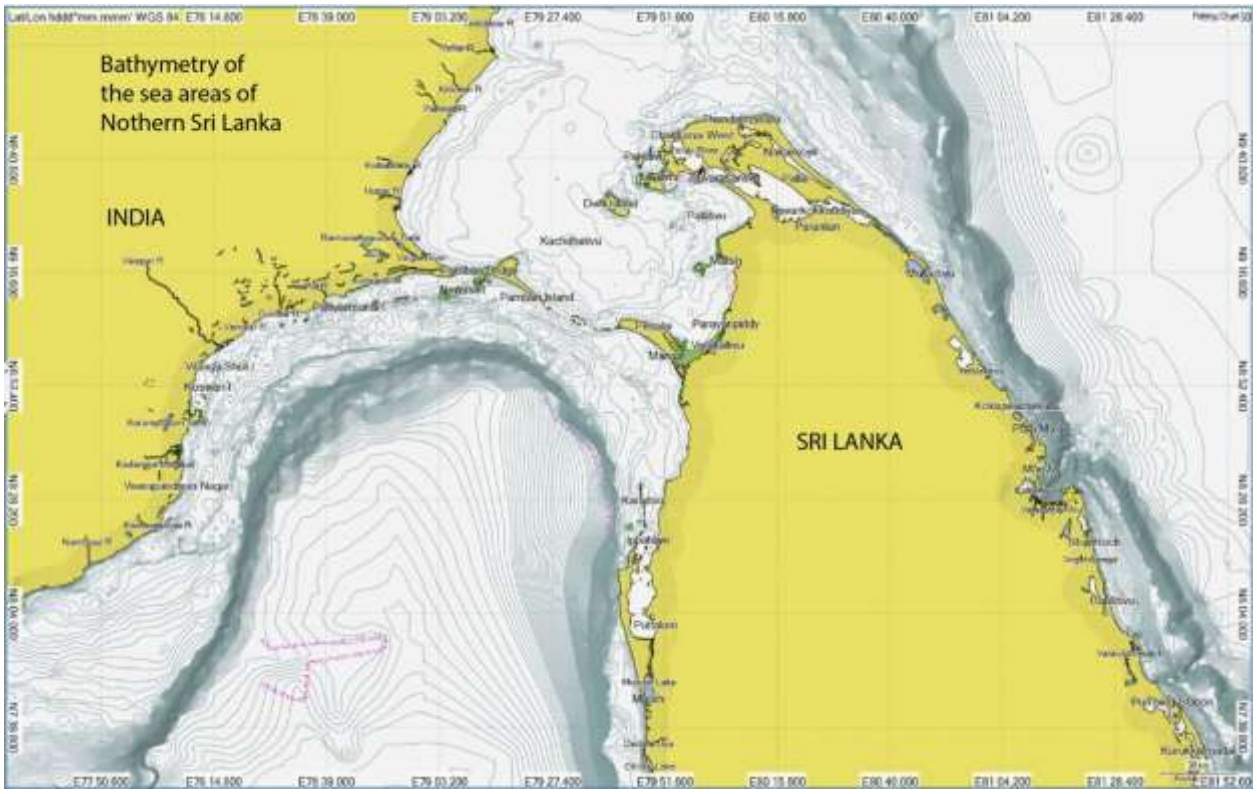
Valvettithurai
Mathagal
Karainagar
Nakarkoyil
Sarasalai
Parititivu
Puliyantivu
Chiruttivu
Chempiyanpatbu
Uraitivu
Pallai
Iyakachchi
Delft Island
Navarkokkaddiyan
Palātivu
Kakerativu
Parantan
Kachchativu
PALK BAY
Kakkativu
Iranativu South
Iranathuvu MPA
Pamban Island
SRI LANKA
Talaimannar
Mannar Island
Parayanpiddy
Adams Bridge
Vedithalathivu Nature Reserve
Mannar Island
Mannar
Vankale sanctuary
GULF OF MANNAR
Silvathura-Vankale MPA
Proposed new MPA's for Dugong and Sea grass
Cheval bank MPA
Ramsar area
Bar-Reef Marine National Park
Karaitivu
Wilpattu National Park
Ippalitivu
E79 25.600
E79 41.700
E79 57.800
E80 13.900

Existing and Proposed Marine Protected area of the project area

MPA	Date of Declaration	Extent (hectares)	
Wilpattu National Park	1938.02.25	131,667.1	(coastal/ terrestrial)
Adams bridge National Park	2015.06.22	18,990	Marine
Delft National Park	2015.06.22	1,846.28	Marine
Vedithalathivu Nature Reserve	2016.03.01	29,180.00	Marine
Vankalei Sanctuary	08.09.2008	4,839.00	Marine
Bar-reef Sanctuary	1996	1,285.4	Marine
Chaval bank MPA	Proposed	200 (aprx.)	Marine
Arippu-Vankale MPA	Proposed	30000 (aprx.)	Marine
Iranathivu MPA	Proposed	400 (aprx.)	Marine

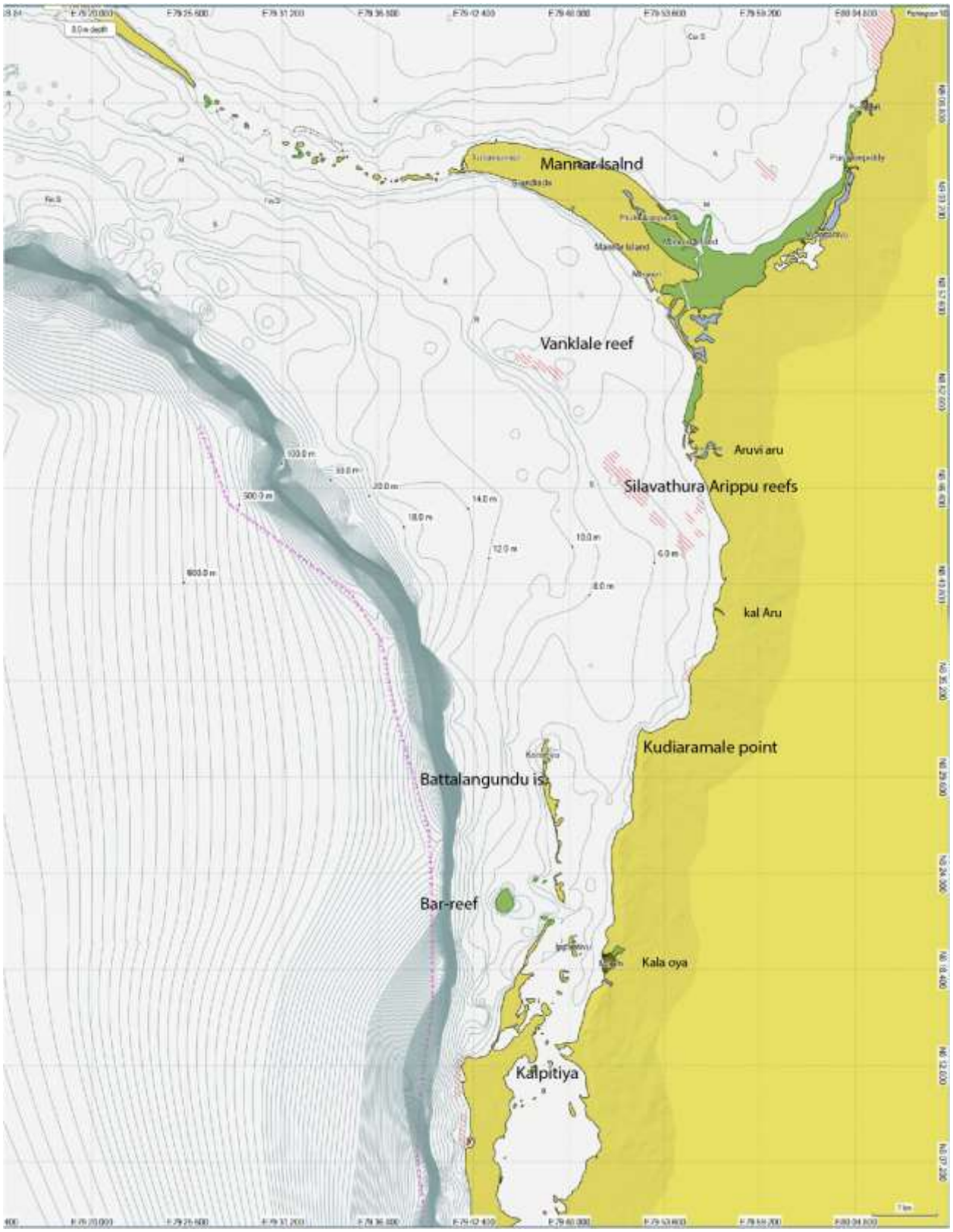
Bathymetry of The Palk Bay and Gulf of Mannar

The sea bed of the Gulf of Mannar and Palk Bay forms an extensive area of shallow seas stretching across the continental shelf areas spread between the North West coast of Sri Lanka and the South Eastern Indian coast encompassing the Hanuman's/Adam's Bridge of shallow shoals that connect between the Mannar Island and Pamban island in India. The primary feature of the region is the vast relatively flat sea floor that is of shallow depths thorough most of its area. This feature provides ideal conditions for the proliferation of extensive sea grass beds.



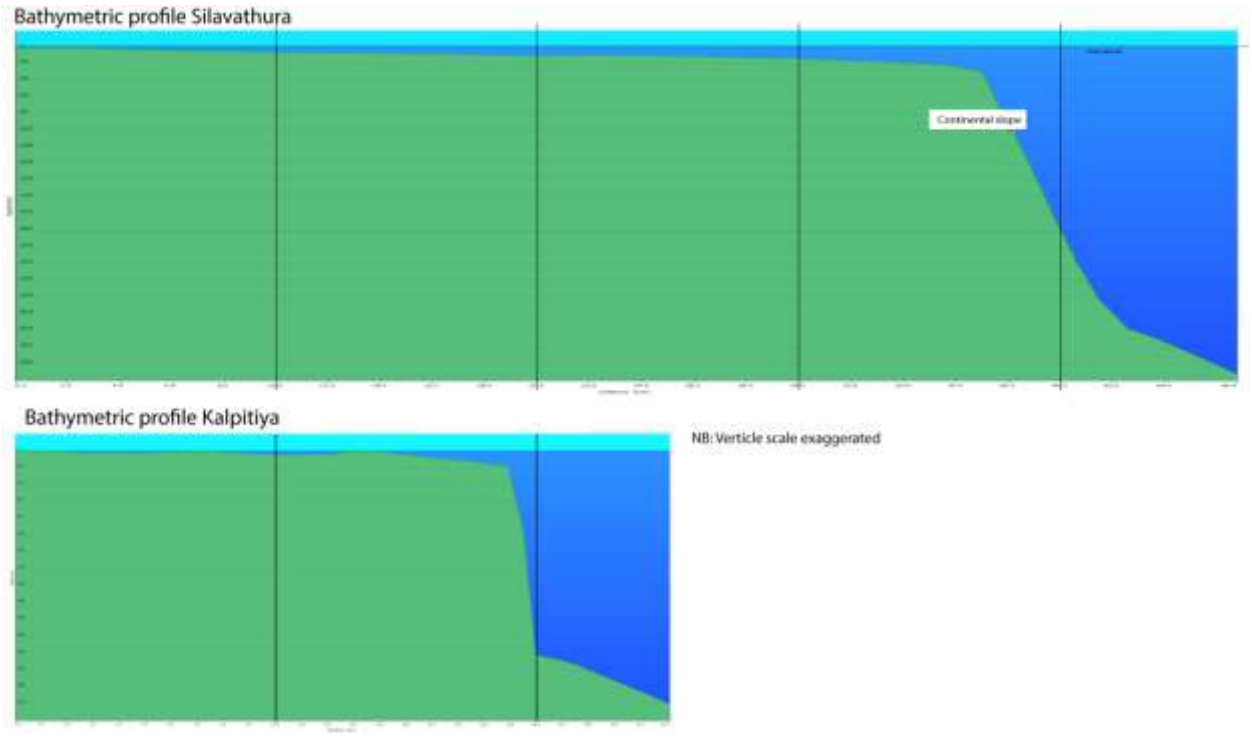
Bathymetry and depth profile of the Gulf of Mannar and Palk Bay showing the morphology of the continental shelf joining Sri Lanka and India.

The survey area began in the South encompassing the Northern part of the Puttalam lagoon and extend outward to include a section of the sea including the Bar-reef Marine Sanctuary and up to the continental shelf edge which is important as a area of high diversity and abundance of Marine Mammals and other off shore fauna. Extending Northward to the Mannar Island. Few samples were carried out in the area North of Mannar Island extending up to Iluppakadavi.



Bathymetry of the survey area

Depth profile of seafloor Gulf of Mannar. (Vertical profile exaggerated)



The submarine geography / bathymetry of the Kalpitiya seas is the key to the high abundance and diversity of Marine Mammals in the area. On one side the carving in of the continental shelf in between the South Indian headland and North West Sri Lanka terminating below the Mannar land bridge brings in an effective deep oceanic water cove close to kalpitiya and Mannar area. The predominant oceanic currents of the open Indian Ocean driven by South westerly Monsoons would drive against the walls of this bathymetric formation resulting in formation of an up-welling area in the sea that feeds a key food chain and may be the focus of many marine life aggregations observed in the area at that time including whales, sea birds and fishes. The Continental shelf is very narrow around Talawila and Kandakuliya headlands reaching in as close as 3-5km. from shore. The continental slope is also very steep in the area causing a sudden drop off allowing most Whales and Marine mammals to approach close to the coast while still staying in the safety of the deep oceans and make quick forays over the shelf to feed in shallower seas.

Beyond the Kudiramale headland and Battalangundu Island the continental shelf widens abruptly and joins with the Indian sub-continent shelf forming a vast plateau of shallow seas expanding throughout the Palk-straight and Gulf of Mannar extending past Jaffna and along the Eastern Sea board of India.

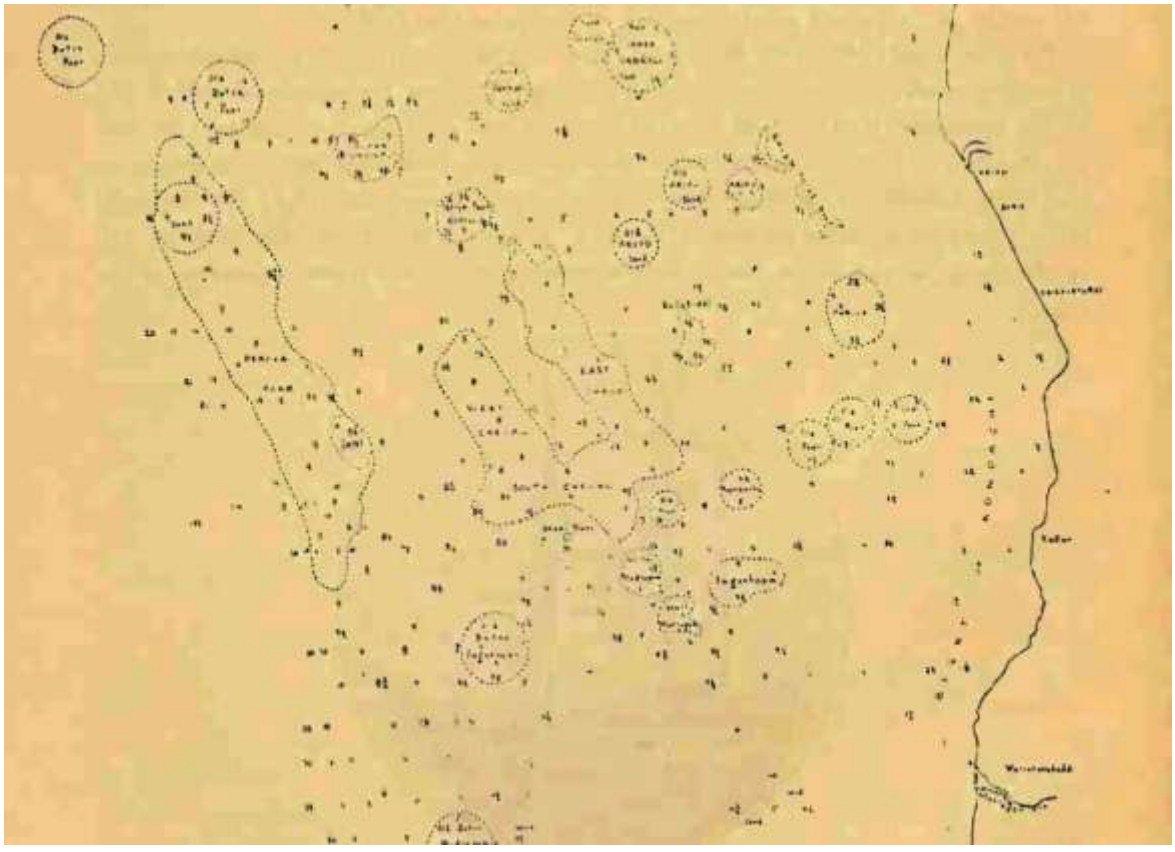
The sea floor over most of this area range from 4-14. m. Depth. The 20 m. depth contour which forms the continental shelf edge over most of the area ranges from 2.7km. from shore at Kandakuliya and reaches out to 10.5km at Uchchimune, 32km. at Silavathura and 35 km. from Mannar island.

The sea floor is composed primarily of Sandy/ muddy sea floors.

The vast shallow sea areas contain extensive sea grass habitats dominated by Sea grass genera Oceana/*Cymodoce, Halophila, Syringodium, Halodule* etc. These extensive seagrass beds provide important habitats for Sea turtles, Rays, and the rare and the last remnant populations of the endangered Dugong and Saw-fishes which are now near extinct in the region.

Several important coral reef are located within the survey area including the Bar-reef at Kalpitiya, Silavathura reef, Arippu reef and the Vankale reef. The Vankale reef is highly degraded as a result of past coral bleaching mortality events and excessive blast fishing activities by locals. The Bar-reef which was a prime coral reef in the western sea board of Sri Lanka was affected by the 2016 Coral bleaching event and has suffered catastrophic coral mortality. The Silavathura and Arippu reefs which also suffered severely during the 1998 coral bleaching event has recovered significantly and remain the best surviving reefs in the area. Coral reefs are also found in the Palk Bay area on Maldiva bank, Iranathivu, Erumathivu and near Jaffna islands.

Seas around Kalpitiya are considered a global hotspot for Marine Mammals including some of the largest aggregations of Sperm whales globally. Over 17 species of marine mammals have been reported from the seas around Kalpitiya and Mannar. The area is also of importance for the migratory sea turtles contributing to the Arribada' in Orissa India and also seasonal sea bird migrations during months of April and August. Significant aggregations of Sea birds are also documented in the area including coastal species including Gulls and Terns and Oceanic Sea birds including Shearwaters, Petrels, Storm petrels and skuas.



Historic maps of the area showing the system of banks composing the Cheval bank complex

Satellite imagery of the area showing key submarine features including the Reefs and Paars composed mainly of sea grass and location names used in the report. The Cheval banks located North of Battalangundu Island and Kudiramale point becomes the most prominent and extensive Sea grass ecosystem in the Gulf of Mannar.

Project activities and findings

Community information gathering on Dugong

Significant data sets based on community interviews had been collected through an activity conducted under UNEP-CMS in these areas conducted by TCP, IUCN and Dilmah Conservation In the run up to the current project and contained valuable information that was used as a starting point. This data set was limited in key areas as the point sources of Dugong records based on community interviews were limited to coastal fishery village locations of the landing site indicated. No data was available of the Sea locations of the Dugong encounters in the UNEP-CMS data sets. It is to be noted that Significant number of fishermen of the area regularly carries small hand-held GPS units for navigation and keeps track of basic locations through GPS coordinates and the information would have been available with the fishermen.

In Assessment of CMS/UNEP data sets and collection protocol the team identifies several areas of inadequacy and practical issues which prevented the data collection method to be efficient in the Sri Lankan situation.

A decision was made by ORCA team to break from the standard methodology and carry out the activity as an informal dialog with local communities aiming at building a relationship with key local informants within each community. Though this approach lacked formality and a set of extensive data sheets but focused more on getting a larger set of more reliable information of key data elements as kill events, locations and times.

The very preliminary nature of the Sri Lankan knowledge situation within the geographic area and almost nonexistent baseline information forced the team to opt from standard data collection that would yield better statistical results to a more open method that would collect more reliable data. The team initially was met with a blank wall where most locals would deny even seeing a dugong in recent times, opening up with information only after multiple visits and building trust with time spent with them. It was a key fact that rapid surveys of this nature were not going to be productive. It was also noted that the data on seniority of a local was not a guarantee of reliable reporting as in some events where the adult population would repeatedly lie indicating no kills had been documented in recent decades while local children readily recognized Images of Dugong and came up with information of Dugong kills, it was an extremely successful approach to achieve the primary target of securing open information pathway and collection of a significantly high number of Dugong kill/Encounter records. The team realized that most of the records whether they were directly reported as kills or sightings were most often comprised of kills and the informants were often involved in the kills. A decision was made to be neutral to the illegality of the kills and promoting prosecution of culprits during the project duration as it was deemed more important to establish the killing and kill processing pattern, type of fishing gear used, areas of high incidence of kills and Dugong encounters etc.

All interviews were carried out by ORCA staff sometimes with assistance of language interpreters where the fishing communities were primarily Tamil speaking. The community survey crews were also engaged in field surveys and had a good knowledge of the sea, geography of the area and fishing practices of local communities from previous experience which helped to understand and focus the interviews better.

community interview survey was carried out to document information of the records Dugong sightings and reports of Kills and community knowledge of the areas of Sea grass occurrence in the region

Total of 257 local individuals were interviewed on 86 days of community surveys carried out on 61 coastal locations.

While almost all kills/encounters were from fishermen operating from small boats it was clear that the kill/ encounters were not local to the coastal fishery harbor sites where the interviews were made. some had ventured over large distances and the fishing pattern has no correlation between landing site and capture/sighting location. Regularly the encounters were documented 10-30km off shore from the fishing wadi (camp). Few instances were recorded where Dugongs were caught in Beach operated seine nets which would be laid to encompass an area at most 1-1.5km (rarely 2 km.) from shore.

It was also noted that the origin of the fishermen and the landing site of the killed dugong was not always the same. In the event of an illegal Dugong kill they would more likely take it to one of the more remote, isolated fishing camps (wadi) and butcher and distribute the meat from there rather than risk bringing it to home port and risk detection by Navy or other authorities.

Often repeated reporting of the same kills by different parties from different fishing wadi was found and needed to be verified and sorted to clear duplicates. The additional recordings of the same event provided verification of the kill/encounter.

Historic maps of the area were studied primarily from the “Herdman Reports” (W. A. Herdman D.Sc, F.R.S., 1903., “Report to the Government of Ceylon on the Pearl oyster Fisheries of the Gulf of Mannar”. The Royal Society. London). That indicated a series of extensive submarine banks in the area. The tracings of the old maps coincided with features on Satellite imagery collected from public domain sources including Google Earth. The resultant base map was used to guide identification of bathymetric features to identify a preliminary sampling plan.

A base map of the locations of the Dugong encounters was devised based on the information collected from community sources. There were some limitations in the data available which needed to be taken in to account in creating maps. While some of the location data provided by villagers was directly from GPS units and provided good accuracy other sources were of a more general nature vis: "10km south of "South-Bar fishing camp" beyond the vankale reef" etc. Most GPS fixes were of a lower resolution but this was not of too much concern as Dugongs were expected to be present in an area rather than a specific location.

A preliminary survey plan was formulated based on the constructed maps giving prominence to the bathymetric features including the submarine "banks / Paars" of the Cheval complex and reported locations of dugong encounters

Field surveys

Field surveys were carried out using locally hired fishing boats as the geographic area was large it was not practical to move a single boat from site to site. Also, this gave the advantage of having a local familiar with the general area as the boat operator to guide the crew to locations and would often become good local contacts in acquisition of information on sea grass beds as well as Dugong reportings.

The traverses were planned based on the assembled Strategic Base maps. Within pre identified strata survey transects were carried out assisted by Side scan sonar used to monitor sea floor profile and identify possible presence of sea grass. Spot sample were carried out in areas of interest identified by Side scan sonar imagery. Spot sampling was carried out by a snorkel diver spot checking and collection of general information of species present at site. In highly turbid days a grab hook was used to carry out spot samples. Random detail samples were carried out in representative strata using SCUBA dives. The general data on bottom features, Biodiversity were recorded and Substrate composition was sampled using 3 x 0.5m. quadrates deployed randomly.

The Side scan sonar unit used extensively by the team was able to pick up large fish and other marine animals. And on several events made detections of probable Dugong encounters.

The field teams were able to collect about 108 records of Dugong kills/encounters during the project activities with 49 records for the time period between 2015 and 2018. 4 visual records of Dugongs at sea were documented during the survey but constituted very brief sightings only without any opportunities for photo documentation. Additional possible encounters were collected from Side scan sonar tracings which depicted Dugong like sonar signatures, Dugong presence in the survey area was also documented by the observation of Feeding scars on Sea grass beds in several locations.13 records of confirmed Dugong kills were documented in 2016 the year where the field community data collection was fully active throughout the year.

A total of 255 samples were carried out including 166 sites with sea grass samples (65% success)

A total 34 of detail samples with quadrates were carried out using SCUBA diving gear on sea grass within the sampled areas.

Substrate /Seagrass Survey

Stratified Random Sampling method was used for selection of the sampling area. Strata were defined using assessment of historic maps overlaid with satellite imagery.

A preliminary survey plan was devised based on the constructed maps giving prominence to the bathymetric features including the submarine “banks” of the Cheval complex and reported locations of dugong encounters.

Consideration had to be given to the scale of the area to be surveyed (Over 2000 Sq Km.) and depths of over 10 m. with limited number of sampling days available the sampling had to be of a lower resolution representative of the area to be sampled.

Within pre identified strata survey Boat transects were carried out assisted by Side scan sonar to identify possible presence of sea grass. Spot sample were carried out in areas of interest identified by Side scan sonar imagery. Random detail samples were carried out in representative strata using SCUBA dives. The general data on bottom features, Biodiversity were recorded and Substrate composition was sampled using 3 x 1m. quadrats deployed randomly.

The use of spot samplings added to the number of points that could be carried out to supplement the Quadrat surveys carried out using SCUBA dives. The number of SCUBA dives that could be carried out was rarely more than one per day due to the significant travel distances to survey sites constrained practical field time to work within safety limits for the team. The spot samples were carried out by a snorkel diver doing free diving to spot observe the location or in muddy water using a grab sample to determine the content. The spot samples are not fully reliable for small leaved inconspicuous varieties (Halophila etc.) as during the short duration of the bottom observation the snorkeler could easily miss documenting small species.

Seagrass Watch –Guidelines for rapid assessment and mapping of tropical sea grass habitats. McKenzie, L.J. 2003 was followed to design survey plan for the project.

The Survey sampled 255 locations sea substrate including 166 sea grass locations and carried out quadrate samples at 34 locations.

This survey stands unique among most Sea grass surveys in Sri Lanka where sea grass surveys are limited to the shallow seas along the coast and lagoon systems. This survey was carried out to primarily sample the extensive off shore sea grass beds of the Gulf of Mannar extending over 30km from the shore and down to depths of over 20m.

During the survey 9 species of Sea grassed were found in various depths from 0.5 m to 14m

- *Oceana serrulata (R.Brown) Byng & Christenh. Ex (Cymodocea serrulata)*
- *Cymodocea rotundata* Asch. &Schweinf.
- *Syringodium isoetifolium* (Asch.) Dandy
- *Halophila ovalis* (R.Br.) Hook.f.
- *Halophila decipiens* Ostenf.
- *Halophila stipulacea* (Forssk.) Asch.
- *Halodule uninervis* (Forssk.) Boiss.
- *Thalassia hemprichii* (Ehrenb. ex Solms) Asch.
- *Enhalus acoroides* (L.f.) Royle

One new species of sea grass was added to the list of Sea grass species documented for Sri Lanka. The species *Halophila stipulacea* was not previously recorded from Sri Lanka and during the survey the team documented the species from 15 locations ranging from Kalpitiya to Vedithalathivu.

As a bonus a large collection of Sea grass specimens were collected, Herbarium specimens produced and deposited at the National Herbarium in the Peradeniya (PDA). A total of over 200 specimens of sea grass along with a collection of algae were handed over to the herbarium. This is of national importance as the existing Sea grass collection at the National Herbarium was insignificant. The collection will be of use to all future marine botanists in the Country.

A paper is under preparation for the documentation of a new record of sea grass species *Halophila stipulacea* in Sri Lankan waters.

Dugong survey

Total of 257 local community individuals were interviewed on 86 days of community surveys carried out on 61 coastal locations.

The field teams were able to collect about 108 records of Dugong records during the project activities with 49 records for the time period between 2015 to 2018. ORCA teams were able to record sightings of Dugongs at sea on 4 occasions within the Battalangundu -Cheval bank areas and near the Bar-reef Marine sanctuary in Kalpitiya. The observations were all brief and the team did not have an opportunity to photo document the specimen. The team also recorded instances of feeding scars on sea grass beds at Cheval banks and near Arippu reef. Both scars were old and new sea grasses were beginning to re grow over them. Possible Dugong signatures were detected on sonar on 3 occasions but the team could not verify the records in any direct means. The image tracing was documented on Sonar recordings on one occasion.13 records of confirmed Dugong kills were documented in 2016 the year where the field community data collection was fully active throughout the year.

The survey identified several “Hotspots” for Dugong where High numbers of Dugongs were killed or encountered in fishing activities and was identified as the Key areas of focus for management of fishery practices of concern for Dugong.

The Bottom set gill nets for rays was Identified as the primary cause of Dugong mortality in the area amounting to over 90 percent of the reported by-catch of Dugongs. Other fishing gear that was used in Dugong killing included Fixed trap nets (Fyke nets), Beach seine nets, Bottom trawl nets, Blast fishing and Harpooning.

General GIS maps were created of the data collected and were provided to project partners DWC and IUCN and were extensively used in designing the proposed protected areas for conservation of Dugong and Sea grass within the area. The processes of identification of the proposed areas were collectively carried out by DWC/IUCN and ORCA teams. The data collected by ORCA and regularly supplied to the project partners had become the baseline information on which management activity programs of DWC and IUCN was based on.

The project produced GIS maps of the findings and the data collected and were provided to project partners DWC and IUCN and were extensively used in designing the proposed protected areas for conservation of Dugong and Sea grass within the area. The processes of identification of the proposed areas were collectively carried out by DWC/IUCN and ORCA teams. The data collected by ORCA and regularly supplied to the project partners had become the baseline information on which management activity programs of DWC and IUCN was based on.

The collected data was analyzed for trends and results and was used to create GIS maps that would be used to plot the distribution of Sea grass beds in the area and Ground truth the satellite image maps.

Constraints

The project encountered problems in carrying out surveys in the Sea area North of the Mannar Island in to the Palk Bay area as the sea conditions were elusive and not favorable for diving activities. While this is an important area the project could only conduct very few surveys in this area while carrying out surveys in a significant area of the Gulf of Mannar between The Mannar Island south ward to Kalpitiya. The survey sampled an area of about 2000sq km. mostly within the Gulf of Mannar area up to a distance of about 20 km. offshore.

The Security requirements were significant in the area due to the nature of the recently concluded war situation in the area. In addition to the permissions from the Department of Wildlife Conservation Security clearances had to be obtained from the Ministry of Defense for the survey and from the NAVY for each survey activity to work, and carry and operate the survey equipment at sea. The requirement caused additional restrictions and time constraints for the team to engage with the NAVY on each trip and secure field clearances before venturing out to sea.

Dugongs

The Dugong is locally known as “Muhudu Ura” in Sinhala and “Kadal Pandi” or “Avariya (Avaliya)” in Tamil.

Based on information provided by community members and the records collected by the team it was observed that on average one dugong per month was being killed often as by catch in the Bottom set gill nets used to catch Rays (Madu dal). In addition to the “Ray” gill nets Dugongs were also caught in other fishing gear including the Fyke nets which are large trap nets deployed upto 10 km. from the shore and Beach seine nets. Deliberate hunting of Dugong was carried out using dynamite Blast fishing or rarely using harpoons (Mandawa). Bottom trawl operations by both Sri Lankan fishermen and Indian poachers are of concern, some instances of Dugongs being caught in Illegal “Leila”and “Surukku” modified purse-seine net operations are also suspected.

The trade in Dugong meat is very lucrative. The high demand for Dugong meat makes it easy to sell as well as fetching high prices. A Large individual can fetch over Rs.600,000 (4000USD)at the point of selling it off on the beach.

The extensive shallow seas that stretch between Sri Lanka and India contain vast seagrass fields and form the home range of the Dugongs who may freely range between the two countries. In Sri Lanka the records indicate that the Dugongs are widespread in distribution across the range. They are now less frequently encountered in populated coastal areas where they were known to previously be regularly seen; including the Kalpitiya lagoon. Early records indicate that on occasion Dugongs have been known to enter river estuaries in Kala oya at Gangewadiya and around Devils point. Most present-day records indicate that the dugongs’ main range is found in the areas of the Cheval banks and along the Arippu- vankale reef ridge. High incidence of Dugong sightings are also reported closer to shore at Iranathivu island. Between Maldiva bank and Vedithalathivu, and on the Northern coast of Battalangundu Island at the entrance to the Puttalam/ Kalpitiya lagoon. The reports of several Dugongs being caught in coast operated Beach seine (Ma-dal) operations indicate the possibility that the Dugongs approach the coast as close as 1-2 km. from the shore.

The present data on Dugong distribution is based on kills or encounters between Fishermen and Dugongs and would indicate the areas of highest overlap of fishing activity with the range of the Dugongs. Higher concentrations of Dugong may exist in further offshore areas where the lower level of encounters documented would result in collection of lesser number of records.

In Sri Lanka the Dugong has proven to be shy of human contact and rarely staying at the surface of the sea when spotted. Most reported observations are very brief. This makes observation and positive records of dugongs at sea very difficult. Most Dugong encounters are of Solitary animals or pairs while few instances of larger pods of over 5 animals have been documented.

Investigations of gut content analysis of killed Dugongs carried out by NARA (pers com. Dr. wasantha Pahalawattarachchi/NARA) indicate they have been feeding on mixed assemblages of Sea grass.

Sample 1 Contained 99% *Halophila*

Sample 2 Contained 48% *Halodule*, 47% *Halophila*

Sample 3 Contained 67% *Oceana*/*Cymodocea*, 23% *Halophila*

This indicates that though there may be a preference for *Halophila sp*. The Dugongs are more generalist in diet. The High concentration of *Oceana*/*Cymodoce* in sample 3 indicates the possibility of high food availability for the Dugong within the range as the *Oceana*/*Cymodoce* sea grass beds are extensive and widespread across the region.

The significant number of records of kills involving Dugong mothers with calves or pregnant females may indicate that the population is still breeding well. About 4 kills involving mothers and calves were documented in 2016

Fishing gear of Concern

Bottom set gill nets for Rays. (Madu Dal)

The "Ray" Gill nets are nylon bottom set nets that hang as a wall underwater reaching about 5m. high from the sea floor and extending over 2 km. in length. Creating an effective impenetrable wall across the sea bed capturing any animal that would pass through it.

This net is identified as the primary threat to Dugongs in the area accounting possibly for over 90% of Kills.

The net is highly destructive and cause alarming level of by catch of non-target species ranging from Sea turtles to Dugongs. In the Battalangundu area alone it is reported that over 50 turtles are killed per day and often thrown away. This could be correlated in the observations of the field teams as high incidence of records of turtle carcasses are regularly observed in the area.

The Dugongs being bottom feeders are highly likely to get entangled in this type of net if it is found in the path of the Dugong. The Dugongs reportedly start spinning when they get caught in the net and in the process trap themselves further being bound by the net wrapped around them. The death is caused by suffocation as they are air breathing mammals and being trapped under water it cannot come to the surface to breathe.

Urgent management of this net is essential to reduce the present mortality levels of Dugongs within the area.

This net is a popular type of net in use in the area and is widely used by the local communities contributing significantly to the economy of locals as the net is very efficient in its catch potential. It would be difficult to ban the use of this net without a significant effort to promote an alternative and less destructive fishery practice.

Such efforts in promoting alternative livelihood must focus on the fishermen in the area of Battalangundu Island, and North along the coast from Mollikulam to Mannar Island with prominence given to South Bar area

Dugong killed in a "Ray gill net"

A "Ray gill net" being loaded in to a boat

Target species –Rays

Dead turtles floating at sea the result of excessive By-catch caused by "Ray gill net" operation

Fyke nets- Fixed trap nets

The fyke nets are large trap nets fitted to the sea floor permanently constructed using Galvanized Iron pipes and nets arranged in a mannar to form a series of central trap chambers with guide wall sections and two long side wings extending over 2 km. to herd fish and other animals in to the net. The nets reportedly catch Dugongs. in most cases, they would remain alive within the net till the

fishermen arrive. Any Dugong kills in Fyke nets would need to be treated as a deliberate kill and not as by-catch as most often the fishermen can release the animal if they wished to.

Beach Seine nets.

Dugongs are reportedly caught in Beach seine nets operated in the Southern shores of the Mannar Island at South Bar, Nadukuda and keeri beaches These are nets deployed from the beach and drawn to the beach and would normally extend 1-2 kilometers from the shore. This would indicate that the Dugongs are caught in near shore areas and that they naturally venture in to shallow seas in this area.

Blast "Dynamite" Fishing

Instances of Killing Dugongs with Blast fishing is usually recorded for animals that are seen at the surface for prolonged periods in the same area. On spotting a Dugong at the surface Boats would normally go out for a hunt locate the animal and use underwater blast of High-powered explosive (Dynamite) to stun or kill the animal. Many Surface hunts seem to target Mothers with calves as the calves reportedly at sea surface while the mother is submerged and are easier to target.

Leila and Surukku nets (Modified Purse seine nets)

These Purse seine net operations have been modified by locals to be capable of deploying in a mannar to be able to catch large shoals of fish or animals by the use of explosives and SC UBA divers. The nets designated to be used off shore is used illegally in coastal waters to cause significant damage to fish and other marine life. These nets are suspected to have been used on a couple of occasions to hunt Dugong.

Bottom Trawling

Bottom trawling is regularly carried out primarily in the area between the Battalangundu Island and Kudiramale point at the entrance to the Puttalam / Kalpitiya lagoon. The sea bed in this area is composed on thick greenish mud with no sea grass detected. The area is a rich fishing ground for the flower prawns *(Penaeus semisulcatus*). There are about 20 small sized trawlers registered under the Fisheries ministry and operate here which has been in , there is concern about the recent expansion of additional Bottom trawl operations to other areas which could become a significant threat to sea grass habitats.

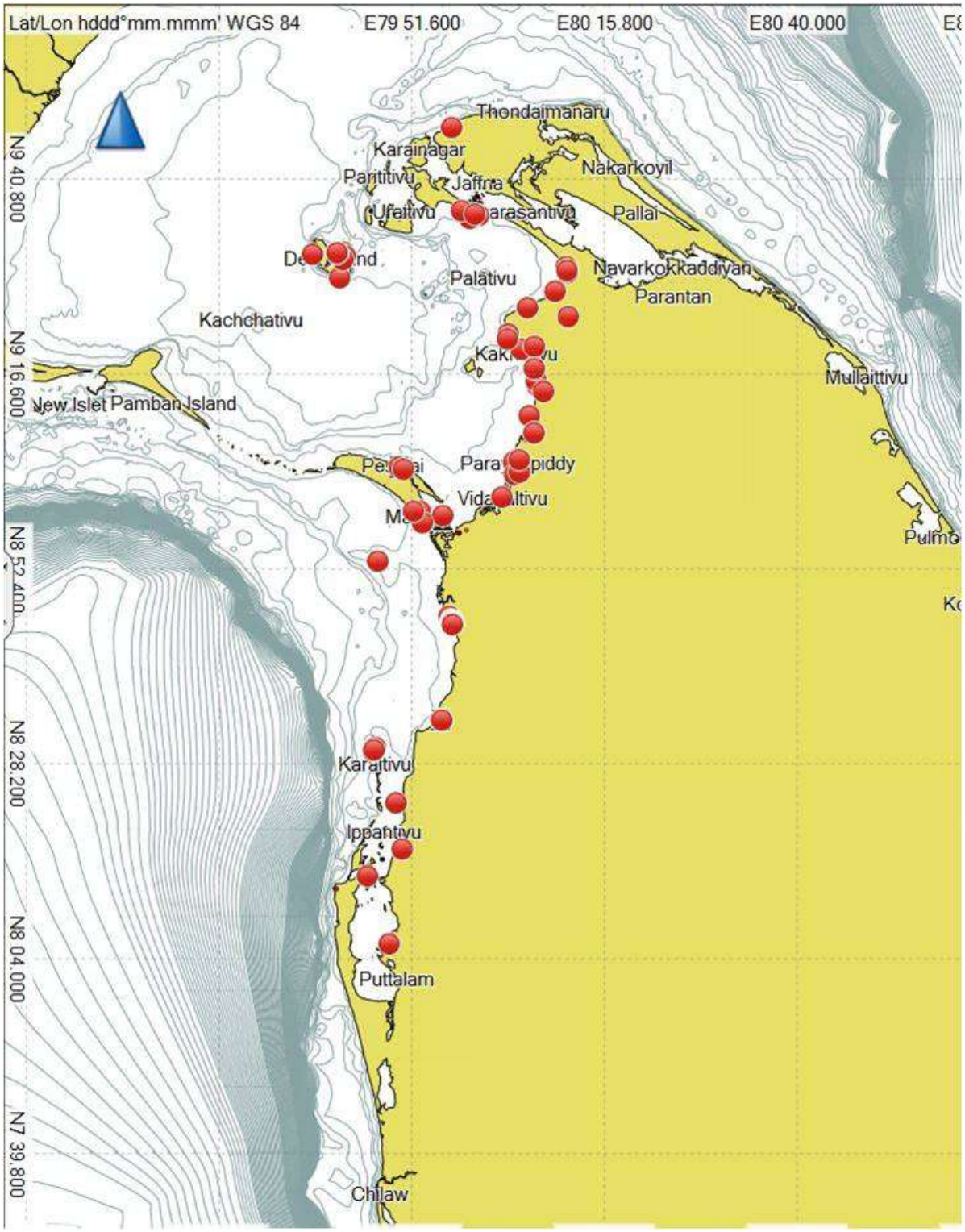
The illegal poaching in the area by large Indian trawlers is of serious concern both for sea grass beds as well as the Dugongs. every night it is reported over 1000 large trawlers enter Sri Lankan territorial waters and according to local fishermen sometimes coming almost 3 km. to the coast and deploy their bottom trawls and run back towards Indian waters clearing large tracts of all marine life in the area, This illegal practice must be stopped at all costs as the harm to the marine environment, fishery resources, Sea grass beds and Dugong populations is high. No data exists about the actual kills of Dugongs caused by this fishery.

Hunting with Harpoons (Mandawa)

The Practice of killing Dugongs with Harpoons was in use during earlier times when Dugongs were more abundant in costal lagoons and Estuaries. The type of gear is still used to hunt Rays in shallow water and examples of Larger “Mandawa” harpoons are found that was used to hunt Dugong.

Smaller example of "Mandawa" harpoon typically used to harpoon fish within the lagoons and a larger Harpoon head used to hunt Dugong from Gange-wadiya in Wilpattu.

The locations of the ORCA coastal community surveys.



Dugong Community survey Beach locations

No	Location	No	Location
1	Delf	33	Dutchbay
2	Mandathive	34	Uchimunei
3	Punguduthive	35	Wellamundalama
4	Colombothure	36	Matty Aru
5	Pallikuda beach - punarin	37	Mampurri
6	Sangupidi bridge	38	Bathalan gundu Island
7	Allapiddi	39	Palliya watta
8	Pumune	40	welle
9	Devils point	41	Palugasthure
10	Kirimunaii	42	Pukkulum
11	Nachikuda	43	Mollikulum
12	Vellan kulum	44	Musali
13	Anthony purum	45	Sillawathura
14	Illupankandavi	46	Sawariya purum
15	Wedithalathive	47	Arippu
16	iranamathanagar	48	Pallimunaii.
17	Molankavil	49	Mannar
18	kiranchi	50	Vankalei
19	walepadu	51	South bar
20	Veravil	52	Thaleimannar
21	Pappamode	53	Old Pier
22	Kandakuliya	54	Urumale
23	gagewadiya	55	Nadukuda
24	Serakkuliya	56	Fessalei
25	Kayakuli	57	Kataspathri
26	Karaitivu	58	Vankalei padu
27	Kalladichena	59	Thoddaveli
28	Sothupitiya	60	Erukkalampiddi
29	Kalpitiya	61	Keeri beach
30	Anawasala		
31	kudawa		
32	Thalawila		

Documented Dugong Kills

Early Records of Dugong Kill Mannar 2010

A pair of large Dugongs killed 16th December 2010Landed in Pesale area Mannar, Killed using dynamite, culprits apprehended and specimens handed over to NARA. The adult female was found to be pregnant in autopsy investigations.

The male dugong was 2.67m. in length and weighed 480kg. and the female was 2.9m in length and 534kg. in weight

Reportedly the female was pregnant at the time of kill

Photographs from the Internet. ownership credited to original source

Early Dugong Kill Kalpitiya Lagoon -2008

Dugong caught inside Kalpitiya lagoon landed close to Talawila in 2008 one of the last documented Dugong kills within the lagoon.

Pictures provided by Commander Ravi Weerapperuma, SL Navy

Dugong Kill South Bar – September 2015

Dugong kill detected by NAVY/ DWC at South-Bar, Mannar, September 2015. The poachers were handed over to the police and DWC for prosecution specimen cutup for Necropsy.

Photo credit: Mohamed Haleem

Dugong By-catch Kill Mollikulam- April 2016

30th April 2016 A large Male Dugong was caught in a "Ray-gillnet"and killed in the Cheval bank area North of Battalangundu Island. The specimen was handed over to the Sri Lanka Navy (SLN) and was brought to Mollikulam Naval base under instructions from Admiral Artigala SL Navy. ORCA teams were informed by the Navy and inspected the specimen. The specimen was handed over to DWC.

It was reported by fishermen that a pair had been seen for a few days in the area North of Battalangundu Island over the Cheval bank area and one was caught in a net a few days after. It is believed that the fishermen attempted to land the Dugong at the Battalangundu Island for processing the meat but fearing detection handed it over to the Navy. Some rumors indicated the possibility that both animals were caught and one was handed over to the Navy while the other was smuggled away for butchering.

Length of specimen 8feet

Weight 280kg.

** Note - Most of the photographs in this section are from external sources who documented the Dugong kills. The images are published in the report as documentary evidence with permission from the original authors.

ORCA does not claim any ownership of these images and the rights for these photographs are owned solely by their respective authors.

ORCA teams help recovery of a killed Dugong with the support of SLN and DWC 30th April 2016 Mollikulam. The specimen was reportedly killed in the ara north of the Battalangundu Island caught as By-catch in a Ray gill net

30th April 2016 Dugong being brought ashore at Battalangundu Island still entangled in the net before being handed over to the Navy at Mollikulam.

The Dugongs reportedly twist and spin when they get entangled in nets causing the net to wrap around the animal causing further entanglement and eventual drowning.

Decomposed large Dugong carcass Thavilpadu beach- November 2016

Semi decomposed Large Dugong carcass washed ashore at Thavilpadu in Mannar peninsula in November 2016- cause of death unknown

Photocredit: S.Kumara

Dugong carcass, Nadukuda beach- Dec 2016

Dugong carcass washed ashore in Nadukuda on Mannar peninsula on 2016 Dec 02

Information from fishermen indicate that it was caught in a Ray-gill net at the western end of the Vankale reef and brought close to the shore by the fishermen and kept anchored till night to bring it out and process. The mooring broke and the Dugong was washed ashore.

Length 6ft. Circumference 4ft.Weight 130-150 kg. estimated

Photo credit: S. Kumara

Detection of Dugong meat Thavilpadu, Mannar- April 2017.

9th April 2017 – the culprits were arrested by the Navy while transporting of 80kgs of Dugong meat in a three-wheeler and was handed over to the Police and DWC for prosecution

Dugong was reportedly caught in a Beach seine net at Thavilpadu, on the southern shores of Mannar Island-

Large male carcass, Pukkulam- June 2017

Large male washed ashore at at Pukkulum, Willpathu,on the 22nd. June 2017 The carcass had deep gash wounds similar to knife cuts and is suspected to have been caught in a net and killed by fishermen. Pukkulam is known to be a favored coastal location where Dugong kills are processed.

weighing reportedly around 300-400 kg

Mothere and Calf, Pukkulam July 2017

A Pregnant mother was found killed at Pukkulam on July 27th 2017 the carcass ejected a fetus post-mortem.

The kill was Reported by Dr Sevvandi Jayakody of the Department of Aquaculture and Fisheries of the Wayamba University,

the female was reportedly over seven feet in length and the calf fetus was about three-and-a-half feet in length and well developed.

5 live Dugongs were sighted within the Kalpitiya lagoon; spotted by a local tour boat operator Samith Isan Fernando on 28th October 2017. The encounter was documented with video and good still photos the animals were reportedly observed between the entrance to the lagoon and in an isolated area near the WIlpattu National Park. The pod was observed to be in a relaxed mood and the visitors had been

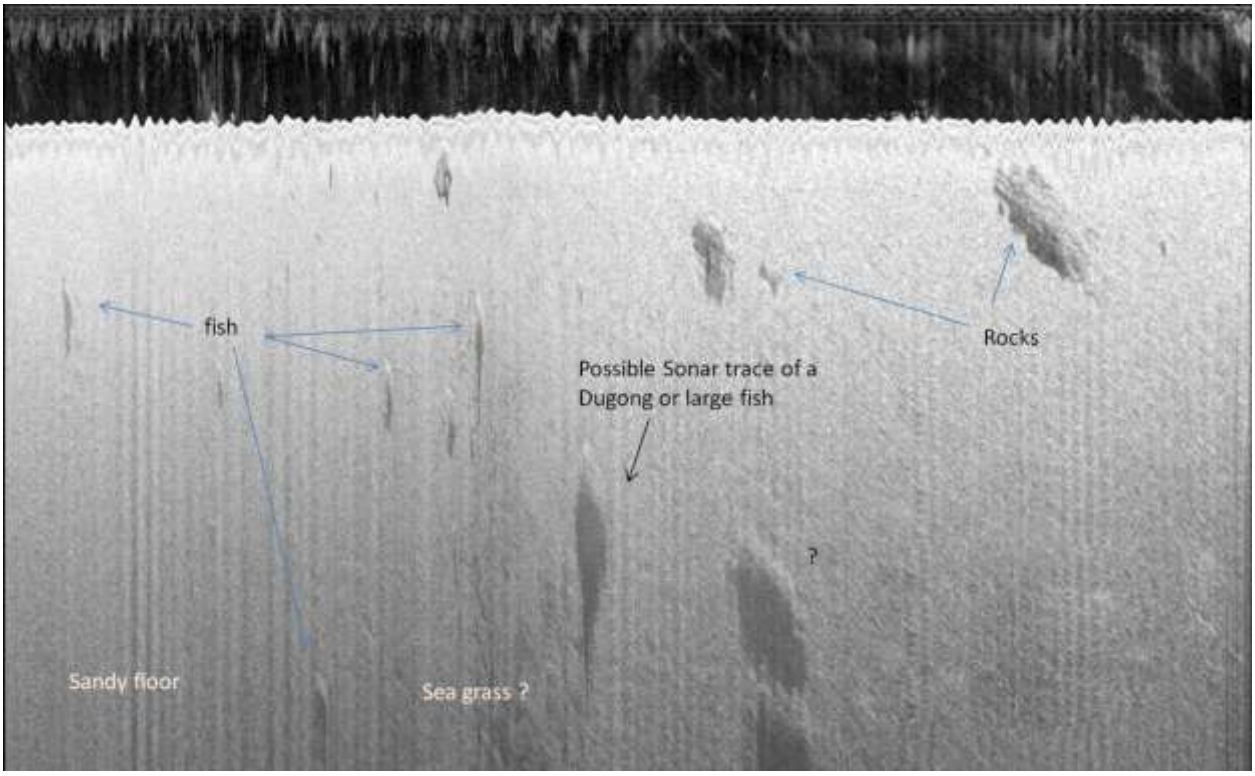
able to follow them for about an hour. It is believed that the Dugongs entered the lagoon to escape rough seas prevalent in the previous days. As no further observations were made in the area it is believed that the group of Dugongs returned to the sea. The lagoon area is about 5m. in depth and consists of muddy sea floors, No sea grass growth detected in the area. There are Sea grass beds containing *Halophila ovalis* and other species in the nearby coastal areas of the Palliyawatta Island in

extreme shallow waters. It is highly unlikely the Dugongs entered the lagoon to feed as they would be in extreme danger of being hunted if they entered the very shallow areas where the sea grass beds are located within the lagoon (about1-1.5m depth)

(Photo credit: Samith Ishan Fernando)

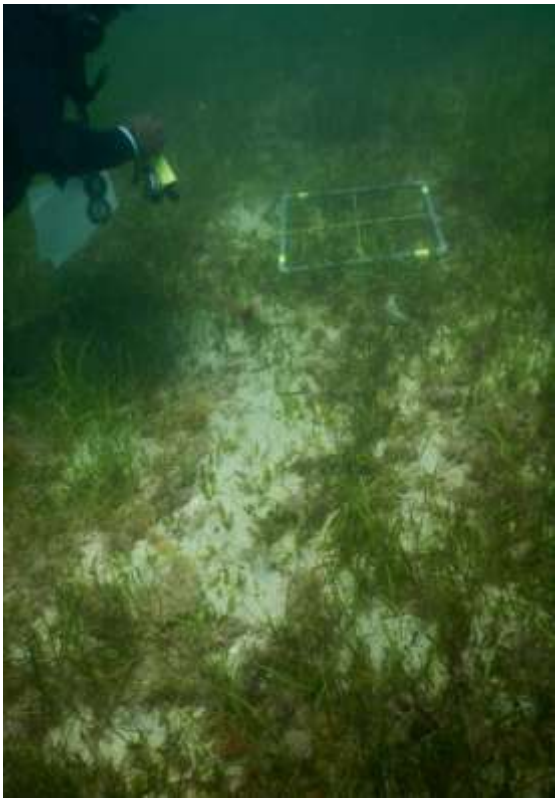
Detection of Dugongs on Sonar tracings.

The team extensively utilized a Side scan sonar to observe and identify substrates and areas of interest. On several occasions underwater signatures of possible Dugong encounters were observed in side scan Sonar tracings. It was not possible to verify the records without a secondary observation.



Possible signatures of Dugongs in a Side scan sonar image

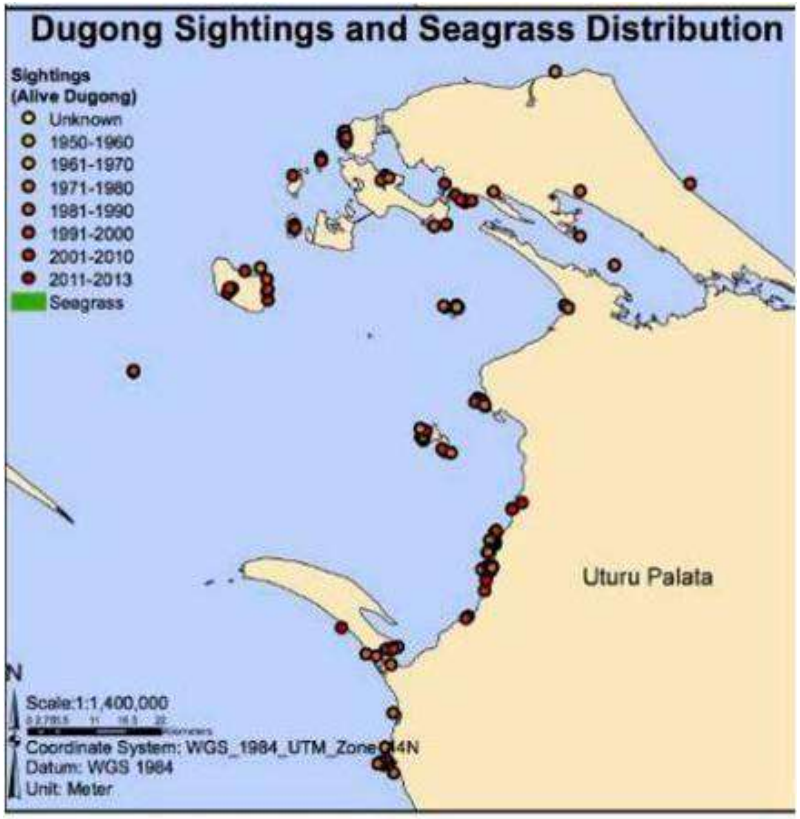
Dugong Feeding Trails



Dugong feeding trails were observed by ORCA teams on several occasions.

These Dugong feeding trails were at Sea grass beds on the inner side of the Arippu reef. The trails are old and have begun to re-grow with sea grasses, 2017

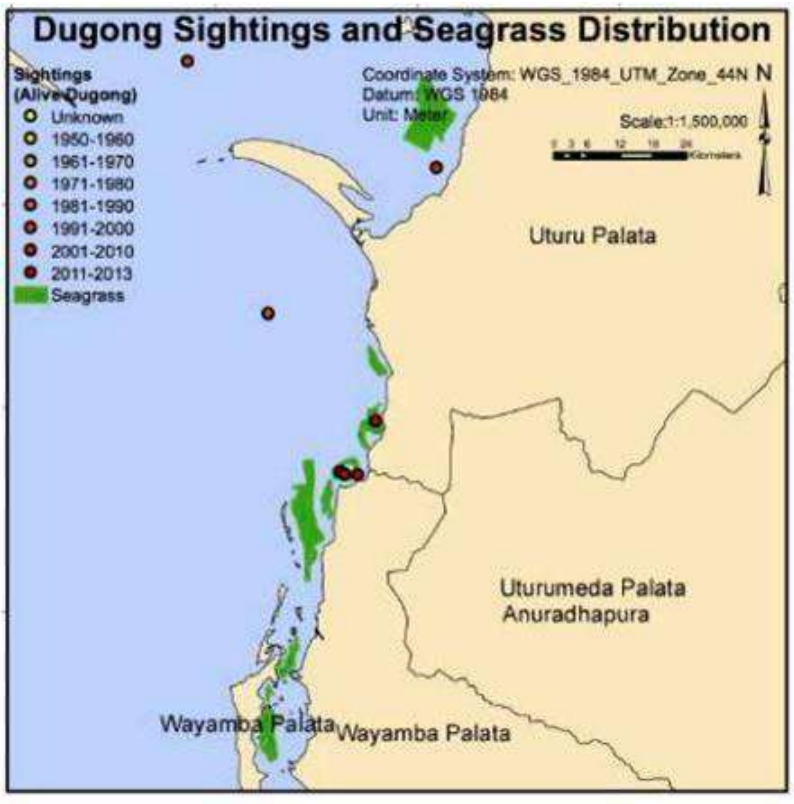
DUGONG DISTRIBUTION



Dugong distribution based on CMS-UNEP Dugong Questionnaire

The CMS-UNEP carried out a preliminary survey of Dugong and Sea grass records based on community-based interviews in partnership with several local partners prior to the present study.

The results were believed to be inadequate as they all represented the coastal location of the interview rather than the location of the sighting/capture of the Dugong out at sea.



The locations of Sea grass beds indicated are also of coastal sea grass areas while not indicating the extensive sea grass systems of the cheval banks region.

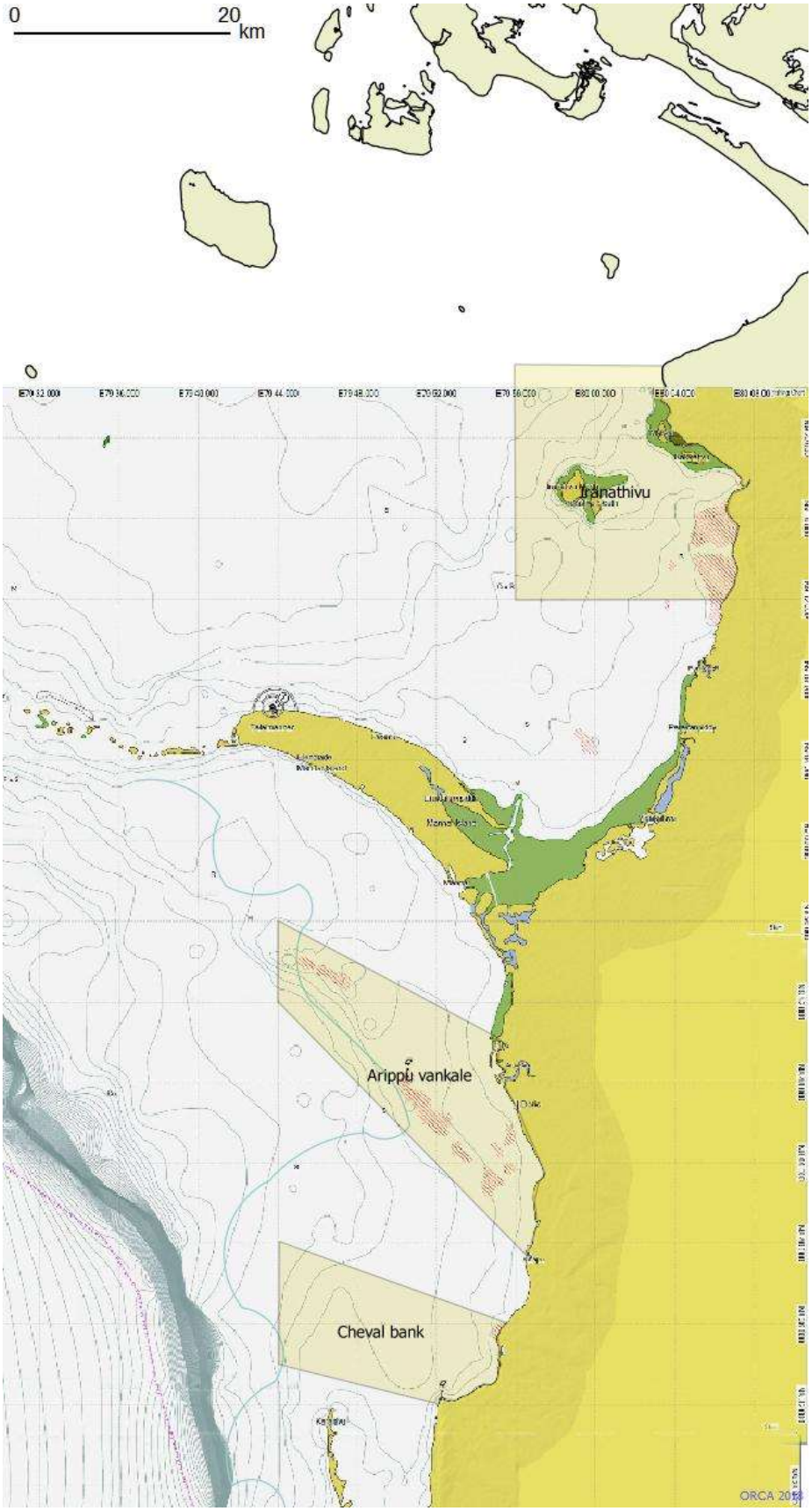
Dugong and sea grass distribution based on data collected by ORCA

The results of present survey indicate the distribution of Sea grass meadows within the Gulf of Mannar with Records of Dugongs based on community information and ORCA records. The additional records collected from the community on the sea areas where the Dugongs were observed provided valuable base info for mapping “Hot spot” areas of Dugong occurrences.

Proposed Dugong and Seagrass MPA's

3 areas of Marine Protected Areas were proposed under the current project. The identification of the areas was carried out by the DWC with the Participation of ORCA and IUCN technical specialists.

The data collected by ORCA was used as the basis on which the site Identification was carried out.



Seagrass

The cheval bank forms an extensive sea grass system that spans from the Battalangundu area and extends northwards as a large U-shaped formation extending up to Arippu area. *Oceana serrulata* is the dominant species sea grass found within the area with *Halophila ovalis, Halodule uninervis* and *Syringodium isoetifolium*, being abundant and becoming dominant is certain areas.

The East cheval banks ridge is composed primarily of sea grass beds dominated by *Oceana serrulata* with *Syringodium isoetifolium*. Though species like *Halophil*a and Halodule were found, their populations were present and spread as an undergrowth within the *Oceana* beds.

The area between the East and West Cheval banks dips in to a depression in the sea bed with sandy floors interspersed with sea grass areas that are dominated by *Halophila ovalis,* the area also contains S*yringodium,Oceana, Oceana* and small populations of *Halophila decipiens* the area is important for conservation of Dugongs as it contain high incidence of Sea grass species preferred as food plants by Dugong.

The extensive Sea grass meadow along the inner edge of the Vankale banks is dominated by *Syringodium* with *Halophila spp*. and *Oceana serrulata.*The most proliferate growth of *Halophila ovalis* is found in the Vankale- Arippu areas and at the southern central section of the Cheval banks.

On the Northern side of the Mannar Island the vast coastal sea grass meadows of Pallimunei extend along the shore of Vedithalathivu reaching up to illuppankadavi. The zone is composed of a thickly vegetated buffer of sea grass extending up to 2km. from the shore flanking the coastline composed largely of mangrove. The zone is dominated by *Enhalus acoroides* forming a diverse multilayer sea grass system with a high biodiversity. Almost all the species recorded within the survey was found to be present in the area. The thick coastal bank of sea grasses abruptly ends and thins out to deeper sparsely populated bank of sea grass that is composed of *Halophila ovalis, H.pinifolia, Syringodium isoetifolium, Halodule uninervis* and *Oceana serrulata.* This low growing sparsely populated deep water sea grass beds that seem to extend up to the Iranathivu island.

The inshore, lagoonal species of sea grass including *Enhalus acroides* and *Thalassia hemprichi* was only observed within the Kalpitiya lagoon and in the coastal sheltered areas on the Northern side of Mannar Island.

One new species of sea grass was added to the list of Sea grass species documented for Sri Lanka. The species *Halophila stipulacea* was not previously recorded from Sri Lanka and during the survey the team documented the species from 15 locations ranging from Kalpitiya to Vedithalathivu.

In addition, the area contains significant populations of the algae *Caulerpa taxifolia* which is identified as an invasive species on Sea grass environments in other parts of the world - while no data exists on the status of this species within the sea grass environments in the region it is probably important to monitor this species to see if it is becoming invasive on the sea grasses.

A collection about 200 Sea grass specimens were collected, preserved and deposited at the National Herbarium collection in the Peradeniya (PDA to supplement the National collection. This is of national importance as the existing Sea grass collection at the National Herbarium was insignificant. The collection will be of use to all future marine botanists in the Country.

9 species of Sea grasses were recorded in various depths from 0.5 m to 14m

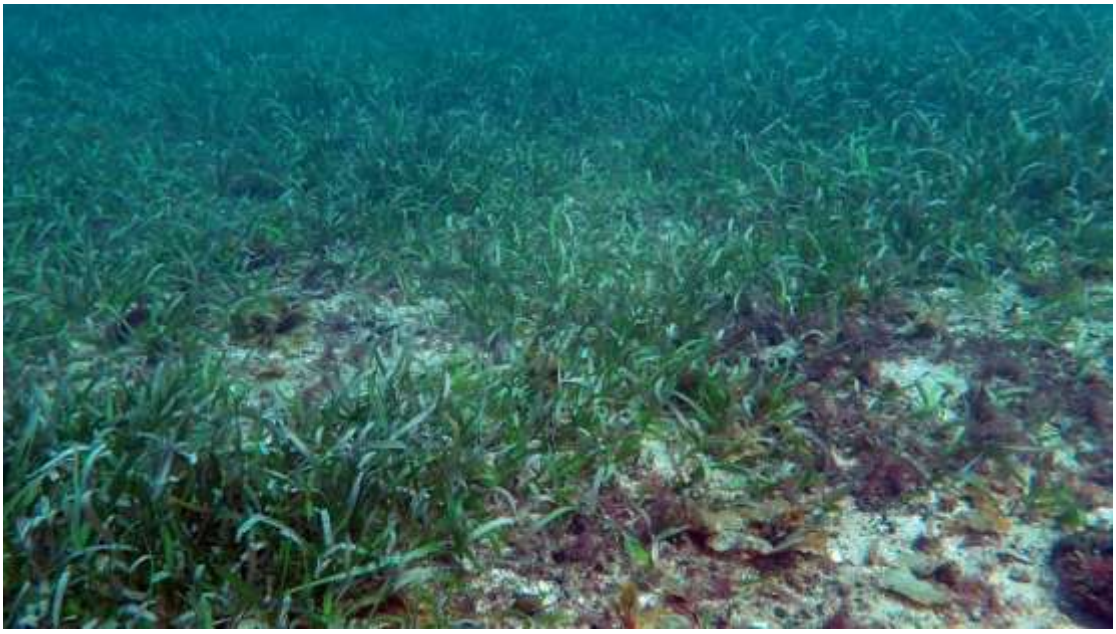
1. *Oceanaa serrulata* (*(R.Brown) Byng & Christenh. (ex- Cymodoce serrulata)*
2. *Cymodocea rotundata* Asch. & Schweinf.
3. *Halophila ovalis* (R.Br.) Hook.f.
4. *Halophila decipiens* Ostenf.
5. *Halophila stipulacea* (Forssk.) Asch.
6. *Syringodium isoetifolium* (Asch.) Dandy
7. *Halodule uninervis* (Forssk.) Boiss.
8. *Enhalus acoroides* (L.f.) Royle
9. *Thalassia hemprichii* (Ehrenb. ex Solms) Asch.

A paper is under preparation for the documentation of a new record of sea grass species *Halophila stipulacea* in Sri Lankan waters.

Halophila stipulacea A new species of Sea grass recorded for Sri Lanka

Oceana serrulata dominated seagrass bed

Syringodium isoetifolium dominated seagrass ecosystem East of Vankale reef



Oceana serrulata (ex- cymodoce serrulata) dominated Seagrass beds Cheval banks

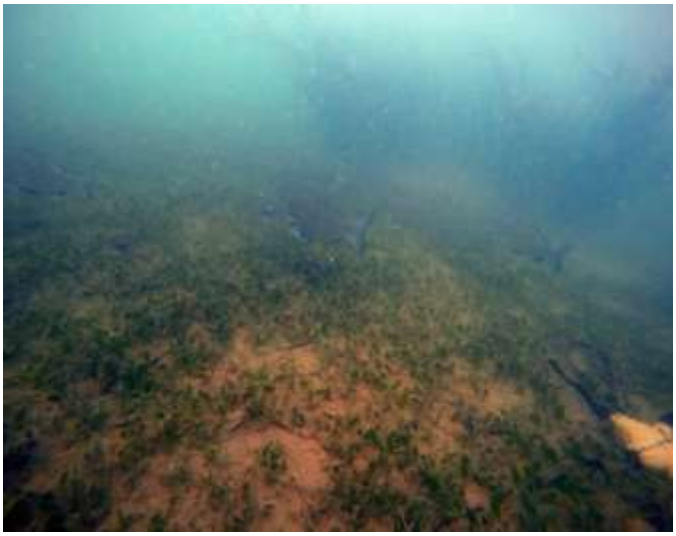
Oceana serrulata dominated Seagrass beds north of Vankale reef

Halophila ovalis dominated Seagrass beds Mid cheval banks

Halophila ovalis dominated Seagrass beds west cheval banks North of Battalangundu Is.

Halophila ovalis-Syringodium Mixed Seagrass habitat

Preparation of sea grass herbarium specimens.



Sea grasses of Lagoons and shelterd shallow seas dominated by *Enhalus acroides*

H

Distribution of Sea grass areas within the survey zone. ORCA surveys

Methodology Substrate /Sea grass sampling

Stratified Random Sampling method was used for selection of the sampling area. Strata was defined using assessment of historic maps primarily from the “Herdman Reports” overlaid with satellite imagery

A preliminary survey plan was devised based on the constructed maps giving prominence to the bathymetric features including the submarine “banks/ paars” of the Cheval complex and reported locations of dugong encounters.

Consideration had to be given to the scale of the area to be surveyed (Over 2000 Sq Km.) and depths of over 10 m. with limited number of sampling days available the sampling had to be of a lower resolution but representative of the area to be sampled.

Within pre identified strata survey Boat transects were carried out assisted by use of a Side scan sonar to identify possible presence of sea grass. Spot sample were carried out in areas of interest identified by Side scan sonar imagery. A mini drone was sometimes used to plot out sea grass areas and attempt aerial observation of Dugongs. Random detail substrate samples were carried out in representative strata using SCUBA dives. The general data on bottom features, Biodiversity were recorded and Substrate composition was sampled using 3 x 1m. quadrats deployed randomly.

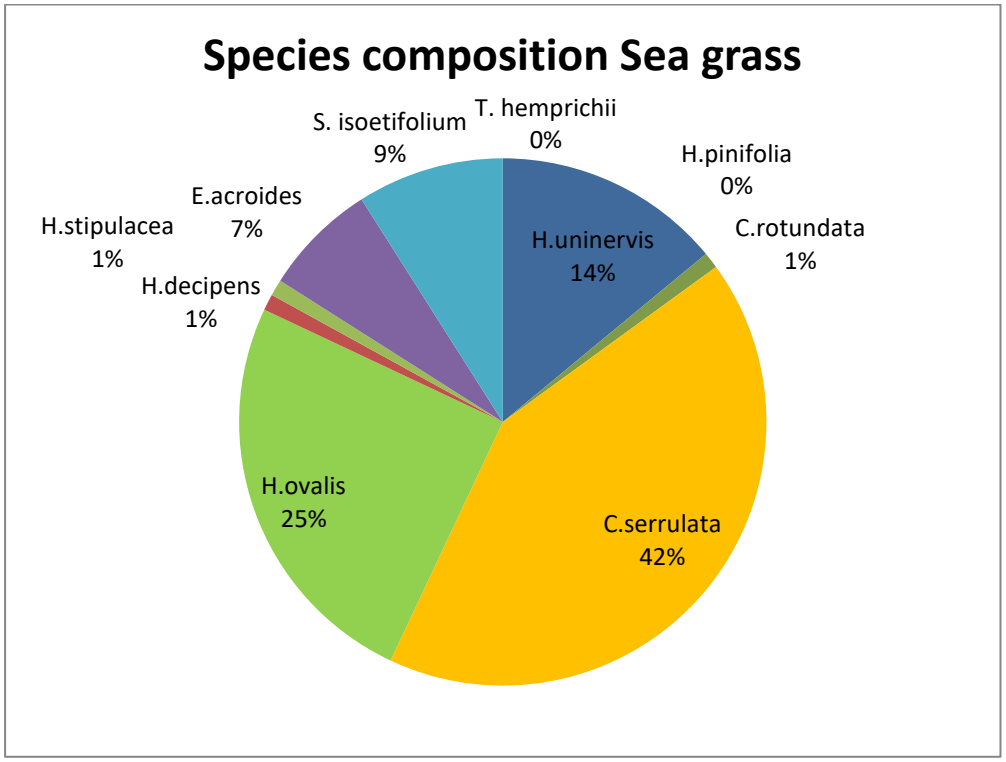
The use of spot samplings added to the number of points that could be carried out to supplement the Quadrat surveys carried out using SCUBA dives. The number of SCUBA dives that could be carried out was rarely more than one per day due to the significant travel distances to survey sites constrained practical field time to work within safety limits for the team. The spot samples were carried out by a snorkel diver doing free diving to spot observe the location or in muddy water using a grab sample to determine the content. The spot samples are not fully reliable for small leaved inconspicuous varieties (*Halophila etc.*) as during the short duration of the bottom observation the snorkeler could easily miss documenting small species.

The collected data was analyzed for trends and results and was used to create GIS maps that would be used to plot the distribution of Sea grass beds in the area and Ground truth the satellite image maps. The samples of the collected seagrasses were deposited at the National Herbarium in Peradeniya.

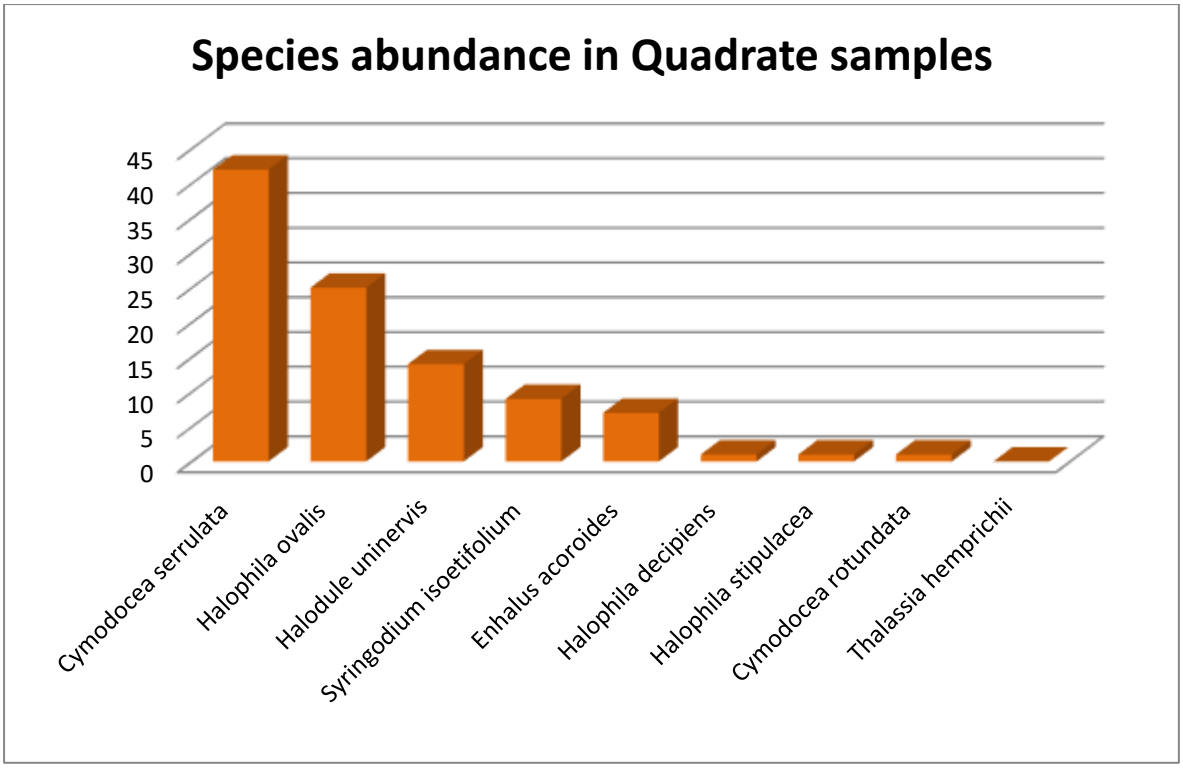
Results

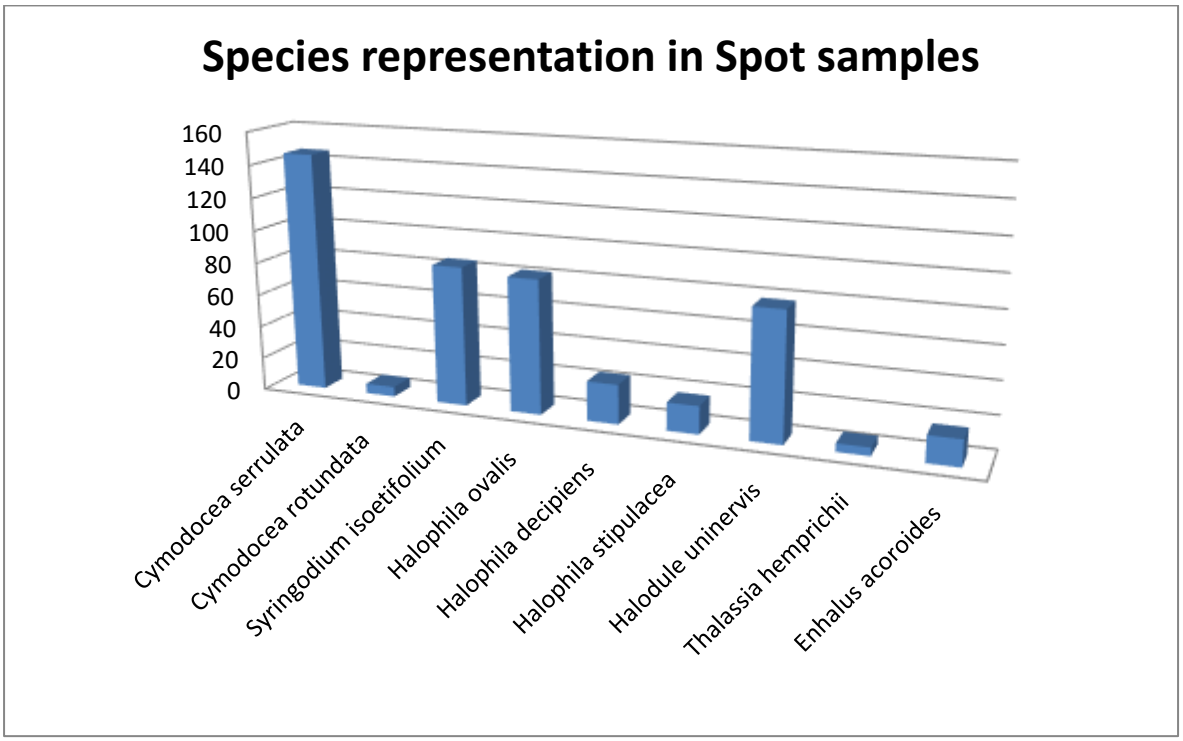
A total of 255 samples were carried out including 166 sites with sea grass samples (65% success)A total 34 quadrates samples were carried out using SCUBA dives to record detail within the survey areas on sea grass.

All sea grass present within the quadrate was counted as cover percentage. Species was identified using standard reference material in books and online including sea grass watch.



Species	Spot samples	Quadrets%
• *Oceanaa serrulata (R.Brown) Byng & Christenh.*	(146)	42%
• *Halophila ovalis* (R.Br.) Hook.f.	(82)	25%
• *Halodule uninervis* (Forssk.) Boiss.	(78)	14%
• *Syringodium isoetifolium* (Asch.) Dandy	(85)	9%
• *Halophila decipiens* Ostenf.	(24)	1%
• *Halophila stipulacea* (Forssk.) Asch.	(17)	1%
• *Enhalus acoroides* (L.f.) Royle	(16)	7%
• *Cymodocea rotundata* Asch. &Schweinf.	(6)	1%
• *Thalassia hemprichii* (Ehrenb. ex Solms) Asch.	(5)	0%





Oceana serrulata was dominant over most areas with a cover of 42% on quadrats and was represented in 146 spot samples over the region, *Halophila ovalis* was the second most abundant species at 25% on Quadrats while being represented in 82 spot samples. *Halodule uninervis*was 14% on quadrats and represented on 78 spot samples, while *Syringodium isoetifolium* composed 9% on quadrats represented on 85 spot samples. *Enhalus acroides* composed 7% of substrates. *Halophila*

decipens, *Halophila stipulacea* and *Cymodoce rotundata* was at 1% and other species present in concentrations less than 1%. within the Quadrat samples.

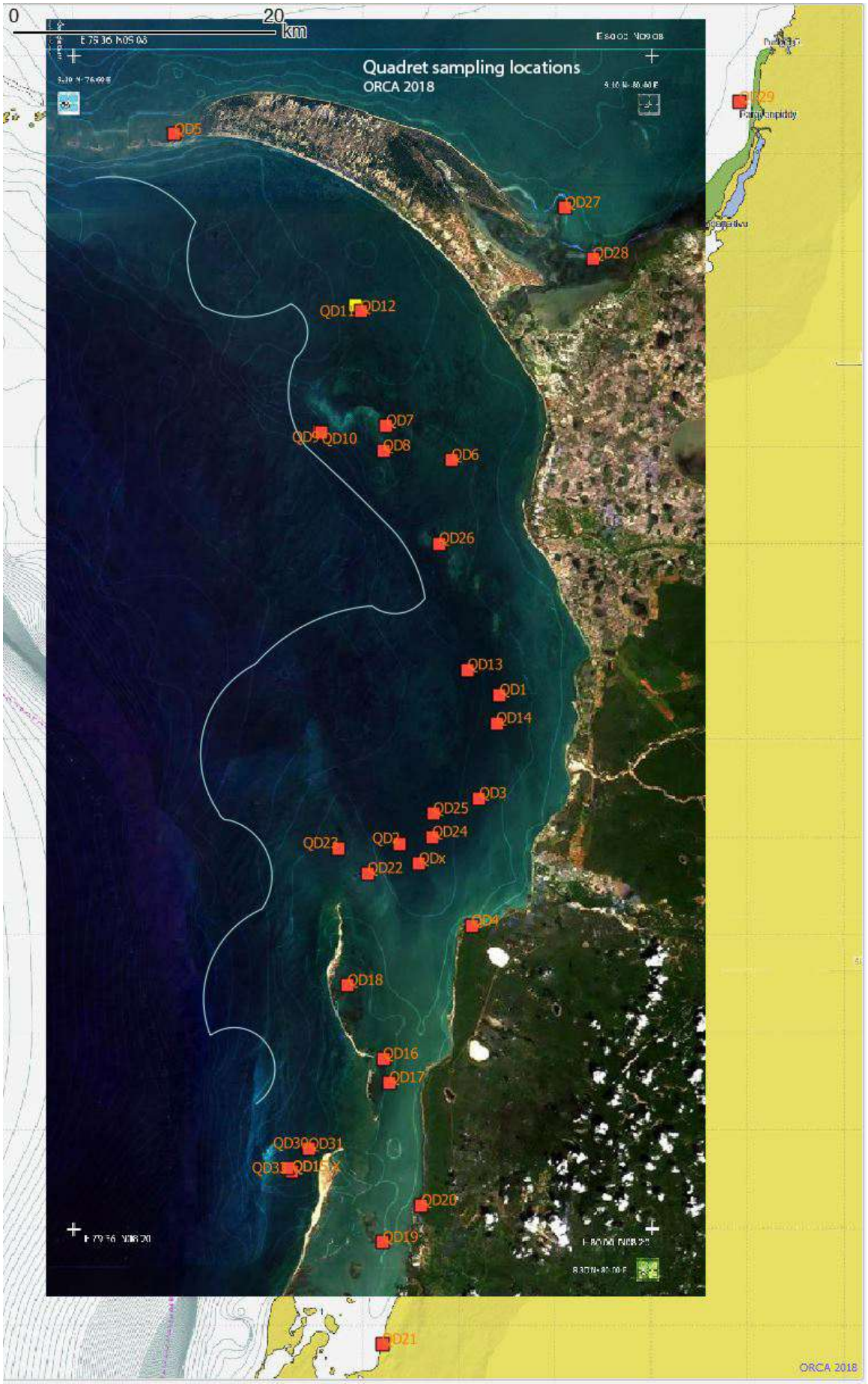
Oceana serrulata was clear dominant throughout the survey area Growing as monospecific strands and as mixed growth sea grass beds and had the widest distribution throughout the region. The *Oceana* beds are extensive spreading over several Kilometers in thick growths within the Cheval bank and Nothern Vankale area.

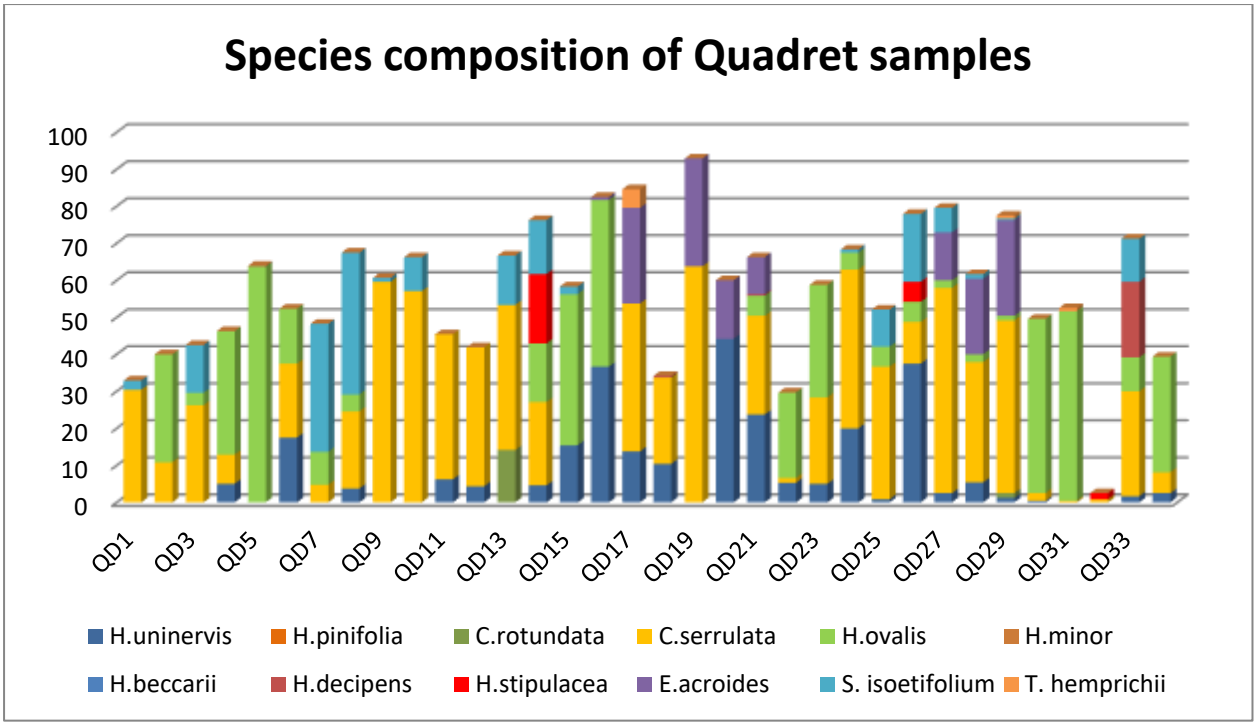
Halophila ovalis dominant seagrass beds were found primarily on areas of clean sand usually in depressions of the substrate which may indicate that the species acts as a pioneer with other species seeming to populate over *Halophila* beds. This species is the primary food species of the Dugongs and was considered a key species in management and conservation of the Dugong.

Syringodium isoetifolium dominant seagrass beds were documented on an extensive sea grass bank that runs parallel to the Pearl bank –Vankale reef inner area. In other areas *Syringodium* was found as mixed assemblages. During months of February- March large quantities of floating *Syringodium* fronds were found forming rafts in the sea off Kandakuliya and Bar-reef. These were observed 15-25km off shore and aggregations of Olive Ridley turtles were observed actively feeding on the floating sea grass mats.

Halodule uninervis accounting for 14% cover and being the third most abundant species was found as part of mixed assemblages. High concentrations were documented in Quadrats 21 and27 located within Enhalus

Enhalus acroides dominated in areas of shallow sheltered lagoons and coastal coves with muddy bottoms *Thalassia hemprichii and Cymodoce rotundata* was also found limited to shallow lagoon or sheltered sea areas.


0
20
km
Quadret sampling locations
ORCA 2018
QD5
QD27
QD28
QD29
QD12
QD7
QD9
QD10
QD8
QD6
QD26
QD13
QD1
QD14
QD3
QD25
QD24
QD23
QD2
QDx
QD22
QD4
QD18
QD16
QD17
QD30
QD31
QD20
QD19
QD21
ORCA 2018



Species clustering and plot-group composition:

The cluster and ordination analyses demonstrate clear differentiation of the seagrass quadrats into several assemblage groups at approximately 60% Bray–Curtis similarity, reflecting differences in both species' composition and relative abundance among plots. The largest group comprised QD2, QD4, QD5, QD15, QD16, QD22, QD23, QD30, QD31 and QDX, and was strongly characterized by *Halophila ovalis*, which contributed approximately 76% of the combined abundance within this group and occurred in all ten quadrats; *Halodule uninervis* (13.4%) and *Oceana serrulata* (9.9%) were secondary components.

A second group comprising QD17, QD19, QD27, QD28 and QD29 was dominated by *Oceana serrulata* (60.1%), with a substantial contribution from *Enhalus acoroides* (28.8%), while *H. uninervis*, *Syringodium isoetifolium* and other species occurred at lower abundances.

The group containing QD6, QD11, QD12, QD18, QD21 and QD24 was similarly dominated by *Oceana serrulata* (60.1%), but was distinguished by a much higher contribution of *H. uninervis* (27.5%), indicating a *O. serrulata –H. uninervis* assemblage.

QD1, QD9, QD10 and QD13 formed a relatively homogeneous *O. serrulata* -dominated group, with *O. serrulata* contributing 82.2% and *S. isoetifolium* 11.5%, together with a small contribution from *C. rotundata*.

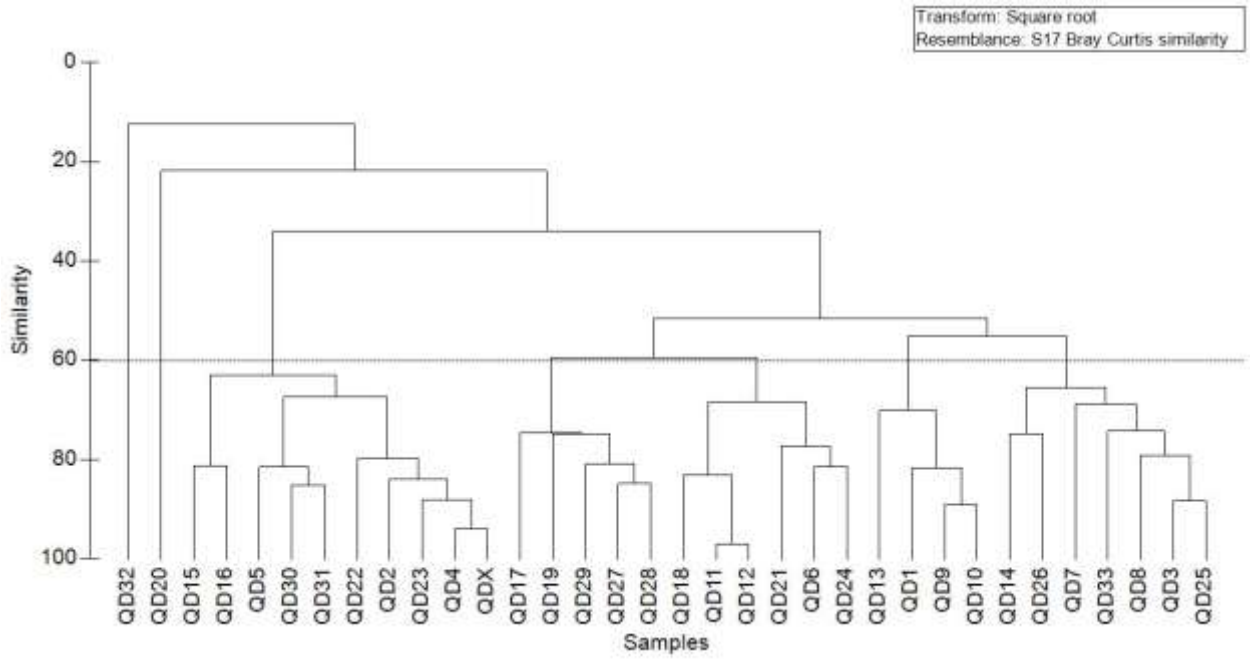
Another distinct group, comprising QD3, QD7, QD8, QD14, QD25, QD26 and QD33, represented a more mixed assemblage in which *O. serrulata* (34.4%) and *S. isoetifolium* (32.2%) were co-dominant, accompanied by H. ovalis (12.1%), H. uninervis (11.1%) and smaller contributions from *Halophila stipulacea* and *H. decipiens*.

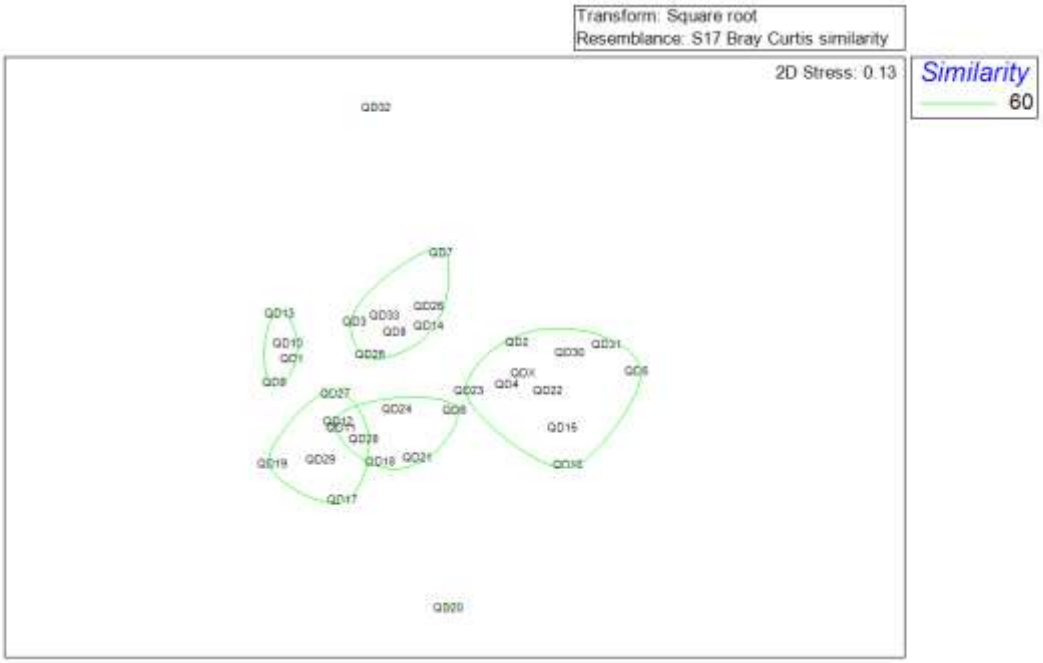
Two quadrats, QD20 and QD32, remained as distinct outliers in the cluster analysis: QD20 was characterized by *H. uninervis* (73.6%) and *E. acoroides* (26.4%), whereas QD32 contained only *H. stipulacea* (66.7%) and *O. serrulata* (33.3%). Overall, the clustering and ordination indicate that *O. serrulata* is the most widespread structural component of the seagrass assemblage, occurring in 30 of the 34 quadrats represented in the matrix, while *H. ovalis* and *H. uninervis* were also widely distributed but showed stronger association with particular plot groups. This pattern is consistent with the report's broader finding that *O. serrulata* was the dominant species across the survey area, followed by *H. ovalis, H. uninervis* and *S. isoetifolium*.

The important ecological message from the analysis is that the seagrass community is not a single homogeneous assemblage. Instead, the plots can broadly be interpreted as:

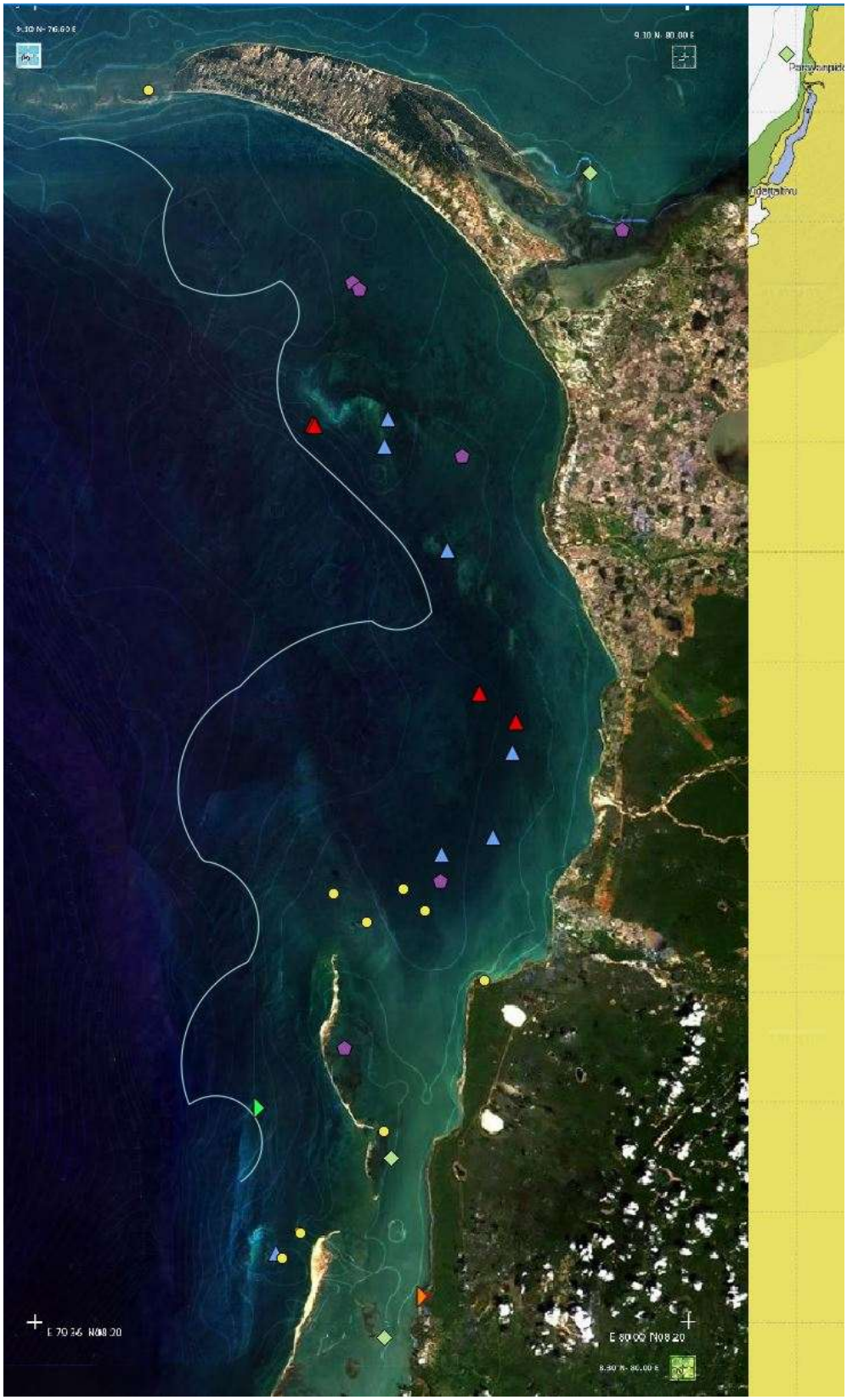
The ordination diagram is particularly useful because it confirms these relationships independently of the dendrogram: the tightly grouped plots represent relatively similar species assemblages, while QD20 and QD32 occur well away from the main group, reflecting their unusual species composition. The report also notes that *O. serrulata* occurs both as monospecific stands and mixed beds and has the widest distribution, whereas *H. ovalis* is particularly associated with clean sandy depressions and *E. acoroides* with shallow, sheltered, muddy areas.

Cluster Analysis of Sea grass Quadrat samples





Ordination analysis of Quadrat samples using square root transformation and Bray Curtis similarity analysis



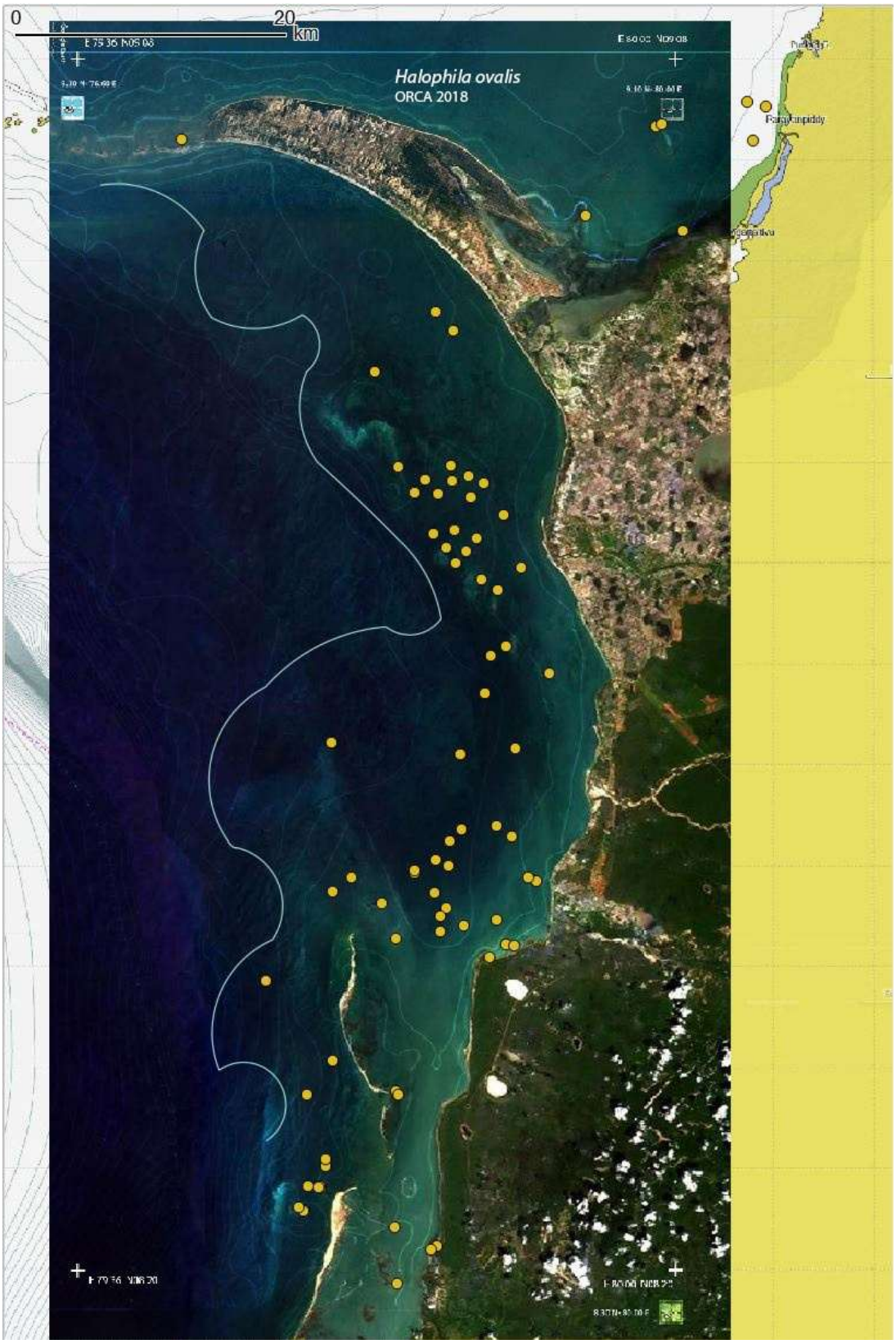
Map showing the distribution of similarity clusters based on above analysis.

Each color icon on the map represents sites linked under a separate similarity cluster

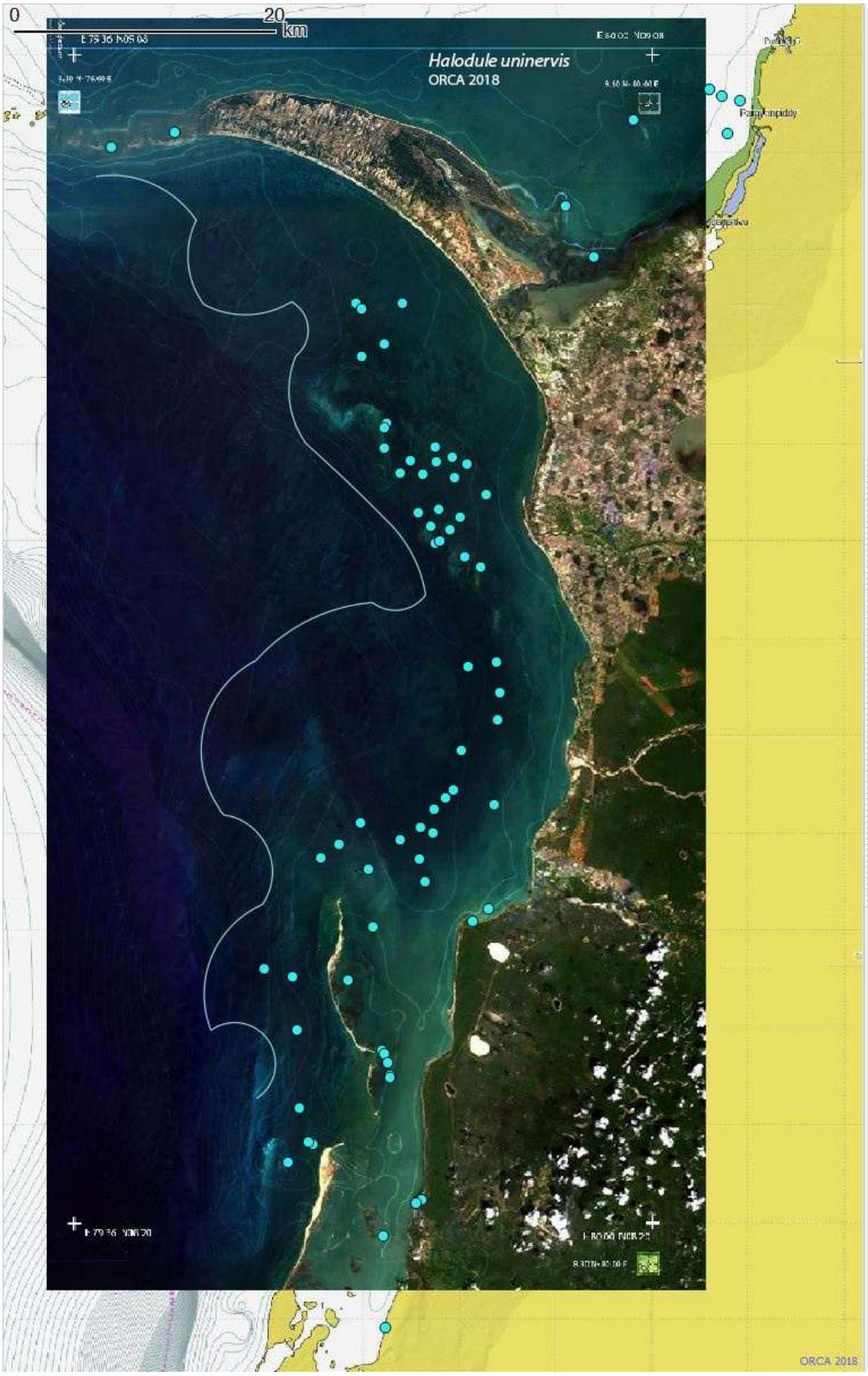
Distribution of Sea grass Species within Project sample area

The Distribution of Sea grass species was mapped using data from the spot samples and Quadrate samples collected.

Distribution of Sea grass species- *Oceana serrulata* – (*Oceana serrulata)*

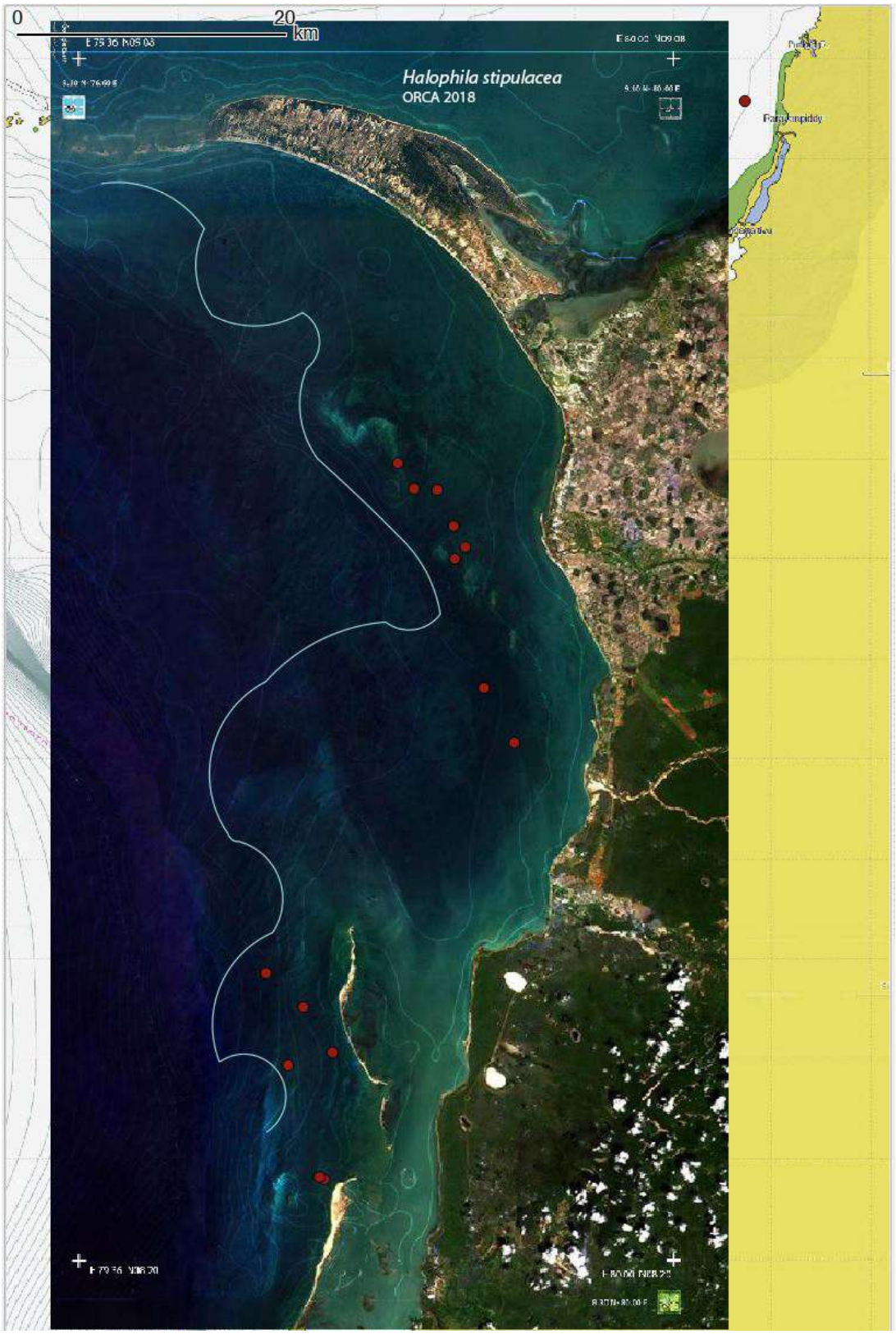


Distribution of Sea grass species- *Halophila ovalis*

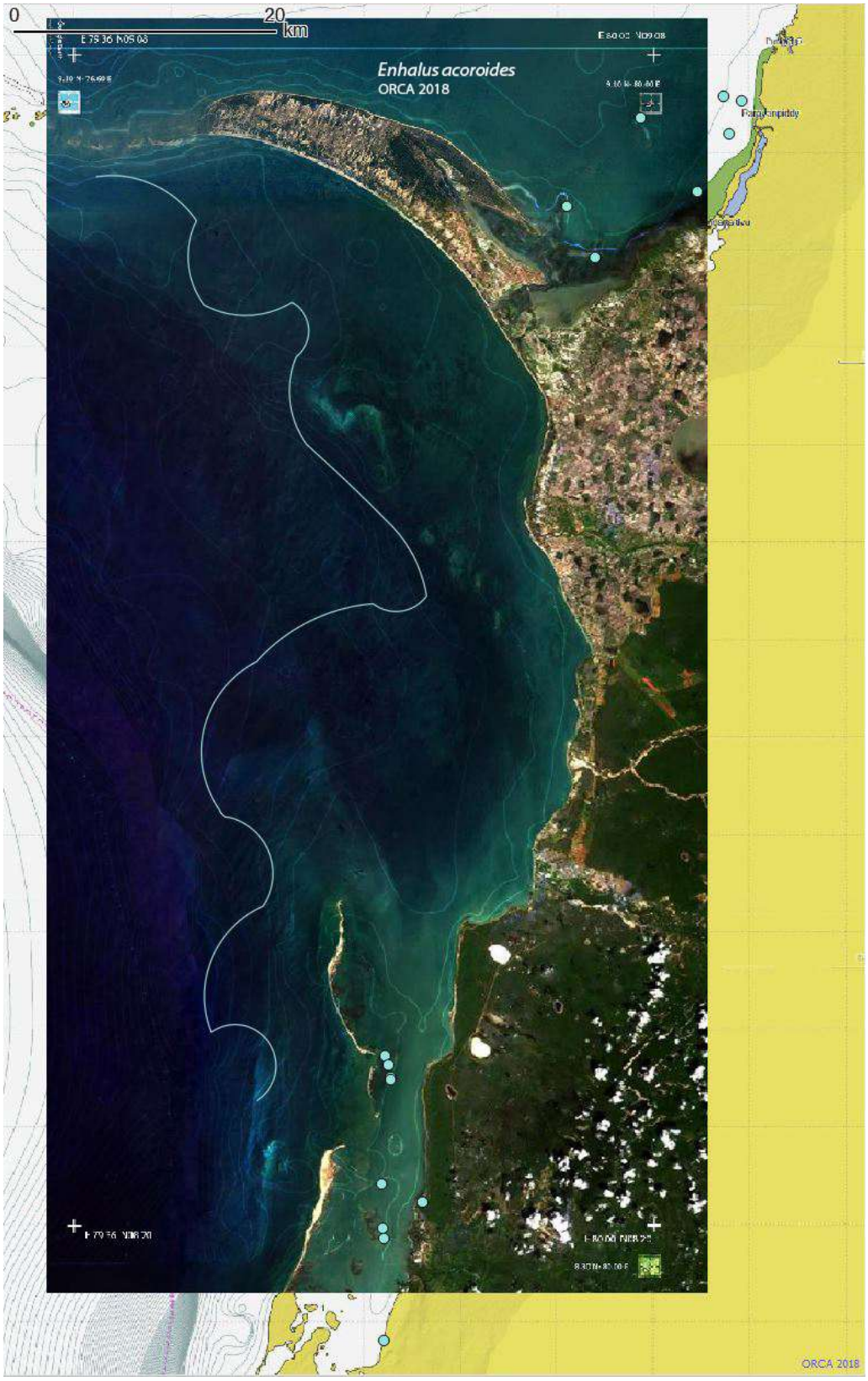


Distribution of Sea grass species- *Halodule uninervis*

Distribution of Sea grass species- *Syringodium isoetifolium*

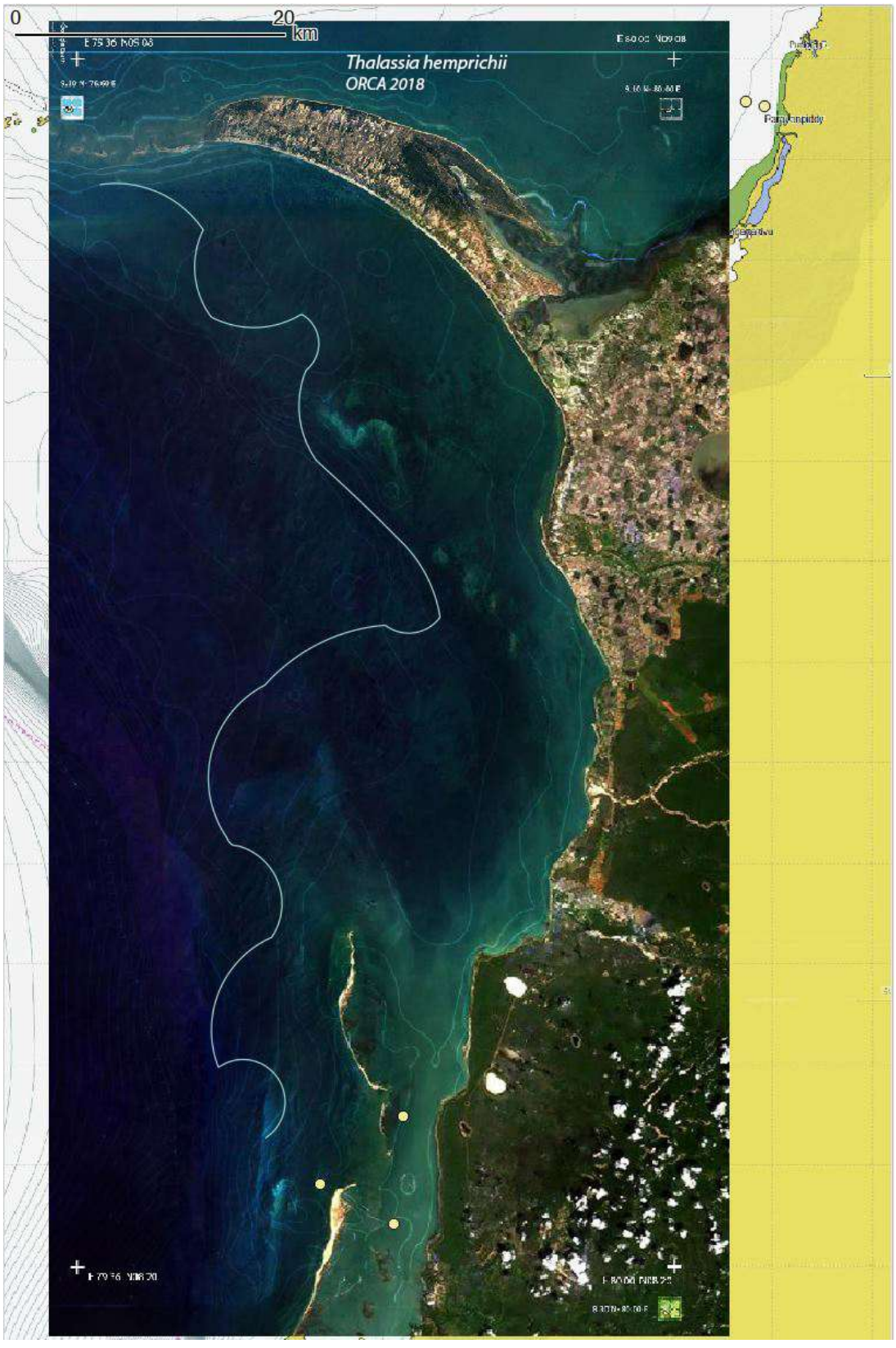


Distribution of Sea grass species- *Halophila stipulacea*

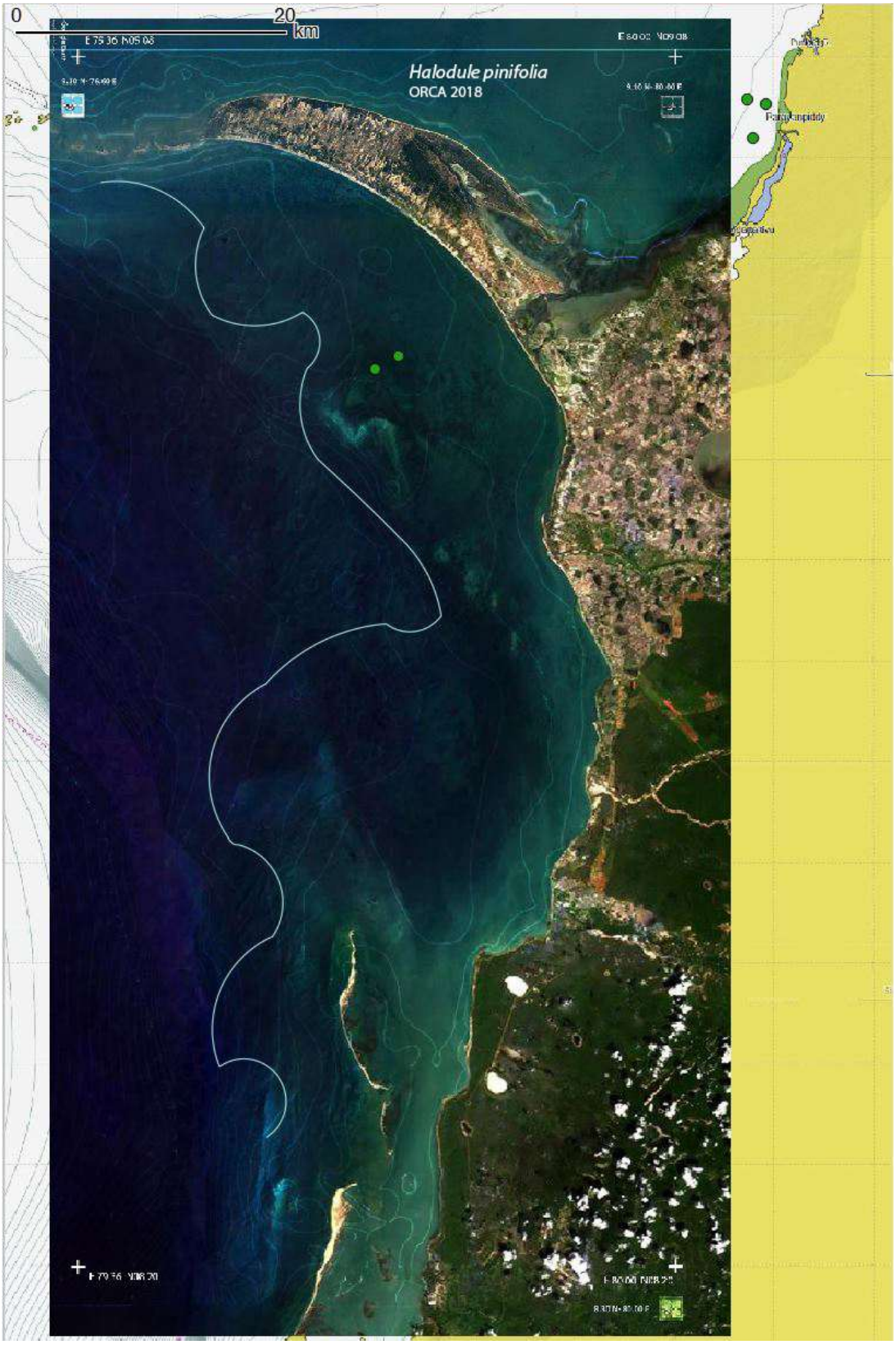


Distribution of Sea grass species- *Enhalus acoroides*

Distribution of Sea grass species- *Cymodoce rotundata*



Distribution of Sea grass species- *Thalassia hemprichii*



Distribution of Sea grass species- *Halodule pinifolia*

Sea grass specimens deposited at National Herbarium Collection

A representative collection of Sea grasses and Algae were collected and preserved for identification purposes. Over 200 specimens were deposited at the National Herbarium –Peradeniya (PDA) to supplement the National collection.

Plants of Sri Lanka

Family : Hydrocharitaceae

Species : *Halophila ovalis* (R.Br.) Hook.f.

Vernacular Name:

Locality: 9 km west from Marichchikattu beach

Date : 2/19/2016 **No:** SS/528

Depth: 8.5 m **GPS:** 8.582222°N 79.838611°E

Coll: Suranjan Fernando, P. Weerakkody, S. Subhashana and K. Lakmal

Notes : Sample collected by a SCUBA diving survey

Project : Collected for the project "Increasing knowledge on Sea-grass habitats and Dugong distribution in North Western Sri Lanka" implemented by Ocean Resources Conservation Association (ORCA), Funded by GEF/UNEP/ CMS/Mohamed bin Zayed Species Conservation Fund.

Property of National Herbarium Peradeniya

Herbarium Sheets provided of Sea grass specimens deposited at the National Herbarium in Peradeniya.

The voucher specimens would carry acknowledgement for source for the Project under the title." **Increasing knowledge on sea grass habitats and dugong distribution at selected sites in North Western Sri Lanka- Implemented by Ocean Resources Conservation Association (ORCA) funded by GEF/UNEP/ CMS/ Mohamed bin Zayed Species Conservation Fund"**

Threats

The scale of the seagrass beds of the area gives them a high degree of stability. No major threats were observed to the seagrasses of the area during the study and most seagrass areas seemed healthy

In some areas significant amounts of the algae *Caulerpa taxifolia* was observed to grow on the seagrass beds. In some global locations this species is considered invasive over sea grass. While no direct impacts from this Algae was observed on the sea grass beds-it is necessary to monitor the species for possible future threats of invasive growth that can harm the seagrass beds.

Algae *Caulerpa taxifolia/ sertularioides a possible invasive on seagrass.*

Post to the elevated high temperatures of the 2016 the early months of 2017 showed markedly cold sea conditions prevailing over most of the area. In areas close to the Bar-reef and on the southern part of the Cheval bank evidence was apparent of sea grass die back and recovery as high concentrations of dead leaf matter was observed among the surviving sea grass beds. Though the seagrass bed had been killed by the cold water the Seagrasses are recovering well sprouting new leaves from the root system that survived under the sand. This is a key survival strategy of sea

grasses where Seagrass meadows in shallow Southern coast reef lagoons periodically are killed by sand filling wiping out the sea grasses but the seagrasses would always return when the Sand is removed to expose the seagrass roots in the next season.

Sea grass Die-back and recovery due to extreme cold-water conditions in early 2017

The threat from the Bottom trawl net operations could be significant in the Gulf of Mannar area as Indian fishing vessels regularly carry out poaching raids in to Sri Lankan waters. The impacts of this needs to be further monitored to document actual damage caused to the sea grass beds. While no direct of Dredging damage was observed on the seagrass beds by Indian vessels. The regular prawn grounds at the mouth of the Kalpitiya lagoon close to battalangundu Island had suffered significant damage with little epi biota remaining over the mud bottoms.

Conclusions

The key hotspots for Dugong in the Gulf of Mannar area are located in..

1. Southern Cheval bank area
2. Arippu,Silavathura,Pearl-bank, Vankale reef area
3. Iranathivu island in Palk Bay

The primary cause of Dugong kills is the Gill net for Rays which account for over 90% of the kills.

On average 1 Dugong kill per month was reported from the area during the survey.

There are significant number of Mothers and Calves being killed indicating the population is still successfully breeding.

The killed dugongs are taken to specific areas where they are regularly processed including The Battalangundu island, Palugahathurai fishing camp within Wilpattu National Park and South Bar in Mannar.

The trade in Dugong meat is very lucrative. The high demand for Dugong meat makes it easy to sell as well as fetching high prices. A Large animal can fetch up to Rs.600,000/- (approx. 4000-4500 USD) at the point of selling it off on the beach.

Recommendations

Urgent management measures need to be brought in to Ban or restrict the use of the Gill net for Rays. As this is one of the most popular nets used in the area it is expected to be a difficult task to achieve this objective. The management of this net need to be done in consultation with the Department of Fisheries to bring in controls through the fishing gear licensing procedures to discontinue the use of this net and ultimately ban it. As an interim measure it may be possible to ban the net in identified Marine protected areas/ Fishery management areas to minimize the incidence of Dugong kill.

The Identification and declaration of Marine Protected areas focusing on Dugong and Sea grass to be given priority. Three key areas are suggested at Cheval banks, Arippu-vankale reef area and Iranathivu Island.

Field monitoring and Enforcement activities need to be strengthened. The remoteness of most sea areas makes it near impossible to monitor fishing activity with current resources of the DWC. It is essential to either significantly enhance capacity of DWC to work regularly in the offshore sea areas or bring in the assistance of the Sri Lanka Navy to carry out activities out at sea as the Navy already has the capacity and do regularly carry out patrols for security and monitoring of smuggling activity etc.

- Ban or Management measures need to be introduced to reduce impact of Ray gill net fishery and Ja-kotu fishery.

- Awareness building and promotion of alternative livelihoods focusing on coastal locations where established Dugong hunting is carried out including Battalangundu and on the coast north of Wilpatthu up to Mannar with special attention on South Bar area.
- Monitoring of remotely located safe Dugong processing points including Battalangundu and Palugahathurai.
- Establishment, monitoring and enforcing a special marine protected areas for Dugong

Postscript

At the time of the starting of the 30-year war in the area the Dugong population was believed to have been near extinct.

The marked reduction/ absence of fishing activities in the area for near 30 year period during the war is believed to have allowed the Dugong population to make a significant recovery.

With the ending of the war and returning of most of the internally displaced fishermen who were evicted by the LTTE the area is seeing a massive blooming of fishing activities that include many non-sustainable fishing gear being used.

Presently High incidences of Dugong kills are recorded from the area.

Unless urgent conservation measures are brought the level of exploitation may deplete the Dugong populations to un-sustainable levels in a very short time.

Acknowledgements

The Project would not have been possible without the active contribution and support of many individuals. Firstly, we wish to thank Commander Ravi Weerapperuma of SL Navy for assisting in securing permission for working out at sea in Restricted Sea areas in the North-West coast still recovering from the recently concluded war. To officers, friends and project partners in the Department of Wildlife conservation for support and providing necessary permits to work in areas governed by DWC. The Project administration Staff of The GEF DUGONG & SEAGRASS CONSERVATION PROJECT. Sri Lankan Project partners, local contacts who supplied valuable information- and last but not least the support crew of ORCA for providing the strength to make the project a reality.

A special thank you and acknowledgement is given to individuals who contributed photographs for the section of dugong kill records. The photographs remain the sole ownership of the respective authors mentioned with the photographs. The images are used in the report for documentation purposes only.

Halophila stipulacea (Forsskål) Ascherson, 1867 -a new species of Sea grass recorded for Sri Lanka

One new species of sea grass was added to the list of Sea grass species documented for Sri Lanka. The species *Halophila stipulacea* was not previously recorded from Sri Lanka The species was observed to have a widespread distribution though out the survey area and during the survey the team documented the species from 15 locations ranging from Kalpitiya to Vedithalathivu. Though the species had a wide distribution range the species was not abundant at any of the sites occurring scattered among other species of sea grasses with around 1% representation in quadrate samples.

Halophila stipulacea was found more abundant along the inner shoreward end of the Silawathura and Vankalai paars. Adjacent to the Silavathura and Vankalai reef systems. The species was also recorded from an area off Bar-reef and extending North along the outer sea area of Battalangundu Island where they were observed to occur in association with other *Halophila*, *Halodule* and *Syringodium* species. The species was not recorded throughout most of the Southern Chaval paars. The species was also not recorded from any of the survey locations within the Kalpitiya lagoon.

The species was also observed to occur in good numbers in a deep-water sea grass area North of the Maldiva banks close to Illuppakadavi and

Vedithalathivu on the Northern side of the Mannar Island. This area contains one of the most lush, diverse and abundant assemblages of Sea grass in Sri Lanka with a thick coastal Seagrass Forrest dominated by *Enhalus acroides, Halophila stipulacea* was found in a deeper water low growing seagrass meadow adjacent and off shore to the main Sea grass area where the Seagrasses contain an assemblage dominated by *Halophila* and *Halodule* species. The full abundance of the species in this region is undocumented as insufficient field work was carried out in this area by the team under the present project.

The species was observed to be restricted to off shore in somewhat deeper water areas of the paars ranging from 3-5m. depth.

Sample locations where Halophila stipulacea was recorded during the survey

Fauna and flora of the Sea grass areas sampled

The key difference between the current survey and most other Sri Lankan Seagrass surveys lay in the fact that the present survey is primarily a Marine survey focusing on sea grass beds located in the sea extending over 30km from the shore and in sea bottom depths ranging from shallow to over 20m. while most other sea grass surveys are focused on coastal, Lagoonal or Estuarine environments located within very shallow water depths.

This section deals with Marine fauna found in Sea grass floors and does not delve in to the general biodiversity of the area which contain many rocky outcrops and reefs which support separate and higher species diversity.

The sea grass beds within the survey were found in waters mostly at a depth of 3-10m. The soil consists of soft sand, rubbly sand or muddy floors with occasional hard substates and is generally flat and featureless. The sea grasses populating the sandy floors create different habitat features ranging where fields of small broad-leaved grasses (Halophila, *Halodules sp*. form open less dense fields while areas dominated by species like *Oceana* and *Syringodium* form fields of dense thickets of fronds that provide more cover and habitat for other species to inhabit.

Most species living within sea grass habitats are cryptic or burrowing in the sand and is difficult to observe and record. The actual diversity would be higher than recorded. Though extensive day time sampling using snorkel and SCUBA diving was carried out over a wide range of Sea grass environments no night time observations were carried out.

No specimens were collected except seagrass and Algae the collection of which was deposited at the Peradeniya National Herbarium.

On a general note sessile fauna including fishes over the seagrass beds were very low. Adult fishes were rarely encountered in any numbers including the expected herbivore species. Moderate abundance of juvenile fishes was observed including lethrinids, Lutjanids, Scolopsids, Siganids etc. Shells, Echinoids, Soft corals and Anemones were found in abundance during the surveys.

Cnidaria – Corals, Soft corals, Anemones etc.

The most prominent Cnidarians encountered in the seagrasses were the large Sea anemones *Stichodactyla haddoni* along with their symbiotic fish species *Amphiprion sebae*. Or species of commensal shrimps. High densities of soft coral *Dendronephtya* were observed in deeper areas in the cheval bank above battalangundu Islands. Some coral species were found sporadically among sea grasses including species of free-Free living corals (Cycloseris spp.)

Phylum Cnidaria

Class Anthozoa

- Subclass Octocorallia (Soft Corals)
    - Order Alcyonacea
        - Family Nephtheidae
            - *Dendronephthya* sp. (Carnation coral)
        - Family Alcyoniidae
            - *Sarcophyton* sp. (Leather coral)
            - *Sinularia sp.* (Finger Leather coral)
    - Order Scleralcyonacea
        - Family Pennatulidae
            - Virgularia densa (Sea Pen)
- Subclass Hexacorallia (Hexacorals)
    - Order Actiniaria (True Sea Anemones)
        - Family Boloceroididae
            - *Boloceroides* sp.
        - Family Actiniidae
            - *Heteractis aurora* (Beaded Sea anemone)
        - Family Stichodactylidae
            - *Stichodactyla haddoni* (Saddle anemone)
    - Order Ceriantharia (Tube-Dwelling Anemones)

        - Family Cerianthidae
            - *Cerianthus* sp.
            - *Pachycerianthus sp.*
    - Order Scleractinia (Stony Corals)
        - Family Merulinidae
            - *Favia* sp.
            - *Favites* sp.
            - *Goniastrea* sp.
        - Family Dendrophylliidae
            - *Turbinaria* sp.
        - Family Poritidae
            - *Goniopora* sp.
            - *Porites* sp.
        - Family Fungiidae
            - *Podabacea* sp.
            - *Cycloseris costulata*
            - *Cycloseris cyclolites*
        - Family Acroporidae
            - *Montipora* sp.

Porifera- Sponges

Cribrochalina c.f. sp.
Callyspongia c.f sp/ gray tube sponge
Lamellodysidea herbacea *Silvery Blue sponge*
Haliclona sp.* Blue Tubular sponge
Brown ball sponge
Yellow cup sponge
Blue tube sponge
Brown tube sponge

Annelida – Segmented Worms

Many species of unidentified polychaete and sabellid worms were observed

Sabellestarte spp.

Platyhelminthes -Flatworms

Pseudoceros scintillates/zebra c.f.

Molluscs- Sea Shells, Sea slugs and Squids

Mollusks are common in sea grass habitats with the majority being assorted Bivalve species which unfortunately is not fully documented fully in present list. Some of the larger shells commonly found included Spider conches, Chank shells and Ramosa murex shells. The sea floors were littered with shells of dead bivalve mollusks indicating an abundance and diversity higher than observed as live specimens.

Phylum Mollusca
Class Gastropoda

- Family Naticidae
    - *Polinices* sp.
- Family Neritidae
    - *Nerita* sp.
- Family Turritellidae
    - *Turritella duplicata* (c.f.)
    - *Turritella* sp.
- Family Strombidae
    - *Lambis lambis*
    - *Strombus* sp.
- Family Cypraeidae
    - *Cypraea tigris*
    - *Cypraea moneta*

    - *Cypraea caputserpentis*
    - *Cypraea arabica*
- Family Cassidae
    - *Cypraecassis rufa*
- Family Muricidae
    - *Chicoreus ramosus*
    - *Chicoreus* spp.
    - *Murex trapa*
    - *Murex* sp.
- Family Fasciolariidae
    - *Pleuroploca trapezium*
    - *Fusinus* sp.
- Family Turbinellidae
    - *Turbinella pyrum*
- Family Volutidae
    - *Harpulina loroisi*
    - *Amoria* sp. (c.f.)
    - *Voluta* sp. (c.f.)
- Family Olividae
    - *Oliva* spp.
- Family Mitridae
    - *Mitra* spp.
- Family Harpidae
    - *Harpa* spp.
- Family Babyloniidae
    - *Babylonia* sp.
- Family Terebridae
    - *Terebra* spp.

- Family Conidae
    - *Conus* spp.
- Family Bullidae
    - *Bulla* sp.

Subclass Heterobranchia (formerly Opisthobranchs & Nudibranchs)

- Family Phyllidiidae
    - *Phyllidia* sp.
- Family Chromodorididae
    - *Mexichromis multituberculata*
- Family Aplysiidae
    - *Aplysia* c.f. spp.
    - Sea hares

Class Bivalvia

- Family Pinnidae
    - *Pinna* sp.
- Family Pteriidae
    - *Pteria* sp.
- Family Malleidae
    - *Malleus* sp.
- Family Margaritidae
    - Pinctada sp.
- Family Ostreidae
    - *Crassostrea* sp.
    - *Lopha cristigalli*
- Family Gryphaeidae
    - *Hyotissa hyotis*
- Family Arcidae

    - *Anadara* sp.
- Family Mytilidae
    - *Perna* spp.
- Family Pectinidae
    - *Chlamys* sp.
- Family Cardiidae
    - *Trachycardium* sp.
- Family Carditidae
    - *Cardita* sp.
- Family Mactridae
    - *Mactra* sp.
- Family Pharidae
    - *Siliqua* sp.
- Family Donacidae
    - *Donax* sp.
- Family Veneridae
    - *Tapes* sp.

Class Cephalopoda

- Family Loliginidae
    - *Sepioteuthis lessoniana*

Crustacea- Crabs, shrimps, Hermit crabs etc.

The Seagrass beds contain many species of crustaceans though most of them are cryptic and is rarely seen in the open. Many species of symbiotic shrimps and Porcelain crabs were observed living among the Sea anemones.

Class Malacostraca

Subclass Hoplocarida

Order Stomatopoda

- Family Gonodactylidae
    - *Gonosquilla* c.f. *sp.*
- Family Lysiosquillidae
    - *Lysiosquilla* c.f. *sp.*

Subclass Eumalacostraca

Order Decapoda

Suborder Pleocyemata

- Infraorder Stenopodidea
    - Family Stenopodidae
        - *Stenopus hispidus*
- Infraorder Caridea
    - Family Alpheidae
        - *Alpheus* sp.
    - Family Thoridae
        - *Thor amboinensis*
    - Family Palaemonidae
        - *Periclimenes magnifica*
        - *Periclimenes brevicarpalis*
- Infraorder Achelata
    - Family Scyllaridae
        - *Thenus orientalis*

- Infraorder Anomura
    - Family Porcellanidae
        - *Neopopetrolisthes maculatus*
    - Family Diogenidae
        - *Calcinus* spp.
        - *Dardanus lagopodes*
- Infraorder Brachyura
    - Family Calappidae
        - *Calappa gallus*
        - *Calappa* spp.
    - Family Matutidae
        - *Matuta lunaris*
    - Family Majidae
        - *Menaethius monoceros*
    - Family Portunidae
        - *Portunus pelagicus*
        - *Portunus sanguinolentus*
        - *Portunus* sp.
        - *Charybdis* spp.
        - *Thalamita* spp.
        - *Scylla serrata*
    - Family Xanthidae
        - *Xantho* c.f. *sp.*

Suborder Dendrobranchiata

- Family Penaeidae
    - *Penaeus* sp.

Echinodermata - Sea Urchins, Sea stars, Sea Cucumbers etc.

The seastar *Pentaceraster affinis* is by far the commonest Echinoderm over the sea grass areas with individuals showing highly variable coloration ranging from white red or black markings. along with several other *Pentaceraster* species including *P. alveolus*. Red-knobbed Seastar *Protoreaster linki* was also found commonly in areas of dense seagrass fields. Several small red seastar species including *Echinaster lozonicus* was also recorded. The open sandy seagrass areas contained high densities of *Astropecten spp*. (Sand/comb seastars)

The Sea cucumbers of the genus Holothuria were common in some areas. Urchins mostly consisted of smaller short branched species and a curious un-identified species of urchin found carrying a half of a bivalve shell as a shield.

A high abundance of Shield Urchins and Heart Urchins and their shells were regularly observed.

Phylum Echinodermata

Class Crinoidea (Feather stars)

- Crinoids

Class Asteroidea (Sea stars)

  - *Luidia maculata*
  - *Astropecten* spp.
  - *Protoreaster linki*
  - *Pentaceraster affinis*
  - *Pentaceraster alveolatus*
  - *Pentaceraster* sp.
  - *Echinaster luzonicus*
  - Red seastar c.f *Echinaster* sp.2

Class Ophiuroidea (Brittlestars)

- *Ophiorachnella gorgonia*

Class Echinoidea (Sea urchins, Sand dollars, and Heart urchins)

- Order Camarodonta
  - *Salamacis bicolor*
  - *Salamacis virgulata*

- Order Echinothuriida
    - *Asthenosoma varium*
- Order Diadematoida
    - *Diadema* sp.
    - *Echinothrix calamaris*
- Order Clypeasteroida (Sand dollars / Irregular urchins)
    - *Echinodiscus auritus*
    - *Echinodiscus bisforatus*
- Order Echinolampadacea
    - Echinoilampas ovata.
    - Peronella lesueuri – Pink Sand Dollar
- Order Spatangoida Heart Urchins

Class Holothuroidea (Sea cucumbers)

- Sea Cucumbers
- *Holothuria atra*
- *Holothuria edulis*
- *Stichopus variegatus*

Fishes

The abundance and diversity of fish species was relatively low over the sea grass beds and consisted of Groupers, Scorpion fishes, file fishes, and other bottom living species. Small schools of Juvenile fish of Mullets, Goatfish, Emperors and Breams were common. Most Seagrass fish species are cryptic and is difficult to observe and the list may not adequately cover all fish species associated with the sea grasses.

In addition to the observed species the area is documented to be home to many of the rare and possibly endangered Saw fishes and Saw Sharks and their allies in Sri Lanka

The following species including Aetobatus narinari, Hypholophus sephan, Himantura spp. and Rhinobatos sp. Were documented in fish landing sites but not directly observed underwater.

Class Elasmobranchii (Sharks and Rays)

Order Myliobatiformes (Stingrays and Eagle Rays)

- Family Dasyatidae (Whiptail Stingrays)
    - *Dasyatis kuhlii* (Blue-spotted stingray)
    - *Dasyatis marginatus* (Black-edged stingray)
    - *Pastinachus* c.f. *sephan* (Cowtail ray)
    - *Himantura sp.*
- Family Aetobatidae (Eagle Rays)
    - *Aetobatus narinari* (Whitespotted eagle ray)

Class Actinopterygii (Ray-finned Fishes)

- Family Clupeidae (Herrings and Shads)
    - *Hilsa kelee* (Kelee shad / Karattaya)
- Family Synodontidae (Lizardfishes)
    - *Synodus* spp.
- Family Syngnathidae (Seahorses and Pipefishes)
    - *Hippocampus trimaculatus* (Three-spot seahorse)
    - *Hippocampus kelloggi* (Kellogg's seahorse)
    - *Hippocampus* spp.
- Family Carangidae (Jacks and Trevally)
    - *Carangoides ferdau* (Barred trevally)
- Family Terapontidae or Kyphosidae (Sea Chubs)
    - *Kyphosus* sp.
- Family Labridae (Wrasses)
    - *Halichoeres* spp.
    - *Aspidontus dussumieri* (Lance blenny / False cleanerfish)

- Family Bothidae (Lefteye Flounders)
    - *Bothus pantherinus* (Leopard flounder)
- Family Siganidae (Rabbitfishes)
    - *Siganus canaliculatus* (White-spotted spinefoot)
    - *Siganus* spp.
- Family Scorpaenidae (Scorpionfishes)
    - *Inimicus didactylus* (Bearded ghoul)
    - *Scorpaenopsis* c.f. *sp.*
- Family Apogonidae (Cardinalfishes)
    - *Apogon* spp.
- Family Gobiidae (Gobies)
    - *Valenciennea* sp.
- Family Callionymidae (Dragonets)
    - *Synchiropus* sp.
- Family Triacanthidae (Tripletails / Spikefishes)
    - *Pseudotriacanthus striglifer* (Long-spined tripodfish)
- Family Monacanthidae (Filefishes)
    - *Pervagor* sp.
    - *Paramonacanthus chirocephalus* juv (Hair-finned filefish)
- Family Tetraodontidae (Pufferfishes)
    - *Arothron* sp.
- Family Latidae (Lates Perches)
    - *Lates calcarifer* (Barramundi / Moda)
- Family Sillaginidae (Smelt-whitings)
    - *Sillago* sp.
- Family Sphyraenidae (Barracudas)
    - *Sphyraena acutipinnis* (Sharpfin barracuda)

- Family Lutjanidae (Snappers)
    - *Lutjanus ehrenbergii* juv (Blackspot snapper)
    - *Lutjanus decussatus* juv (Checkered snapper)
- Family Lethrinidae (Emperors)
    - *Lethrinus nebulosus* juv (Spangled emperor)
    - *Lethrinus* sp.
- Family Nemipteridae (Threadfin Breams / Monocle Breams)
    - *Scolopsis bilineata* juv (Two-lined monocle bream)
    - *Scolopsis bimaculata* juv (Thumbprint monocle bream)
    - *Scolopsis affinis* juv (Peters' monocle bream)
- Family Mullidae (Goatfishes)
    - *Upeneus tragula* juv (Freckled goatfish)
    - *Mulloidichthys flavolineatus* juv (Yellowstripe goatfish)
    - *Mulloidichthys vanicolensis* juv (Yellowfin goatfish)
    - *Parupeneus indicus* juv (Indian goatfish)
    - *Parupeneus macronema* juv (Long-barbel goatfish)
- Family Cirrhitidae (Hawkfishes)
    - *Cirrhitichthys* sp.
- Family Pomacentridae (Damselfishes)
    - *Amphiprion sebae* (Sebae anemonefish)
    - *Neopomacentrus azysron* (Yellowtail demoiselle)
    - *Pomacentrus* spp.
    - *Dascyllus trimaculatus* (Threespot dascyllus)
- Family Pseudochromidae (Dottybacks)
    - *Pseudochromis* sp.
- Family Haemulidae (Grunts and Sweetlips)
    - *Plectorhinchus* sp. juv

Ascidians

Several un-identified species of Ascidians were observed on the sea grass areas.

Marine Mammals

The extensive sea grass beds of the Gulf of Mannar and Palk Bay is the exclusive home range of the elusive Dugong. The range of the Dugong extends over the shared continental shelf over in to the Indian coast. Two groups of Indo-pacific Humpback dolphins were observed one within the Kalpitiya lagoon and another separate group resident on the Mannar Islands area. An incident was documented where a pod of Finless porpoise *(Neophocaena phocaenoides)* was caught on a beach seine net in Jaffna in an area with high abundance of sea grass indicate that this species may also occur in Seagrass habitats

Dugong dugon	Dugong
Sousa chinensis	Indo-pacific Humpback Dolphin
Neophocaena phocaenoides	Indo-pacific Finless porpoise

Marine Reptiles

The Gillnet fishery for rays which is one of the primary fisheries in the area is responsible for significant by-catch mortality of Sea turtles in the area. According to fishermen estimates around 50 turtles are killed in the nets per day in the Mannar-Kudirimale section of the coastline. This note is in some ways verified by the high incidence of turtle carcasses found floating in the sea during survey work. Green Sea turtles are reported from the shoreward sections of the survey area while Olive ridley turtles are found further offshore sometimes in periodic aggregations along the continental shelf edge.

Though several species of Sea snakes are generally reported from the area no sea snake species were encountered during the present survey.

Lepidochelys olivacea -	Olive Ridley Turtle
Chelonia mydas -	Green Sea turtle

Algae

Sea grass beds contain a good diversity of co-existing algal species. In several instances Algae were observed to be competing with Sea grasses and dominating some areas locally. These included species of Ulva, Padina, *Caulerpa sertularioides* and *C. taxifolia*

Phylum Chlorophyta (Green Algae)

Class Ulvophyceae

Order Bryopsidales

Family Caulerpaceae

Caulerpa fergusonii cf.

Caulerpa racemosa

Caulerpa sertularioides

Caulerpa taxifolia

Caulerpa sp.

Family Codiaceae

Codium arabicum

Codium geppiorum

Family Halimedaceae

Halimeda discoidea

Halimeda macroloba

Halimeda opuntia

Family Udoteaceae

Avrainvillea amadelpha c.f.

Avrainvillea erecta

Order Cladophorales

Family Siphonocladaceae / Valoniaceae

Valonia sp.

Phylum Ochrophyta / Class Phaeophyceae (Brown Algae)

Order Dictyotales

Family Dictyotaceae

Dictyota sp.

Lobophora variegata

Padina spp.

Stoechospermum polypodioides

Order Ectocarpales

Family Scytosiphonaceae

Colpomenia sinuosa cf.

Order Fucales

Family Sargassaceae

Sargassum sp.

Turbinaria sp.

Phylum Rhodophyta (Red Algae)

Class Florideophyceae

Order Bonnemaisoniales

Family Bonnemaisoniaceae

Asparagopsis sp.

Order Corallinales

Family Corallinaceae

Amphiroa fragilissima

Jania sp.

Order Halymeniales

Family Halymeniaceae

Halymenia durvillei

Order Nemaliales

Family Liagoraceae

Liagora ceranoides

Order Peyssonneliales

Family Peyssonneliaceae

Peyssonnelia sp.

Order Ceramiales

Family Callithamniaceae

Spyridia c.f. sp.

Seagrass

Family: Hydrocharitaceae

- Enhalus acoroides (L.f.) Royle
- Halophila decipiens Ostenf.
- Halophila ovalis (R.Br.) Hook.f.
- Halophila stipulacea (Forssk.) Asch.
- Thalassia hemprichii (Ehrenb. ex Solms) Asch. [1]

Family: Cymodoceaceae

- Cymodocea rotundata Asch. & Schweinf.
- Halodule uninervis (Forssk.) Boiss.
- Oceana serrulata (R.Brown) Byng & Christenh.* (ex -(Cymodocea serrulata)
- Syringodium isoetifolium (Asch.) Dandy [1, 2]

Photo Gallery…….

Lobophora variegata

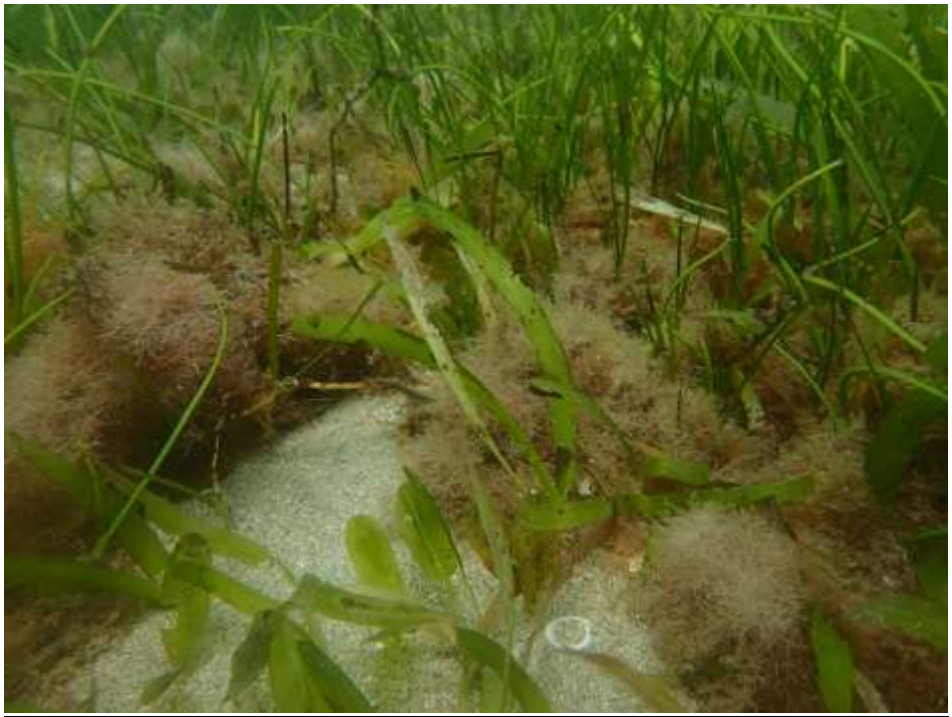
Halimeda macroloba

Valonia utricularis

Avrainvillia amadelpha c.f.

Caulerpa sertularioides

Caulerpa fergusonii

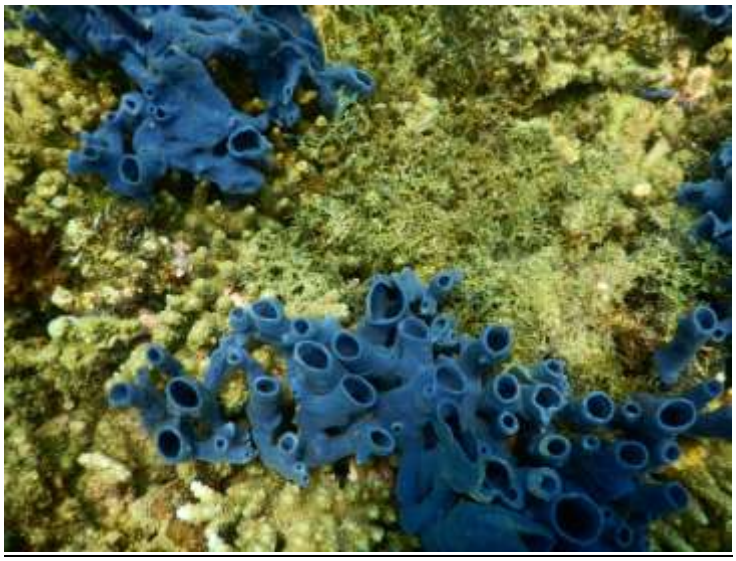


Spyridia c.f. sp.

Colpomenia sinuosa

An unidentified species of large algae

Un-identified Sponges



Pentaceraster affinis

Pentaceraster affinis

Pentaceraster alveolatus

Pentaceraster affinis

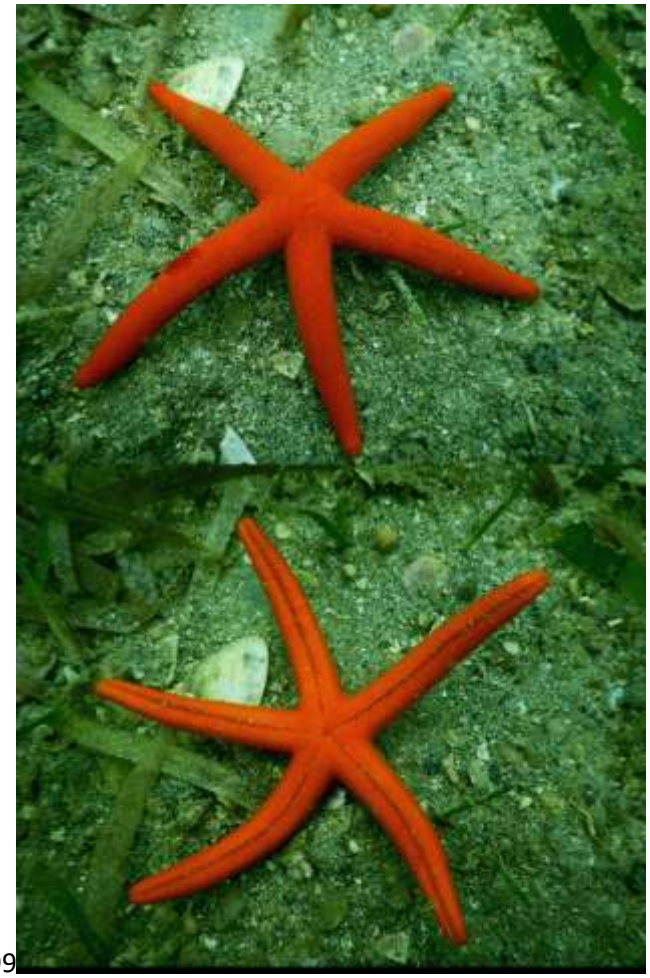
Astropecten sp.

Protoreaster linki

Luidia maculata

Echinaster luzonicus

Ophiorachnella gorgonia c.f.
Brittle star



Echinaster sp.2

Salamacis virgulate -decorator Urchin

Salamacis bicolor – Decorator Urchin

Un-identified juvenile urchin living under sea shalls
c.f. Salamacis sp.

Echinodiscus auritus

Seastar *Luidia maculata in defensive pose*

Dendronephthya sp. – Soft Coral

Boloceroides sp- Sea anemone

Cycloseris cyclolites - coral

Cycloseris costulata - coral

Heteractis aurora

Beaded Sea anemone

Cerianthus sp.
Tube Anemone

Soft coral
Sinularia sp.

Neopetrolisthes maculatus – Porcellain crab on *Stichodactyla haddoni*- Haddon's Carpet anemone

Ancylocaris brevicarpalis- Peacock tail Anemone shrimp on *Stichodactyla haddoni*- Haddon's Carpet anemone

Ancylomenes magnificus- Magnificiant Anemone shrimp on *Stichodactyla haddoni*- Haddon's Carpet anemone

Amphiprion sebae Clownfish on *Stichodactyla haddoni* - Haddon's Carpet anemone

Pinna sp. -Ear shell

Chicoreus ramosus – Ramose Murex

Turbinella pyrum – Chank shell

Harpulina loroisi - Volute shell

Murex trapa

Epinephelus sp.

Pervagor sp.

Inimicus filamentosus

Pseudoceros scintillates/zebra c.f.
-Flatworm-

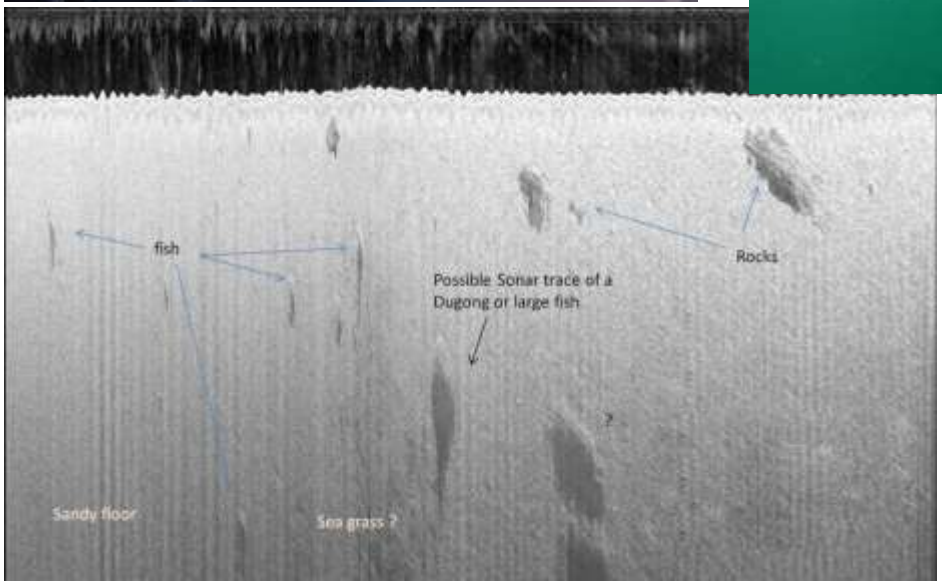
Portunus pelagicus

Indo-pacific Humpback Dolphins near Mannar Islands

Field survey photos.

Most of the field surveys were conducted using small boats and SCUBA diving.

Side scan Sonar was used extensively to map and Identify habitats for surveying extensive unknown sea areas.



While most of the surveys were carried out using small FRP boats a live abord vessel “Ceywave” was used as a live abord station to facilitate the survey of the further off shore areas

Use of mini drones were used to rapidly monitor larger seagrass areas

Comparative notes between Pearl fishery (Herdman) reports and present status of Gulf of Mannar marine environment.

The "Report to the government of Ceylon on the pearl oyster fisheries of the gulf of mannar" -w. a. Herdman -1903 (Herdman reports) provides an invaluable source of reference to the structure, status and bio-diversity of the Gulf of Mannar with a focus on the Pearl oyster fishery of the early 20th Century. The report gives a detailed account of most areas of the Gulf of mannar giving details of the layout of the "paar's their substrate composition and fauna and flora recorded at each site.

The report consists of 5 books with general introductory texts to the Pearl fishery and the paars where the Pearl oysters were harvested from. The books also contain extensive descriptions of demersal fauna recorded under each taxonomic group ranging from copepods to Sea urchins and fish.

During the inception of the present study a remote sensed survey of the area was carried out using Google earth imagery and other sources of the area which indicated sub-sea features that seemed to correspond with the maps included in the Herdman reports. These include the large U-shaped feature identified as the Cheval paar located north of Battalangundu Island and Kudiramale point. The present survey sampled 255 locations of sea substrate carrying out spot and detailed substrate sampling using snorkel and SCUBA dives.

In comparing the two data sets significant disparities become apparent. The Herdman report while describing most of the sea areas and marine animals and algae of each site in detail contain only a few reference to the presence of seagrasses in the area which in the present context form the dominant and most extensive biotic component of the area.

In her supplementary report *"The Marine Algae, with a Note on the Fructification of Halimeda"*, Mrs. Ethel S. Gepp The Botanist for the survey lists the following species of Algal from the Mannar Pearl Banks including algal genera *Halimeda, Caulerpa, Codium, Enteromorpha, , Sargassum, Dictyota, ,Padina, Turbinaria, Gelidium, Gracilaria, Hypnea, Laurencia, Amphiroa etc. But does not include any references to the presence of Seagrass*

Under the section "Description of the Pearl Banks" it notes *"…the shallow sandy stretches are often covered with Halophila* and other marine herbage, forming meadows in which juvenile oysters and fish abound." Again, under the "Environment of the Paars" another passage states: *"…beds of Thalassia hemprichii* occur adjacent to certain paars, their root systems binding the sand and affording shelter to crustaceans and young mollusks. While the descriptions of all the major paars do not carry any further references to sea grass despite extensive listings of other fauna and algae.

Few references are also found to the presence of Dugong in the report including references-: *"…the*

dugong, or sea-cow, is occasionally met with in these waters, grazing upon the beds of Halophila and other marine herbage." Referring to the fisheries in Mannar it is also indicated that *"Dugong are also taken here, they feed upon the Zostera which is plentiful all around."*

The general lack of references to the vast and dense seagrass meadows that dominate the whole of the Gulf of Mannar at present in the Herdman reports raises several questions. During the present survey most of the "paar" substrates indicated in Herdman reports could not be identified along with habitats suitable for any Pearl oysters. Only a few pearl oysters were recorded occasionally with no large oyster aggregations observed in any part of the survey. The rocky or gravel type habitats were sparce with most of the sea floors consisting of vast fields of Sand or areas of Sand overgrown with Seagrasses. A large U-shaped structure similar to the shape of the Cheval bank in the Herdman reports is clearly evident in present day satellite imagery but is presently composed of dense fields of Seagrasses.

The species *Halophila, Thalassia hemprichi, Zostera*, are mentioned in the Herdman report but the presently dominant species of *Oceana, Syringodium, Halodule* was not reported. The species *Thalassia hemprichi* was only observed in inshore lagoonal habitats in the present survey and may have been a mis-identification of another broad-bladed sea grass variety.

In conclusion either overall, less importance had been placed in reporting on sea grasses within the Herdman report indicating lower ecological value given to sea grasses. Or deliberately omitted due to non-relevance as Oyster habitats.

The third possible reason may be accelerated habitat change over the past century which may have triggered a population bloom and conversion of substrates in to Sea grass dominant habitats.

The reason for the commissioning of the Herdman Report at the turn of the 20th century was also due to the significant ecological changes affecting the area that was leading to reduction of the Pearl oyster populations and the ending of the millennia long Pearl oyster fishery of the Gulf of Mannar.

The question is open on what caused the major difference in ecological context of the region between the two surveys. Was it due to the limited scope of reporting of the first survey omitting references to a significant component of the survey area or did the area undergo extensive ecological transformation changing from sandy areas interspaced with rocky "paars" to an ecosystem dominated by vast meadows of Seagrass within a span of 100 years.

<u>Coral Reefs</u>

Though references to the Coral reefs is sparce in the report- Very few mentions are found of the major Coral reefs that exist at present at Silavathura, Arippu and Vankale. The report makes a note "About 1 mile further inshore lies Aripu Coral Reef, round which is a hard patch of nearly 1 mile across, with depths of 2- to 4 fathoms."

The secondary report published by T. Southwell and J. C. Keb.vHam in 1912 give much more significant reporting of the Coral reefs of the area. "Aripu Reef lies due west of Aripu tope, at a distance of 4 miles, and occurs on the edge of the inshore overfalls of a shallow water plateau of

from 2 to 3 fathoms, which extends out from the shore, and starting at Kutrimalle Point sweeps gradually in a curve to the north-west, and finally west-north- west. The coral reefs commence off Silavatarai, and are named Silavatarai, Arippu, and Vankalah reefs. Silavatarai reef forms the southern extremity. These coral reefs, which extend in a north-westerly direction for a distance of 5 miles, cover an area of about 4 square miles, and terminate on the west in from 4 to 5 fathoms of water."

And describes the layout of the Coral reefs "The reef is made up of three groups of coral, including the Silavatarai patch, which dry at low water. Madrepore predominates, and occurs in great variety. On this reef the sea breaks in places, which is accounted for by shallow water, there being a depth of under 6 feet in parts.

Vankali Reef lays off the port of that name and north of the deep arm of the sea mentioned as dividing this from the Aripu reef. It occurs on the edge of the overfall of the shallow inshore plateau, which here extends in a more westerly direction, and is at the northern extremity, 9 miles from the shore. The plateau inside is shallow, i.e., 2 to 2| fathoms. The coral grows in dense solid masses on the overfalls, and terminates on the west face in from 5 to 6 fathoms. The most massive growths occur in from 1 to 2 fathoms. The reef covers an area roughly of 6 square miles, and is 6 miles long. It terminates north, where the shallow plateau ends, and soundings deepen to 5 fathoms.

The characteristic of the coral growth here is *Turbinaria cincerens* in huge masses, rising abruptly, and growing in separate dense growths with deep chasms between, which make walking over the reef (of which an extensive area dries at low water) a dangerous business, unless one is attended by a boat and companions, for one might get badly hurt by a sudden fall into the deep abysses, and as the coral overlaps, it would be an easy matter to find oneself fast under the overhanging edge. On this reef, as on the Bar reef, the sea does not break, due to the fact that the coral grows out into deep water."

REPORT TO THE GOVERNMENT OF CEYLON ON THE PEARL OYSTER FISHERIES OF THE GULF OF MANAAR. By W. A. HERDMAN, with supplementary reports upon the marine biology of ceylon by other naturalists. 1903.

CEYLON MARINE BIOLOGICAL REPORTS. Part VI. REPORT ON CERTAIN SCIENTIFIC WORK DONE ON THE CEYLON PEARL BANKS DURING THE YEAR 1911. T. Southwell and J. C. Keb.vHam, 1912

ORCA Team.

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