Performance Report
2019

National Aquatic Resources Research and Development Agency

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Table of Contents

Research and Development Performance -2019

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Improvement of productivity and promotion of aquatic resources in a sustainable manner is a main challenge for the future development in the fisheries and aquatic resource sector in Sri Lanka. Proper identification of research and development priorities is imperative to address critical issues and solve them scientifically. The research and development framework for the year 2019 was formulated with the participation of stakeholders in the field of fisheries and aquatic resources. The studies identified with the stakeholders for the year 2019were mainly focused on:

Marine and coastal resources: Large pelagic and small pelagic fish resource assessments, potential fish zone forecasting; exploration of unutilized stocks: octopus and ray; ecological and biological assessments including stock identification, demersal fish and corals ; destructive fishing methods ; stock enhancement by providing artificial habitats ; conservation studies on whales and turtles; economic assessment on cost of production on different fishing vessel categories ; capacity development of skippers on fishing and vessel operations. Environmental studies including environmental pollution studies, ocean processes and dynamics, other phenomena such as harmful algae and micro-plastic and preparation of environmental profile for five coastal lagoons. In addition, preparation of coastal charts and updating of existing nautical charts in harbour approaches.

Inland aquatic resources and aquaculture development: Feed development and culture trails with sea bass, ornamental fish and sea cucumber; studies on propagation of sea weed and aquatic plants ; breeding technology development captive / induced for high value fish species and seed production, culturing of sea weeds, sea cucumber, freshwater aquatic plants and oysters with community participation; wetland and environmental management; institutional and policy studies on investment barriers ; studies on suitable intensity level of stocking fish fingerlings for inland reservoirs and preparation of zonal plan for oyster culture

Post harvest processing and utilization: Preparation of suitable vessel design to reduce quality loss by incorporating new technologies; improvement of post-harvest handling and processing technologies assessment of quality of ice; value-added products from fish, fishery products and aquatic plants

Research reports and findings will be shared with relevant stakeholders to take necessary action for the sustainable development of the fisheries and aquatic resources sector. Scientific data will be presented and published at the scientific session of NARA which is to be held in June this year with the participation of stakeholders.

Marine Biological Resources Division

Assessment and monitoring of marine finfish fishery resources in Sri Lanka

Project No: 2.1

Officer/s Responsible: Dr. S.S.K. Haputhantri, Dr. R.P.K.Jayasinghe, Mr. R.A.M. Jaythilaka, Ms. K.H.K Bandaranayake, Mr. K.R Dalpadathu, Mr. M.Weerasekara, Ms.T.Balawardhana, Ms.U.Wimalasiri

Part 1: Assessment and monitoring of small pelagic and large pelagic fishery resources via port sampling

Large Pelagic Fishery

Port sampling and fisheries statistics

Large Pelagic Port sampling is a collaborative fisheries data collection programme implemented by the Marine Biological Resources Division (MBRD) of NARA, Department of Fisheries and Aquatic Resources (DFAR) and Statistics Unit of Ministry of Fisheries and Aquatic Resources Development (MFARD) for obtaining large pelagic fish landing data. Large pelagic resources mainly comprise of tuna and tuna-like species. The large pelagic port sampling survey in Sri Lanka was started in the 1990's by NARA. The main objective of the survey was to obtain catch and effort data on large pelagic fish, in particular on tuna and tuna-like fish.

IOTC data submission and attending for working parties organized by IOTC

Currently, it is a mandatory requirement to submit large pelagic fisheries data to the Indian Ocean Tuna Commission (IOTC). The data collected annually via the port sampling programme needs to be analyzed and then submitted to the IOTC before 30th June. The data submitted to IOTC needs to comply with the relevant resolutions implemented by IOTC. In the submission, catch data, effort data, length frequency data, information on discards and vessel information etc. are provided in detail as per the requirements of those resolutions. As a result of complying with the resolutions relating to data submission, Sri Lanka has been able to achieve an 87% compliance rate in 2019. It is 6 % increase as compared to the previous year (83% in 2018). This is a great achievement when compared to our past records and compliance records of other coastal states in the Indian Ocean.

IOTC organizes several working parties and these working parties are conducted annually. In 2019, Five MBRD scientists participated for five working parties. They prepared and presented papers at the respective working parties.

Titles and abstracts of the papers presented

Some biometric parameters of Auxis thazard (Lacepède, 1800) (frigate tuna) – data from fishery dependent and fishery independent surveys conducted in Sri Lankan waters:

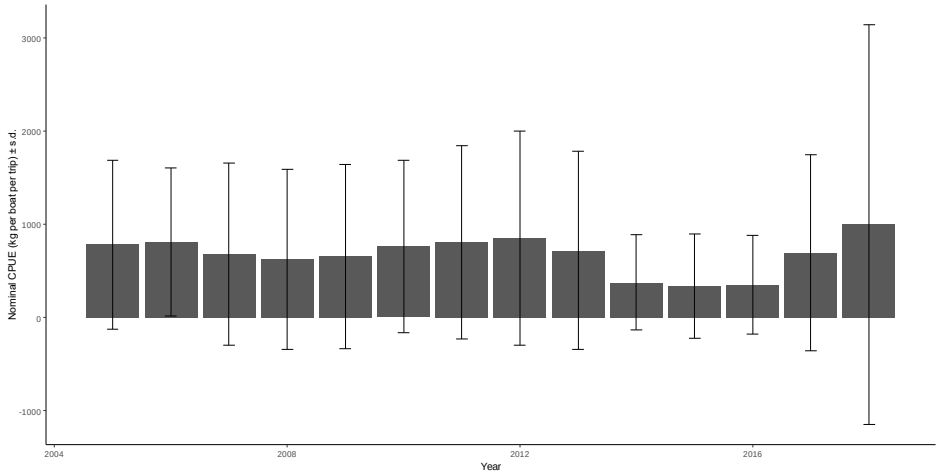
The neritic tuna catch in Sri Lankan waters is mainly composed of *Auxis thazard* (frigate tuna), *Auxis rochei* (bullet tuna), *Euthynnus affinis* (kawakawa) and *Scomberomorus*

commerson (narrow- barred Spanish mackerel). Among them, frigate tuna is the dominant species presently contributing over 40% to the total neritic tuna production. Though several studies have been conducted to estimate some biometric parameters of the frigate tuna in Sri Lankan waters, all of the studies have focused on fishery dependent data. This paper attempts to estimate the biometric parameters of frigate tuna using both fishery independent data and fishery dependent data. Length–weight relationship (LWR) was calculated using the equation $W = aL^b$ and the Fulton's condition factor (K) was estimated from the relationship $K=100W/L^3$ (W = total weight; L = total length) to assess the condition of the selected fish. Fishery dependent data from 373 specimens were obtained from the samples collected from the coastal fisheries catches from October 2015 to September 2017. Fishery independent data of 254 specimens was obtained from the samples collected from R/V Dr. Fridtjof Nansen Ecosystem survey conducted in Sri Lankan waters from 24 June 2018 to 16 July 2018. The total length and the weight of the fishery dependent samples ranged from 21.50 cm – 44.20 cm and 118.89 g – 1430.90 g respectively while those parameters of fishery independent samples ranged from 14.00 cm – 19.00 cm and 20.00 g – 80.00 g respectively. The LWR for the commercial catch and the fishery independent catch were $W = 0.003L^{3.428}$ and $W = 0.037L^{2.540}$ respectively. The estimated K value for the commercial catch and fishery independent catch were 1.48 ± 0.15 and 1.03 ± 0.16 respectively. Considering the growth pattern of the two studies, commercial catch showed a positive allometric growth while fishery independent survey showed a negative allometric growth. Based on the results of the K, it can be concluded that the population consisting of larger fish from the commercial catches was at a better condition than the juvenile population studied during the fishery independent survey. According to the results of the fishery independent survey, two possible nursery grounds for *Auxis thazard* in the Sri Lankan waters were identified.

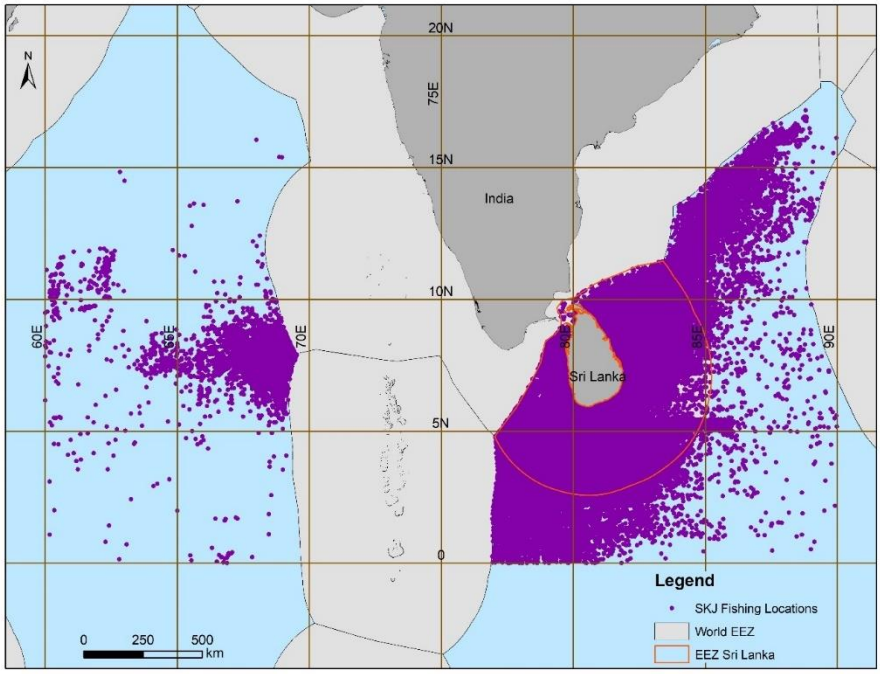
Use of port sampling and logbook data for the analysis of catch rates of Skipjack Tuna (Katsuwonus pelamis) in gillnet fishery of Sri Lanka:

Fourteen years port sampling data (2005-2018) and three years logbook data (2016 - 2018) in the gillnet fishery of Sri Lanka were used to analyze the catch rates of skipjack tuna. Skipjack tuna is the main target species in the Sri Lankan gillnet fishery. All gillnet catches including the catches made by popular gear combinations operated in the gillnet fishery (gillnet–longline and gillnet-ringnet) were considered under the port sampling. Five vessel types operated in the tuna fishery have caught skipjack tuna. Year, month, boat type, gear type, trip duration (in days) and number of net panels used per fishing operation were incorporated for the analysis. Fishing location (5° square) obtained from fisheries logbooks with regard to gillnet fishing operations made during 2016 – 2018 was also considered for this audit. The logbook data exists at present only for multiday fishing vessels. The skipjack tuna Catch Per Unit Effort (CPUE) was estimated in terms of catch in kg per boat per trip. Gamma based Generalized Linear Models (GLMs) were fitted to determine the relationship between above mentioned explanatory variables and CPUE for two data sets separately. Around 1.3% of the total operated vessels which contained

zero catches of skipjack tuna in the port sampling data were excluded for the analysis. The GLM model fitted to port sampling data explain around 48% of the total deviance and vessel type was found to be the most important parameter. Inclusion of 5° square fishing zones for GLM modeling may help only to slightly improve the GLM results.



Variation in nominal CPUE of skipjack tuna in gillnet fishery of Sri Lanka during 2004-2018. The error bars refer to the standard errors



Spatial distribution of skipjack tuna fishing grounds: 2016 - 2018

Present status of threatened and conserved species entanglement in multiday tuna fishery in Sri Lanka

Sri Lanka is one of the oldest and most important tuna producing island nations in the Indian Ocean. Multiday fishing crafts in Sri Lanka are mainly operated targeting tuna and tuna like species and this is a multi-gear, multi-species fishery. Certain threatened and conserved species are protected in Sri Lanka by the existing law notably, oceanic white

tip shark, three species of thresher sharks, whale shark, marine mammals and turtles. It has been reported that accidental catching of above species in fishing gears frequently operated in the tuna fishery such as gillnets, longline and ring net. The present study was undertaken with the aim of studying the present status of threatened and conserved species recorded in the tuna fishery for improving the conservation and management of them. Log book data of the Sri Lanka tuna fishery operated during 2016 to 2018 with multiday fishing vessels in EEZ of Sri Lanka and high seas were used for this audit. A total of 4014 records of incidental catches of threatened and conserved species were reported, of which 73.1% were caught to gillnets 16.0% were caught to longline and 10.9% were caught to ring nets. However, for all gear, the live release rate of incidental catch was around 90% and zero mortality was recorded for ring nets. When comparing three consecutive years, entangling of conserved shark species especially thresher sharks to fishing gear was considerably higher in 2018 and probably this may be due to the enhancement of thresher population after imposing a total ban on thresher sharks in 2012. Moreover, total turtle entanglement in all the gears was 3351 of which gillnet was the highest (80.6%). However, around 87% of sea turtles were released live. Furthermore, Green turtles were the most common among turtle by-catch records. A total of 672 and 945 Green turtles were recorded in 2017 and 2018 respectively. Among them, 89.5 % was reported in gillnets followed by longline (8.2 %). Occasional dolphin catches were also recorded mostly for gill nets. The results revealed that gill net is more responsible for catching protected species than other gears. Further, the records indicate a slight increasing trend in the total entanglement with the highest number of 2327 reported in 2018. However, 88% of them were released live. The slight increase of recorded catch of threatened and conserved species could be mainly attributed to the improved logbook fisheries data collection system in Sri Lanka.

Sword fish catch rates in relation to Sea Surface Temperature and Chlorophyll-A concentration within EEZ Sri Lanka

Swordfish (*Xiphias gladius*) is one of the important bill fish species landed as a by catch of the tuna- longline fishery. In 2018, the production of swordfish in the longline fishery within EEZ was 5795 mt which constitutes about 42% of the total bill fish catch. Remarkable changes of the monthly catch rates of sword fish can be observed from different zones of the country and may probably be influenced by the monsoon driven temperature and chlorophyll fluctuations. Therefore, the present study was undertaken to understand temperature and chlorophyll a effects in the CPUE variations of swordfish within the EEZ, Sri Lanka. The values of Sea Surface Temperature (SST) and Sea Surface Chlorophyll a (SSC) were obtained from remote sensing data while catch rates were based on 2016 longline fishery data of log books. A Generalized Additive Model (GAM) was fitted for describing the relationships between oceanographic parameters and sword fish catch rates. The result of GAM shows that the relationships between swordfish catch rates and two oceanographic parameters are significant at 0.05 level ($p<0.01$). The higher catch rates of swordfish were observed from the areas where SST varied between 28.8-30.6 °C and SSC ranged from 0.11-0.16 mgm^{-3}. However, the strongest relationship was observed between SST and swordfish CPUE. The GAM results show that space-time factor

also has more influence on swordfish catch rates where high catch rates are primarily associated in productive areas of Sri Lankan EEZ.

Way forward for an improved data collection and data management system for marine fisheries in Sri Lanka

The coastal and off-shore fisheries in Sri Lanka are rather complex due to its multi-gear, multi-craft and multi-species nature. Collection of fishery dependent data is therefore a challenging task. This research discusses the existing data collection and data management systems practicing at present in the marine fishery of Sri Lanka: Port Sampling Program (PSP), Log Book Data Collection Programme (LBDCP), Observer Program (OP) and Vessel Monitoring System (VMS). It also discusses in detail about new PSP, which is currently in progress under Sri Lanka- Norway bi-lateral project.

The existing PSP is a manually adopted offline process, from the collection of data at the landing sites to the entering of data into the database (PELAGOS). Therefore, there was a need for improving the present PSP, especially, introducing Information and Communication Technology (ICT) for fisheries data collection, data storing and data processing. This upgrading is currently being done under the Sri Lanka-Norway bi-lateral project, 2016-2019. There is currently a process of applying for a second phase from 2020-2022.

The first step of the WP I was reviewing the previous reports and publications on improving the data collection system. Consequently gaps, weaknesses and other issues associated with the current process were identified. Secondly, a baseline survey was conducted to collect baseline data associated with fish landings such as number of boats operated, boat types, gear types, fish species caught, seasonality of fisheries and fishing time. The data and information of baseline survey were explored and processed in order to prepare new data collection forms, developing a new sampling strategy and developing a mobile data collection application.

By now, the project has reached several milestones. The new sampling strategy has almost been developed. The manual for port sampling data collection and data reporting forms have been prepared. A mobile application for electronic data collection has been developed. It is expected to start parallel test data collection using both manual data forms and the electronic tabs followed by a careful validation process. The collection of data under the new system is ready to implement since 2020.

Establishment of the upgraded system for fisheries data collection, data storing and data processing will support to enhance the efficiency of data collection and data processing and also to improve the quality of fisheries statistics. Finally, this will further support to improve the fisheries management and policy formulation in Sri Lanka as well as to improve the compliance on data related resolutions adopted by the regional and international fisheries management organizations such as IOTC.

Small pelagic fishery resources

Introduction

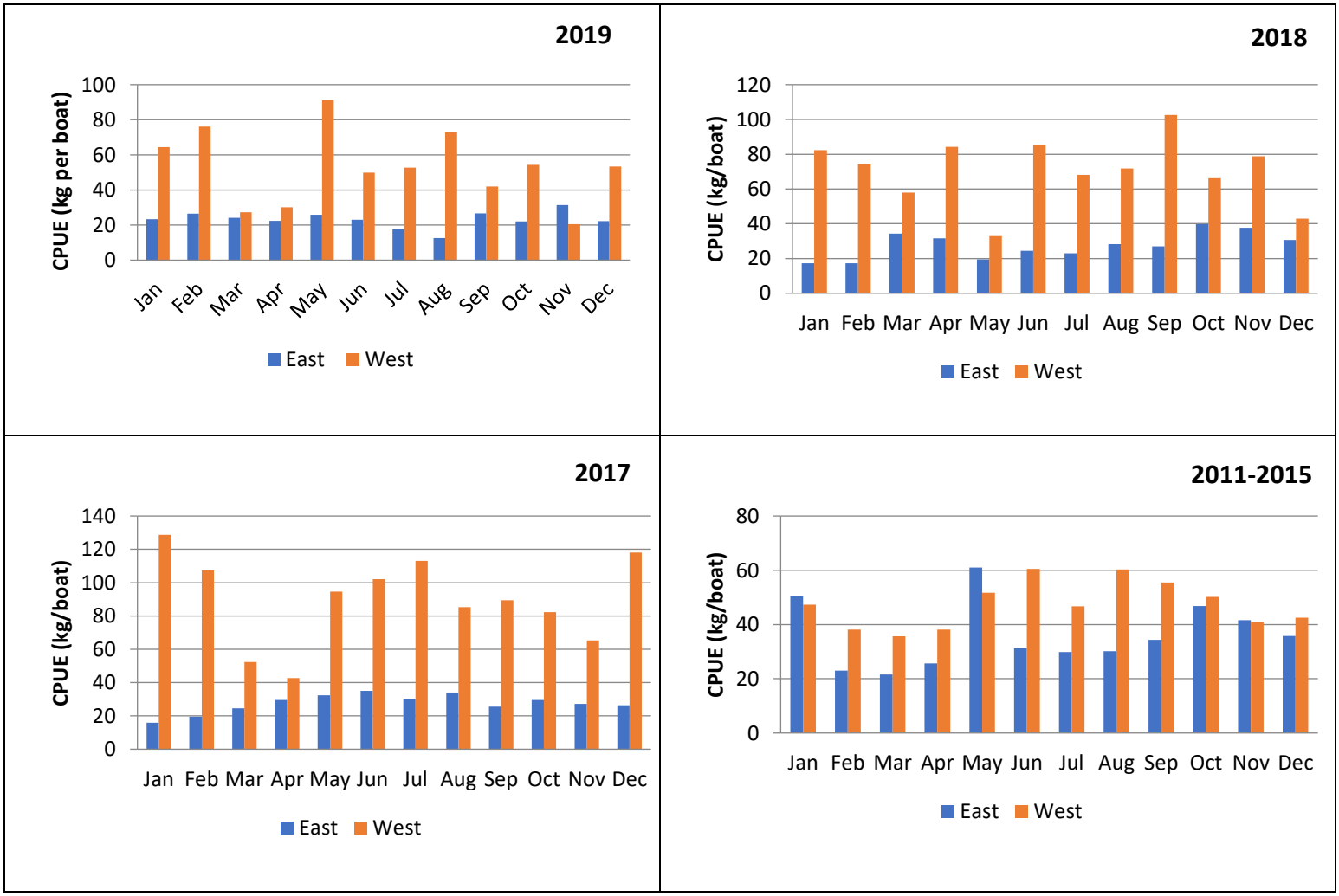
The small pelagic group represents over sixty marine species found in Sri Lankan waters. However, the key target species in the fishery are sardines, herrings, anchovies and mackerels. The small-scale artisanal fishermen who mostly operate with Outboard Engine Fiber Reinforced Plastic (OFRP) boats mostly target small pelagic. Small mesh gillnet is being widely used for catching small pelagic species for a long period while beach seines are also being seasonally operated.

Methodology

MBRD continued to carryout port sampling data collection programme in 2019 at major small pelagic fish landing sites with a key objective of studying the trends in the fishery. Data were stored in the small pelagic database maintained by the division. The catch and effort data analyses are being undertaken by the MBRD which includes the landing data of the latest year as well as the previous nineteen years.

Results and Discussion

Comparatively higher catch rates were always recorded from the West coast of Sri Lanka than the East coast from June to October during the Southwest monsoon. In 2017, most of the months recorded considerably higher catch rates (Figure 1). This may be mainly due to favorable oceanographic conditions.



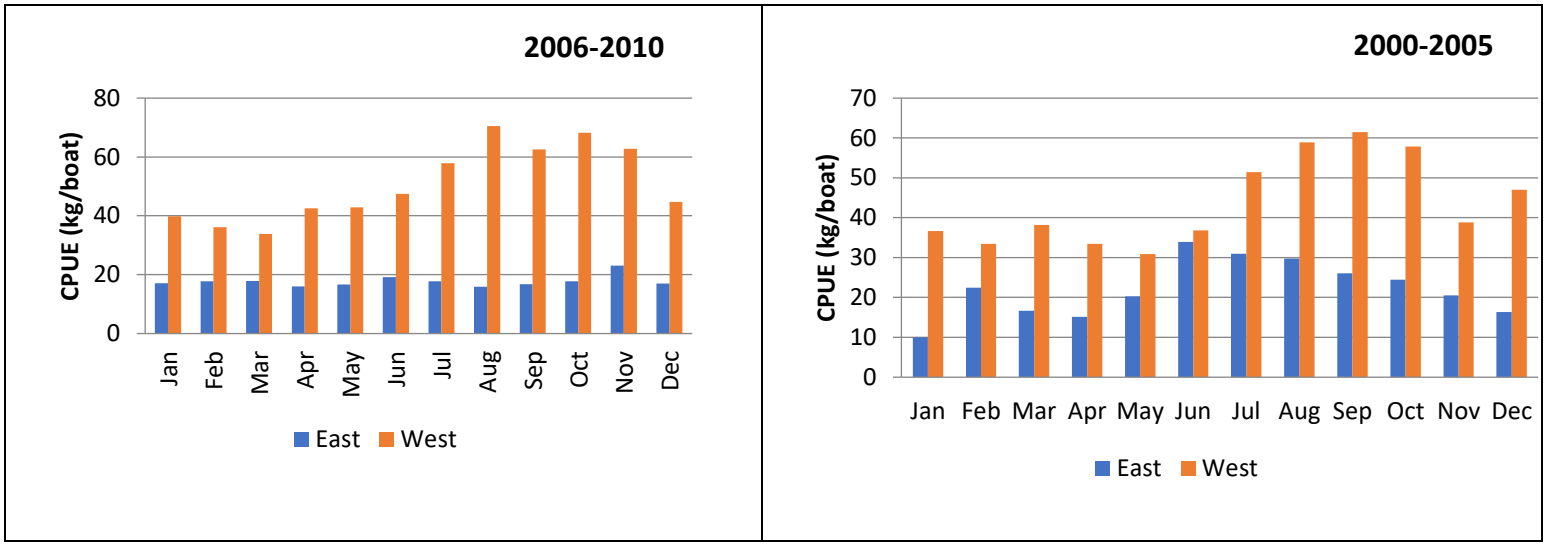


Figure 1: Seasonal variation of catch rates of small pelagic fish resources from 2000 to 2019

Though there was an extraordinary increase in the Catch per Unit Effort (CPUE) in 2017 probably due to extreme favourable oceanographic conditions, it has then continuously been decreased in 2018 and 2019 respectively (Figure 2).

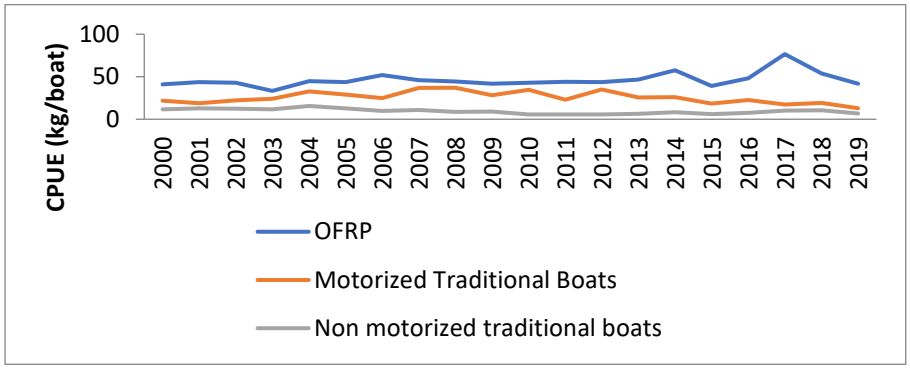


Figure 2:

Trend of small pelagic fishery (based on CPUE) over the past years (2000-2019)

Amblygaster sirm is one of the key species in the small pelagic fishery, and noted a remarkable decrease in relative contribution as well as CPUE over the recent years.

Based on this evidence, it is necessary to introduce appropriate management initiatives. However, catch variations of small pelagic species could be expected periodically due to the fluctuations of temperature and chlorophyll contents. In the meantime, there are many indications and evidences for unsustainable utilization of the resource. Therefore, status of the resource should be continuously monitored in order to understand the trend of the resource and thereby to focus on proper management measures. At present, formulation of a Fishery Management Plan for the Small Pelagic Fishery in the West coast of Sri Lanka is in progress under the Norwegian technical guidance.

Recommendations

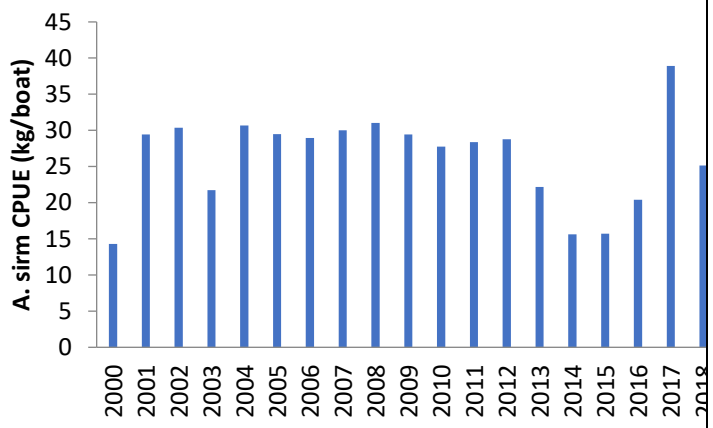


Figure 3: CPUE trend (zero catch) of *A. sirm*

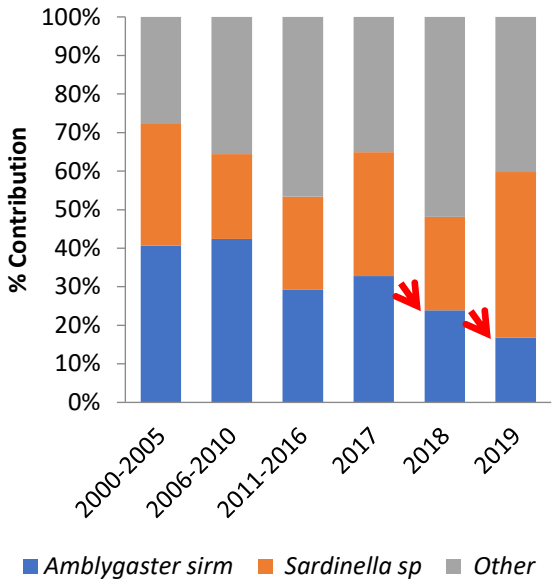


Figure 4: Percentage contribution of key small Pelagic species

1. Effective management measures via introducing appropriate fisheries management tools need to be taken to control the small meshed gillnet fishing operations. Emphasis should be given to the management of the *Amblygaster sirm* fishery via introduction of minimum meshed size regulations in small meshed gill net fishery (not permitting to use less than 1/1/16 inch or 2.70 cm) which potentially avoids catching immature fish.
2. Closed seasons during the spawning season need to be introduced.
3. Formulation of fisheries management plans for sustainable utilization of small pelagic fish is also recommended.

Part II: Present status of the sea cucumber fishery in Northern and North Eastern Sri Lanka.

Introduction

Sea cucumbers (Class Holothuroidea) are a highly diverse group of marine invertebrates. They are found in many marine habitats such as with corals, sea grass beds, rocks, muddy and sandy flats. According to some scientific studies, over 1000 species belonging to six orders and 25 families have been identified and they thrive in different types of habitats throughout the world. However, they are most common in the Indian Ocean and the South West Pacific.

Sea cucumbers are locally known as 'muhudu kekiri', 'muhudu kudallan' or 'atta' but are not used locally as a food item or for any other purpose. Among the identified sea cucumber species, there are nearly 200 known species found in the waters around Sri Lanka. About 75 species have been shown to be present in shallow waters while nearly 50 species can be collected from the inter-tidal areas.

In Sri Lanka, the sea cucumber fishery has operated since the late 80's having been introduced by the Chinese. As with many coastal fisheries, Sri Lanka's sea cucumber fishery is primarily artisanal and contributes to the livelihoods of fishermen in the coastal region. As with most sea cucumber producing countries, production is not meant for local consumption but rather for export to Asian countries. The export statistics for the sea cucumber products in recent years are shown in the Table 1.

Table 1: Export Quantities of Fish and Fishery Products (Mt)

Exported Item	2009	2010	2011	2012	2013	2014	2015	2016	2017
Beche de Mer	105	178	272	255	259	165	169	136	150

Source: Custom Returns/ Statistics Unit - Ministry of Fisheries and Aquatic Resources Development

The rapid development of the sea cucumber fishery in Sri Lanka occurred during the last few years due to the high demand for 'beche-de-mer' on the international market and the attractive prices offered. This has changed the previously unimportant and unregulated fishery into a commercially important one in which fishers invest considerable effort. As the sea cucumber fishery in Sri Lanka has been developed without routine monitoring, very little historical information is available on the target species and the level of exploitation. Now, however, sea cucumber populations are showing some signs of depletion.

The aim of this study was to provide managers information on the status of sea cucumber stocks in relation to current levels of exploitation. The objectives of this study were:

1. To identify the species composition, their relative abundance in the commercial catch in North and North East coastal waters
2. To estimate the stock size by the 'Depletion method'

Methodology

In order to achieve the objectives, fishery dependent survey was carried out.

Site selection

For the study, Jaffna, Mulativu, Trincomalee and Baticaloa administrative districts were selected. In Jaffna district, 'Suganth International' was selected for the data collection as they were the major buyer for sea cucumber in the region and had been responsible in collecting more than 80% of the catch in the area (Figure 1A). In Mulativu district, there were 13 collection centers ('Waadi') located in the coastal area (Figure 1B). In Trincomalee district there were three buyers (Figure 1C) who collected the catch from three different regions. One had been collecting the catch around the 'Erakkandi' area while the second person had been collecting the catch from 'Lankapatuna' area. The third person had been collecting the catch surround the Trincomalee harbor area.

Figure 1A: Sea cucumber landing sites at Jaffna

Figure 1B: Sea cucumber landing sites at Mulathivu

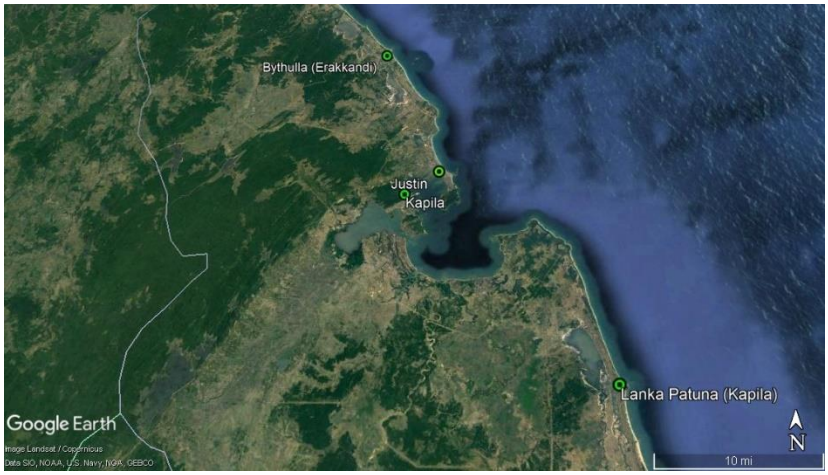


Figure 1C: Sea cucumber landing sites at Trincomalee

Data collection

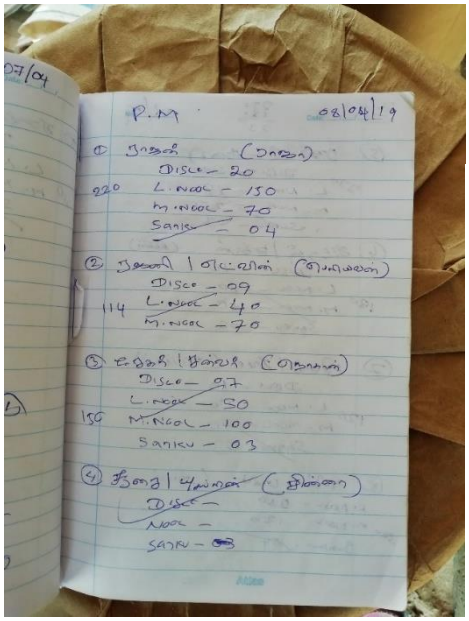
Field visits were conducted during the season of the respective regions. Thus, 2 field visits were conducted to each collecting center around the middle of the season and close to the end of the season. Data was extracted from the personal log books of the collectors in the landing sites. The species were identified using available published literature and guides.

Data was collected from the 'Suganth International' in Jaffna district as they had been collecting the majority of the sea cucumber catch in the district. In the Mullativu district, data was collected form 9 collection centers. In the Trincomalee district, complete data set for the entire fishing season was collected from the sole collector in the Erakkandi area. Data from the Harbour area had been available only for the first two months (March and April) and the collector mentioned that he had given up the trade due to some reasons. Data from the Lankapatuna area could not be obtained as the collector was not willing to provide the data. In the Batticaloa district, data had only been available for March due to the ban of the night diving since April, divers had not gone for cucumber fishery.

Figure 2: Processing of the sea cucumber catch in Suganth International premises at Jaffna.

Figure 3: Processing of the sea cucumber catch in Mulathivu.

Figure 4: Processing of the sea cucumber catch in Erakkandi, Trincomalee



SUGANTH - JAFFNA
Purchase Analysis

All Items — From 01-07-2019 to 31-07-2019

Item Details	Unit	Nett Purc. Qty.
Conch Shell Kachan	Pcs.	79.000
Conch Shell Paddy Damage	Pcs.	12.000
Conch Shell Paddy No 0 - 5	Pcs.	10.000
Conch Shell Paddy No 04	Pcs.	40.000
Conch Shell Paddy No 05	Pcs.	34.000
Disco (A)	Pcs.	97.000
Disco (B)	Pcs.	109.000
Disco (C)	Pcs.	1.000
Hooral Fish (F)	Kgs.	378.000
Hooral Fish (M)	Kgs.	188.000
Pavakkai	Pcs.	1,103.000
Pavakkai PPT 2	Pcs.	1,976,335.000
Sand Fish Rs 100	Pcs.	222.000
Sand Fish Rs 1000	Pcs.	47.000
Sand Fish Rs 1100	Pcs.	3.000
Sand Fish Rs 1200	Pcs.	16.000
Sand Fish Rs 1300	Pcs.	10.000
Sand Fish Rs 150	Pcs.	8.000
Sand Fish Rs 1500	Pcs.	130.000
Sand Fish Rs 1600	Pcs.	1.000

Figure 5: (A) data from the log books (Mulathivu) and (B) data from Jaffna

Data analysis

Data on species, number of individuals of each species per boat, number of boats operated per day were extracted from the log book data. The assessments were conducted using the Leslie-DeLury DMs with the Catch and Effort Data Analysis (CEDA) software. The following indexed recruitment model was used:

$N_{t+1} = e^{-M} (qCPUE_t - C_t + \lambda R_t)$,

where 't' is the time interval (week), 'N' is the population size in numbers at the start of the time interval t, 'M' the natural mortality rate, 'q' the catchability coefficient, 'Ct' the total catch during the time interval t, 'λ' the recruitment constant of proportionality, 'Rt' the recruitment index and 'CPUEt' the catch per unit effort during the time interval t. Effort and the total number of individuals were used as the input data for the software. Application of the model relies on a number of assumptions, including constant catchability and no significant movement of fish in or out of the local area. 'M' was assumed to be not significantly different from zero over the time period for which the model was fitted.

For the Mulathivu district, the catch data was scaled up for 13 collection centers. For Erakkandi area in Trincomalee, sea cucumbers had been collected via scuba diving and skin diving. Thus the assessment was done for both fishing methods separately. Considering the Jaffna district, the effort data could not be obtained as there has been no well established cucumber fishery in Jaffna thus the collecting company received the catch by several sub-collectors. Therefore, only the production trend was analyzed. In Batticaloa district, there were five sea cucumber collectors. They had been mainly targeting species from night diving. Due to the night diving ban since April, they had not

carried out the fisherytill then. Thus, due to insufficient data, analysis was not carried out for Batticaloa district. Stock assessment was carried out for dominant species in the catch of Mulativu and Trincomalee (Erakkandi) districts.

Microsoft Office Excel 2013 was also used for data analysis.

All the results were expressed by number of individuals per different species.

Results and Discussion

Current status of the sea cucumber fishery in Jaffna district.

Fishery, Fishing season and methods.

There was neither sea cucumber collection centers (Waadi) nor well established fishery for sea cucumbers in the Jaffna district except for fishery for Pawakkai. Few divers in GurunagarJatty area and adjacent areas involved in scuba diving for mainly Disco (*Holoturiaspinifera*), Jaffna attaya (*Holothuriascabra*), Narinool (*Holothuriaatra*) and Sangu (*Turbinella Sp.*). In addition to the scuba diving, Jaffna attaya (*Holothuriascabra*) had been harvesting from sea cucumber farms. The harvest had been taken from February to April in 2019. For the scuba diving, there was no clear fishing season for sea cucumbers and chank. When analyzing the catch data, the production had been continuous during the period of data collection (From January to September) though there were some fluctuations.

Fishery for Pawakkai (*Stichopusnaso*) (Figure 7) was different from the rest of the sea cucumber fishery in Jaffna district. There were about 80 fishermen involved in the fishery for Pawakkai. The only known large aggregation of the Pawakkai sea cucumber which was economically harvestable had been identified close to the Point Pedro in Jaffna district. The fishing ground for the Pawakkai had been located about 16 km away from the Point Pedro (Figure 6). The average depth of the area was around 35 ft.

Figure 6: The fishing ground for Pawakkai sea cucumber off the Point Pedro

As the fishing method, instead of diving, fishermen used 4" mesh sized gill net and scoop net (Athanguwa) with OFRP boats for capturing the sea cucumber. They had laid the net in the evening and had collected the net in the morning. Pawakkai sea cucumbers become active at night. When the net had been collected in the morning, the Pawakkai sea cucumber had been attached to the net and had been collected in to the scoop net while pulling the net out of the sea (Figure 8). The Pawakkai sea cucumbers start to dissolve soon after they die thus, as soon as the fishermen had brought the catch to the collection center, the catch was boiled (Figure 9).

7A

7B

7C

Figure 7: The Pawakkai sea cucumber in the catch

Figure 8: Fishing method for Pawakkai

9A

9B

9C

9D

9E

Figure 9: Processing of the Pawakkai sea cucumber

The species composition of the sea cucumber fishery in Jaffna district

The catch was composed of Disco (*Holoturia spinifera*), Kiri nool (*Bohadschia* sp.), Nari nool (*Holothuria atra*), Pawakkai (*Stichopusnaso*), Jaffna attaya (*Holothuriascabra*) and Sangu (*Turbinella Sp.*). Among them Pawakkai (*Stichopus vnaso*) was the dominant species with 99.22% during the study period of January to September, 2019. Figure 10 illustrates the percentage distribution of the recorded species in the catch of the Jaffna district.

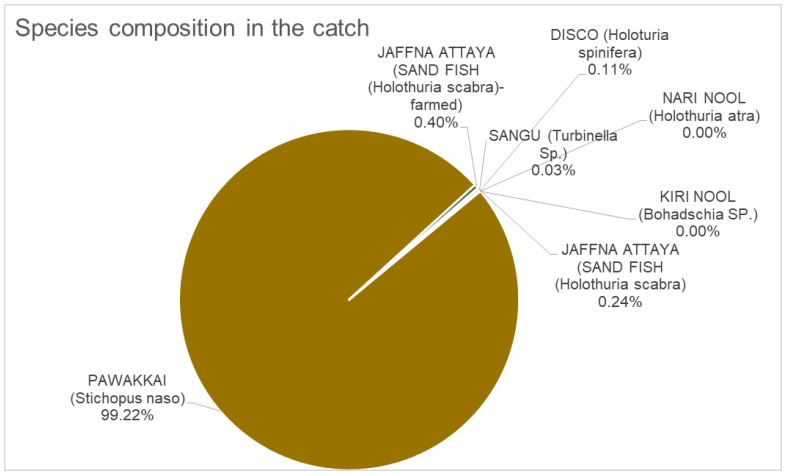


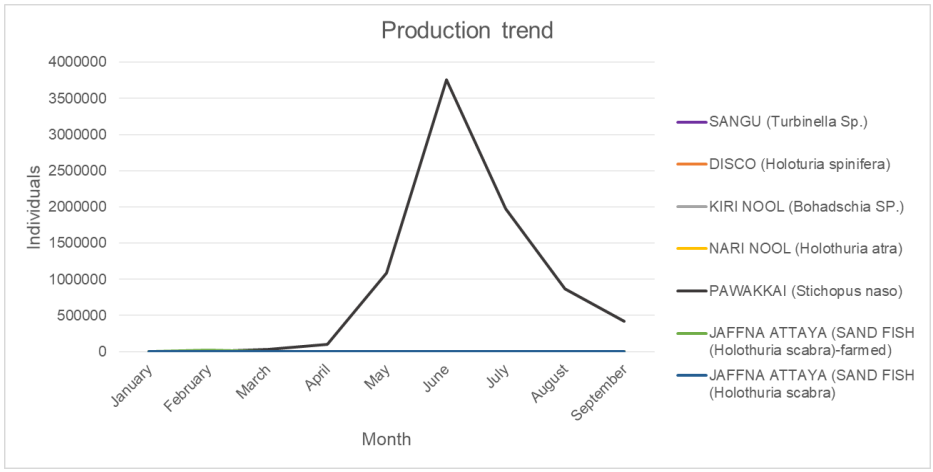
Figure 10: Percentage distribution of the species recorded in the catch of Jaffna district.

Disco (*Holoturia spinifera*), Jaffna attaya (*Holothuria scabra*) and Sangu (*Turbinella* sp.) contributed 0.11%, 0.24% and 0.03% to the total catch respectively. Considering the Kiri nool (*Bohadschia* sp.) and Nari nool (*Holothuria atra*), their contribution was insignificant when compared to other species in the catch. In addition to the wild fishery, Jaffna attaya (*Holothuria scabra*) from culture farms had contributed 0.40% to the total catch in the Jaffna district.

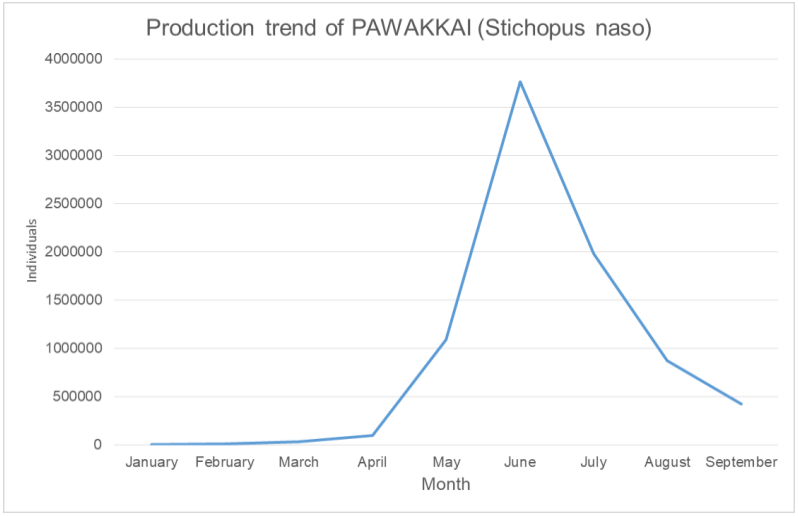
Some of the previous fishery independent surveys had revealed the presence of *Holothuria leucospilota*, *Stichopus horrens*, *Stichopus herrmanni* in Jaffna district coastal waters but these species had not been recorded in the commercial catch of the present study.

The production trend of the sea cucumber fishery in Jaffna district

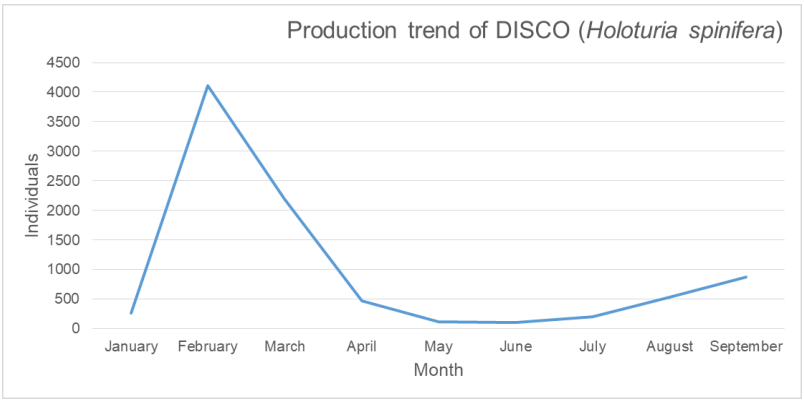
A continuous production was observed throughout the period of data collection (January to September) except for Kiri nool (*Bohadschia* sp.) and Nari nool (*Holothuria atra*). The catch of Kiri nool (*Bohadschia* sp.) was 0 from May to August and the catch of Nari nool (*Holothuria atra*) was 0 from June to August. The peak Pawakkai (*Stichopus naso*) production could be observed from May to July. The monthly variations of the production of the dominant species are illustrated in figure 11.


Production trend
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
Individuals
January
February
March
April
May
June
July
August
September
Month
SANGU (Turbinella Sp.)
DISCO (Holoturia spinifera)
KIRI NOOL (Bohadschia SP.)
NARI NOOL (Holothuria atra)
PAWAKKAI (Stichopus naso)
JAFFNA ATTAYA (SAND FISH (Holothuria scabra)-farmed)
JAFFNA ATTAYA (SAND FISH (Holothuria scabra)

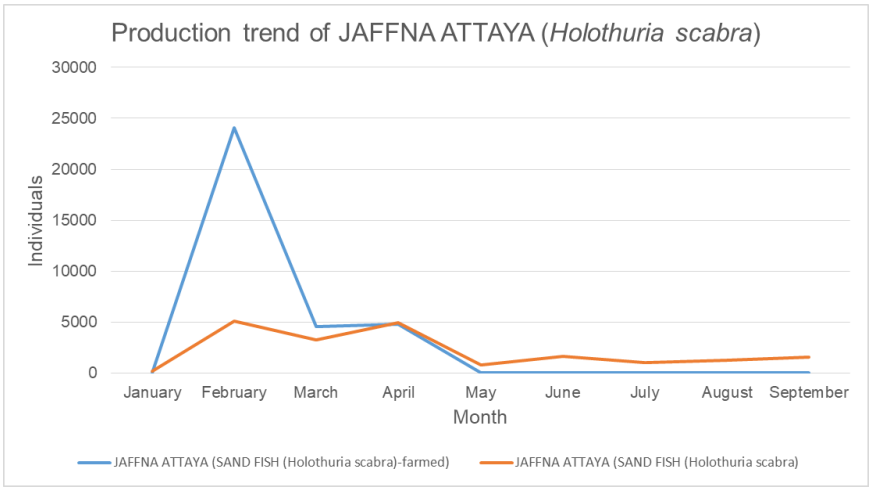
A


Production trend of PAWAKKAI (Stichopus naso)
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
Individuals
January
February
March
April
May
June
July
August
September
Month

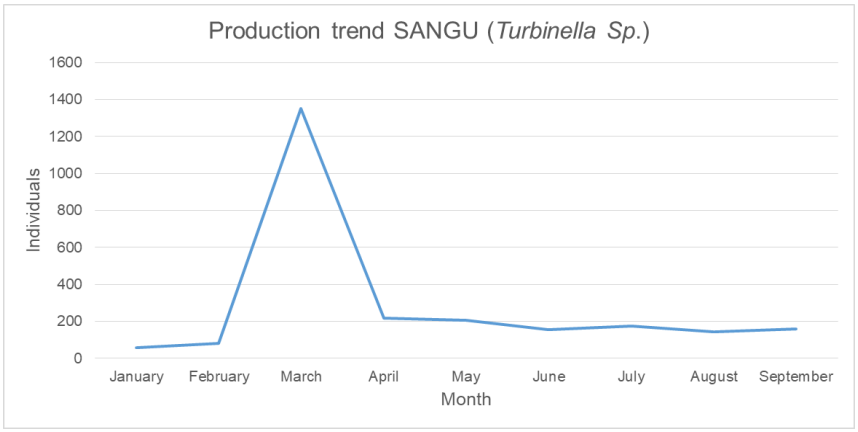
B


Production trend of DISCO (Holoturia spinifera)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Individuals
January
February
March
April
May
June
July
August
September
Month

C



D



E

Figure 11: Production trend in Jaffna district; A – All species; B – Pawakkai; C – Disco; D – Jaffna attaya; E – Sangu

Current status of the sea cucumber fishery in Mulathivu district

Fishery, Fishing season and methods

In the Mulathivu district, there was a well-established seasonal fishery for sea cucumbers. In 2019, there were 13 collection centers for sea cucumbers and 2 marine ornamental fish collection centers (waadi) located in the Mulathivu coast. According to some previous studies the fishing season had prevailed from April to October or May to September. But in 2019, the fishing season for sea cucumbers had initiated since the onset of March to end of September. During the season, ~ 200 OFRP boats had been anchoring in the coast even though all of them had not operated in a single day. SCUBA diving was the only method that had been used for capturing the sea cucumbers in the area. Since the

implementation of the ban of night diving since April, all the fishing activities had been carried out during the day time.

A

B

C

Figure 12: A – a Waadi in the Mulathivu coast; B – Sea cucumber catch in Mulathivu; C – inside a Waadi

The species composition of the sea cucumber fishery in Mulathivu district

According to the results, Puna (*Thelenota anax*) was the dominant species in the catch during the fishing season in 2019 with 76.88% contribution to the total catch. In addition, Kiri nool (*Bohadschia* sp.), Disco (*Holoturia spinifera*), Curry fish (*Stichopus* sp.), Sangu (*Turbinella* sp.) and Pawakkai (*Stichopus naso*) contributed to the rest of the catch. During the three months (July – September), divers from 4 collection centers had been involved in harvesting Pawakkai (*Stichopus naso*) in Point Pedro area in Jaffna, sailing about 70 km from Mulathivu to Jaffna. This activity had caused to add the Pawakkai (*Stichopus naso*) to the total catch of Mulathivu district by large numbers. The magnitude of this

contribution by the divers of only four Waadi was visualized by Pawakkai (*Stichopus naso*) becoming the second highest contributing species to the total catch by 19.04%. The attempt of Mulathivu divers to enter in to the Pawakkai fishing ground in Jaffna had caused a dispute with Jaffna fishers who had been fishing Pawakkai by gill nets. The contribution of Curry fish (*Stichopus* sp.) to the total production was insignificant. Figure 13 illustrates the species composition in the catch of Mulathivu district.

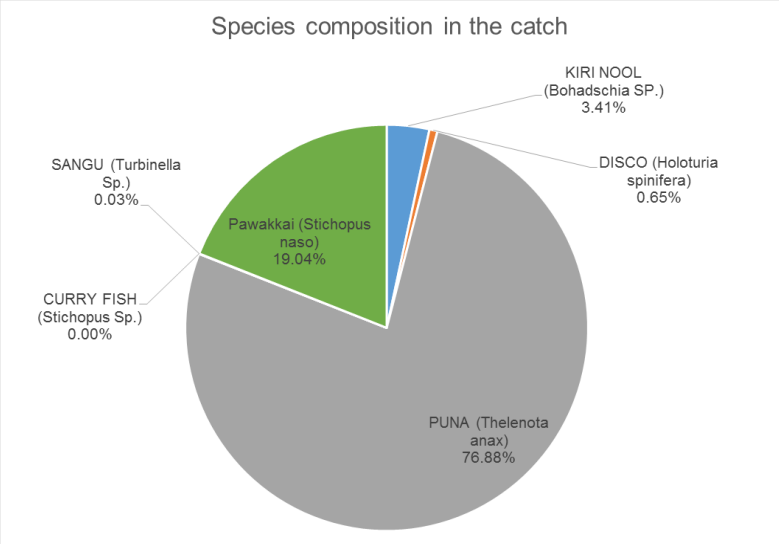
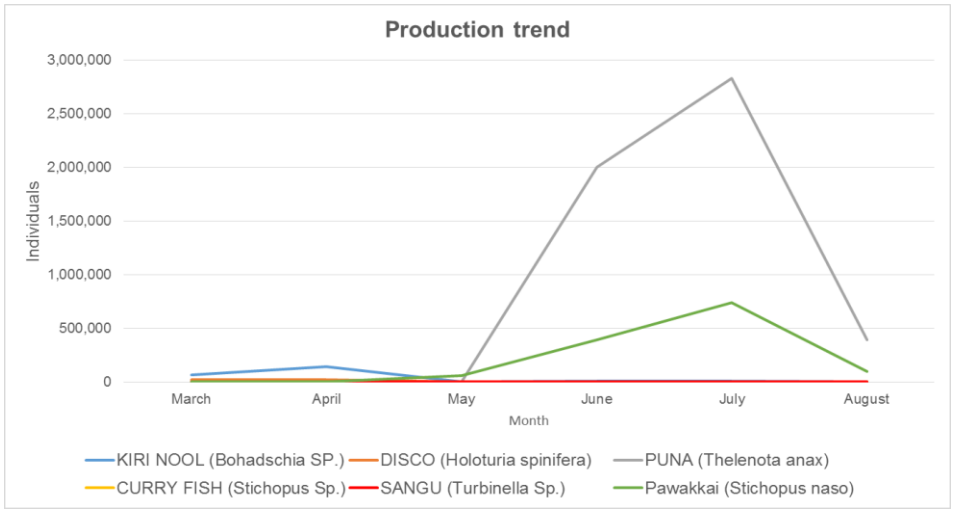


Figure 13: Percentage distribution of the recorded species in the catch of Mulathivu district.

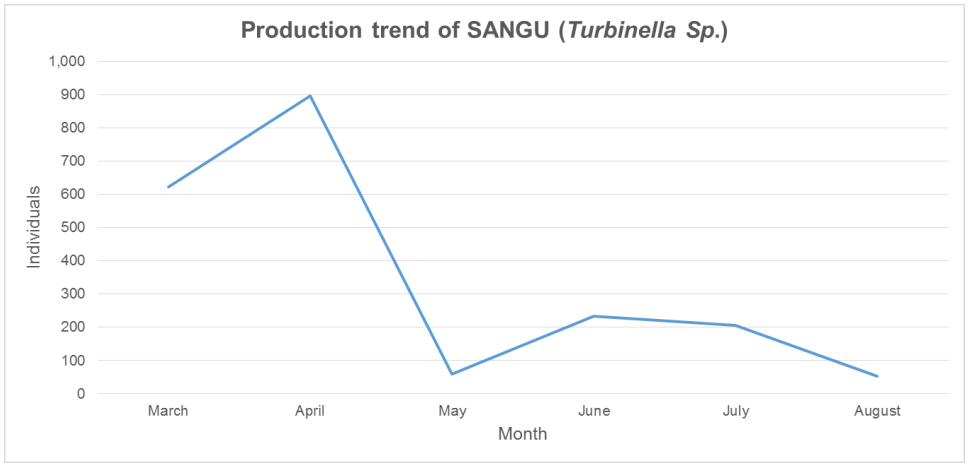
When comparing the results of this study with the results of the study, alteration of the species composition can be identified in Mulativu district. 'Kiri nool attaya' (*Bohadschia marmorata)* (96%) was the most prominent species caught in day fishing while 'Disco attaya' (*Holothuria spinifera*) (72%) is the most prominent species in the night fishing in Mulativu district in 2017. 'Disco attaya' (*Holothuria spinifera*) (3%) was the second largest species caught while 'Kalugal attaya' (*Actinopyga miliaris*), 'Dumburu nool attaya' (*Bohadschia vitiensis*) and 'Puna Attaya' (*Thelenota anax*) were in minor quantities (less than >1%) in the day time catch. Even though, according to the results of this study, 'Kalugal attaya' (*Actinopyga miliaris*) and 'Dumburu nool attaya' (*Bohadschia vitiensis*) had not been recorded in the day time catch.

The production trend of the sea cucumber fishery in Mulathivu district

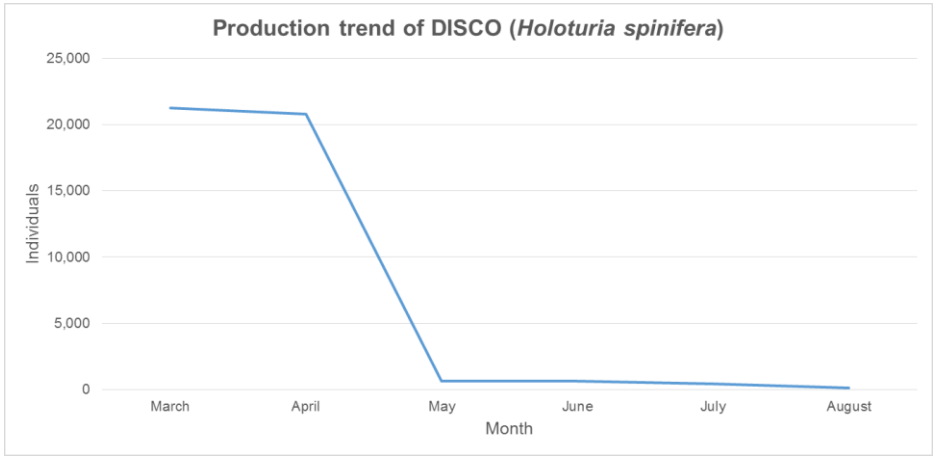
A sudden drop of the production could be observed from the last week of April to end of May mainly due to the civil unrest of the country. Only three Waadi had been functional during this period. In addition, unexpected extreme weather (wind) conditions had also caused to cease the operation during some weeks in this fishing season. Figure 14 illustrates the production trend in Mulathivu district.


Production trend
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Individuals
March
April
May
June
July
August
Month
KIRI NOOL (Bohadschia SP.)
DISCO (Holoturia spinifera)
PUNA (Thelenota anax)
CURRY FISH (Stichopus Sp.)
SANGU (Turbinella Sp.)
Pawakkai (Stichopus naso)

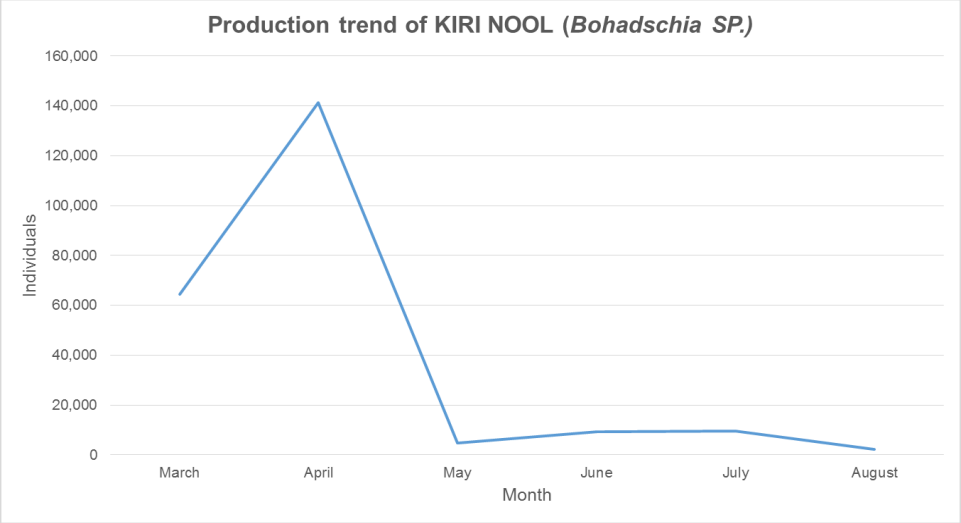
A


Production trend of SANGU (Turbinella Sp.)
1,000
900
800
700
600
500
400
300
200
100
0
Individuals
March
April
May
June
July
August
Month

B


Production trend of DISCO (Holoturia spinifera)
25,000
20,000
15,000
10,000
5,000
0
Individuals
March
April
May
June
July
August
Month

C



D

Figure 14: Production trend in Mulathivu district. A – Total production; B – Production trend of Sangu; C – Production trend of Disco; D- Production trend of Kiri nool.

Stock assessment

Stock assessment for Kiri nool attaya (*Bohadschia marmorata*) and Puna Attaya (*Thelenota anax*) was conducted using the CEDA software package.

Kiri nool attaya (*Bohadschia marmorata*)

According to the results, the initial stock at the onset of the fishing season was estimated as 475048 individuals and the final stock size at the end of the fishing season was 40772 individuals (R^2 = 0.92). According to the results 91.42% of the stock had been harvested by the end of the fishing season in 2019. The exploitation trend of Kiri nool attaya is illustrated in figure 15.

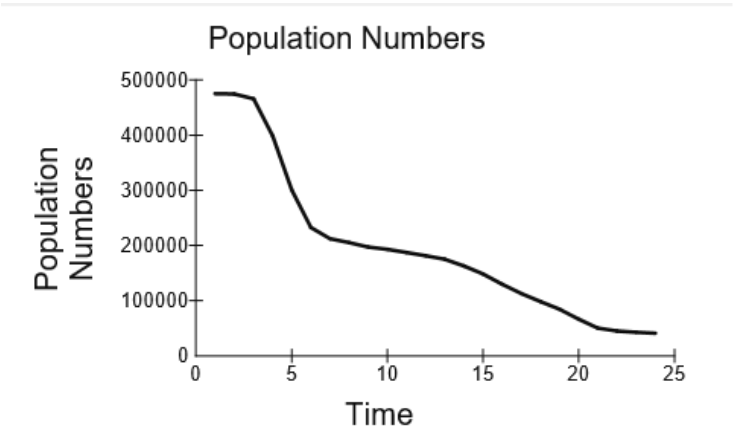


Figure 15: The exploitation trend of Kiri noolattaya in Mulathivu.

According to the results, it is proven that there was an intensive fishing pressure on the Kiri nool attaya in Mulathivu district. It had caused the stock to decline more than 50% during the fishing season that could lead to a local extinction of the stock. This overexploitation of the local Kiri nool attaya in Mulathivu district was further evident by the attempt of some divers to harvest Pawakkai during the last few months.

Puna Attaya (*Thelenota anax*)

According to the results, the initial stock at the onset of the fishing season was estimated as 12996532 individuals and the final stock size at the end of the fishing season was 7772657 individuals (R^2 = 0.96). According to the results 40.19% of the stock had been harvested at the end of the fishing season in 2019. The exploitation trend of Puna Attaya is illustrated in figure 16.

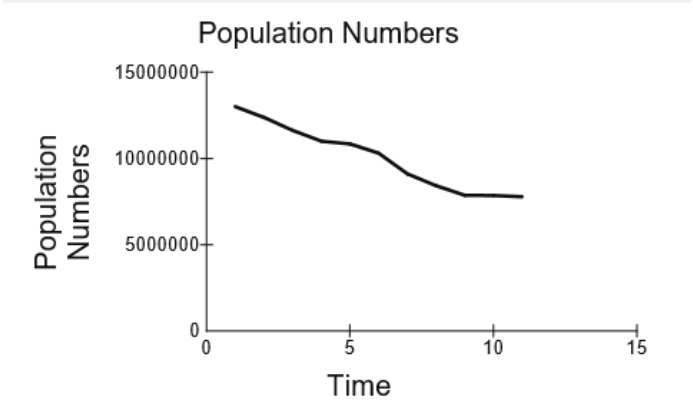


Figure 16: The exploitation trend of PunaAttaya inMulathivu.

According to the results, the fishing pressure had not been severe as more than 50% of the stock had survived at the end of the fishing season.

The unavailability of 'Kalu gal attaya' (*Actinopyga miliaris*) and 'Dumburu nool attaya' (*Bohadschia vitiensis*) in the present study, which had been recorded in 2017 catch, might be a result of local extinction of these stocks.

Current status of the sea cucumber fishery in Trincomalee district

Fishery, Fishing season and methods

The fishing season for the sea cucumbers in Trincomalee district had initiated from February and continued till end of September in 2019. Even though the collector at Trincomalee harbour area had abandoned the trade since the civil unrest in the county in April, the collector in Erakkandi area had continued the fishery throughout the season. According to the collector in the harbour area, he had received the catch from a few scuba

divers as well as from fishermen. The catch had come from different areas such as 'Werugal', 'Kunathivu' and 'Saampur'. In Erakkandi area, the catch had been collected mainly by scuba divers. In addition, a few skin divers had been engaged in sea cucumber collection in shallow waters on a more or less daily basis. In the Erakkandi area, there were 15 OFRP boats available for the sea cucumber fishery, though all of them had not operated in a single day. The third collector had collection centers (Waadi) at Lankapatuna area and there were 10 OFRP boats involved in the sea cucumber fishery.

A B

Figure 17: Sea cucumber fishery in Trincomalee district. A – Boats for diving in harbour area; B – Processed catch in Erakkandi area.

The species composition of the sea cucumber fishery in Trincomalee district

Considering the catch data of the collection center near the harbour area, Nool Attaya (*Bohadschia* sp.) was the dominant species in the catch with 67.16% contribution to the total catch. Gal Attaya (*Actinopyga mauritiana*) was the least abundant species in the catch with a contribution of 1.24%. In addition, Sangu (*Turbinella* sp.), Jaffna Attaya (*Holothuria scabra*), Black Nool, Brown Nool Attaya (*Bohadschia vitiensis*) and Saani Attaya (*Stichopus herrmanni*) had contributed to the total catch. Figure 18 illustrates the species composition in the catch from the collector at harbour area.

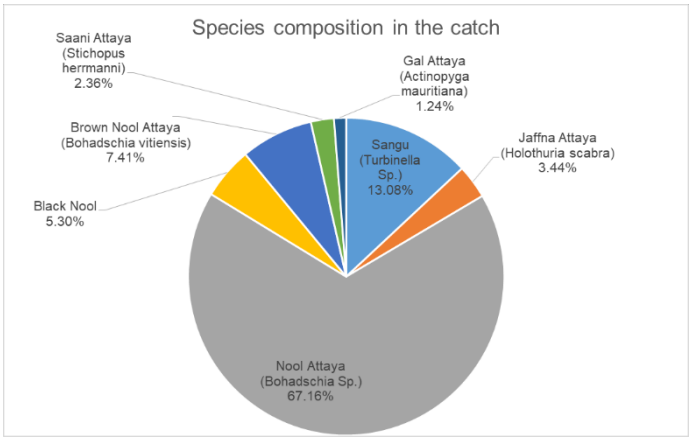


Figure 18: The species composition in the catch from the collector at harbour area.

Considering the catch data of the from the Erakkandi area, Puna Attaya (*Thelenotaanax*) was the dominant species in the catch from scuba diving with 91.57% abundance. In addition, Gal Attaya (*Actinopyga mauritiana*), Nari Attaya (*Holothuria atra*), Nool Attaya (*Bohadschia* sp.) and Dambala Attaya (*Stichopus chloronotus*) had been included in the catch. Figure 19 illustrates the species composition in the catch from scuba diving in Erakkandi area.

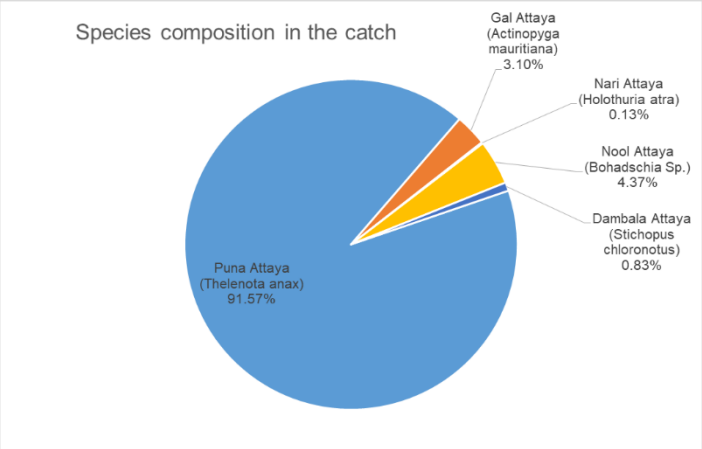


Figure 19: The species composition in the catch from scuba diving in Erakkandi area.

According to the results of the catch from the skin diving, same species composition could be identified as in the catch of scuba diving but with different abundances. Puna Attaya (*Thelenota anax*) was the dominant species in the catch from scuba diving with 86.82% abundance. Figure 20 illustrates the species composition in the catch from skin diving in Erakkandi area.

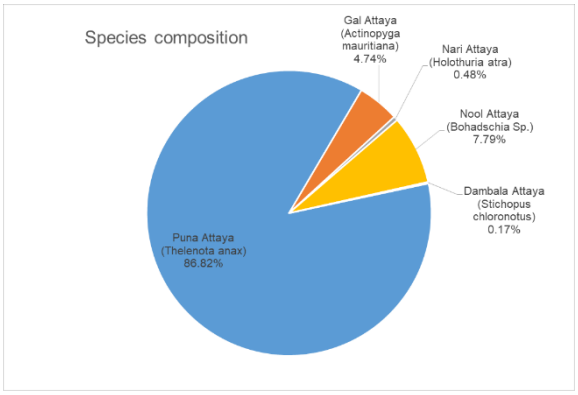


Figure 20: The species composition in the catch from skin diving in Erakkandi area.

The production trend of the sea cucumber fishery in Trincomalee district

As the sea cucumber collection had ceased since May in the collection center near the harbour, figure 21 illustrates the trend in the production till then.

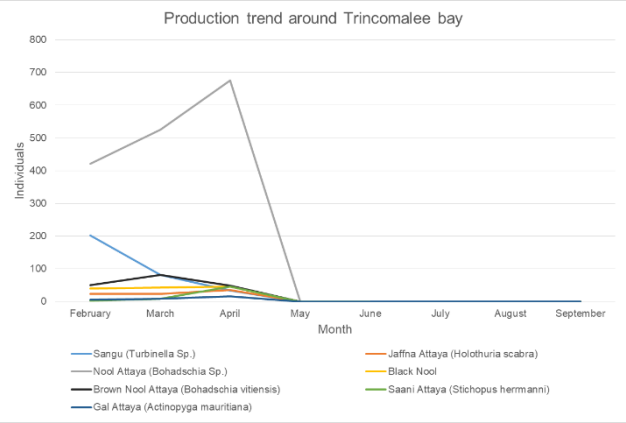
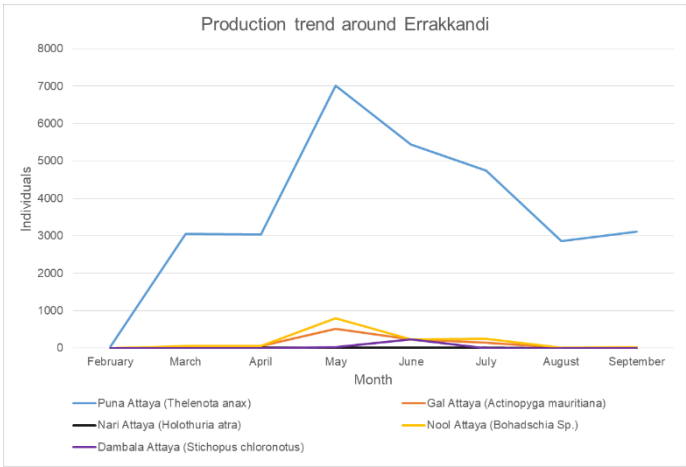
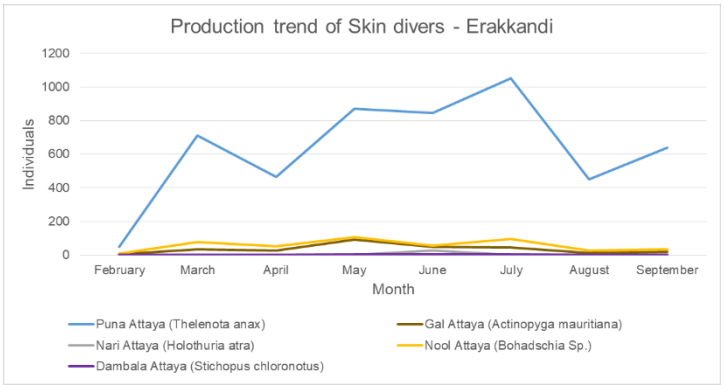


Figure 21: Production trend in the center near harbor in Trincomalee district

Considering the data from the Erakkandi center, higher production from scuba diving could be observed from April to June. Considering the production trend of the catch of skin diving, higher production could be observed in May and July. When interviewing the owner of the collection center, he had said that higher production could have been observed in August. But the unfavourable weather conditions that had prevailed might be the reason for alteration of the fishing trend. Figure 22 illustrates the production trend in scuba diving and skin diving.



A



B

Figure 22: The production trend in Erakkandi area. A – Scuba diving; B – skin diving.

Stock assessment

An attempt was made to estimate the stock by the CEDA software package for the species in the catch. But the data of the scuba diving did not fit to the model except Puna Attaya (*Thelenota anax*) and Gal Attaya (*Actinopyga mauritiana*).

Puna Attaya (*Thelenota anax*)

According to the results, the initial stock at the onset of the fishing season was estimated as 93126 individuals. At the end of the season the remaining estimated stock was 63244 individuals (R^2 = 0.68). Thus during the fishing season, 32.09% of the stock had been exploited. The trend in exploitation is illustrated in figure 23.

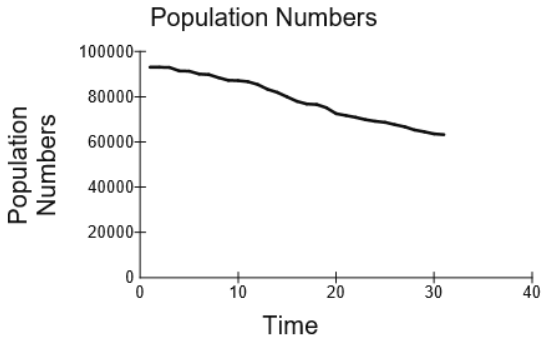


Figure 23: The exploitation trend of Puna Attaya in Erakkandi (by scuba diving).

Gal Attaya (*Actinopyga mauritiana*)

According to the results, the initial stock at the onset of the fishing season was estimated as 1978 individuals. At the end of the season the remaining estimated stock was 988 individuals (R^2 = 0.23). Thus during the fishing season, 50.05% of the stock had exploited. The trend in exploitation is illustrated in figure 24.

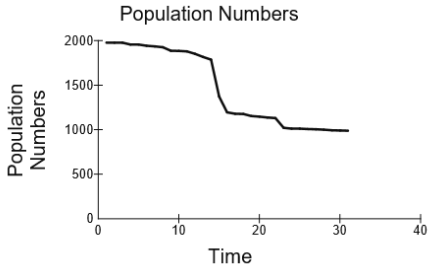


Figure 24: The exploitation trend of Gal Attaya in Erakkandi (by scuba diving).

Considering the data from the skin diving, none of the species data fitted to the model.

Conclusions

Based on the findings of this study it can be concluded that:

1. There was a very high fishing pressure on Kiri nool attaya (*Bohadschia marmorata*) in the Mulathivu district which could lead to the over exploitation of the stock
2. Species composition of the catch in Mulathivu district has altered which could be a result of local extinction and over exploitation of some species.
3. Gal Attaya (*Actinopyga mauritiana*) stock in the Erakkandi region should be monitored closely.
4. Fishery for other species studied in this research seemed to be sustainable in 2019.

Recommendations

1. Immediate appropriate management actions should be applied for protection of the Kiri nool attaya (*Bohadschia marmorata*) as 91.42% of the stock had been harvested during the fishing season.
2. Continuous monitoring should be applied in order to maintain a sustainable fishery for the Gal Attaya (*Actinopyga mauritiana*) in Trincomalee (Erakkandi area) as 50.05% of the population had been removed by the scuba diving.
3. It is recommended to carry out a fishery independent survey (under water survey) to assess the available biological stocks and their distribution for formulation and implementation of the management strategies.
4. It is recommended to carry out an underwater survey in Pawakkai (*Stichopusnaso*) fishing ground in order to identify the distribution of the stock.

5. Further, as there had been some evidence of Pawakkai (*Stichopus naso*) being reproduced asexually, a comprehensive biological study should be carried out.

Molecular based studies on feeding predation in commercially important fish species

Project No: 2.2

Responsible officer/s: Mrs.Deshini Herath

Introduction

Studying the feeding habits of fish is important to understand relationships between the prey and the predator and how they live together with other marine organisms. These correlations help in the management of the fishery of the prey organism as well as of the predatory organism. The feeding patterns of fish depend on the availability of food in the environment that they live in. If fish are in an environment where food in available freely, they will feed on specific prey items favourable to them, but when food is scarce fish will feed on any available food item (Ahmed *et al*., 2015).

The feeding habits of fish have been studied by analyzing the contents of the stomachs of fish. Hynes, (1950) described several methods that are used for studying feeding habits of fish: the occurrence method, the number method, the dominance method, the volume and weight methods, the fullness method and the points method. The volume and weight method was used in this study to calculate the percentage of each prey category in the stomach.

The identification of prey items can be done using morphological features of the prey categories. When the morphological features are not available for identification, molecular methods could be very useful. The identification of the species is then done by amplifying a particular part of a gene which is then matched with a database for identification.

Objectives of the project

1. Molecular identification of prey items found in stomachs of commercially important fish species such as yellowfin tuna, neritic tunas, swordfish and sharks using appropriate primer/primer combinations.
2. Determination of the pray-predator relationships of the species studies.

Methodology

Samples were collected from Negombo, Beruwela and Chilaw. The stomachs of yellowfin tuna (*Thunnus albacores*), skipjack tuna (*Katsuwonus pelamis*), swordfish (*Xiphias gladius*), kawakawa (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*) were collected from these fish markets and labelled. The stomachs were transported to the laboratory on ice and analyzed.

The stomach content was first categorized into prey categories by identifying the prey morphologically (eg: small fish, crustaceans, cephalopods etc.). The weight of each prey

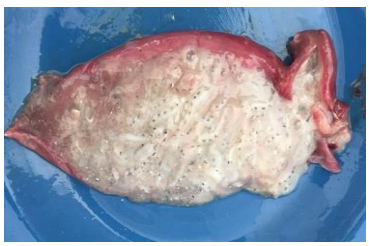
category was recorded. Within each prey category, the different species present were then identified morphologically. Species that were not identifiable using morphological features were stored in alcohol to be identified by DNA barcoding.

For DNA barcoding, the DNA of the prey items was extracted using the conventional phenol chloroform method and by using the Promega Wizard genomic DNA extraction kit. The extracted DNA was run on an agarose gel to quantify the DNA. The mitochondrial COI PCR was carried out for the extracted DNA using relevant primers. For the amplification of fish prey species, the universal fish identification primers FISHF1 (5'-TCAACCAACCACAAAGACATTGGCAC-3') and FISHR1 (5'-TAGACTTCTGGGTGGCCAAAGAATCA-3') were used and for the identification of invertebrate prey items, the universal primers LCO1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and HCO2198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3') were used the PCR amplification reactions. The amplified DNA was then sequenced. The consensus sequences obtained from the alignment of the forward and reverse sequences using Bioedit software were matched in the NCBI blast database and the BOLD database (Ratnasingham and Hebert, 2007) to identify the prey to the exact species.

Results and Discussion

The stomachs analyzed contained prey items such as small fish, crustaceans (prawns, shrimps, crabs, etc.) and cephalopods (cuttlefish, squid and octopus) (Figure 1). In addition, combinations of prey items in one stomach could be seen. Combination of small fish and crustaceans, small fish and cephalopods and crustaceans and cephalopods could be seen in the fish stomachs analyzed. In addition, items such as plastics, polythene and net pieces were also observed.

Sardinella



Lizard fish (*Trachinocephalus myops)*

Figure 1: Some prey items found within the stomachs of the fish analyzed.

The percentage analyses of the stomachs analyzed (by weight) are given in figure 2 and 3 respectively for kawakawa and frigate tuna. The stomachs which contained completely digested prey material were not included in this percentage calculation.

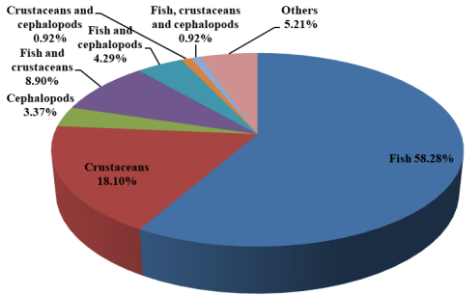


Figure 2: Percentages of different prey categories in kawakawa stomachs analyzed.

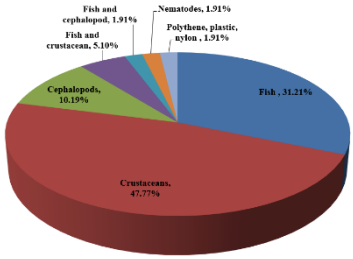


Figure 3: Percentages of different prey categories in frigate tuna stomachs analyzed.

Table 1: Species of prey identified by using molecular methods.

Prey category	**Common name**	**Species name**	**Sample types in which prey were found**
Fish	Sardine	*Sardinella longiceps*	Skipjack tuna, Kawakawa, Frigate tuna
	Hurulla	*Amblygaster sirm*	Skipjack tuna
	Big eye scad	*Selar crumenophthalmus*	Kawakawa, Frigate tuna
	Lizard fish	*Trachinocephalus myops*	Frigate tuna
Crustaceans	Indian prawn	*Penaeus indicus*	Kawakawa
	Kadal shrimp	*Metapenaeus dobsoni*	Kawakawa
	coastal mud shrimp	*Solenocera crassicornis*	Kawakawa, Frigate tuna
	zebra mantis shrimp	*Lysiosquillina maculata*	Kawakawa
	Crab	*Percnon guinotae*	Kawakawa

	Squat lobster	*Munida iris*	
Cephalopods	Cuttlefish	*Sepia pharaonis*	Kawakawa, Frigate tuna
	Sandbird Octopus	*Amphioctopus aegina*	Kawakawa

The prey species identified by using molecular methods are shown in Table 1. The major prey item for kawakawa was small fish, followed by crustaceans and cephalopods. For frigate tuna the major prey item was crustaceans, followed by small fish and cephalopods. Some stomachs of both kawakawa and frigate tuna showed the presence of a combination of prey items, such and fish and cephalopods, fish and crustaceans and crustacean and cephalopods. Some stomachs showed the presence of all 3 types of prey categories within a single stomach. For skipjack tuna, small fish was the major prey item observed. As most of the stomachs of the fish species other than kawakawa and frigate tuna contained mainly digested material, the percentages could not be determined for these. Other items such as polythene, plastic and net pieces were also detected in certain stomachs. The stomach analysis revealed that kawakawa and frigate tuna have been feeding on small fish, crustaceans and cephalopods. This indicates that they are non-selective feeders, feeding on any prey item abundantly available in the surrounding environment.

Conclusions

The results indicate that the commercially important fish studied, namely skipjack tuna, kawakawa and frigate tuna are all nonspecific feeders and ingest prey that is freely available in the surroundings.

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Bio –physical monitoring of coral reefs and DNA bar-coding of coral species

Project: 2.3

Officer/s Responsible: Mr. K.G.S Nirbadha, Dr. S.S.K.Haputhanthri, Mrs. D. R. Herath, Dr. R.P.P. K. Jayasinghe, Mrs. Y.C. Aluvihare

Introduction

The Kayankerni reef is a little known reef and it is a major ornamental fish collection site in the Eastern coast of Sri Lanka. The reef is located Between Valachchane and Vakare, North of Batticoloa (approx 7° 59.500 N, 81° 32.000 E). This reef contains high diversity of coral and associated habitats. The reef compares with other marine sanctuary and national parks and is a very diverse and sensitive reef habitat. The Reef and the adjacent marine habitats have been gazetted as a new Marine Sanctuary on 11th April 2019. The main part of the reef is roughly 2.5 km in length along the coast at the Southern end of the Vandalous Bay. The water within the inner area of the reef is on average 2-2.5 m in depth while the outer ends of the reef may fall down to about 4-5 metres.

Table 1: Protected Marine areas in Sri Lanka

Materials and Methodology

Name	Year of declaration	Area/ha	Responsible agency	Legislation Body	Permitted activities	Prohibited activities
Hikkaduwa National park	1979*	104	DWLC	FFPO	Recreational activities	Fishing and extraction of other natural resources
Pigeon Island National Park	2003	471.4	DWLC	FFPO	Recreational activities	Fishing and extraction of other natural resources
Bar Reef Marine Sanctuary	1992	30,670	DWLC	FFPO	Recreational activities Artisanal fisheries	Commercial fishing & other resource extraction
Rumassala Marine Sanctuary	2003	1707	DWLC	FFPO	Recreational activities Artisanal fisheries	Commercial fishing & other resource extraction
Kayankerni Marine Sanctuary	2019	953	DWLC	FFPO	Recreational activities Artisanal fisheries	Commercial fishing & other resource extraction

Kayankerni marine sanctuary (Figure 1) was selected for the study. Five belt transects were conducted in outer and inner sites and most of these sites were shallow >3m (Table 2).

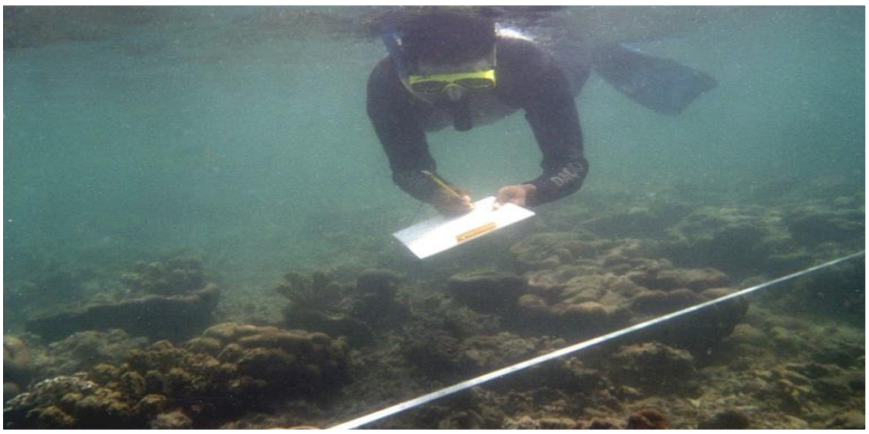
Study sites

Figure 1: Study sites at Kayankreni Marine Sanctuary

Table 2: Characteristics of the study sites

T.number	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
Coordinates	7°55'29.14" N	7°25'29.34" N	8°00'27.02" N	7°55'22.16" N	7°59'09.33" N	7°55'22.16" N
	81° 35'34. 01"E	81° 10'24. 10"E	81° 28'34. 59"E	81° 33'24. 22"E	81° 30'28. 93"E	81° 33'34. 22"E
Depth	2m	3m	2.5m	3.5m	2m	2-3m
Place	Inner	Outer	Inner	Outer	Inner	Outer

Underwater visual census was conducted, following English *et al*., (1997). Fish abundance and species richness were quantified using 50 m x 5 m belt transects and fishes were encountered within 2.5 m on either side and above the 50 m transect line and they were identified to the lowest taxon. Fish identification followed that of (Collins pocket Guide 1994) and Fish Base (ver. 06/2011) as shown in the Fig. 2. Mean fish density was calculated per site. Species richness and density indices were compared with Hilomen *et al*., 2009



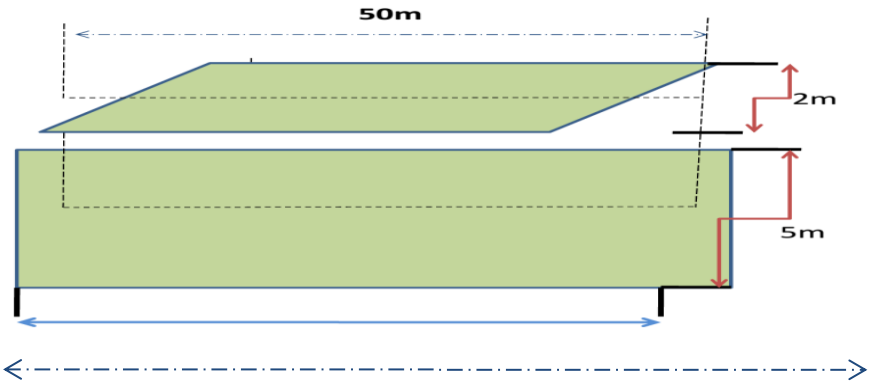


Figure 2: Use of the belt transect

Results and Discussion

Live corals were dominant in the inner areas while outer areas of the reefs had coral rubbles mainly (Figure 3). *Acropora* sp. was the most abundant coral.

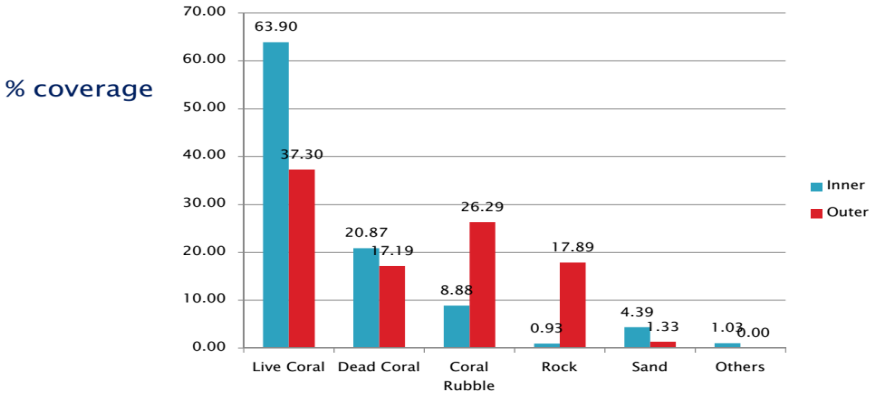


Figure 3: Substrate coverage of the study area

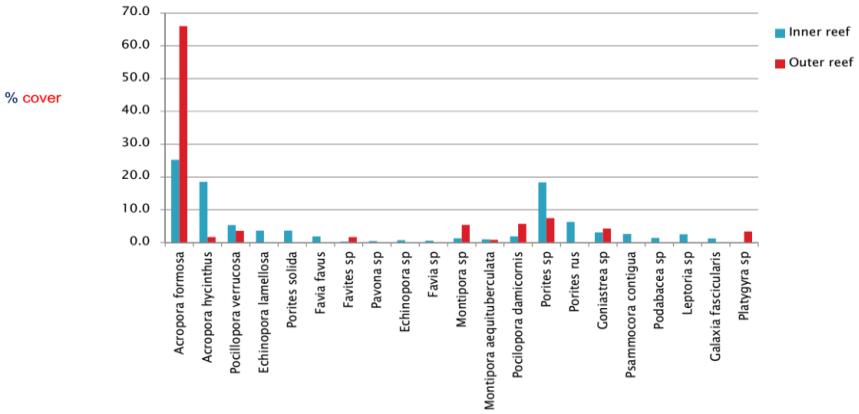


Figure 4: Live coral coverage of the study area

Table 3: Dominant fish families found during the survey

Family	Species	Density(no. of fish/1000m²)
Apogonidae	*Apogon sp* *Apogon aureus*	88 38
Caesionidae	*Caesio cuning*	32
Chaetodontidae	*Chaetodon decussatus*	30
Labridae	*Labroides dimidiatus*	22
Leognathidae	*Leiognathus sp*	65
Lutjanidae	*Lutjanus fulvus*	22
Pempheridae	*Pempheris sp*	67
Pomacentridae	*Abudefduf vaigiensis* *Chromis dimidiata* *Chromis virides* *Pomacentrus indicus* *Pomacentrus similis*	169 24 41 23 37

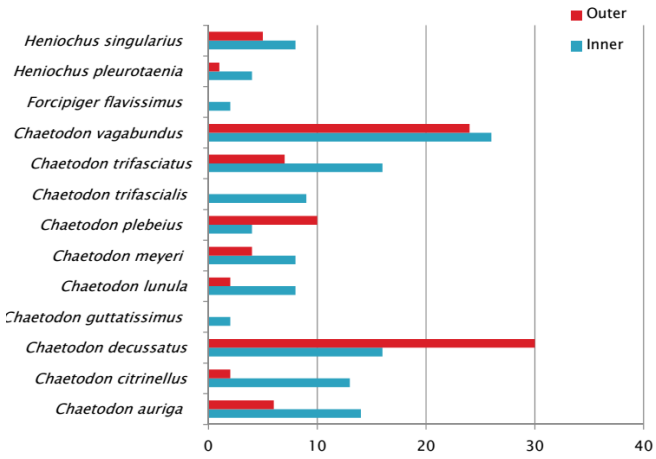


Figure 5: Relative abundance of butterfly fish species

a. Abundance Index

Inner Reef Fish Density *1500/1000m² = Moderate
Outer Reef Fish Density 1200/1000m² =Moderate

(Abundance index Hilomen et.al 2009)

Fish Density (no. of fish/1000m²)				
Very Poor	Poor	Moderate	High	Very High
0 - 201	202 - 676	677- 2,267	2,268 - 7,592	>7,592

* Statistically higher abundance within inner reef (p< 0.05)

Discussion and Conservation

A total of 108 fish species representing 30 families, such as Acanthuridae, Apogonida, Balistidae, Blenniidae, Caesionidae, Carangidae, Chaetodontidae, Cirrhitidae, Diodontidae, Fistularida, Gerridae, Gobiidae, Holocentridae, Kyphosidae, Labridae, Leiognathidae, Lethrinidae, Lutjanidae, Mullidae, Muraenidae, Nemipteridae, Ostraciidae, Pempheridae, Plotocidae, Pomacanthidae, Pomacentridae, Scaridae, Serranidae, Siganidae and Zanclidae were recorded during the survey in the inner reef area and 70 species were recorded in just outside reef area. The results of the study showed that the estimated mean fish density ($1500/1000m^2$) was significantly different from the estimated mean reef fish density just outside the reef $1200/1000m^2$ ($\alpha = 0.05$). However, the estimated target species density between inside and outside the reef showed no significant difference at 0.05. Similarly the density of non target species inside and just outside also showed no significant difference. These results indicate that target fish densities inside and outside the marine sanctuary were more or less same. The study emphasises the need of introduction of further conservation and management measures in order to improve the reef fish populations of Kayankerni reef.

Assessment of the blue whale population living in the South coast of Sri Lanka and studying the interaction of marine mammals with fisheries.

Project No: 2.5

Officer/s Responsible: Mr. U.S.P.K. Liyanage

Introduction

Cetacean diversity within the EEZ of Sri Lanka is very high compared to the other countries in the region, but their diversity, distribution and abundance are not well studied. Since these creatures are threatened worldwide, national and international attention has been given strongly within past few years towards their conservation and management. The Blue whales are the most threatened cetacean species in Sri Lanka and they are facing multiple threats such as ship strikes, disturbances due to the commercial whale watching industry and environmental pollution associated with maritime transportation etc. Intentional killing and landing of small cetaceans could be stopped with awareness building among the fishes and consumers with strict implementation of the regulations by relevant authorities. Increasing cetacean population and growing trend of fisheries and marine mammal interactions within and outside of the EEZ has been reported. Sri Lankan fishermen who are engaged in the long line fishery complained regarding the depredation issue specially related to the yellowfin tuna.

For implementation of a proper management plan for the blue whales, their population size is very important. Further, since there is no any recent previous study on the fisheries and marine mammal interactions, this study is of utmost importance to update the knowledge and improve the status of management levels in relation to the international standards.

Methodology

To study the fisheries and marine mammal interactions, questionnaire survey was carried out based on the major fisheries harbours in Sri Lanka aiming to:

Estimate the amount of loss (Financial)

Type of loss and damage – net damage and depredation etc.

Suspected fisheries and responsible marine mammal species for depredation.

Boat owners or crew members of OFRP and multiday fishing boats (IMUL) were surveyed. Information was collected regarding the last fishing trip they had completed. In OFRP boats information was collected based on the past fishing year.

The blue whale population size of Sri Lanka is estimated using the mark and recapture method through photos which are collected on a daily basis in collaboration with the commercial whale watching operators.

Results

Through the questionnaire survey of IMUL boats, three marine mammal species damaged to the hooked yellow-fin tuna, skipjack tuna, marlin and sailfish have been identified. These species are

A. False killer whale -*Pseudorca crassidens* - (20 % of the interviewee identified)

B. Pigmy killer whale -*Feresa attenuate*- (21 % of the interviewee identified)

C. Melon headed whale - *Peponocephala electra*- (19 % of the interviewee identified)

Some interviewees not properly identified.

IMUL boat operators use three fishing gears types separately or in combinations

1. Long-line 41%	4. Long-line and Gill net 4%
2. Ring net 21%	5. Ring net and long-line 2%
3. Gill net 17%	6. Gill net and Ring net 15%

Long-line operators are more vulnerable to marine mammal attacks rather than other gear operators. 51 percent of the longline operators were subjected to the depredation losses accounting to Rs. 969,374 per boat per trip. Ring net operators were rarely affected by depredation, but blackfish (medium size whales) species are dispersed fish schools. Attacks on the gill net entangled tuna are rarely recorded.

Types of damage

1. Hooked yellow-fin tuna fish ruptured completely except their head. Since the longline is very long (4-50 nautical miles) fishermen are unable to collect line. Frequently fishermen found only heads of yellowfin tuna but not seen marine mammals.

2. Eating bait

3. Tuna and other fish species disappear when blackfish species come close.

4. Extra running cost to find new fishing areas

Depredation of yellow-fin tuna in longline fishery is a severe case which make considerable economic loss compared to the other varieties because it is the major target species with high market price.

Actions taken by the IMUL operators avoid depredation.

Action	**Long-line operators**	**Gill net operators**	**Ring net operators**
Stop fishing operation & leaving away	X	X	X
Mixing burn oil into the water			X
Mixing diesel into the water			X
Switch off light		X	X

Majority of long liners have no action against depredation since their long lines are 20-50 nautical miles long.

According to the interviewed FRP boat operators (n=100) who use gillnet for fisheries, fisheries and marine mammal interactions are severe during the calm season of the sea. Further, fishermen who used FRP to catch sardines, scads and other coastal species have suffered due to net damages and predation of the entangled fish by bottlenose dolphins and medium size whales. 24 percent of the interviewed fishes identified bottlenose dolphin as a suspected species, but the majority have no idea about the species.

Study on blue whales

In addition to the current surveys, the Dr. Fridjtof Nansen survey provided an excellent opportunity to study the distribution and abundance of the marine mammals throughout the waters of the island at a particular time period for the first time in history. Marine mammal stranding data were also collected throughout the coast of Sri Lanka with the support of field data collectors of NARA, Department of Wildlife Conservation and some other agencies in Sri Lanka. By the opportunistic survey platform 13 species of cetaceans were identified from the Southern coastal region. Blue whale (*Balaenoptera musculus*) was the most dominant, threatened and economically important cetacean species found in the waters of Sri Lanka, which are aggregated on the dense shipping lane from Dondra head to Galle and are more dangerous and vulnerable to ship strikes. Population assessment result of the blue whale during the Southwest monsoon of the 2018 revealed that 633 (95% confidence interval Low 285 Max 1405) CV 41.19 %. Further, results revealed that the blue whales are aggregated along the sub marine canyons in the South, Southwest and Northwest coastal regions during the Southwest monsoon period. Blue whale distribution and abundance have correlation with the SST, Chlorophyll and density.

By photo identification from January to December 2019, 21 blue whales were found with damages to their fluke and body by the fishing gears, including two whales with long lines attached to their bodies.

From January to December 2019, 330 blue whale individuals (including re-sightings) were identified from South coast area. These data (photo) is being shared with the Southern ocean blue whale catalogue to study their worldwide migration pattern.

Table 1: No of blue whale individuals identified monthly

Jan	Feb	Mar	Apr	May	Sep	Oct	Nov	Dec
32	71	46	66	2	37	17	28	19

Recommendations

It is very important to launch research towards the use of dolphin pingers to repel the harmful cetacean species.

Awareness building among the fishes on marine mammal conservation.

Spiny lobster fisheries management and in-situ conservation of berried spiny lobsters

Project No: 2.6

Officer/s Responsible: Mr. U.S.P.K. Liyanage Ms.Udeshika Wimalasiri

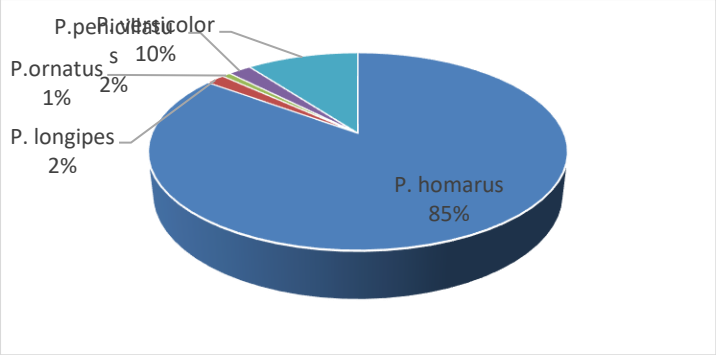
Introduction

Commercial exploitation of the spiny lobsters has accelerated worldwide with the high demand and lucrative prices received for them as a luxurious food commodity. The coastal stretch of the South coast (Galle and Matara districts) of Sri Lanka provides a favourable environment to five species of spiny lobsters. Majority of the small-scale artisanal fishes who do not have enough capital to harvest deep sea fishery resources are engaged in the spiny lobster fishery. Over exploitation of the resources are not exceptional to the spiny lobsters. Declining catch per unit effort (CPUE), changes of the species composition and large amount of small lobsters represented in the catch reflect the threatened level of the natural stocks. Stock enhancement and strict implementation of the management regulations are most important steps to conservation and management of the fishery. Current status of the fishery is of utmost important to understand the exploitation level and to adjust the available regulations to emphasize the healthy stock.

Major lobster landings sites and collecting centers in the South (Weligama, Tangalle, Hambanthota, Kirinda, Amaduwa) were visited once a month for fisheries and biological sampling. Carapace length, total length, sex, species composition, presence or absence of external eggs or spermatogonia, craft type, gear and catch volume were recorded. In addition to the field sampling, berried lobsters were kept in the cage constructed at the Matara and Polhena seas until they released their external eggs. This programme is continuing in collaboration with the Polhena fisheries co-management committee.

Species composition

Among the five species of lobsters represent in the catch, Scalloped spiny lobster (*P. homarus*) contributed 85.2 percent to the catch. Second major species, the Painted spiny lobster (*P. versicolor*) represented 10% of the catch. Since the majority of Ornate lobster (*P. ornatus*) live in deeper waters (below 30 m) and the fishing operations are conducting in shallow waters their representation of the catch is small but the species is not under threat.



Length frequency analysis

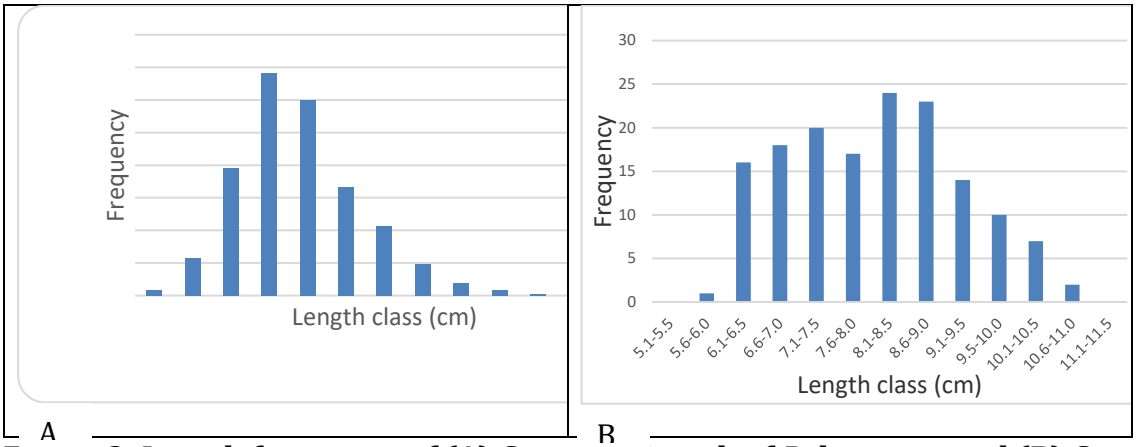


Figure 2: Length frequency of (A) Carapace length of *P. homarus* and (B) Carapace length of *P. versicolor*.

Length frequencies of the major species (scalloped spiny lobster) are quite good compared to the past years. It appears that there is an increasing trend in the mean size of lobsters (7.42 cm carapace length), less number of individuals in small length classes and high frequencies of larger length classes. Mean carapace length for both sees of *P. homarus* is 7.42 cm, which is 1.42 cm higher than the minimum legal size. Further, number of undersize lobsters (carapace length below 6 cm) is 3 percent of the total catch. According to the length frequency distribution chart, *P. versicolor* stock is healthier than the *P. homarus* stock. Few individuals of *P. ornatus* were found in the catch but all of them were below the minimum legal size. Mean length of the catch has been increasing to significant levels and it has been revealed that the fishing pressure on the stock is less than in the past years.

Catch Per Unit Effort (CPUE)

Three types of crafts and two types of gears are mainly used by the lobster fishermen in Hambanthota district. Catch per unit effort for the net operating fishermen are given in Table 1.

Table 1: Catch per unit effort for the net operating fishermen

Craft	Net Piece/Craft	Kg/craft/Day	Kg/net piece/day
FRP	12.58±5.5	1.506±1.288	0.119.7138
MTRC	9.4±4.4	1.566±0.810	0.166.5957
NMTC	6.86±4.41	1.269±0.827	0.184.9854

There is a significant difference between the catch of the crafts (P=0.331, α =0.05) and landing sites (P=0.314). Data frequency is not enough for calculate the CPUE for the lobster rings.

Conservation of the berried females

The community based conservation programme launched for the berried females till they released their eggs, is very successful. Fishermen of the Polhena fisheries management society had stocked 45 female lobsters during the year (2019) and released approximately 11,250,000 (250000 X 45) larvae to the ecosystem.

Figure 3: Lobster rearing cage at Polhena

Conclusions

Spiny lobster resources of the Hambanthota district is growing.

Fishermen are not respecting the current regulations yet and are catching berried females in large scale.

A large number of berried females were contained in the catch during the month of November.

Bottom set gill net is the main fishing gear used to catch lobster and is a prohibited gear set on the coral and reef areas.

Recommendations

Strict enforcement of the regulations for egg removing are needed

Introduction of eco-friendly fishing gear on behalf of the bottom set gill net

Amending of the second closed season (the September and October months should be declared as October and November).

Biological, Fisheries and other aspects in shark fishery in Sri Lanka

Project No: 2.7

Officer/s Responsible: Mrs.D G T C Balawardhana, Dr. S.S.K.Haputhantri

Introduction

Sharks are migratory carnivorous fish and play a crucial role in the ecosystem as top predators. They are highly vulnerable to increasing fishing pressure in many oceanic regions. Studies about sharks in the Indian Ocean are limited, despite they being frequently caught as by-catch mostly in tuna longlines by the tuna fishing fleets.

As a small island state, Sri Lanka is highly dependent on its marine living resources. The island is endowed with a 1340 km long coastal line and enjoys a relatively large EEZ with a surface area of 517 000 km^2 (FAO, 2016), which is only interrupted in the Northeast, adjacent to Indian territorial waters. The Fisheries sector in Sri Lanka plays an important economic role, contributing US$ 338 million, or about 1.2% of the total Gross Domestic Product, to the country, and providing direct employment to 56,000 people. Importantly, more than 2.5 million people in coastal communities depend directly and indirectly on fisheries (Fisheries Outlook, 2016).

According to Joseph (1999), the fisheries sector of Sri Lanka changed significantly with the introduction of motorized fishing vessels, synthetic fiber fishing gears and establishment of Exclusive Economic Zone (EEZ) in the 1970s. Fishing activities expanded outwards, leading to a rapid development of the offshore fishery (Hasarangi & Maldeniya, 2012). The shark fishery, which is a substantial fishery, captures coastal and bottom living species in localized coastal areas. Previously, bottom trawl, large-mesh gill net and hook and line were the major fishing gears used for catching sharks in coastal areas. But after the introduction of synthetic gill nets in 1970, pelagic shark landings increased more rapidly than that of coastal and demersal sharks (Joseph.1999). In the 1990s, the major fishing gears used for shark fishery became the drift longline and drift gill nets.

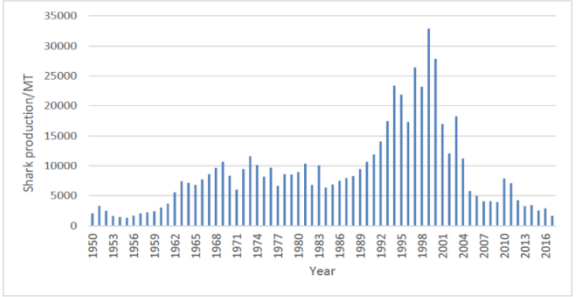


Figure 1: Trends in shark catch in Sri Lanka (1950-2016). Source: IOTC database

Shark landing in Sri Lanka declined drastically after the peak landings in 1999, probably as a result of the development of more profitable tuna fishery. At the same time, several

regulations taken by the government have contributed to this decline (Hasarangi *et al*., 2012). Despite the decline, in 2013, Sri Lanka was the top 16th in the world ranking of shark fishing country (Lack & Sant, 2003). Shark catch was, however, reduced to 2% of the total pelagic shark production after 1999, and sharks were mostly caught and landed as bycatch production of tuna fishery. According to statistics (Balawardhana *et al*., 2018), silky shark was the dominant species until 2017, followed by Blue shark. Since 2018, the Blue shark has been the dominant species, followed by silky shark and hammerhead sharks (NARA, PELAGOS database).

This declining trend could be mainly attributed to the recently implemented rules and regulations for conservation and management of sharks in Sri Lanka. This study aimed to investigate the existing fishery and reproductive biology of sharks in Sri Lanka.

Method

The data collection was carried out on a monthly basis in Negombo, Beruwala, Mirissa, Dondra and Tangalle fisheries harbours from February to December, 2019 (Figure 2). Fisheries data including type of fishing vessel, fishing gear, fishing operation details, fishing location and target fishing group were collected during the survey. Landed shark species were identified up to species level using shark identification guides. In addition, morphometric and meristic characters were recorded and measured. Bycatch fishery and target shark fishery was recorded with the fishing operation details. In addition, information on the shark fin trade was collected from shark fin collectors.

Figure 2: Fishery harbors which collected shark landing data

Results

A total of 1,237 individuals belonging to 14 species and 6 families were recorded during the survey. Silky shark (*Carcharhinus falciformis*) and Blue shark (*Prionace glauca*) were the dominant shark species recorded followed by Scalloped Hammerhead (*Sphyrna lewini*), Smooth Hammerhead (*Sphyrna zygaena*), Longfin Mako (*Isurus paucus*) and Shortfin Mako (*Isurus oxyrinchus*) (Figure 3). Pelagic longline, gill net and ring net were

responsible for the shark by catch landing in Sri Lanka. According to the results of the survey, the highest shark landing was recorded in Negombo fishery harbour followed by Mirissa, Beruwala, Tangalle and Dondra respectively (Figure 4).

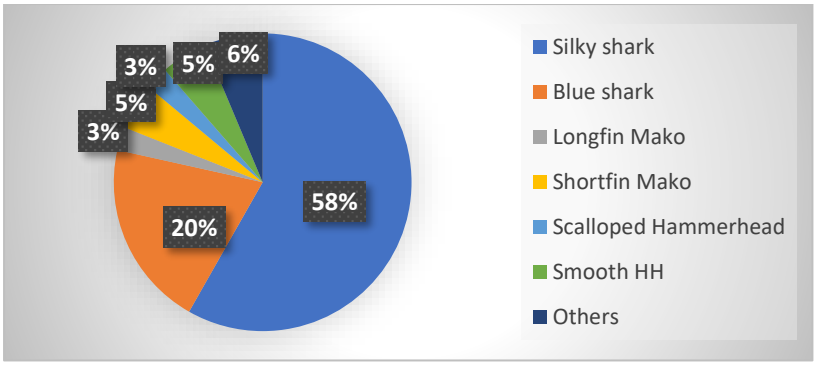


Figure 3: Percentage composition of different shark species recorded during the survey.

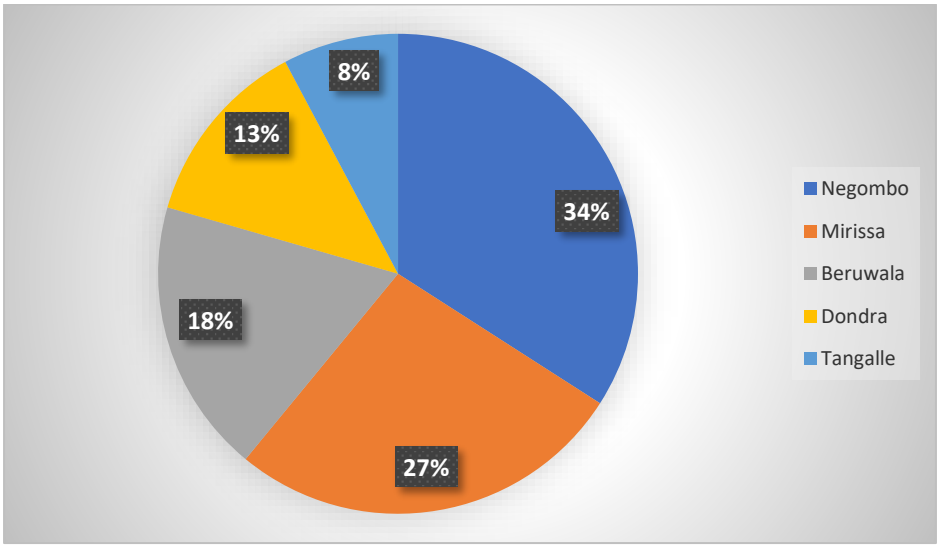


Figure 4: Shark landings in different fishery harbors

Sex ratio of the landed sharks was recorded as 1:1 during the study for Silky sharks and Blue sharks, which is similar to previous studies in the Indian Ocean. Maximum total length recorded for Silky shark, Blue shark, Scalloped Hammerhead, Smooth Hammerhead, Shortfin Mako and Longfin Mako sharks were 260 cm, 183 cm, 218 cm, 280 cm, 190 cm and 138 cm respectively. During the survey, four pregnant silky and blue

sharks were recorded. Maturity stages of the female sharks were not possible to analyze. But male sharks were categorized as either mature or immature according to the length and the level of rigidity of the clasper. Accordingly, 55% of the male sharks were recognized as mature.

Shark fins export is the main use of shark landings. Statistics of the Export Development Board (EDB) revealed that Hong Kong is the main country which export fishery by-products including shark fins (HS Code- H.030571) followed by Malaysia, Singapore and Vietnam. But there is no separate HS code for the shark fin. Hence, exact quantity of shark fins exported has not mentioned in EDB records. There are several shark fin collectors in each fishery harbors and they buy whole shark from the auctions. Then they remove shark fins and flesh is sale for meat or dry fish. Shark fin collectors sell dried shark fins directly to shark fin exporters in Sri Lanka.

Discussion

According to the study, most of the landed sharks were mature. Juvenile shark landing was very low. Silky sharks and blue sharks have been the common species found in Sri Lanka for many years. Hence, detail studies about these common species are important. Most of the shark landings are due to the bycatch of tuna longline. But there are very few numbers of boats in Negombo and Beruwala which target sharks. Shark longline is used as the fishing gear for catching shark. In addition, there are very few numbers of boats which target deep water sharks in Sri Lanka. Deep water shark fishery (Katu moru fishery) can be seen in Thalawila, Beruwala and Mirissa areas, but this fishery is highly seasonal.

The commercial important parts of the sharks in Sri Lanka are fins, skin and jaws. The liver oil is extracted from deep sea sharks for the export market, and meat is consumed locally. Demand is high for the collagen and elastin fibers of the dried shark fins, which are used for the shark fin soup (Samaraweera & Amarasiri, 2004). Silky shark and blue shark are the dominant species in the fin trade and the fins are exported mainly to Hong Kong, Korea, Maldives, Singapore and Taiwan (Department of Agriculture, 2009). Since sharks are generally vulnerable to overexploitation because of the late maturity, low fecundity and slow growth, unregulated fishing and increasing demand for shark fins were the reasons for implementation of management plans by many international agencies (Jayathilaka & Maldeniya, 2015). Implementation of policies and regulations enforcing Monitoring Control Surveillance (MCS) to combat Illegal, Unregulated and Unreported (IUU) fishing, as well as the prohibition of shark fining at sea and of the catch of three vulnerable thresher shark species, whale shark and oceanic white tip shark, were the key features implemented to bring the shark fishery under control (Jayathilaka & Maldeniya, 2015).

There is a lack of knowledge about status of the shark fin trade in Sri Lanka. Shark fins export trends, conversion factor analysis need to be done in addition to a detailed study on the biology and ecology of key shark species in order to manage the shark fishery resources.

Recommendations

Detailed study about Silky sharks and Blue sharks stock status in Sri Lankan waters.

Long term monitoring of shark landing in Sri Lanka.

Conversion factor analysis for shark fin exports.

Research on ecological aspects of major shark species in Sri Lanka.

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Sea urchin fishery development in Sri Lanka (Continuation)

Project No: 2.8

Officer/s Responsible: Dr. S.S.K. Haputhantri, Ms D. Herath, Ms D.G.T.C Balawardhana ,Ms H.B.U.G.M. Wimalasiri

Introduction

Sea Urchins are high demand-sea food in countries like United States of America, China and Japan. The important part of their body is their gonad. These gonads are known as "Roe". The Roe have different nutritional values according to research done by various authors all around the world.

Sri Lanka has not yet considered commercial exploitation of Sea Urchin. But there is a possible international market for Urchins. Therefore, it is important to study the distribution of edible sea urchin species in Sri Lanka.

Last year MBRD conducted a study to investigate reproductive cycle and feeding behavior of common sea urchin found in South and East cost of Sri Lanka. This study will be a continuation of that study to identify other sea urchin abundant areas and their nutritional values.

Objectives

- To identify distribution of the edible sea urchin around Sri Lanka.
- To identify the nutritional composition of different sea urchin species around Sri Lanka.
- To identify the population genetics of the sea urchin around Sri Lanka.

Results

Sea urchin distribution

Around the country, 22 areas were so far identified as sea urchin abundant areas. From those areas 4 common edible species were found. Among those most abundant edible species of sea urchin was Stomopneustes variolaris. Details of distributed areas and estimated abundance were given in the table 01. Midigama was the highest Stomopneustes variolarisabundance location followed by Koggala.

Table 1: Sea urchin dominant locations and their abundance

	Estimated abundance (individuals/m^2)			
Species found / Location	*Stomopneustes variolaris*	*Diadema sp*	*Tripneustes gratilla*	*Echinothrixs diadema*
Arugambay	5			
Peanut point	6			
Panama	7			
Kudumbigala	9			
Okada	4			
Lanka Patuna temple	6			
Verugal	5			
Kayankerni	8			
Punnakuda	6			
Alampil	5			
Pulmudei	11		2	
yala	8			
Hambantota	9			
Ambalantota	10			
Ussangoda	8			
Kalametiya	7			
Kudawella	12			
Nilwella	17	3	4	2
Hiriketiya	15	1	2	
Midigama	22	4	3	
Seethagalla	15	3	3	
Matara	18	2		
Koggala	20		1	
Hikkaduwa	19	3	2	
Dehiwala	12			
Morawala	18			
Trincomalee Harbour		12		

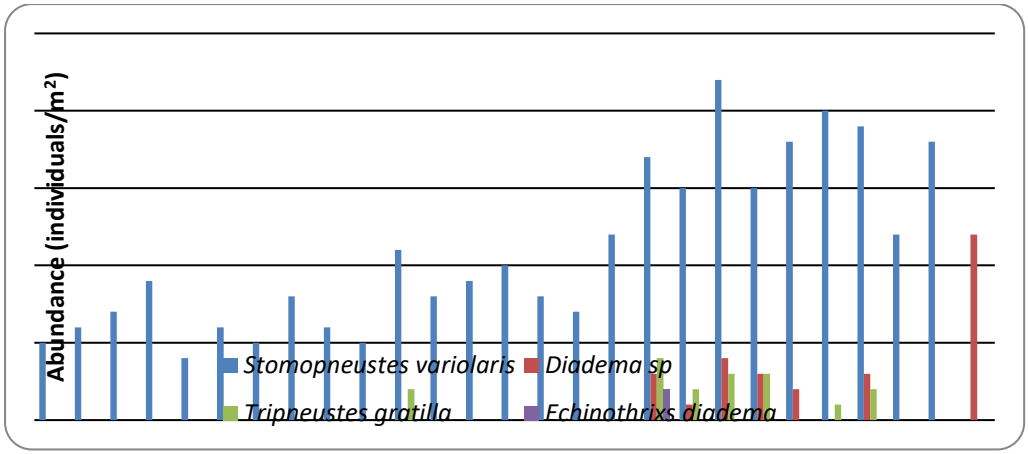


Figure 1: Abundance of four commonly found edible sea urchin species in Sri Lanka

Fat content analysis

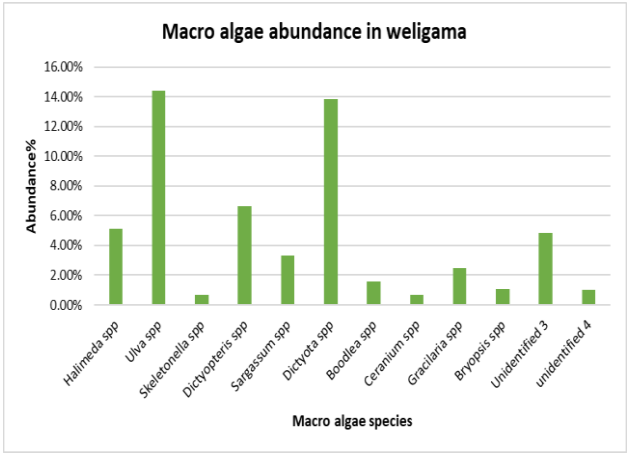
Fat content analysis indicated high gonad fat content in Kottegoda and Midigama area samples.

Table 2: Mean total fat % found in different sea urchin species from different locations

Place	**Species**	**Mean Total Fat % (W/W wet)**	**SD**
Kokilai	Fire Urchin (*Astropyga radiate)*	3.137	0.070
Trinco Harbour	Diadima Urchin (*Diadema* sp.*)*	1.187	0.153
Midigama	Sand Urchin (*Tripneustes* sp.)	2.586	0.010
Pulmudai	Black Urchin (*Stomopneustes variolaris)*	3.003	0.021
Nayaru	Black Urchin (*Stomopneustes variolaris)*	1.935	0.074
Sallikovil	Black Urchin (*Stomopneustes variolaris)*	2.526	0.031
Midigama	Black Urchin (*Stomopneustesvariolaris)*	3.421	0.068
Kottegoda	Black Urchin (*Stomopneustes variolaris)*	4.327	0.013
Kottegoda	Black Urchin (*Stomopneustes variolaris)*	3.382	0.031
Nilwella	Black Urchin (*Stomopneustes variolaris)*	4.550	0.001

Gut content analysis

Gut content of black sea urchins inhabited in Negombo and Weligama areas was analyzed. The results indicated that gut content of black sea urchin was different in these locations during the study period. In Negombo, *Phyllodictyon*sp. was the most abundant seaweed found in black sea urchin stomach while in Weligama *Ulva* sp. was the most abundant species (Figure 2).



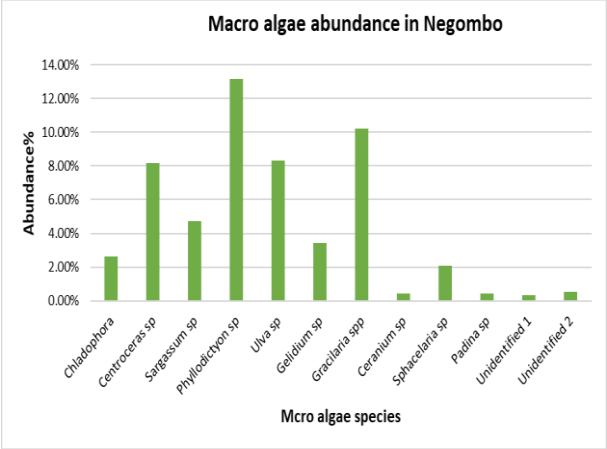


Figure 2. Percentage abundance of seaweeds found in the guts of black sea urchins found in Weligama and Negombo area.

Recommendations

1. Wild harvesting of sea urchins should not be promoted.
2. Availability of sea urchin in shallow sea areas of Sri Lanka is not enough for commercial extraction. Therefore, culture practicesshould be encouraged in order to avoid the over exploitation in natural stocks.
3. Sea urchin mariculture should be started in Sri Lanka as a pilot project under the guidance of NARA and NAQDA.

4. Most abundant edible sea urchin species in Sri Lanka is *S.variolaris.* but there are other economically important edible species of sea urchins such as *Tripneustesgratilla,* which could be attempted as a potential culturable species.
5. A nutritional analysis and an analysis to find out the concentration of heavy metals accumulated within the gonads are recommended to carry out furthermore.
6. Further studies are also recommended to identify other sea urchin abundantareas around the country.

Sri Lanka – Norway Bilateral project to improve the management of fish resources of Sri Lanka (Continuation)

Project: 2.9

Officer/s Responsible: Dr. S.S.K. Haputhantri, Dr. R.P.P.K. Jayasinghe,Mr. S.S. Gunasekara

The bilateral project between Sri Lanka and Norway commenced in late 2016. In the beginning of October 2018, an addendum to the contract with the Norwegian Embassy in Colombo was signed extending the project till 31.12.2019.

The project until mid-2018 had two main work packages; "Coastal Fisheries Statistics & collection of landing data" and "Technical assistance and competence building in Fisheries Research". After the extension, a new work package "Bringing Science to Management" was included, and it was decided to extend the data collection for coastal fisheries to cover all Sri Lankan fisheries.

WP 1: UPGRADING COASTAL FISHERIES SAMPLING PROGRAMS AND DATA MANAGEMENT

Introduction

The Work Package 1(WP1) was initiated with the aim of improving the fisheries data collection system for marine fisheries in Sri Lanka to provide reliable statistical landing data covering the entire country for sustainable management of the coastal fisheries. Three local partners are responsible for the implementation of this work package: MBRD of NARA, Department of Fisheries and Aquatic Resources (DFAR) and the Statistics Unit (SU) of Ministry of Fisheries and Aquatic Resources Development (MFRAD).

Methodology

In the work package 1, baseline survey data has been evaluated and improved. The report from the baseline survey conducted by DFAR and NARA in 2017 was completed in 2018 and a sampling strategy was under development in 2019 to ensure representative and reliable statistics for all fisheries, including coastal fisheries. A lot of effort has gone into improving the quality of the baseline data, as errors occurred partly due to missing automatic validation when registering data. Enhancing data quality has been considered important, since development of sound sampling design depend heavily upon baseline data analysis and the quality of these data.

Landing data is planned to be part of an integrated fisheries data system, which incorporates other data sources as well, for example vessel registry, licenses, and fishermen's registry. Integration of different related data sources into one system is considered a major strength, since it will enable coherent validation of data and more flexibility to analysis and reporting outputs.

The format of the data collection sheets developed in 2017 has been agreed on by all parties. With the ongoing development of new database these data collection sheets were transferred into software applications for tablets, in order to register data electronically at the landing sites using tablets. The tablet application interface was developed based on developed paper sheets and database design. In the beginning of data collection, mainly paper data sheet will be used. Tablet application will be introduced in a second phase for data collectors, but will be used for entry into the database, based on the completed paper sheets.

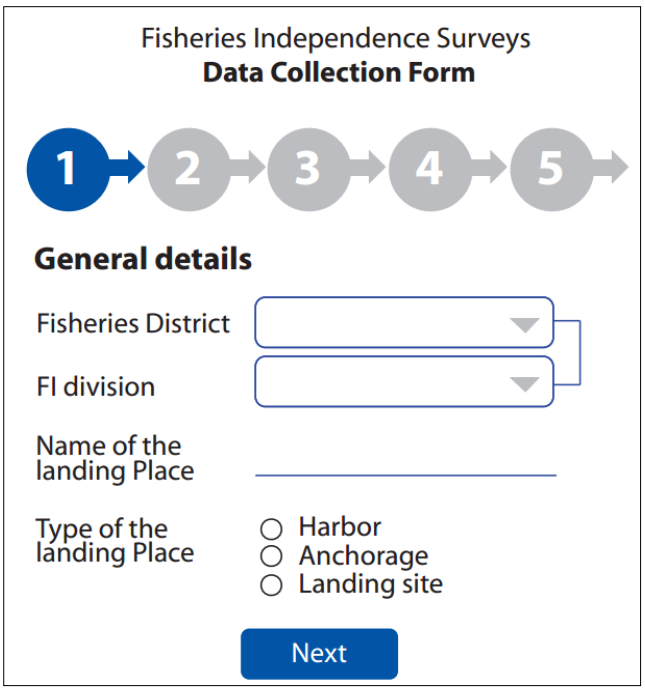


Figure 1. Tablet application interface developed based on data collection sheets prepared by NARA, DFAR and MFAR

Meetings and workshops

A workshop was held 21st to 25th January 2019 to discuss data infrastructure and how landings database will be integrated with other data sources within the system, and also discuss data registration interface, database maintenance (coding tables etc), corrections, access and output facilities. That meeting was held at NARA premises with the participation of NARA, DFAR and MFAR/SU officers (Figure 04).

A series of video meetings between Norway team and Sri Lanka project partner agencies (NARA, DFAR and MFARD/SU) was held to discuss the WP 1 activities and the progress etc. A series of regular internal meetings was held between NARA, DFAR and MFARD/SU for preparing the data collection forms & data collection manual and for discussing other matters related to other components of WP1.

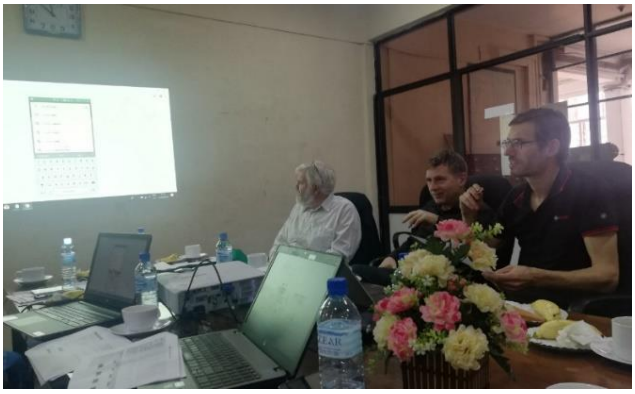



Figure 2: Meeting conducted from 21st to 25th January 2019 at NARA premises. (First picture shows the Norway officers and 2nd picture shows the workshop participants)

A successful training workshop on "R" programming language was held in 25th to 28th November 2019 at Paradise beach hotel Negombo (Figure 03). Two Norwegians participated the workshop as resource persons. During this four-day residential workshop the participants (NARA, DFAR, MFARD/SU) learned key features of R such as data structures, calculations, tabulating and aggregating data, merging data, looping, descriptive statistics, graphics and map creation etc.

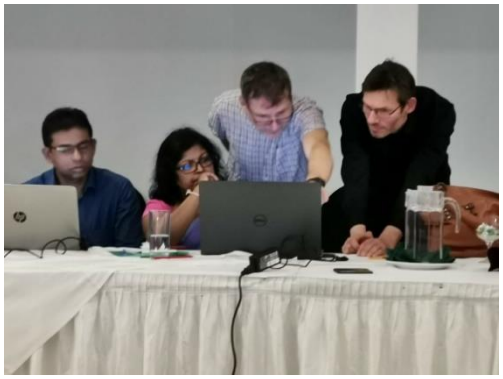



Figure 3: Training workshop on "R" programming language during 25th to 28th November 2019 at Paradise beach hotel Negombo.

A training programme was conducted at NARA premises on 29th December, 2019 for MBRD Research Assistants and Field Research Assistants. The objective of the training programme was providing basic training for them about new port sampling data collection, which is going to implement in 2020. They were mainly trained on new software application which has been already incorporated into data collection tablet. Moreover, they were trained on morphological identification of different groupers found in Sri Lankan waters.

Project continuation

At the moment, sampling design, tablet registration software and database are in finalization stages, and the goal is to have the new data collection programme tested and piloted by the end of the year. There will also be carried out a WP1 data training workshop in Sri Lanka in the end of the 2020, based upon test data from the new database, in order to familiarize and strengthen the knowledge to these data, and how to retrieve and analyses them. This will be an initial start to strengthen the capacity to use the data for various purposes, enabling flexible use to meet the requirements of Sri Lankans fisheries management and science. Along with this, DFAR has also planned introduction and training of the data collectors, on how to use the new software for data registration, and how to comply with the sampling programme.

Hence, within current project period and phase, the system will be established and up and running.

In order to settle the system within the related institutions, both for the collectors that going to carry out the important task of collecting the data (data input), but also for efficient use of the data generated (data output), the project team strongly suggest to continue the evaluation, refinement, administration, maintenance, quality enhancement, and analysis in a new project phase 2 from 2020-2022.

This will also make sure that the new system is properly implemented on a permanent basis, so that Sri Lanka can make efficient use of these data on a long term run.

WP2: TECHNICAL ASSISTANCE AND COMPETENCE BUILDING IN FISHERIES RESEARCH

Overview:

The main achievement has been preparation and training to undertake data analysis and reporting from the R.V. Dr Fridtjof Nansen survey in 2018. This has been carried out in close cooperation with the EAF Nansen programme. All formalised training activities agreed to in the project document have been finalized in 2018, and advanced training has been provided both in swept area abundance estimation and acoustic abundance estimation on board the Dr. Fridtjof Nansen. As part of this, a workshop was carried out to compare the data with historical information and create a document with scientific recommendations from the survey. The planned general competence building from

lectures are completed in this component of the project. The theoretical competence of NARA personnel has been tested at sea and in laboratory work during the Dr. Fridtjof Nansen survey and to some extent during surveys with the local research vessel, RV Samuddrika. New survey training in 2019 are supposed to advance and consolidate the training completed so far in the project. Work on a data policy and data management plan to ensure safe data storage in NARA has started.

The project has helped in upgrading the data and instrument infrastructure on board the local research vessel as well as advice on the routine running of the vessel. Most of the recommended adjustments to the deck arrangement of Samuddrika was completed early in 2018. A Benthic video sled was made and tested during a trial survey where NARA scientists have shown that they are fully capable to run such a survey. However, the survey was terminated early due to technical problems with the ship. NARA is still struggling to make the vessel operational and is not able to run research surveys on a routine basis.

Activities conducted in 2019

Establish time series data collection at NARA

Since NARA is needed time series data, under WP2 it was considered to establish time series data collection system.

A workshop was held at NARA in February to decide initially what are the parameters to be considered in time series data collection

An Acoustic Survey for pelagic fishes was conducted in the Northeast coast at the first time series data collection in Sri Lanka

Implementation of a data policy and data management at NARA

NARA is lacking of proper data policy and data management system

A workshop was held at NARA in February 2019to initial a data policy and data management system

Drafts of these two documents were completed.

Conduct benthic video survey in selected areas

A frame (video sledge) was constructed at NARA.

Surveys to be conducted in October to estimate the benthic animal abundance.

Acoustic surveys on commercial small pelagic species Northeast coast and Southwest coast

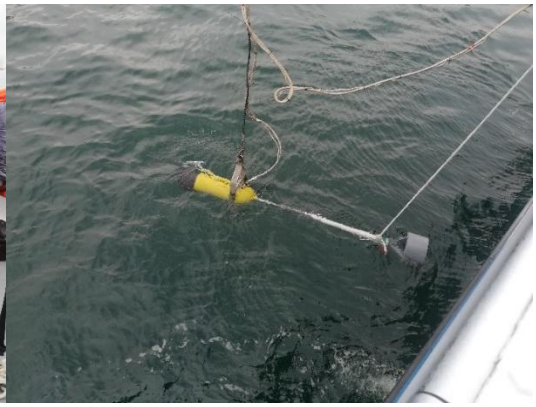
First acoustic survey for pelagic fish was conducted in the Northeast coast in August 2019 and in Southeast coast in December 2019

Research Vessel Sammuddrika was used.

Norwegian Scientist Mr. AtleTotland guided the survey (NE survey) and it was a good opportunity to capacity building of NARA Scientists on Acoustic surveys

EK 15 Echosounder and LSSS software was used

The survey estimated that the total biomass of small pelagic fish (PEL1) and medium pelagic fish (PEL 2)were 164 tons and 7280 tons respectively.



Objectives of the Acoustic Surveys

The main objective is to establish a time series on pelagic resources with the main aim of producing indices on the status and development of the pelagic fish resources after continuation of surveying for many years. In addition, capacity building of NARA's scientists for acoustic estimates (instrument arrangements, calibration, acoustic data collection, data processing, abundance estimation, survey and sampling design, reporting and survey planning) of pelagic resources. Since this is the first acoustic surveys with RV Samuddrika, how the facilities can be improved for acoustic surveys are also considered.

Methodology

Acoustics

Survey design and acoustic sampling

A survey plan was made prior to the survey (Figure below). The plan originally indicated one stratum along the coast north of Trincomalee. A random, systematic zig-zag transect design was chosen as the available survey time was limited and this is the most time efficient design. It was decided to attempt a survey coverage of no less than 7 if possible. As the coverage of the northern strata went smoothly, a new stratum south of Trincomalee was planned during the first stratum coverage. Unfortunately, it was not possible to cover the southern strata due to lack of permission to survey this area. We had not foreseen the quick and smooth execution of the coverage of the first stratum and the application to expand the coverage into a new area came too late,

The StoX application was used to define the strata boundary definitions bases on available previous depth strata from the RV Dr. Fridtjof Nansen survey of 2018 to coverer the depth range 10 – 75 meters. This is assumed to cover the main range of distribution of coastal small pelagic fish.

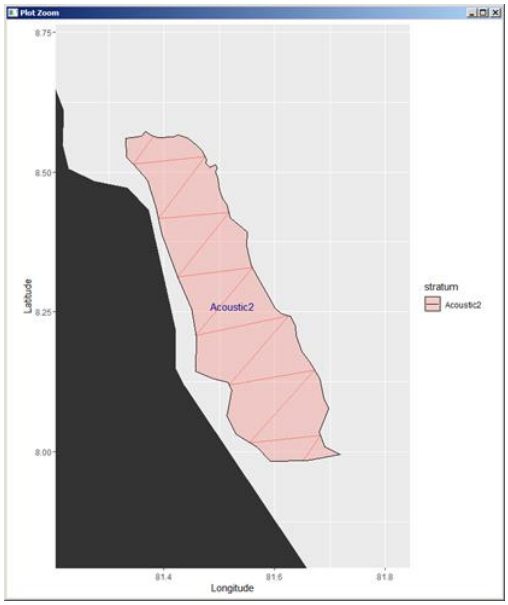


Figure 4: Survey tracks in the NE Coast

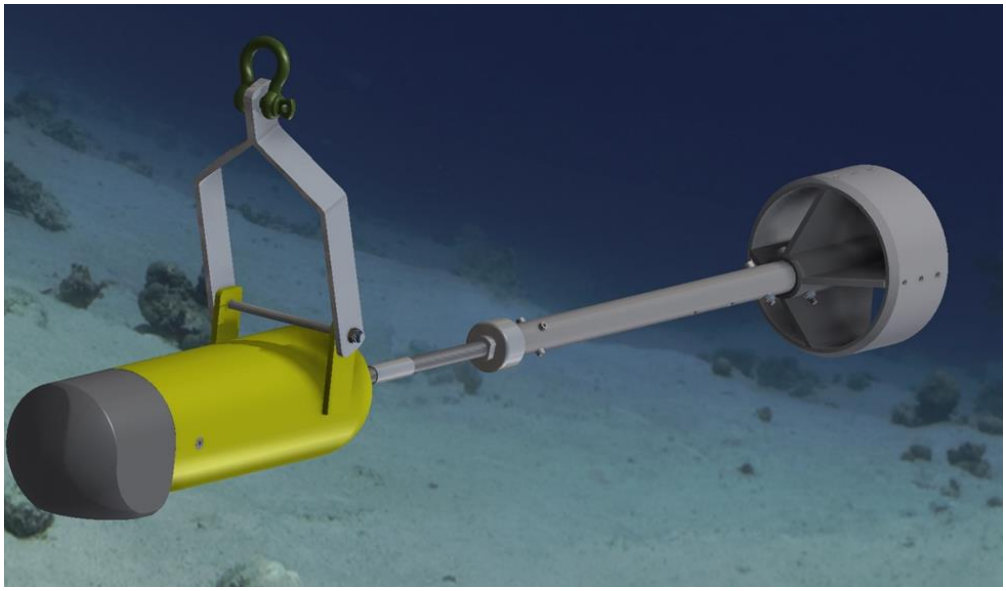


Figure 5: The NARA towed body for echosounder transducer

Results

The total biomass in NE was estimated in to 7280 tons, with a sampling variance expressed as Coefficient of Variance (CV) of 34%. These were estimated by mean and standard deviation of 500 bootstrap replicates. 90% of the bootstrap replicates were between 3655 ton and 11946 tons.

Conclusions

The study reveals that the highest concentrations were found towards the southeast, but particularly close to the northern border of the survey area. This gives a clear indication that the area coverage was insufficient to measure a distinct part of the pelagic fish stock. If the survey was to be part of a timeseries, a shift in the coming years fish distribution would introduce a huge bias. From this we can conclude that this year's survey, as is, cannot be used to evaluate the trends in stock development as part of a timeseries. However, NARA is planning a more extensive coverage of the east coast soon.

WP 3 BRINGING SCIENCE TO MANAGEMENT

Work Package 3 (WP 3) has been in operation since February 2019. Three workshops have been conducted to establish a common understanding of the situation in Sri Lanka based on available data and relevant experience from fisheries management both in Norway and in Sri Lanka was presented at the first workshop. Two important fisheries, in terms of their role for food supply and income, were identified as candidates for the development of management plans: the fisheries for small pelagics on the west coast and demersal species in the south-east region. Draft management plans have been developed. Assistance from WP 1 was useful for the work on the draft management plans by, among other things providing inputs to the improvement of questionnaires to obtain more information as inputs to the management plan.

Given the limited data availability for Sri Lankan fisheries, and the limited use of regulation so far, phase II of the bilateral project aims towards gradually developing management plans and more specific regulations, where the management advice is based on the best available knowledge. As the data situation is improved through the work of WP 1 and WP 2, the increased knowledge base will be used in the development of management advice.

Project No. 2.9 (b): Genetic study of marine biological resources in Sri Lankan water

Introduction

Sri Lanka is an island in the Indian Ocean rich in biodiversity in both fauna and flora. The land is rich in marine diversity due to the tropical climatic conditions in the ocean around the country. Nearly 2500 fish species out of 31 100 extant fish species have been recorded in the Indian subcontinent (Froese and Pauly, 2009). Hence, the study of diversity among fish species is really essential to strengthen the knowledge in the fishery sector. Due to this reason, this research was targeted to study the genetic level variation of some key species collected during the Dr. Fridtjof Nansen survey in Sri Lankan waters. Moreover, the findings will help to fill the knowledge gap of genetic basis of fish composition in Sri Lankan marine waters.

DNA barcoding has been used as an efficient tool for the identification of existing species and also to find cryptic species (Dona *et al*., 2015). DNA barcoding has provided an added advantage for the identification of biodiversity in global fauna in recent years. Fish DNA barcoding by using Cytochrome C Oxidase type I (*COI*) gene has been used for identification, authentication, and phylogenetic analysis (Ward *et al*., 2005, Ratnasingham and Hebert, 2007). DNA barcoding using COI gene has been used to discriminate closely related animal species, specially marine and freshwater fishes (Hajibabaei *et al*., 2005; Ward *et al*., 2005; Lakra *et al*., 2009). Recently the identification of fish and fish related products has become an important topic for the authentication process due to adulteration. Furthermore, barcode based fish identification systems provide a path for detection of phylogenetic relationships among the species and to identify taxonomic status of the species. DNA diversity among species is helpful to resolve taxonomic ambiguities and to discover new species among the morphologically similar individuals in a fish stock (Hebert *et al*., 2003). For instance, record of cryptic species of *Lethrinus nebulisus* in Indian waters and the same results were obtained as the presence of a cryptic species in Sri Lankan waters. Finally, all these accurate details of fish species would help to manage a sustainable fishery while maintaining a maximum harvest and to improve ecosystem research and conservation.

Objectives

Study the genetic structure of key species distributed in Sri Lankan marine waters

Identification species structure of fish populations

Study the polygenetic relationship of fish species

Identification of sequence variations of fish species due to natural mutations

Materials and methods

Collection of fish samples: Samples were collected from different points in the ecosystem survey by the Dr. Fridtjof Nanson research vessel (Tables 1, 2 and 3).

Genetic Analysis: Total DNA was extracted by using Qiagen's DNeasy Tissue Kit following the manufacturer's protocol. DNA was eluted and stored at -20 °C. PCR was carried out with the universal *COI* primers.

FishF1-TCAACCAACCACAAAGACATTGGCAC

FishF2-TCGACTAATCATAAAGATATCGGCA

FishR1-TAGACTTCTGGGTGGCCAAAGAATCA

FishR2-ACTTCAGGGTGACCGAAGAATCAGAA (Ward *et al*., 2005).

This primer pair amplified a COI fragments of 550-600 bp length of the mitochondrial genome. PCR was performed in a final volume of 50 µl containing 5 µl 10× Taq Polymerase Buffer, 5 µl (25 mM) $MgCl_2$, 5 µl 0.5 mM dNTPs, 1 unitTaq polymerase (Perkin Elmer) and 0.5 µl each of 25 pmol/µl FishF1 and FishR1. PCR products were check for positive amplification in 1% agarose gel with 100 bp DNA ladder. Purified PCR products were sent directly to Macrogen (Korea) for sequencing. Sequences were analyzed by using appropriate bioinformatics methods. Sequences were aligned with ClustalX Multiple Sequence Alignment Program version 1.7 (Thompson *et al*., 1997) and Bioedit software. Further analysis was carried out for the aligned sequences. Phylogenetic analysis was carried out using MEGA software and polymorphic sites and haplotypes were detected by using DnaSP version5.0 software. Phylogenetic relationships among sequences were assessed using maximum likelihood (ML) method and Kimura two parameter model in MEGA v7.0.21 (Tamura *et al*., 2013).

The *L. lentjan* fishes were found in fish catch of seven trawling stations (Table 1).

Table 1: Station number, GPS location and the name of the station

Station number	GPS co-ordinate		Region	Number of samples
11	9.803	80.76	North East	1
19	9.0025	81.0023	Central East	1
26	8.2835	81.5105	Central East	6
40	6.8792	81.9035	South East	7

The *L. nebuloses* were found in fish catch of nine trawling stations (Table 2).

Table 2: Station number, GPS location and the name of the station

Station number	GPS co-ordinates		Region	Number of samples
11	9.803	80.76	North East	4
13	9.6443	80.837	North East	3
19	9.0025	81.0023	Central East	1
20	8.8635	81.1462	Central East	1
27	8.3193	81.5505	Central East	1
40	6.8792	81.9035	South East	6
44	6.5813	81.8455	South East	2
45	6.4945	81.741	South East	1
78	7.1463	79.715	South West	2

The *Decapterus russelli* fishes were found in fish catch of seven trawling stations (Table 3).

Table 3: Station number, GPS location and the name of the station

Station number	GPS co-ordinate		Region	Number of samples
9	9.8542	80.4955	North East	6
14	9.5792	80.7403	North East	6
26	8.2853	81.5105	Central East	4
28	8.1517	81.657	Central East	5
33	7.7057	81.8307	South East	7
52	5.9225	81.1907	South region	2
67	6.0805	80.0518	South region	2

Results

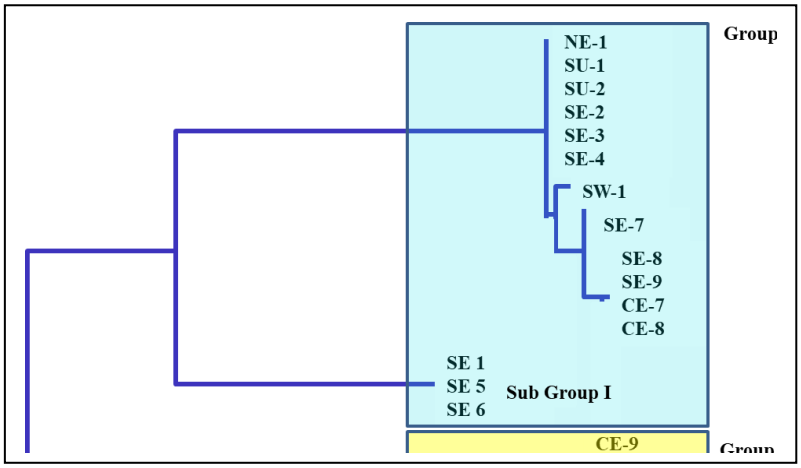


Figure 1: K2P distance neighbour-joining tree of *L. lentjan* species collected from Sri Lankan waters. NE-north east, SE- south east, SU- South, SW-south west, CE-central east region.

The multiple sequence analysis of *L. lentjan* COI region resulted in 81 nucleotide polymorphisms in COI sequence region and seven haplotypes. Average number of nucleotide differences between populations is 66.125. Average number of nucleotide differences within group I is 17.61 and no difference within group II.

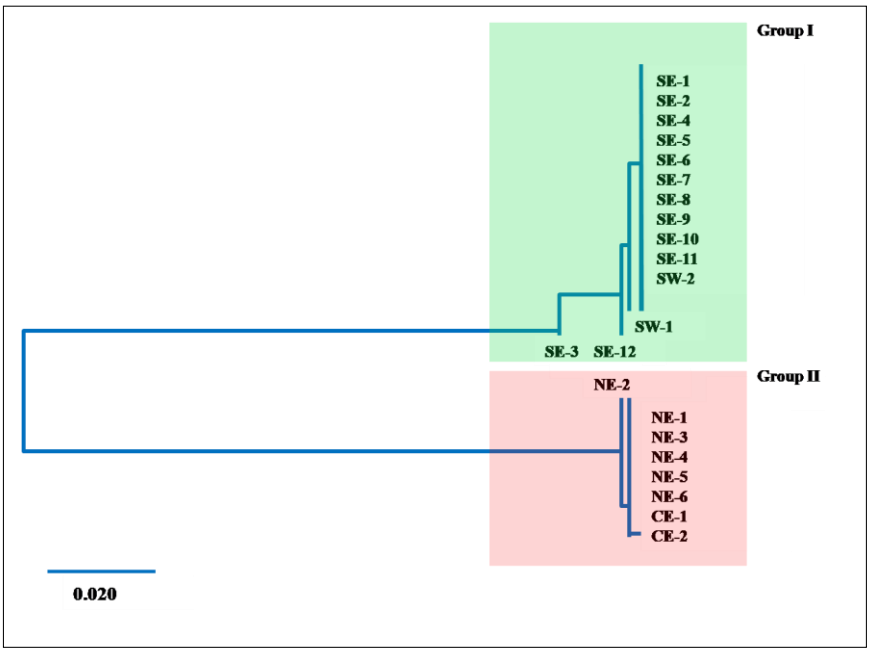


Figure 2: Kimura two parameter (K2P) distance neighbour-joining tree of *L. nebulosus* individuals collected from Sri Lankan waters. NE-north east, SE- south east, SW-south west, CE-central east region.

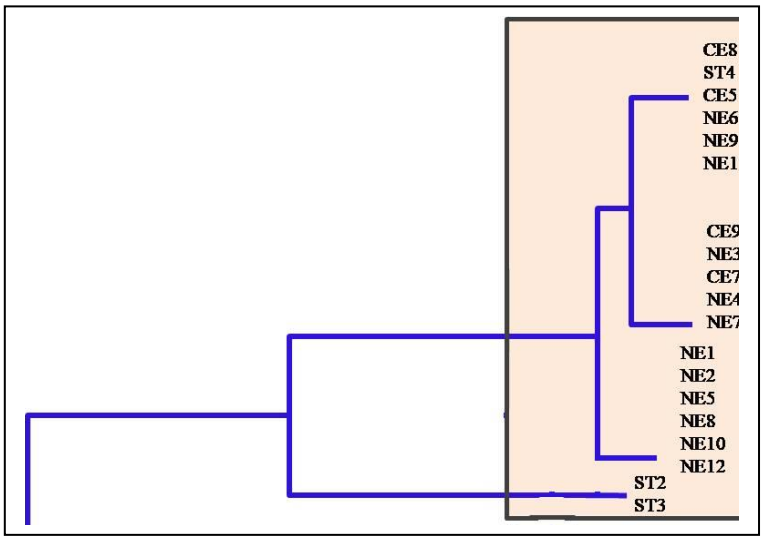


Figure 3: K2P distance neighbour-joining tree of *Decapterus russelli* species collected from Sri Lankan waters. NE-north east, SE- south east, ST- South, CE-central east region.

The multiple sequence analysis of *Decapterus russelli* COI region resulted in 114 single nucleotide polymorphism in COI sequenced region and nine haplotypes. Average number of nucleotide differences between the two groups was 87.667.

DNA bar-coding method for identification of fish species

DNA barcoding has been used as an efficient tool for the identification of existing species and also to find cryptic species. Fish DNA barcoding by using Cytochrome C Oxidase type I (*COI*) gene has been used for identification, authentication, and phylogenetic analysis. DNA barcoding using *COI* gene has been used to discriminate closely related animal species, specially marine and freshwater fishes. Furthermore, barcode based fish identification systems provide a path for the detection of phylogenetic relationships among the species and to identify taxonomic status of the species. In this study the morphologically difficult to identified samples collected during the Dr. Fridtjof Nansen survey were used to identify by using DNA barcode techniques.

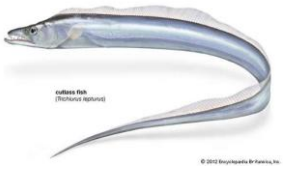
Table 4: Collected unidentified samples during Dr. Fridtjof Nansen Survey and the DNA bar-coding of list of fish species

Station number and the ID	Collected unidentified sample	Species name	Morphology of the fish
St 71 ID 147		*Acanthurus mata*	
St 50 ID 92-1		*Torquigener brevipennis*	
St 48 ID 105		*Bythaelurus hispidus*	
St 48 ID 110		*Gephyroberyx darwinii*	
St 39 ID 81-1		*Conger japonicus*	

St 39 ID 81-2		*Hoplolatilusfronticinctus*	
St 39 ID 81-3		*Scolopsis xenochroa*	
St 39 ID 81-4		*Pseudamia gelatinosa*	
St 39 ID 81-6		*Dactyloptena orientalis*	
St 60 ID 67		*Acanthocepola indica*	

St 76 ID 140		*Histiopterus typus*	
St 80 ID 152		*Tetragonurus cuvieri*	
St 67 ID 128		*Bregmaceros sp*	
St 67 ID 132		*Minous coccineus*	
St 76 ID 134		*Cubiceps squamiceps*	
St 76 ID 135		*Cubiceps pauciradiatus*	

St 48 ID 90		*Chlorophthalmus corniger*	
St 65 ID 125		*Psenesara furensis*	
St 67 ID 127		*Ophichthuspolyophthalmus*	
St 48 ID 106		*Polyipnuspolli*	
St 73 ID 149		*Nasovlamingii*	
St 48 ID 107		*Physiculusmicrobarbata*	
St 73 ID 148		*Cubiceps pauciradiatus*	

St 77 ID 144		*Tripterodon orbis*	
St 48 ID 102		*Ostracoberyx dorygenys*	
St 76 ID 124		*Trichiurus lepturus*	
St 48 ID 89		*Diaphus watasei*	
St 48 ID 103		*Apterichtus klazingai*	
St 67 ID 130		*Sirembo jerdoni*	
St 67 ID 130		*Dipterygonotusbalteatus*	

St 72 ID 150		*Echeneis naucrates*	
St 48 ID 75		*Zenopsis conchifer*	
St 79 ID 70		*Aprion virescens*	

St- Station number, ID-given identity number for the collected fish sample

Discussion

The mitochondrial COI gene sequence analysis clearly defined two main phylogenetic groups in *L. lentjan*. In group I (Figure 1) there is a subgroup which was classificed based on COI sequence variarion. The fish collected from south east area showed slight nuclotide variation to other individuals of group I and clusterd as a subgroup within group I. A divergent group with individuals from central east region seperatly and distantly clustered as group II (Figure 1), which provides information on the existance of two cryptic species seperated from main species. As reef fishes are non-migratory fishes, there is a limited breeding between populations. Due to this reason diverse species can be identify within the population. In a long period of time it can develop divergent group with huge neuclotide variations to the main species. Based on this priliminary study, it can be recommended to conduct stock assesment of the species with more stations and with more number of samples in future.

According to the results there were two distinct phylogenetic groups which clearly separated the *L. Nebulosus* population in Sri Lanka (Figure 2). The two groups are highly divergent which means that there are two cryptic species. The sequence divergent of the two clades and average nucleotide different was 56.139. Huge nucleotide diversity was observed among the two groups with 116 polymorphic sites. Even though, there were

high polymorphic sites observed, only four haplotypes were recorded. This implies that most individuals shared common single nucleotide polymorphism regions. The two groups showed the clear geographical differentiation. Individuals collected from south east and southwest regions were clustered in group I and north east and central east was clustered in group II. This analysis provides the ecological and evolutionary diversification and clear separation of two cryptic species bases on the region. The occurrence of two clades of *L. Nebulosus* based on the geographical distribution was described in Healey *et al.*, (2018) and Borsa *et al.*, (2013).

The *Decapterus russelli* species distributed in Sri Lanka clearly separate in to two phylogenetic groups (Figure 3) and within the group there are subgroups developed based on nucleotide variations. This study provides evidence on the presence of two cryptic species of *Decapterus russelli* in Sri Lankan waters. The mitochondrial COI gene sequence analysis clearly defined two main phylogenetic groups. The fish collected from south area showed slight nuclotide variation to other individuals of group I and clustered as a subgroup within group I. Individuals from all regions were grouped in to group I. A divergent group with individuals from central east region was seperatly and distantly cluster as group II (Figure 3).

DNA bar-coding method proves the effective and efficient method for identification of morphologically unfamiliar or difficult to identify species. The samples collected during the trolling are mostly deep water fishes and they are not commonly seen in fish catches around coastal areas in Sri Lanka. Theefore, DNA bar-coding method provided their correct species level identification and those samples can be used as a guide for future studies and to get knowledge of rarely seen deep water fishes in the ocean.

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- **Aluwihare YC**, Sruthi A (2019) Study the genetic variation of *Lethrinus nebulosus* (Forsskål, 1775) distributed in Sri Lankan waters. NARA Scientific Sessions, 2019, National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15, P 25.
- **Aluwihare YC**, Fernando C (2019) Study the genetic variation of *Lethrinus lentjan* (Lacepède, 1802) species distributed in Sri Lankan waters. NARA Scientific Sessions, 2019, National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15, P26.

From the Genetic study of marine biological resources in Sri Lankan waters, ten undergraduate students were trained in the MBRD Biotechnology laboratory.

Publications

Journal publications

1. M. I. G. Rathnasuriya, A. Mateos-Rivera, A. G. G. C. Bandara, R. Skern-Mauritzen, R. P. P. K. Jayasinghe, J. O. Krakstad& P. Dalpadado 2019.DNA barcoding confirms the first record of a *Desmodema polystictum* (Ogilby, 1898) egg and all-time high adult catches in the IndianOcean. 33"Marine Biodiversity Records 22. 12-31

2. Herath D.R., Perera H.A.C.C., and Hettiarachchi G.H.C.M. (2019). Biological and molecular variations in *Auxis thazard* (frigate tuna) found in the coastal waters around Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, 47(3): 333-340.

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1. Dalpathadu K.R., Jayasinghe, R.P.P.K. and Haputhantri S.S.K., (2019). Some biometric parameters of six selected fish species in Sri Lankan waters. 37th Scientific Sessions, National Aquatic Resources Research and Development Agency, (2019), Sri Lanka.

2. Liyanage, U.S.P.K. (2019).Spiny lobster fishery in Hambanthota District, Sri Lanka -An update. Abstract presented at the Annual Scientific Sessions, National Aquatic Resources Research and Development Agency.

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5. Jayawardane I.D.S.S., Aluwihare Y.C., Dalpathadu K.R., Haputhantri S.S.K. and Athula J.A. (2019). Study the mitochondrial COI gene sequence variation of two isolated populations of *Cephalopholis sonnerati* (Valenciennes, 1828) in east and west coasts of Sri Lanka. Proceedings of the International Research Conference, UvaWellassa University, Sri Lanka, 7-9.

6. Herath D.R., Perera H.A.C.C., Dangalle C.D. and Hettiarachchi G.H.C.M. (2019). Mitochondrial DNA analysis of the two species in the genus *Auxis* found in Sri Lanka. Proceedings of the NARA Annual Scientific Sessions 2019.

Proceedings

1. Haputhantri S.S.K., Weerasekera S.J.W.W.M.M.P. and Ariyaratna M. M. (2019). Use port sampling and logbook data for the analysis of catch rates of Skipjack Tuna (*Katsuwonus pelamis*) in gillnet fishery of Sri Lanka. IOTC–2019–WPTT21–37. Twenty first Session of the Indian Ocean Tuna Commission (IOTC) Tropical Tuna Working Party.

2. Dalpathadu K.R., Herath D.R. and Haputhantri S.S.K. (2019). Some biometric parameters of *Auxis thazard* (Lacepède, 1800) (frigate tuna) – data from fishery dependent and fishery independent surveys conducted in Sri Lankan waters. IOTC–2019–WPNT09-12. Ninth Session of the Indian Ocean Tuna Commission (IOTC) Neritic Tunas Working Party. Mahe, Seychelles.

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Inland Aquatic Resources and Aquaculture Division

Economics and strategies for profitable sea bass culture in lagoon net cages

Project No: 3.1

Officer/s Responsible: Dr. D.A. Athukorala

Asian Sea bass culture has been identified as a profitable business due to its high export demand. Asian Sea Bass (*Lates calcarifer*) culture is most popular in South Asian countries. As sufficient brackish water resources, there is a good potential to develop Sea bass culture also in Sri Lanka and some farmers are already engaged in Sea bass farming, Most of the sea bass farmers presently earn less profit due to the absence of proper strategies for the culture of sea bass in lagoon net cages. This project is aim to recommend proper strategies for profitable culture of sea bass in lagoon net cages.

Objectives

Perform a cost-benefit analysis for small scale sea bass culture methods practice presently in Puttalam lagoon of Sri Lanka, to compare the economics of different small scale sea bass culture methods in Puttalam lagoon of Sri Lanka and recommend proper strategies for profitable sea bass culture in lagoon net cages.

Activities carried out

Awareness meetings & Frame surveys for farmers at Gangewadiya and Serakkuliya area were conducted. Questionnaire surveys for 22 sea bass fish farmers at Gangewadiya and Serakkuliya were completed. Thirty seven sea bass cages were monitored and data collected in 28 net cages and fish growth data were collected in 18 sea bass cages

Results

Table 1. Summary of the results of frame survey of sea bass farming at Serakkuliya and Gangewadiya

	Serakkuliya	Gangewadiya
Number of Sea bass farmers	74	6
Number of part time Sea bass farmers	50	4
Number of full time Sea bass farmers	24	2
Number of Sea bass cages observed	123	27
Number of Sea bass cages operating	48	27
Average Cage Size (Stage 1)	1.9m x 1.9m x 1.3m	1.9m x 1.9m x 1.0 m
Average Cage Size (Stage 2)	3.4m x 1.9m x 1.3m	1.9m x 1.9m x 1.0 m
Cage mesh size (Stage 1)	8 mm	8 mm
Cage mesh size (Stage 2)	25 mm	25 mm

Average initial stocking density	40 fish/m3	70 fish/m3
Main feed type used	Trash fish	Formulated feed
Cage Frame Material	PVC	PVC
Cage Net Material	Plastic	Plastic
Anchor Material	Wooden poles	Wooden poles
Feeding Frequency	1 or 2	2
Average sea bass selling price	Rs. 450-550	Rs. 450-550

Table 2.Economic analysis of Sea Bass culture / net cages

Details of Costs and Returns	Value
Cage Construction Cost per culture cycle (Rs.)	2894.00
Fingerling cost (Rs.)	3600.00
Feed Cost (Rs.)	24676.00
Total Production Cost (Rs.)	31170.00
Average Yield of Fish (kg)	80.60
Fish Selling Price (Rs./kg)	500.00
Total Revenue (Rs.)	40300.00
Net Income (Rs.)	9130.00
Production Cost (Rs kg^{-1})	387.00
Net Income (Rs kg^{-1})	113.00

Outcome:
Status of the economic viability of sea bass cage culture in lagoons

Output:

Economically feasible strategies developed for sea bass cage culture in the lagoon

Recommendations:

-Use net cages about the size of approximately 1.9m x 1.9m x 1.0 m

-Use 8 mm size mesh nets for first 2-3 months of the culture and 25 mm size mesh nets later. -----Clean net cages once a week for first 2-3 months of the culture and once a month later.

- Maintain the initial fish stocking density at not higher than 40 fish/m2.

- Provide balance formulated Sea bass feed or balance formulated Sea bass feed with trash fish.

-Feeding the fish twice a day.

-Keeping watch on the possible disease conditions during rapid salinity fluctuation seasons and apply suitable treatments on time.

Conclusion:

By placing 1.9m x 1.9m x 1.0 m net cage with 40fish/m^3, fed with, 42% protein feed for 9 months farmer can get around Rs.9000/cage net income. It can be recommended as strategically best practice

Study of optimal micro-habitat features for mariculture of sea cucumber, *Holothuria scabra* in coastal waters of Sri Lanka

Project No: 3.2
Officer/s Responsible: Mr. P. A. D. Ajith Kumara and Mr. C. B. Medagedara

Introduction

Tropical sea cucumbers in general occupy a wide variety of habitats, including coral reefs, coastal lagoons and sea grass beds. Most of the commercially exploited species (Order: *Aspidochirotida*) are deposit feeders, consuming organically rich detritus mixed with inorganic sediments. Earlier studies showed that juvenile sandfish can be found in shallow sea grass beds, but the optimal habitat features within these macro-habitats were largely unstudied.

Objectives :

We aim to determine the conditions for a range of key habitat features that would produce the best stocking success, measured by survival, growth and behavioural responses of sand fishes.

Activities Carried Out:

Community-based sea cucumber farming

Establishment of hatchery facilities for *H. scabra,* collection and conditioning of broodstock, induce breeding and larval rearing

Monitoring of sea cucumber farming in Northern coastal waters

Conducting an awareness and other extension programmes

Results:

1. Community-based Sea Cucumber Farming

A study was carried out to evaluate the growth and survival of *H. scabra* cultured in two selected sites, Serakkuliya and Illipantivu in Puttalam lagoon with the active participation of community. Mean growth of *H. scabra* recorded for Serakkuliya (520.37±31.34) is significantly higher than Illipantivu (410.37±46.57g, ANOVA; $p< 0.05$). Maximum body weight of *H. scabra* cultured in Serakkuliya and Illipantivu pens were 570.86 g and 432.68 g, respectively. Minimum and maximum daily growth rate of sandfish in Serakkuliya was 0.32g and 1.1g whereas that of Illipantivu site was 0.21g and 0.91g. But the particular months of which minimum and maximum daily growth rate recorded, did not coincide for two sites. The survival rate of *H. scabra* in two sites, llipantivu and Serakkuliya were 40% and 75% respectively. The mean salinity and mean water temperature were 31±2.26 ppt and 29.9±2.94^{o}C for Serakkuliya site. Those values for Illipantivu site were 28±3.00 ppt and 28.2± 3.65^{o}C respectively.

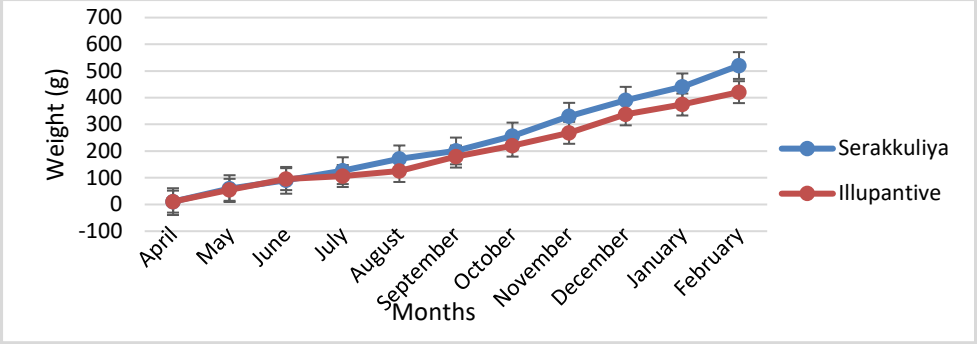


Fig.1: Mean growth of *H. scabra* in two culture sites

Establishment of hatchery facilities, collection, conditioning of broodstock

Three broodstocks were maintained in fiber glass tanks and two lagoon pens (in front of NARA Kalpitiya station and Serakkuliya) in order to produce quality broodstock. They were fed with formulated feeds while live feed cultures were maintained at the beginning of each breeding trials. Brooders suitability for artificial seed production was frequently checked. Several breeding trials were performed first quarter of the year.

3. Monitoring of sea cucumber farming in Northern coastal waters

Fifteen 15 no's commercial sea cucumber forming sites have been monitoring at regular 2 month interval in Northern Province. Several maps were produced so as denote existing farms, abandoned farms, juvenile collection grounds and suitable areas for further expansion of the industry.

Soil characteristics, micro-habitat conditions and selected water quality parameters were analyzed in respect to stocking densities.

Farms were clustered according to habitat types *viz*, seagrass beds (7no's), sand beds (4 no's), and micro-atolls (4no's Sediment quality of soil samples in each farms were analyzed by standard sieve fractionation method and results are given in table 1.

Table 1. Grain sizes of sediment (%± sd) in *Holothuria scabra* farms in different habitats.

Particle diameter (*m*m)	Component	Habitat type Seagrass beds	Sand beds	Micro-atolls
0-0.63	Silt and clay	2.71±0.90	0.72±0.35	0.04±0.01
0.63-0.125	Very fine sand	6.10±1.91	6.76±1.80	0.71±0.37
125-250	Fine sand	37.81±4.52	49.72±8.43	14.63±3.87
250-710	Medium sand	29.82 ± 6.24	43.44 ± 6.33	36.22 ± 9.23
710-1400	Coarse sand	7.65 ± 1.87	17.44 ± 3.03	26.31 ± 6.03
1400-2000	Very coarse sand	3.13±1.03	9.20±2.24	13.91±5.63
>2000	Gravel	0.59±0.22	4.89±1.20	8.18±3.71

Organic content of the sediment samples was determined by combusting weighed samples. Initial stocking size, and weight gained of animals were measured by sub sampling 20 juveniles from each pen and then pooled according to habitat types table 2.

Table 2. Some selected parameters measured at *Holothuria scabra* farms in different habitats in the Northern Province (The values are given in minimum and maximum range and $\pm$ denotes standard deviation).

Parameter	Unit of measurement	Habitat type Seagrass beds	Sand beds	Micro-atolls
Organic matter (initial)	(%) (in dry weight)	4.97-9.32	0.68-1.80	1.01-3.21
Organic matter (final)	(%) (in dry weight)	3.07-6.61	0.72-1.97	1.83-2.19
Salinity	(ppt in range)	28-36	30-34	32-34
Initial stocking size	(g)	80.0$\pm$10.52	100.0$\pm$20.82	110.0$\pm$18.31
Stocking density	No's m^{-2}	2.5-3	2-4	12-20
Mean growth rate	g day^{-1}	1.25 $\pm$ 1.07	0.33 $\pm$ 0.29	0.44 $\pm$ 0.3

4. Awareness & Training Programmes:

(a). For Community People:

Community people in Serakkuliya and Illipantivu villages in Puttalam district were given training on sea cucumber grow-out farming techniques.

(a). For University Students:

One residential breeding programme was conducted for University Vocational and Technical College (UNIVOTEC) Anuradhapura (22.02.2019). They were given first hand on experience on different aspects of sea cucumber mariculture *viz* broodstock handling & preparation, spawning tank preparation, induced breeding, egg collection, incubation, preparation of larval rearing facilities, live feed culture, nursery tank preparation and feeding.

Conclusions/ Recommendations:

When compare ten months of culture period between two selected culture sites, there is a significant high growth observed in Serakkuliya Community-Based Farm (CBF) site than Illupantivu CBF site. From June to November, remarkable salinity fluctuations were observed in Puttalam lagoon and that would cause lower growth rate in Illupantivu pen rather than Serakkuliya.

According to the final results newly selected Serakkuliya and Illupantivu areas in Puttalam lagoon are suitable for sea cucumber farming in future. Nevertheless, relatively low survival rate was recorded in both sites.

Sea cucumber juveniles whose weight below 10.0 g is not suitable to direct introduce to grow out farming.

Highest observed growth rate was recorded when sea cucumbers were cultured in sea grass habitats and that means they are more preferred to these environment. Because. silt clay substrate may facilitate them to grasp organic matters from bottom sediments when feeding could result in higher growth rate when compare to other habitats.

There weren't any relationships with percentage organic matter content in the farms with the time (or growth of animals). But the results could be changed when further growth of animals.

If sea cucumbers are cultured in sandy habitats they will have to give supplementary feeds because low growth rate was recorded in these habitats in present study.

Output:

Built up awareness among fishing communities, university students and Governmental officials on sea cucumber artificial seed production, feed preparation and grow -out farming

Training fisher-folks on community-based sea cucumber farming
Identified some suitable areas for sea cucumber farming in Puttalam lagoon
Mapping of sea cucumber farming areas in Jaffna lagoon
Identified micro-habitat features for sea cucumber farming
Dissemination of the technical *know-how* by preparing reports and scientific publications
Outcome:
Draft protocol develop for monitoring of sea cucumber commercial farming
Identified most suitable habitat features for sea cucumber farming in Northern Province
Farming potential of sea cucumbers in Puttalam lagoon was technically verified

Improving spat collection methods for commercial scale oyster farming and experimental reef restoration for enhancing the spat availability

Project No: 3.3

Officer/s Responsible : Mrs. A.S.l.E. Corea and Mr. C. B Medagedara

Introduction

Edible oyster culture has commenced in the Puttalam district and few community projects are ongoing. Main problem for expanding the culture activities is unavailability of spat. Presently spat collection is from the wild. But sufficient spat of suitable size, cannot be collected this way for commercial culture. Therefore, using spat collectors during breeding seasons near natural oyster beds is being carried out.

Increase the commercial bivalve culture among fisher communities was the major objective of the project. This would be achieved by building more oyster reefs so that a steady breeding population is established in areas suitable for culture, to collect sufficient spat for commercial oyster culture and Disseminate technical knowhow among oyster farmers

Results

Aiding commercial oyster culture

Community based commercial oyster farms in Kandakuliya, Anawasala and, Janasavipura were monitored and provided spat for culture. Kandakuliya lagoon is a small lagoon and has a good breeding population of oysters therefore the community is self-sufficient with spat. But as Anawasala and Janasavipura did not have a breeding population nearby, spat were provided for culture activities by using spat collectors. For this purpose, spat collectors developed using PVC plastic and plastic casing were deployed as these proved to be good attachment material and easy to remove spat from the collectors.

Spat attachment material

Two new types of spat attachment material has been tried out as spat collectors and were compared with the previously used material. The two new materials used were used vehicle tyres, and plastic shells. Spat attachment has been low in both materials compared to the pvc collectors. These had an attachment density of 3/ 100cm^2.

Shifting oyster reefs to new locations

Two reefs were shifted to new locations and were monitored for their growth and survival the survival was affected by fouling organisms at Kalpitiya. The shifted reefs were of the size 2 x 1 x 0.25 m size. Number of live oysters were counted in a 0.5 x 0.25 x 0.25area for monitoring the survival and growth of the new reefs and a control reef kept in the original site. The numbers in shifted reefs declined after shifting but now has settled and is increasing.

Knowledge dissemination - Awareness program (Illupanthive Island)

One awareness program was carried out to inform about developments on oyster culture and spat collection to the community. It was participated by 10 members

Topics covered were Oyster production in Puttalam lagoon and community based farming in Kandakuliya, Anawasala and Janasavipura, Oyster rack culture and culture structures, Oyster spat collection through collectors, Sustainable oyster production and manual cleaning with depuration procedure, Dispatch to market .





Maintenance of depuration plant and improving hygienic conditions

3,783 numbers of oysters have been depurated and earned Rs 18,915.00 per year of 2020. The first batch of oysters depurated in month of June due to replace of old wooden racks with newly developed PVC racks

Out put

2 new oyster reefs in Kalpitiya area (Kalpitiya and Janasavipura)

Integrated approach to efficient and sustainable intensification of food fish;Tilapia culture with aquatic plants (edible/ornamental) relation to different formulated feed regimes.

Project No: 3.4

Officer/s Responsible: Dr. M.G.I.S. Parakrama

Small scale pond culture systems limited to confined area for fish and also it could be accumulated too much waste and pollutants very frequently, causing to the poor growth of fish. As such high nitrate levels occurs in such pond systems can be absorbed by plants if those are in the system. Also the plant can filter the water, supplying better environment to the fish to grow. Using this theory, an experiment to compare the NARA formulated experimental feed with recently manufactured commercial Tilapia feed for small scale Tilapia cum ornamental/ edible plant culture will be investigated.

Objectives are to compare nutritious feed for Tilapia farming and to Intensification of fish farming with aquatic plant culture.

Experiment plan is as follows;

Treatment	Feed A (20% protein)		Feed B(25% protein)		Feed C(30% protein)		Feed D (control/cattle feed)	
Stocking density	5/m^3	10/m^3	5/m^3	10/m^3	5/m^3	10/m^3	5/m^3	10/m^3
Pond part Volume	10 m^3	10 m^3	10 m^3	10 m^3	10 m^3	10 m^3	10 m^3	10 m^3
No. stocked	50	100	50	100	50	100	50	100
Feed cost	105/=		117/=		120/=		50/=	
Time period	120 days							
Feeding regime	Twice a day (5-7% body wt)							
Ave. initial wt/ fish	2.3 - 3.4							
Ave. weight gain/juvenile fish	195g	128g	190g	113g	203g	126g	132g	90g
FCR	1.6		1.9		1.5		2.9	

Results:

Aquaphonic system (fish/ plant culture)

Floating bed size	2.1 m^2

Total beds	8 (Area appx. 17m^2)
Plant wet weight harvested from one bed	2 kg (4 bundles)
Total harvest	16 kg (32 bundles)
Selling price	Rs.30/ bundle
Total income (Rs)	32 x 30 (960/=)
Harvesting time	2 weeks
No of Plant harvests for one fish culture cycle	12 (for 6 months)
Total income from plants for one fish culture cycle (No soil/ no fertilizer/less labour)	12 x 960.00 = 11,520.00
Recommended area for culturing plants (floating beds) in 1 ha fish pond	2500 m^2
Total income calculated for plant harvest in I hectare fish pond per 6 months fish culture cycle (Rs)	11,520.00/17m^2 x 2500m^2 = 1,694,117.00




Conclusions

According to the experiment, 20% protein is enough for tilapia grow out culture.

Best experimental feed in the trial is - Feed A (lowest price)

Intensification can be done using simple and low cost aqua phonic plant culture techniques.

Recommendations

Fish cum aquatic plant culture is very profitable practice.

Floating plant culture beds can be recommended for fish ponds using aqua phonic techniques.

Outcomes

Low cost feed for Tilapia culture.

Introducing low cost simple aquaphonic systems to small scale farmers

Increasing the total income of farmers through fish cum plant culture

Assessment of Fisheries and Aquaculture potential in floodplain ecosystems of Nilwala river basin.

Project No: 3.5

Officer/s Responsible: Mr. K.W.R.R. Amaraweera

Nilwala is one of the longest rivers (78 km) in southern Sri Lanka flowing through Matara District. During the rainy season low lands of river basin are inundated by floods and render the land unavailable for crop production. According to the Department of irrigation Inundation area map Nilwala ganga basin in May 2017, 12.6% of the total land area of Matara District. Flood water and lands are considerably underutilized and can be used for aquatic productivity (Dey M. M. *et. al* (2006)). According to a study conducted by IUCN Sri Lanka (2005), 25 species of fish inhabit Kirala Kale wetland in Nilwala river basin. Therefore, it is worth to carry out a survey on aquatic biodiversity and assess the fisheries and aquaculture potential in those flood affecting areas to uplift the economic and social status of the local community.

The main objective of this study is to asses fisheries and aquaculture potential in Thihagoda, Malimbada, Athuraliya, Matara and Kamburupitiya where the most inundated flood DS divisions of Matara District in Nilwala river basin, as a potential economic compensation for the flood affected local community. Under that, specific objectives were to asses water quality, aquatic biodiversity, ecosystem services and land use patterns in Nilwala flood plain, to asses temporal variations in flood effect, assess fisheries potential in Nilwala river basin and to get the maximum utilization from flood plain water bodies for aquaculture production.

To fulfill the project objectives, a preminary survey was carried out to demarcate flood plain aras of Nilwala river basin and suitable sampling locations was selected for collecting environment data,flood inundation data, water availability and rainfall data (Department of Irrigation). Water quality parameters tested were Temperature, pH, DO, salinity, Turbidity, Nitrate, Phosphate, chlorophyll a, and Heavy metals- Cd, Pb, As, Hg while the soil quality was assessed by soil textural group and pH. Survey on Socio-economics & land used patterns was conducted for vulnerable families in 20 DS divisions in Matara District Reverine fishery monitoring were initiated and mapping of aquaculture potential areas is in continuation. Awareness workshops were conducted for relevant groups.

MajorFindings

Thihagoda, Malimbada, Athuraliya, Matara and Kamburupitiya are the most flood inundated DS divisions of Nilwala river basin for example at least 30% of total lands in each DS division was inundated by floods in May 2017(According to the site survey and Literature survey).

Water quality parameters and soil qualities in selected sites in Nilwala floodplain are in the suitable range for fish culture development.

According to the prepared GIS map calculated potential aquaculture area is 9 km ^{2} in Matara

DS Division & it is 50% of total flood inundation area in Matara Ds division.

According to the socio-economic survey vulnerable families in 20 GS divisions more than 60% paddy lands were banded due to the floods and failures of Nilwala scheme. It was recorded that vulnerable families have knowledge or experience in fish keeping (< 5%). Most farmers in Matara DS Division use abandoned paddy field for farming green leaves.

In revarine fishery, Tilapia, Giant gouramy, Loolla, are the preferred fish species & the most demand species is freshwater prawn.

Outputs-

Baseline database of water quality in selected sites of Nilwala floodplain

GIS Map for potential 20 aquaculture sites in Nilwala Flood plain

Baseline data of a riverine fishery useful for recommendations for management

Recommendations:

Selected 20 sampling sites suitable for fish culture development and abundant flood lands can be used for Aqua culture development.

According to the prepared GIS map calculated potential aquaculture area is 9 km ^{2} in Matara

DS Division & it is 50% of total flood inundation area in Matara Ds division.

Constraints:

First five months in 2019 unable to carry out field works properly because of I have to travel long distance from Colombo to Matara Nilwala areas.

Study on climate change impact on selected vulnerable endemic fish species & their ecosystems and develop *ex-situ* conservation strategies.

Project No: 3.6

Officer/s Responsible: Mrs. R. R. A. R. Shirantha

Objectives of the project were to propose mitigation and climate change adaptation strategies for vulnerable endemic fish species, conserve rare threatened fish species, study the effect of climate changes on fish breeding efficiency and to identify important ecosystems outside the protected area net work.

To fulfill the objectives, literature surveys on climate condition impact on localized fishes and micro habitats and climate data of the selected research areas collection were initiated and in progress.

Study of the water quality and the habitat conditions of *Malpulutta kretsiri* at Bambarawana Mapalagama stream (Gin river basin), *P. cumingii* at Gilimalee (Kalu river basin), *P. bandula* at Galapitamada (Kelani river basin), *Puntius titteya* at Waharaka (Attanagalu river basin), *Systomus asoka* at Kutlgala (Kelani river basin) and *Dawkinsia srilankensis* at Kubalwela (Aban Ganga basin) were monthly monitored with records of length data and population size of each species at each stream site studied.

Six captive breeding trails of *Pethia melanomaculata* and *P. cumingii* X *P. reval* were completed by giving water stress as a spawning inducer. The water quality parameters i.e. Dissolved Oxygen content (mg/l), pH, TSS, Alkalinity (mg/l), water temperature (°C) and conductivity (µs/m.) etc at each breeding and larval rearing tank were collected and data analysing is in progress. An experiment to develop colour intensity of *P. melonomaculata* under three different tank conditions; covered tank of granite substrate with enough cervices, open tank with granite, sand substrate with water plant cover and gravel substrate with adequate 24 hour aeration was completed.

Study on most critically threatened wild populations outside protected area network, wild specimens collection, conditioning and rearing them were done while providing specimens for national exhibition and awareness programs.

Last year initiated study on the population composition and distribution pattern of *Systomous asoka* in Kelani river basin was completed. The survey area covered the Makandawa Forest Reserve, Girankiththan Oya, Siri Oya, Handun-Ella, Man-kethi-Ella in Kitulgala and Kiri Oya, a tributary of Rakwana Oya, and Aratha Oya; a tributary to Magal Oya and Seethawaka Ganga in Deraniyagala. The population count was taken through direct observation made with naked eye and snorkelling.

Conducting awareness programs & technology transferring were performed through the ornamental fish farming and culture training programs.

Major Findings

The colouration of *P. melanomaculata* can be intensified in captivity with gravel substrate and adequate (>18 hrs) Oxygen supply. Under this condition this species can be promoted as a candidate for the tropical ornamental fish industry.

Yatiyantota Pallewattahena stream at 6◦59' 40".4 N & 80◦19'.013E; a left side tributary to Kelani proper river was identified as the stream that is of >500/km river reach of *Pethia reval.* It is an important ecosystem outside protected area network of the country that to be protected for future of the ornamental fish industry.

Systomus asoka population size was approximately 30 in Deraniyagala, 348 in Girankittha Oya and 25 in Makandawa Forest Reserve. Only viable population is found in Girakittha Oya at Kitulgala that needs conservation measures.

Outputs

One endemic common species introduced to ornamental fish industry

Population distribution map and population size data of the critically endangered fish species *Systoums asoka*.

One year baseline data for climate change impact assessment on the selected endemic fishes.

Recommendations

Tic-tac barb is a good candidate for tropical ornamental fish industry.

Systomus asoka population in Deraniyagala and Kitulgala. It needs immediately adopted conservation measures as mini hydro power dams has already brought negative impacts due to alteration of water regime.

It appears that southwest monsoonal rain pattern change has impact on the breeding and recruitment of *Pethia bandula* in Galapitamada Pellegama stream and *Dawkinsia srilankensis* in Aban Ganga as these species showed one recruitment (in September) in 2019 despite of their usual two recruitments per year. However, long-term studies are needed to make a definite conclusion.

Constraints:

Lack of enough man-power, extreme weather condition at the study locations in several months

Monitoring disease conditions of shrimp aquaculture industry in Sri Lanka

Project No: 3.7

Officer/s Responsible: Dr. P.P.M. Heenatigala

Marine black tiger shrimp, *Penaeus monodon*, is one of the most economically important native cultivated species of Sri Lanka due to the bigger size and high demand as food delicacies across the globe. They contribute to nearly 99% of the total production of the captured and cultured shrimps in Sri Lanka. However the production of cultivated shrimp has been hampered by periodic losses due to diseases. A global shrimp survey by the Global Aquaculture Alliance (GAA) in 2001 revealed a rough overall loss of cultured shrimps due to disease, approximately 22% in a single year. With respect to disease agents, GAA survey revealed that 60% of losses were attributed to viruses and about 20% to bacteria. Thus, the majority of our effort on disease control (80%) should clearly be focused on viral and bacterial pathogens (Flegel *et al*,2005).

More than 15 viruses have been reported to infect marine shrimp. They cause disease in shrimp specially penaeid shrimp family. Viral infection found not only in cultivated shrimp but also in wild shrimp and other crustaceans. White Spot Syndrome Virus (WSSV) is the causative agent of widespread disease related with high mortality rate in cultured shrimp. It causes up to 100% mortality in commercial shrimp farmhouses, resulting in huge losses to the shrimp farming industry.

However most are giving less concern for the bacterial diseases compared to the viral infections in the sector. Apart from indigenous bacteria in estuarine water, application of artificial feed and fertilizers, high stocking density and shallow nature of water in intensive and semi intensive farms leads to high bacterial population and they compete with shrimps for food and oxygen, causing stress and disease (Moriarty, 1997).

Among water and food borne pathogens in coastal ecosystems the members of the family *Vibrionaceae* contribute 60% of the total bacterial population (Simidu and Tsukamoto, 1985). A sudden increase of bacterial load in culture systems could develop bacterial infection directly and making shrimps susceptible to infection indirectly. *Vibrio*s in *Penaeus monodon* occurs due to stress, high stocking density, unstable environment and Virion particles. *Vibrio*s can also act as primary pathogen to White Spot Disease as population of the bacterial species increases with the onset of the viral disease. Also, the bacterial species might have facilitated WSSV to enter the chitinous body of shrimp due to its chitinolytic activity (Jose *et al*., 2009).

Serious viral and bacterial disease outbreaks in shrimp culture systems revealed that the shrimp industry had to be better prepared with more knowledge about shrimp and their pathogens so that disease prevention methods could be improved.

Objectives of the project were to monitor the disease outbreaks in shrimp culture industry in Sri Lanka and identify the WSSV resistant shrimps while identifying the associated factors (environmental and microbiological) which affect for the disease spread. Also aim to develop a data base of current usage of chemotherapeutant in shrimp hatcheries and their efficacy.

To identify WSSV resistant shrimps following activities were carried out:

Twenty two WSSV outbreaks reported samples were collected (With disease symptoms:34 numbers; without disease symptoms: 14 numbers)for PCR confirmation and screening for the WSSV resistant gene, from Naguleliya, Muthupanthiya, Madurankuliya, Bangadeniya and Kottapitiya area.

PCR analysis was conducted for the shrimps with WSSV disease symptoms to confirm the WSSV infection. At the same time PCR analysis was carried out for the apparently healthy shrimps collected from the WSSV infected ponds to screen the WSSV resistant gene.

Results:

PCR results confirmed that the WSSV infection of the all shrimps collected from WSSV suspected ponds. All apparent healthy shrimps also confirmed as WSSV infected shrimps by PCR. Thus further analysis to screen for the WSSV resistant gene was not carried out and the study will be continued for next year.

Identification of underline courses for luminescent Vibriosis

Post Larvae and Shrimps were collected from *Luminous* disease infected shrimp hatcheries and ponds in Western and North western province of the country. During the year 18 Luminous disease outbreaks were reported. One outbreak was reported in shrimp pond culture system and other were (17) reported from shrimp hatcheries. 23 samples (Shrimp and PLs) were collected to isolate the luminous disease causing bacteria in Naguleliya and Ambakandawila area.

Isolation of luminous *Vibrio* species and obtaining pure cultures were achieved using TCBS selective medium, Tryptic Soy Agar (TSA) and Tryptic Soy Broth (TSB). Spread plate method and streak plate method was used to isolate the luminous bacteria and to obtain pure cultures. Cultures were incubate at 28°C and Stock cultures were prepared as glycerol stocks and stored in – 80^{o}C refrigerator till further analysis. Water quality of the pond water was analyzed when required.

During the early part of the year, with the low temperature (24 ± 4^{o}C) in the night luminous disease outbreaks were common in shrimp hatcheries. In the middle of the year the luminous disease outbreaks were again observed with the high salinity (28.0 ± 3.0 ppt) .However luminous disease outbreak was commonly reported in hatcheries (17 incidences) and occasionally in farms (01 incidence).

Recommendations:

Among the samples collected the WSSV resistance shrimps were not identified. Thus screening should be continued with more samples with different sampling strategy.

Detailed study on causative bacteria species and the approved drug suitable to control the Luminous disease should be identified. Study should be continued for the next year.

Outputs

Data base initiation on viral and bacterial pathogens in the shrimp farming industry.

Aware farmers regarding the proper use of chemotherapeutants for disease management in shrimp culture.

Reporting on disease conditions

Constraints:

Delay of purchasing chemicals.

Lack of staff for lab work

Surveillance of Tilapia Lake viral infections in Wild and Farmed Tilapia species in selected farming areas.

Project No: 3.8

Officer/s Responsible: Dr.A.D.W.R.Rajapakshe

Aquaculture has significantly contributing to the global food security and provide vast amount of employment opportunities during the past three decades. However, disease outbreaks have significantly impacted the growth of aquaculture by reduction of production. One of the main routs of pathogen spread is clearly associated with trans-boundary movements of live aquatic animals for the purpose of improvement of aquaculture. According to recent records, Tilapia Lake Virus (TILV) has become a emerging causative agent of a significant disease of wild/farmed tilapia in many countries (Israel, Colombia,Ecuador,Thailand,Malaysia,Peru,Indonesia,Mianmar,VietNam,Philipines,Egypt ,Tanzania,Uganda and India). As the surrounding countries are already affected by this pathogen, Sri Lanka has a great risk of entering the pathogen. Tilapia pond culture is been practiced mainly in these two provinces and different varieties of tilapias have been cultured. Consequently this project was initiated to surveillance in order to control and management and to get emergency preparedness on TiLV.

Objectives of the project were to understand the establishment of TiLV condition in Western, North Central area, reduce the risk of disease introduction to the island and to improve the protection measures for viral infection

Results

Clinical symptoms were not recorded in each ponds and Tanks throughout the sampling period. According to the histopathological data all the samples were negative for the Ti LV(Fig.1 & 2). RNA extraction should be done for PCR analysis.

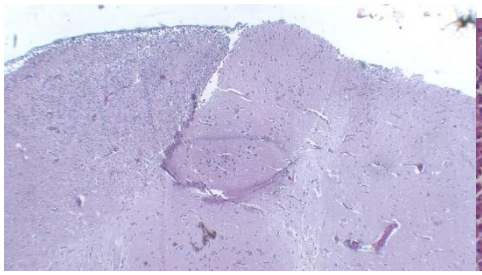
Water Quality in 5 ponds –Gampaha District

Site	DO_2	pH	Water Tc®	Air Tc®	Salinity
G1	1.26 -9.4	6.73 -8.56	28.5 - 30.5	26 – 31.3	0
G2	3.81 -13.9	6.31 -6.76	29.5 - 33.3	28.2- 31.5	0
G3	4.76 -12.5	4.67 -8.38	30 - 33.6	29.1 -32.2	0 -10
G4	2.88 -9.9	4.96 -7.53	29.6 -34.2	29.9 -31.2	0 -10
G5	3.30 -9.2	6.74 -7.38	30.2 - 34.5	26.8 -31	0 -9

Clinical Observation of 6 Tanks

Tank	No.of Samples	Clinical symptoms
Kalawewa	36	Not detected

Balaluwewa	34	Not detected
Nuwara Wewa	26	Not detected
Nachchaduwa wewa	30	Not detected
Mahakanadarawa wewa	25	Not detected
Rajanganaya wewa	28	Not detected



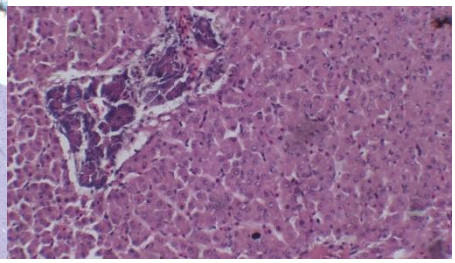


Figure 1. Brain of the tilapia Balalu wewa Figure 2 Liver section of the tilapia in Rajanganaya Wewa

Conclusions:

According to the histopathological evidence 6 tanks in Anuradapura district and 5 ponds in Gampaha district are free of TiLV.

Recommendations

Surveillance programme should continue for the confirmation of TiLV free country.

Out puts

Histopathological evidences for not occurrence of TiLV infections in study area

Aware of Fisherman and tilapia farmers on Tilapia Lake Virus disease.

Constrains

Not received the RNA extraction kit on time.

Biofloc Technology as an Integral Approach to Enhance Production and Ecological Performance of Sri Lankan Ornamental fish Aquaculture

Project No: 3.9
Officer/s Responsible: Mr. E.D.M. Epasinghe (Activities 2, 3 and 5)
Mr. E.D.M. Epasinghe and Dr. Prajani Heenatigala (Activity 4)
Mr. E.D.M. Epasinghe and Dr. A.A.D. Amaratunga and Mrs. S.R.C.N.K. Narangoda (Activity 1)
Mrs. A.M.A.N. Adikari (Activity 6)

Maintenance of existing ornamental fish breeding unit of IARAD- Development project

Objective

Explore the possible contribution of BFT application to ornamental fish aquaculture production, while maintaining sustainable practices

Activities carried out

Studied water quality parameters of the BFT system with different carbon sources.

Evaluated reproductive performance of female guppies (*Poecilia reticulata*) in BFT

Evaluated larvae performance of guppies (*Poecilia reticulata*) in BFT

Studied stress resistance through the salinity stress and starvation tolerance of male guppies and fry stages in BFT

Studied stress resistance of male guppies for packing stress in a export packing system (Lim et al., 2003) and effect on dead on arrival during 7 days (DA7) in BFT

Maintained existing ornamental fish breeding unit of IARAD

Major findings

Based on the results of this project, locally available carbon sources as rice polish powder (RPP), wheat flour (WF), molasses (MOL) can successively be used to control total ammonia nitrogen (TAN) in the biofloc (BFT) system. During the experimental period, water changes were not done and guppies were grown in same water for more than 60 days. This result is similar as the experiment conducted in 2018 with same carbon sources.

Survival rate is over 90 % in all locally available carbon sources. In 2018, same experiment results were obtained except WF, because survival rate was 63.3 %. The highest survival (96 .0 %) was observed at MOL and RPP treatments.

Highest body weight and length could be achieved by using RPP as a single treatment. Therefore, it can be identified that RPP is the most performed ones under the experimental condition.

Liver histopathology revealed that numerous intracellular fat depositions compared with the control treatment. Histopathology slides revealed that normal cellular structure in control treatments. This result is same to the 2018 results in histopathology of liver.

Reproductive performance studies exposed those females grown in biofloc systems have higher number of fry compared to the control. Fry stages showed that are came from biofloc treatments had more resistance to the salinity test compared with the control.

Output

Biofloc technology is introduced to the Sri Lankan ornamental aquaculture industry.

Recommendations

BFT can successively be adopted to grow guppies without changing water for 60 days. Rice polish powder is the most performed C source therefore it can be recommended for using in BFT. Further studies require investigating the effect of BFT on health condition of guppies, especially for fat depositions in the liver.

Constraint

Packing trial did not perform.

Modification of features of selected aquatic plants using somatic hybridization technique and in *vitro* propagation of seaweeds

Project No: 3.10

Officer/s Responsible: Mrs. D.M.S.Sugeeshwari and Dr.V.Pahawattaarachchi

Introduction:

To increase the value of exports and to cope with international market demand, the improvement of new aquatic plant varieties for desirable traits such as variable color, and form are the key to success. Related or relevant genera of cultivated crops contain a large reservoir of genes covering a variety of desirable traits. However, reproductive incompatibility generally prevents simply hybridization between taxa. Somatic cell fusion enables nuclear and cytoplasmic genomes to be combined, fully or partially, at the inter specific and inter generic levels to circumvent naturally occurring sexual incompatibility barriers. Therefore, in this study willing to conduct experiments to develop new traits of *Cryptocoryne wendtii* and *Anubias baarteri* var.*Nana* by applying somatic hybridization techniques.

Scientific research on seaweed development is particularly timely: the potential for expansion of seaweed cultivation depends on the sector's capacity to produce seaweeds with modified morphological features (e.g. thicker blades), higher growth rates or delayed (or even no) fertility. In macro algae, the development of *in vitro* culture systems facilitates mass proliferation of biomass all year round for the production of valuable compounds under controlled conditions. Culture systems are also a source of novel genetic variants with useful traits arising from somaclonal variation. The techniques for somatic embryogenesis or dedifferentiation of somatic cells often induce morphological variants in seaweeds. Such morphological and developmental variation has advantages for genetic improvement programs and also can be used as an efficient means of germplasm storage and selection. The new variation can be transient, reversible or permanent. Thus, in this study *in vitro* propagation of seaweed and somatic hybridization technique are going to be study.

Objectives were to develop protocols for *Microsorium pterous Anubias baarteri* var.*Nana, Kappaphycus alvarezii and to* develop a morphologically modified aquatic plants

Activities carried out were develop protocols for the *Microsorium pterous Anubias baarteri* var.*Nana, Kappaphycus alvarezii* to produce highest numbers of shoots or callus from explants, genetically modified of aquatic plants. isolation of protoplast for *Cryptocoryne wendtii* and opening of new plant house, maintenance; conducted studies on *Anubias barteri var nana* otissue cultured plants in aquaculture waste water based media.

Major Findings :

Java fern callus initiation was able to get by using 4 mg/L 2,4- Dichlorophenoxyacetic acid with MS medium with 1g/L activated charcol.

Highest number of sphorophytes was generated by adding 0.5 ppm giberalic acid to the water. The average number of 12 sphorohytes/leave was initiated.

Sterilization of Anubias ex plant was give 80% survival by using 70% ethanol 30second and 6% clorox for 15 minutes and 4% clorox 10minute and five times washed with strilized distilled water.

Maximum shoot initiation was able get by suplementing2 mg/LBAP and 0.5 IBA.

Maximum number of shoot multiplication was able to get by using 2mg/L BAP added to the MS medium.

Maximum root initiation was done by using 0.5 mg/L IBA in MS medium.

Maximum number of thallus of *Kappaphycus alvarezii* initiation could be achieved by using 4mg/L BAP and 0.5 mg/L IBA in sterilized sea water culture media.

The proptoplast isolation was done by using 0.2% (w/v) pectinase and 2% (w/v) cellulose digestion.

The best Growth performance of *Anubias barteri var nana* was showed in the used of 0.05g/L artificial fertilizer in hydrophonic tank.

Output

Providing best protocol for micro propagation of Aquatic plants, better growth of the aquatic plant culture industry

Conclusions:

1. Callus initiation of *Microsorium pterous* (Java Fern) could achieve with MS medium supplemented with 4 mg/L 2,4- Dichlorophenoxyacetic acid.
2. Highest number of sphorophytes was generated by adding 0.5 ppm giberalic acid to the water. The average number of 12 sphorohytes/leave was initiated.
3. Ex plant sterilized with 70% ethanol 30 seconds followed by 6% clorox (liquid soap)15 minutes, 4% Clorox 10 minutes five times with sterilized distilled water was able to give 80% survival of ex plants.
4. Shoot initiation was with 2mg/L BAP and 0.5 IBA of ***Anubias barteri var nana.***
5. Shoot multiplication was 2 mg/L with BAP of ***Anubias barteri var nana***.
6. Root initiation was 0.5 mg/L IBA with MS medium for the ***Anubias barteri var nana***.
7. Maximum number of thallus initiation could be achieved by using 4mg/L BAP and 0.5 mg/L IBA in sterilized sea water culture media.

Empirical modeling of benthic species distribution, abundance and diversity in Rekawa lagoon: scope for the future culture base fish production

Project No: 3.11
Officer/s Responsible: Mr. J.S. Jayanatha and Mrs. W.K. Suwandahannadhi

Benthic species are main factors for fish production in the shallow coastal lagoons. Habitats losses and the impacts from the climate changes driven factures also critically influence on the distribution and abundance of benthic orgasm in shallow costal lagoons. There are future possibilities to develop several aquaculture practices (mud crabs, seabass) in this particular lagoon area. Importantly, the results of predictive modeling of communities can also enhance our understanding of how various environmental variables influence the distribution of communities. This may influence directly on natural shrimp and fish production. This study will be provided helpful to minimize any adverse changes from the effluent and expansion of the culture in future.

Rekawa lagoon is small coastal lagoon connected to the sea with a 3 km narrow inland waterway (Gunarathna et al, 2010).It has an area about 230-250 ha with an average depth of 1.4m. Kirama-oya (Tangalu-oya) is mentioned as main fresh water influx to the lagoon and other two small freshwater streams take water during rainy season. Most parts of the lagoon are encircled with a mangrove belt.

Objectives of the project is to comprehensive asses of the overall species distribution changes with other environment factors; such as, sea grass meadow, mangroves and seasonal influx. Also identify zoo benthic relationship with fish production, shell fish distribution the lagoon. The study is to assess the quality benthic habitats by the applying the empherical modeling of the macrozoobenthose species distribution.

Main strategies for spatial allocation of sampling sites are systematic sampling based on a regular distribution of the sampling sites over the whole lagoon area, random sampling sites were randomly distributed over the whole area for this study used random sampling method. Van Veen grabs (215 cm^2) was used to collect benthos sample from the random sampling location in whole lagoon area. Four replicates were engaged to collect benthos from each sampling point.

Samples were sieved in order remove fine sediments other extraneous materials. Samples were gently removed. When the clay sediments are present in that samples that were bracken up the sediments in water inside the bucket by adding filtered-seawater. To performed sieve used 0.5mm sieving set

Shannon index can be used to study diversity in each study sites. $H' = -\Sigma\, p_i \ln p_i$

Evans and dominance are simply two side of the same coin. The Simpson index is based on probability of any two individuals drawn at random from an infinitely large community belong to the same species.

$D=\Sigma\ p^2_i$

$D=\Sigma ni(ni-1)/N(N-1)$

D is increases, diversity decreases that value is typically between 0-1

Equitability=H/Hmax

Comparing communities by Jaccard's Index We can compare biodiversity levels across the site. It can be fraction of the species they share

$J=S_c/S_a+S_b+S_c$

SaabdSb are the numbers of species unique to sample a and b

Sc is the community species tow samples

Results

The benthic sampled about 486 sampling to identify and calculated diversity and their distribution in the community, ecosystems. All 1739 species individuals were identified under the 11 genera. The highest abundance was recorded from the Family Gammaridae followed by the Chironomidae (midge fly larvae). The most abundance mollusk species was *Mactra stultorum* recorded in all sampling site except site number 15 in fresh water canal.

According to diversity calculation the Shandon diversity index rerecord as (H) 2.38182, this value referred to as they community have highest diversity than the other costal lagoons. Equitability is 1.034, typical values for the Equitability are 1, and these vales mean the community has highest diversity. Community organism really diverse typically one is high diversity, abundance of individual is diverse. Typical value generally between 1.5 to 3.5 in most ecological studied, and index incorporates both components of biodiversity can be seen as both strength and weakness.

Output

Diversity in each locations were studied, further aquaculture possible sites can be listed and drainage from the crab city can be monitored base on the diversity in benthos organism. In Future any changes of the water flow could be compared with this study.

Constraints- During the flood some location could not be reached due to the water level. Several locations were removed.

Establishment of seaweed farming by increasing culture diversity and ensuring mother stock availability

Project No: 3.12

Officer/s Responsible: Mr. J.S.Jayanatha, Mr. Upul Liyanage, Dr. P. Jayasingha and Dr. V. Phalawattarachchi

Objectives were to increase quality seed stock availability to carter demand from both North and South, maintain both green and brown *K. alvarezii* varieties and monitoring different environmental condition and their growth , variation of carrageen content and introduction of community base culture for the Northern coastal area.

Activities carried out:

Continuation of seed propagation through mass selection using existing cages ; Post harvest analysis for seasonal variations of carrageen content; Mapping cultured sites and potential areas and selected new location to increasing community base culture in southern region; Development of community base culture sites-Kudawella, Polhena, Unakuruwa

Results:

Mother stocks maintain and Growth study

Mother stocks maintaining activities and growth study were carried out during the study period. Growth study was conducted in several trails during the rough and calm session.

Water quality parameters were collected during the study, Tem, pH, TDS also measured.

Within 2019 seed stock management, growth of seeds in 2 week was nearly 2 times and in the 7 weeks it was 5to 6 times from the initial weight. The highest TDS (g/L) recorded during the rough condition from August –October; however, due to the high mixing this was not effect on growth.

The highest pH values are recorded during the rough season, Temperature has not significantly changes during the growth trials. Quantity of good quality seeds delivery to Community Base Culture sites from the seed stock is nearly 1 tone

Figure 1. *K. alvarezii* brown and green varieties

Community base culture development activities

Community base culture activities started in Southern in fist time by the NARA, 6Six members from this area were we selected for the initial stage. Carrying capacity of the site is about 1000Kg initial seeds which would be 5000-6000Kg after 45 days.

Outputs

First ever community based farming in Sothern region initiated.

Expected production from that site will be 4000Kg- 5000Kg per cycle.

Seed garden with a propagation protocoal & capacity 2000Kg at Dondra.

Constraints:

During the rough season expansion of culture trial are limited.

Ice-ice disease herbivores fish

Ice-ice condition due to the water quality and climate changes

herbivores fish grazing sharp propergules

Assess the present level of harvesting of finfish/shell fish in Negombo lagoon for developing relevant fishery management strategies

Project No: 3.13

Officer/s Responsible: Mr. M. Gammanpila

Reliable and up-dated information on fishery resources in Negombo lagoon is a major deficiency. National Biodiversity Strategic Action Plan 2016-2022 has reviewed in

sustainable development goals, under target 6 and 7 to identify in fishery management areas (FMA) and implement programs to address the identified gaps and assess the level of harvesting of freshwater/marine finfish/shell fish. Therefore NARA is to suppose for establishing a comprehensive fish catch data collection in the lagoon during in 2019.

The primary goal of this activity is to accurately quantify total fisheries catches for Negombo lagoon to generate reliable data/information on fisheries conducted in the lagoon and contribute to sustainable management of fisheries in the lagoon and, thereby at supporting national economies and protecting the livelihoods(of phase involved in the fisheries sector.

The secondary goal is to assess the present level of resource exploitation and make suitable recommendations for improvement of the fisheries management system in Negombo lagoon.

The catch is based on the data and information collected from landing sites located within the Negombo lagoon. Due to the complexity of the fishery and limited resources, stratified sub-sampling was selected for monitoring. Samples were taken from major landing sites in each fisheries inspection (FI) divisions around Negombo lagoon. The mean catch, in kg per craft/single operation was considered as the catch per unit effort (CPUE) with respect to each craft and gear type. The catch data was recorded by species wise and presented by craft, species, gear and corresponding weight (kg).

Following results were obtained by the collected data;

Species composition of the catch

Fishing techniques: Number of crafts/ number of fisher/ gear type

Catch Per Unit Effort (CPUE) of each technique. Units: kg/ effort specific to gear and craft type.

Estimated Yield. kg/ fishing area/ month.

Perceived changes in catches: percentage of fishers reporting declining catches, increasing catches or no change in numbers, weights and species.

Major Findings and outputs

The highest CPUE was recorded from brush park fishery (9.91 ± 2.81 kg) followed by stake net fishery (9.12 ± 4.36 kg) and drag net fishery (8.69 ± 5.9 kg). Trammel net (2 & 5 inches mesh size) is the most common fishing gear used by traditional fishing crafts. CPUE values of trammel net vary 4.43 to 6.82 kg operated from theppam and canoe respectively.

Trammel net contributed nearly 50% of lagoon fishery followed by 17.8% of Brush Park, 10.8% of stake net and 10.5% of drag net fishery.

Estimated total monthly catch of lagoon fisheries varied from 17,000 to 67,000 kg and highest production was recorded during first inter monsoon period (February to April) and production was continue declined afterwards due to extreme weather conditions prevailing in other months.

Heavy windy condition and heavy rainfall prevail in Negombo area, likely to disturb operating of fishing gears and many fishers refrain from fishing resulted gradual decreasing of total catch from April 2019.

Peak occurrence of juvenile of high value species such as groupers within the year was highly variable. Year round occurrence of juveniles was also observed but peak months fell on the October-November. Recruitment may follow a monsoon pattern and peak in abundance occurred generally during the northeast monsoon period.

Recommendations

It was observed that juvenile fishes caught in brush parks were not released back to the lagoon that violates traditional customs of their fishery. Therefore it is important to introduce new regulation for managing and regulating of brush park fishery in Negombo lagoon. Females to the largest and oldest classes highlight the importance of maintaining a wide length/age distribution and relatively high number of spawners in the larger/older year-classes in order to protect the stock reproductive potential. Based on the length-frequency distribution pattern of high value fish species such as grouper, exploitation should be control in the months of September to November. This would allow the young recruits to grow and reproduce thereby ensuring resource sustainability.

Constraints

Inadequate staff in Regional research center of Kadolkele, Negombo

Unavailability of vehicle for research work

Survey on natural pearl oyster resource in North West & North coasts regard to regain the pearl industry in Sri Lanka

Project No: 3.14

Officer/s Responsible: Mr. Chathura Medagedara and Dr. V.Pahalawattaarachchi

Sri Lanka in the past was famous for precious pearls and it was one of the main sources that induced foreign invaders to the island. Sri Lankan pearls enjoyed a wide international popularity. However, during the last few decades the once flourished pearl culture industry has disappeared. According to historical records, the coastal area from Chilaw to Silawathura had been hugely famous for pearl oysters. During last few years some records were there for existing the pearl beds from Silawathrei. Nevertheless no data available under a systematic study as well no initiative for the pearl farming yet, revival of the industry after many, many years and to introduce as a new industry to Sri Lanka is aiming in the project.

Objectives were to identify the existing pearl oyster stocks and benthic seagrass habitats and identify the culture sites through available site selection criteria and spot culture experiments

According to the historic records, the pearl banks had been situated in the Gulf of Mannar and Puttalam (North West Sri Lanka sea board) and in the Northern sea area. Literature survey was conducted in the first two months in order to gather available information on the pearl oyster fishery in ancient era and under the British Empire in Sri Lanka. Based on the information gathered from the fishermen and divers in Mannar area, Arripu to Silawathura sea area select to collect live specimens of pearl oysters. During the field visits, GPS points were collected to make a detail map and samples were collected from 40 feets deep bed. Further number of underwater photographs of the existing pearl oyster beds were taken. Samples were measured and send to identification process. Due to the monsoon alteration, the sea area off Mannar became rough by mid-March and it was unable to carry out spat collection and culture site selection. Culture site selection first moved to Trincomalee bay to identify possible sites for commercial culture of pearl oysters year-round.

Possibility of Walleppadu Kiracnhi site

Field trip was conducted to Kiranchi, Walleippadu sea area for identify suitable places for initiate Pearl oyster culture project.. The sites visited 08 Km far from the shore were more than 20 feet and salinity was 35ppt and rough weather condition was prevailed. The sheltered area found at Wallippadu area along the sea cucumber farms located on deep trenches in coral garden. Depth was recorded as 10-13 feet and salinity was 35ppt.

Identified suitable community based farmers for initiate Pearl oyster culture project via the Chairman of fisheries society, Kiranchi . Subsequently they were awered on existing

oyster culture project and the history and the prospects of the supposed pearl oyster culture project.

Culture trail in Kiranchi

Pearl oyster samples were transported to Kiranchi where the rafts were already established. Pearl oyster samples were stocked in special culture bags with the amount of 35-40 individuals per bag. Prepared oyster rafts were launched in selected deep trenched sea cucumber farm and oyster bags tied up, ten structures per raft. Sample sizes were recorded, shell height, shell length and thickness parameters
T1(32.21±3.2mm,23.56±2.11mm,16.24±2.66mm),T2(34±4.68mm,20.15±3.66mm,17.1 ±2.14mm) and T3 (35±5.21mm, 24.65±2.54mm,18.32±2.14mm) respectively. Level of salinity was recorded as 33ppt. Oyster rafts were anchored using 25 Kg cement blocks and 10mm nylon ropes. Oyster culture bags were suspended in water.

Output:

Built up awareness among fishing communities, on community based pearl oyster culture

Identified of Natural pearl oyster stocks, GPS location map prepared and live samples were taken for species identification by MBRD

Recommendation:

More samples should draw and stocked for better culture practice. Local fisher folks should aware about importance of pearl oyster mariculture in future. Local culture should successful to start commercial culture of pearl oysters.

Constraints:

Climatic changes acted as the major killing factor of this year because due to prolong South Western monsoon period from Mid of March to end of October sampling of pearl oysters from 13Km away from Silawathura sea area was difficult. Before the monsoon period commenced natural pearl oyster stocks were identified according to literature and interviews with sea cucumber divers. Site selection for start pearl oyster mariculture was complicated due to physiochemical parameters of selected places should match with parameters of the natural site. Finally, natural deep trenched sea cucumber farms at Kiranchi was selected for raft culture method. Security issue raised by community based farmers because thieving of rafts and oysters happened in month of October. Nearly 30% mortality was observed after one month in deposited culture structures, transportation stress may be happened, during the next year project transportation process should be developed.

Determination of sustainable carrying capacity estimation for culture based fisheries in selected perennial tanks in Southern Province –A case study in collaboration with NAQDA

Project No: 3.15

Officer/s Responsible: S.Jayanatha, V.Pahalawattaarachchi, NAQDA officials

Ridiyagama and Badagiriya reservoirs categorized under the minor perennial reservoirs, Rididyagama tank has 889 ha reservoirs areas. The fisherman association called as Gramiya Deewara san vidanaya; with about 165 fishermen, 102 registered canoes. Badagiriya has 486 ha reservoirs area; which used by 40-45 canoes to engaged in fishing.

This study aim to conduct study on carrying capacity and potential yield in both reservoirs. Other hand, several limnological data also recorded during the study. These reservoirs has introduced fishery (put and take) by several carp species and introduced Tilapia, *Macrobachuim* as well. Rather than that, few endemic species also reported in minor scale. Furthermore small cyprinids are commercially been not harvested in both.

Results-

The production and limnological data can be summarized Badagiriya has highest fishing intensity rather than Ridiyagama.

Forty four canoes are engaged fishing in Bandagiriya reservoir in a day. According to analysis around 43 boat days were engaged as efforts and annually it was around 14176 boat days. The total annual production was 1860.94tones; which contributed majority from Tilapia carp species in general harvesting regimes. However, community requested reduced mesh sizes for caught Rohu. As results there was a recorded sharp increase in production, 1713.33 tones, in August. Total production was estimated at 1860.94 tons per year including the production of August. The August production strategies were designed by the fisherman due to the community request.

The fishing intensity at Bandagiryia needed to be considered as two ways with harvesting strategies and without that special case. Therefore, gin general harvesting regime, fishing intensity recorded as 29.16 boat days/ha/year.

Characteristics	Badagiriya	Ridiyagama	
fishing intensity			
FI	29.72 boat days/ha/year	38.96 boat days/ha/yr	

STR1 without			
Starergi 1production	3.51ton	not concern	
RA	486ha	889ha	
no of fishermen	45-50	102-105	
per/ha/yr	3.83ton		
mean depth	3.72m		
Annual production	1860.94ton	246.21ton	
Kg/fishermen			
Yield	3829.10 Kg/ha	279.47Kg/ha	

The Bandagirirya production change can be seen as, 3829.10 Kg/ha reduced to 315.25 Kg/ha reduced.

The Rididyagama reservoir production was recorded in annually about 246.21 tons corresponded to 34639.2 boat days per year. Fishing intensity also recorded 38.96 boat days/ha/yr. this was highest than the Bandagiriya.

In general condition the highest production was recorded from Tilapa (54.80%) followed by carp species 42.82% and Macrbachium was 2.38%. However, their harvesting strategies what they have introduced in August, with that condition the highest coming from the carp followed by Tilapia 71.8% and 26.9% respectively. However, these strategies can be used where it's not effected on prolonged stocking and productions. Our suggestion is this kind of harvesting stretches can be implemented in different reservoirs.

The highest nitrate concentration mean recorded during the April –June. In S12 as recorded highest nitrate concentration during the January –March followed by the S1 and S10 Rather than other place. S12 sit located near to Mal Ara, which, provided fresh water mainly influx from this way to Bandagiriya. Lowest nitrate concentration was recorded during the rainy season. It may have effect due to the dilution of nitrate concentration and increase agricultural by using reservoir adjacent.

Output- identified potential harvesting quantity and potential production. Limnological changes also formulated. That can be used to prediction in future stocking and harvesting.

Outcome- Fishermen are stocking for restocking purposes, but they were not harvested at fully. Therefore, sustainable utilization can be recommended through the situation. Livelihood safety for fishermen through scientific base study can be established.

Publications

Research papers /Conference Proceedings

1. C.B Medagedara, M.S.M Fahim, J. Pushpakumara, A.J Jayatissa, P.A.D Ajith Kumara (2019). Servival and growth of the sea cucumber ***Holothuria scabra*** in two selected sites in Puttalam Lagoon, Sri Lanka. Proceeding of Scientific Session of National Aquatic Resources Research and Development Agency (NARA) July, 26th 2019. Sri Lanka.
2. Malshani, C.B Medagedara, M. Fahim, S. Corea, B.D.M Mihiran and V. Pahalawaththaarachchi (2019). Feasibility of using introduced mature oyster (***Crassostrea madrasensis)*** stock bed to collect spat for oyster farming. Proceedings of the 25th Anniversary Scientific Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources (SLAFAR), 19th August 2019, Faculty of Fisheries and Marine Science and Technology, University of Ruhuna, Matara, Sri Lanka.
3. R. R. A. Ramani Shirantha 2019. Some aspects of Ecology and captive breeding of *Pethia melanomaculata* (Cyprinidae) endemic to Sri Lanka. , Annual Scientific Session of NARA, Colombo.
4. M. G. I. S. Parakrama "Experimental Culture Trial to Compare the Growth Performance and Survival of *Lates calcarifer* (Bloch, 1790) Fingerlings Fed With Low-Cost Simply Formulated Feed vs Fish Offal. Can It Be A Solution For Small Scale Farmers?" published in the international symposium of World brackish water Aquaculture conference (BRAQCON 2019) held on 23rd -25th January 2019, Chennai, India.
5. M. G. I. S. Parakrama "A comparative indoor trial study for evaluating plant based formulated feed vs non plant feed for tilapia fingerlings" abstract published in the proceedings of NARA Scientific Sessions, 2019
6. M. G. I. S. Parakrama "Plant based formulated fish feed vs non plant based feed; A comparative indoor trial study to evaluate the growth performances of Tilapia fingerlings up to juvenile stage" Scientific poster presentation in NARA Scientific Sessions, 2019
7. Ayesha Malshani, C.Medagedera, M. Faheem, S. Corea, B.D.M.Mihiran and V Pahalawattearachchi (2019) Feasibility of using introduced mature oyster (*Crassotreamadrasensis*) stock bed to collect spat for Oyster farming - 25thAnnual

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8. A.S.L.E. Corea, and C. B.Medagedera (2019) A New Record of Bivalve Species, *Garielongata*(Lamark, 1818) (Family: Psammobiidae) in Puttlam Estuary, North Western Province, Sri Lanka. - International Forestry and environment symposium Negombo, Sri Lanka.
9. A.S.L.E. Corea, (2019) Water Quality and Plankton Productivity near Sea bass Culture Facilities in Chilaw lagoon and Negombo lagoon, Sri Lanka- 75th Annual sessions of the Sri Lanka Association for advancement of science (SLAAS) Colombo Sri Lanka
10. V.Pahalawattaarachchi and W.Rajapakshe (2019). Distribution and diversity of benthic macro invertebrates fauna in mangrove soils of Puttalam Lagoon. Abstract presented in NARA Scientific Sessions on 26th 2019 at NARA Auditorium
11. Prelimanary study on development of a protocol for the acclimatization of *Kappaphycus alavarezii* (seaweed) in laboratory conditions. D.M.S.Sugeeshwari, V.Pahalavattaarachchi, D. Madurangika. *Scientific Session, 2019*, National Aquatic Resources Research and Development Agency, P 4.
12. Jayasinghe P.S, V. Pahalawattaarachchi, K.K.D.S. Ranaweera and Ruchitha Perera.*2018* Chemical composition of six edible seaweed species available in the coastal belt of SriLanka. Journal National Aquatic Resources Research and Development Agency , vol 45-47 *52-62pp* http://www.erepository.nara.ac.lk/handle/1/1632(published in 2019)
13. Jayasinghe P.S, V. Pahalawattaarachchi and K.K.D.S. Ranaweera Seaweed based jam as a source of nutrition. Journal National Aquatic Resources Research and Development Agency,vol.45-47 *85-98 pp.* http://www.erepository.nara.ac.lk/handle/1/1635(published in 2019)
14. Epasinghe E.D.M, B.V.A. Nethmini, V. Pahalawattaarachchi, K.L.W.T. Maduka, T.A.D.W. Karunaratne, N.P.P. Liyanage and H.M.P. Kithsiri (2019)The effect of locally available carbon sources on zero water exchanged guppy (*Poecilia reticulata*) growing system, Abstract presented in NARA Scientific Sessions on 26th 2019 at NARA Auditorium
15. Jayanatha J.S., U.S.P.K. Liyanage, G.A.H. Galahitigama, V. Pahalawattaarachch(2019).Specific growth of *Kappaphycus alvarezii* (Doty) in the Southern coastal waters of Sri Lanka; Poster presented in NARA Scientific Sessions on 26th 2019 at NARA Auditorium

Paper article/leaflets

- An article (Sinhala medium) in the NARA Sayurunetha journal on “Kalapu kakuluwan wagaakireema pilibanda oba denagathayuthu de” Journal printing done
- Prepared leaflet on’’ tilapia lake virus disease’’ to deliver among the tilapia farmers.

Fishing Technology Division

Study the fishing efficiency of Mono filament nets comparison with Nylon nets used in inland reservoirs of Sri Lanka

Project No: 1.1

Officer Responsible: Mr. N.D.P.Punnyadewa, Mr. Madushanka and Mr. Kelum Prabath

The project was collaborative project with National Aquaculture Development Authority of Sri Lanka. In Sri Lanka three categories of reservoirs, fisheries are being conducted in different scales. Main fishing gear is gill net; minimum allowable legal eye size is 3.5inch. Before 1996, fisherman used to use monofilament gill net for fishing activities. But due to the high efficiency, use of monofilament net has been prohibited in inland reservoirs in Sri Lanka, without any studies of gear efficiency. Therefore, NAQDA and FTD are being conducted a research on Efficiency of monofilament net and nylon net for fisheries in inland reservoirs.

To conduct the experiment, 6 reservoirs were selected. Three reservoirs from North central province as Hurulu wewa reservoir, Aluthdiwul wewa reservoir and Manankattiya wewa reservoir. Ridiyagama reservoir, Kattakaduwa reservoir and Murutha wela reservoirs were selected from Southern province. NAQDA have agreed to provide all net materials for the whole experiment including monofilament nets. Monofilament net is not available in local market. Three eyes sized were selected as 3.5", 4.5" and 5.5". There is delay on receiving of net sample from NAQDA Before the experiment, initial catch data were collected. However, 50% of nets were provided by NAQDA and fishing nets were distributed for the net mending works. Several trial fishing activities were conducted in reservoirs of southern province and species were identified and data were collected. According to the obtained data, Thilapia contribute more in to the total catch and minimum contributed species was freshwater prawn species. However, monofilament nets were not received as the request. Experiment is continuing up to end of next year.

Study the fishing efficiency of Mono filament nets comparison with Nylon nets used in inland reservoirs of Sri Lanka.

Net mending and trial fishing activities at Southern province






Deployment of Fish Aggregating Devices (FADs), Fish Enhancing Devices (Submerge FEDs) to enhance the fish production in coastal water

Project No: 1.2

Officer Responsible: Mr. N.D.P.Punnyadewa, Mr. Madushanka and Mr. Kelum Prabath

Deployment of low-cost Fish Aggregating Devices (FAD) and Fish Enhancing Devices (FED) are popular fishing technique in many countries of the Asian region. Even in Sri Lanka these low-cost FADs and FEDs are used quite successfully in the western and southern areas and sea. These as having good potential whereby the small-scale fishers in the other parts of the country can earn good incomes. Therefore, under the project number 1.2 in order to the request of fisherman in Weligama, Rumassla, Polhena and Unawatuna area. Totally64submerged FEDs were deployed in selected locations with community participation. Generally, submerged FEDs are safer than floating FADs because its encounter less hazardous from drifting fishing nets and fishing boats, fishing gears and other natural disasters. Reinforce concrete anchors were used for fixed and hold the FADs in a certain location, at the bottom. Two types of materials were used to construct submerged FADs as metal and concrete. Submerged FADs were pyramid shaped. Reinforcing the concrete FADs are strengthen the concrete against cracking which may cause by the impacts during deployment and while in use. Data collection process will be started after the monsoon around December, 2019 and January, 2020.

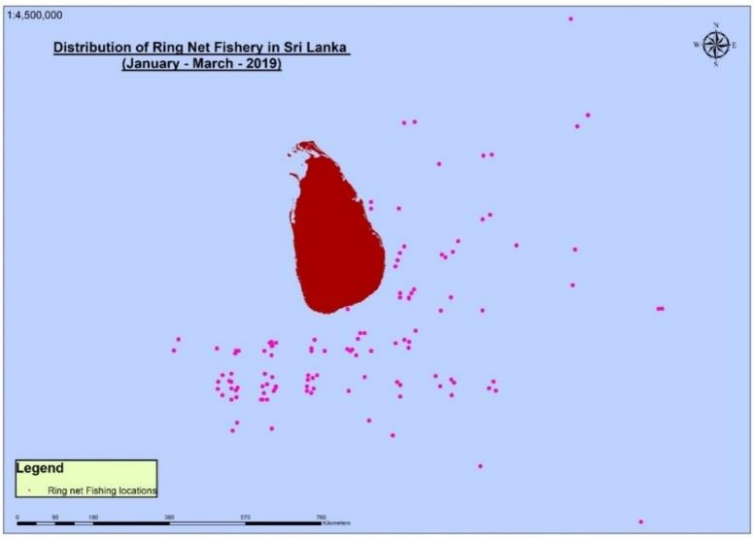
Deployment of Concrete and Iron bar FADS at Southern coastal area

Study of flotsam associated fishery conducting in offshore area to introduce management strategies for sustainable fishery

Project No: 1.3

Responsible Officer/s: Mr. N.D.P.Punnyadewa, Mr. Madushanka and Mr. Kelum Prabath

Marine fisheries sector of Sri Lanka is conducted in three area as Coastal area, within EEZ and beyond EEZ. In the coastal area there is huge variation in fishing gears used by fisherman However, in other two places, gill net, ring net and long line are the most dominant gears. In Sri Lanka there is a certain fishing practice associate with Flotsam (Floating object) using Ring net. Fishermen used to catch fish around floating objects in the deep-sea using ring net by encircling of the object. Only multiday fishing communities engaged in this fishing methods and around 1500 fishing boats in Sri Lanka engaged with this fishing technique. When observe a floating object like wood log, fishing crew encircle the object and catch aggregated, almost all fish. Fish are normally aggregated to floating objects to shade and feed. Therefore, fishermen able to catch large quantity of fish by one effort. The catch contains mature and immature and multi species of fish. After the harvesting, boat landed and sells the harvest in local market. They bring large quantity of fish by single trip. Therefore, to analyse the catch composition, area of the fishing, fish catch data are being collected in Beruwal, Tangalle and Kudawella fishery harbours. GPS location of fish harvested collected by using boat log book data. Same time retail price of the fish species, length frequencies date is being collected at the fishery harbours.**Frigate tuna(***Auxisthazard***)**, **Skip jack Tuna(***Katsuwanospelamis***)**, **Rainbow runners (***Elagatisbipinulata***)**, **Indian scad (***Decapterusrusselli***)** and **Yellow fin tuna(***Thannusalbacarus***), Trigger fish (***Canthidermis maculatus***)**are being studying under this project. According to the collected data, *Decapturusrusselli* is the most dominant species in the catch of ring net boat. Other species contribute in very low percentage. Data collecting is extended up to 2020.



Socio Economic and Marketing Division

Market Research of Consumers preference of Tilapia

Project No: 8.2

Responsible Officer: Mr. M.M.A.S Maheepala

Introduction

Sri Lanka Inland and Aquaculture fish production shows an increasing trend in the present. In 2017, Sri Lankan Inland and Aquaculture fish production recorded as 82540 mt, which is around 60% increases compared to the 2010 production. However, some issues such as lack of demand during some period and low price limit the investment towards aquaculture development entrepreneurs in the country. Therefore, according to the request of NAQDA, the research focus to identify Tilapia fish marketing and to identify the issues related to the Tilapia fish sale.

This research collected data related to Tilapia fish consumption from consumers in two different districts namely Colombo and Polonnaruwa in 2019. Based on the Stratified random sampling techniques, consumers in Grameniladaree Divisions (GN) of randomly selected Divisional secretariats were selected for this study. Data were collected via interview using structured questioners. The sample size is 304 that comprised 206 from Polonnaruwa district and 98 from Colombo district. All statistical analysis was conducted using SPSS software and percentages of responses in each category were calculated. Cross tabulation was used to examine relationship between preference levels of the two different districts. Further independent "t" statistic was used to find significant differences of the quantity of inland fish purchase in the districts.

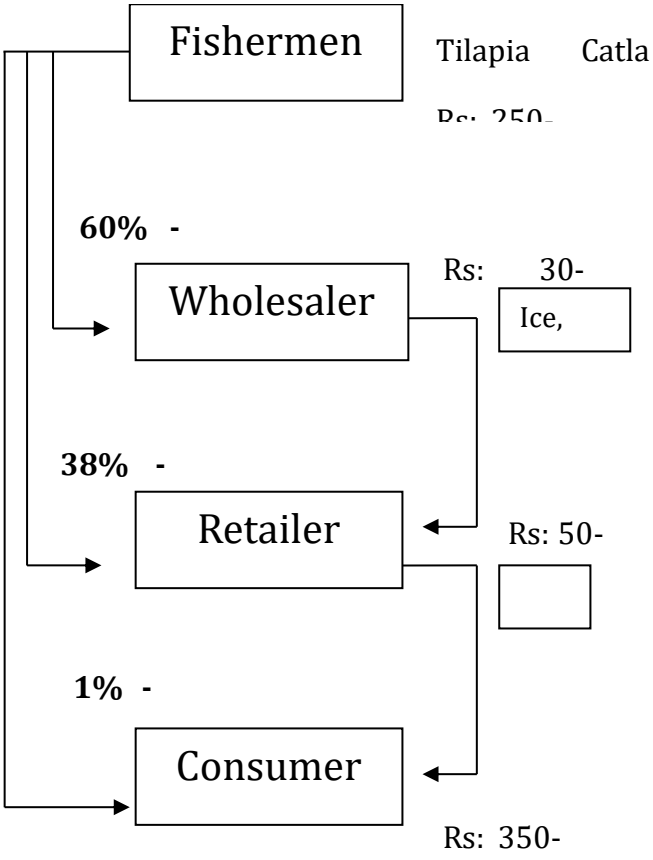
Identifying consumers preference is help to improve the condition of the goods according to the requirements of the Consumers. It helps to increase the demand and finally increase the production. Therefore, purpose of this study is to understand consumer preferences and the demand for tilapia products in Sri Lanka. In addition to that to challenges and opportunities on value chain of Tilapia Fish is also considered under this study.

The study calculated monthly consumption of Marine and Inland fish, Dry fish, Chicken, and Egg quantities of two difference districts. According the result, it was found that higher quantity of marine fish consume by the household of Colombo (5.11kg) while the higher quantity of Inland fish consume by the household of Polonnaruwa district (5.38kg). Dried fish consumption quantities of household of both districts were somewhat similar. Colombo district household consume higher quantity of chicken (2.05kg) than the households of Polonnaruwa district (1.07kg). Egg consumption of the household of the Colombo district was around double compared to the consumers of Polonnaruwa district.

Consumers education level was considered in the interviews conducted for the study. Accordingly it was analyzed changers of the consumption quantities of fish and other

products compared to the level of education. Result found that, consumers of low level of education consumed low quantity of marine fish and higher educated consume higher amount of marine fish. However, this positive relationship could not been seen in the Inland fish consumption. Similarly, It wasn't able to find the relationship between level of education and the quantitative dried fish, chicken and egg consumption.

Half of Consumers in Polonnaruwa district, purchase fish from the bicycle / bike (50%) and then retail shops (38%), while the 19% of consumers of Colombo districts stated that there are no special places to buy inland fish. Further, 9% consumers of Colombo district used to purchase fish from retailers shops.



Although there are different types of fish and fishery products for Inland fish, consumers are willing to purchase fresh fish. Especially 95% of consumers of Polonnaruwa district like to fresh form of Inland fish, while 30% of Colombo district consumers like are also like fresh inland fish. Tilapia is major inland fish species that contribute highest quantity to total inland fish production. 98% of consumers like to purchase for their consumption, while only 38% consumers in Colombo district like Tilapia fish. "Chi-square" and "t" statistics clearly showed the significant differences of preference and the quantity of Tilapia fish consumption in two difference districts.

The study found main actors of the Value chain analysis inland fish supply chain. Accordingly, there were four main actors such as fishers, wholesalers, retailers and consumers were met in the value chain. Following graph explain actors the fish prices changes in the chain.

There are some suggestions that were target to improve inland fish production, socio-economic status of the fishers, inland fisheries management and value additions proposed by the fishers, wholesalers and consumers. Based on them and the observations following suggestions are made for the development of inland fisheries in the country.

Apply existing management plan which practiced for the tanks that are not administrated by NAQDA

CFC involvement for fish purchase from inland landing centers.

Introduce Public, Privet, and Fishers community participation for aquaculture Fisheries.

Institutional Coordination to minimize IUU fishing and to improve productivity of the reservoirs and tanks

Conduct consumers' awareness (preparation, quality, taste etc) programmes

Improve Value Chain of Inland and aquaculture fisheries (Ice, filet, frozen, labeling, branding etc..)

Introduce Alternative livelihoods (tourism) for fishers

Conduct Market Survey (willingness to pay for different value added products) for value added products.

Value chain Analysis of Deep-sea Fisheries in Sri Lanka

Project No: 8.4

Officer Responsible: Mrs. D.W.L.U. De Silva

Introduction

Fishing has been a major economic activity in Sri Lanka for many centauries and has been the major livelihood of the coastal communities. The fisheries sector in Sri Lanka has been considered as one of the major potential areas for expansion of the economy. The sector plays a vital role with respect to provision of direct and indirect employment opportunities for 560,000 and livelihood for 2.6 million people (MFARD 2015), generation of income, foreign exchange earnings and provision of reasonably priced protein source for the rural and urban areas in the country. Marine fishery is the most important sub sector in fisheries industry of the country and provides more than 80% contribution for national fish production. Marine fishery has two sub sectors namely; deep sea and coastal fishery. Deep sea fishery has an immense important in seafood industry of Sri Lanka. Deep sea fisheries target medium and large pelagic species mainly tuna and tuna like fish predominantly for export markets. There are 4,196 multiday boats are operating in deep sea fishery in Sri Lanka. All most all the deep-sea fish species are high valued. Having an overall picture on current situation of such high valued fisheries sectors is an imperative part to promote and enhance the efficiency and to take management decision in favor of the augmentation of the industries. Value chain analysis is one of the best tools to be used to evaluate the all activities and processes involve in any industry from the production until it reaches the end consumer. It can be used as a tool to address the prevailing issues and constraints in sectors and assist the policy makers in policy formulation for possible developments. In Sri Lankan contest post-harvest fish loss has become a serious problem in dep sea fishery which has to be addressed immediately. And also cost of production of deep-sea fishery is in long term discussion as it directly affects to the social and economic well being of fishers. The information communication technology plays an important role in development of world seafood industry.

Objectives of the study

To estimate the commercial post-harvest loss of deep-sea fishery of Sri Lanka

To estimate the optimum cost which maximize the profit of offshore fleets according to the length of fleet and nature of fleets

To study the extend of the application of ICT (Information and Communication Technology) in deep sea fisheries activities

Methodology

The study was conducted using several data collecting techniques including direct interviews using pre tested semi structured questionnaires and unstructured interviews and in-depth interviews. Different secondary data sources were used to collect background information and literature. Unstructured interviews parallel with preliminary site visits were conducted to collect background information and to test the questionnaire. The study was conducted in four major fishery harbors namely Negombo, Tangalle, Beruwala and Trincomalee based on number of boats registered and annual landed catch. Secondary data were collected from 180 IMUL boats and information were gathered on handling operation and preservation practices, total catch, catch composition, duration of fishing trips, ice usage, fish unloading, cost of production, use of ICT tools, *etc*. Before the data collection, enumerators were trained to assess the quality of fish with the guidance of IPHT staff of NARA. Based on the visual observations enumerators sorted the fish lot of a particular boat into four quality categories (Grade 01-Grade 04; Superior quality – inferior quality).

Key findings

Post- harvest loss: The commercial pos-harvest loss calculations were done base on the type of fishing gear used. Longline, gill nets and ring nets are the main fishing gears used in deep sea fisheries. The average fish catch of long line, gill net and ring net were 3,126, 2,216 and 6,022Kg per fishing trip. The catch composition of these fishing gears was different. The long line fish catch was dominated by big eye tuna (53%) followed by yellowfin tuna (21%) and bill fish species; sword, marlin and sail fish (26%). The gill net fish catch was dominated by skipjack tuna (76%) followed by yellowfin tuna (22%) and some other species in small quantities (2%). The majority of fish come from ring net was Indian scads (57%) and skipjack tuna (32%). Table 01 shows the quality grade wise fish catch of each fishing gear.

Table 01: Quality grade wise fish catch in percentage

Fishing gear	Grade 01	Grade 02	Grade 03	Grade 04
Longline	50%	28%	12%	10%
Gill net	30%	45%	8%	17%
Ring net	16%	20%	36%	28%

Source: Socio-economic survey/SED/NARA/2019

In long line fishery nearly 50% of fish landed as grade 01 whereas the lowest grade 01 quality fish landing was reported on ring net. Nearly 64% of fish landing of ring ne was below grade 02. The majority of fish catch landed from gill net fishery was belong to grade 02. There was no proper pricing system or auction taken place at the harbors and many

companies purchase fish for export market as a bulk at a pre-determined price. Any way by means of the quality grades and prices of fish the commercial post-harvest fish loss was calculated for each fishing gear. The lowest commercial post-harvest loss was reported by the longline fishery (7%) while the highest was in ring net fishery (40%). The commercial post-harvest loss of gill net fishery was 18%.

The ice usage is very crucial for maintaining the fish quality throughout the storage on the boat. Therefore, the ice: fish ratio was calculated. The recommended ratio for ice use as per guided by the post-harvest technology division of NARA is 3:1 to 4:1 (ice: fish). This study found that the. ice: fish ratio in ring net fishery was 1:1 and it was far below the recommendation and hence the ice usage in ring net fishery is not at a satisfactory level. But in the longline and gill net fisheries the ice usage was 4:1 and has met the recommendation. All most all the sampled longline fishery boats had store big fish in belly down position after the evisceration. But in ring and gill net fishery most of the boats do not practice such a systematic method of storing fish. Most of the time fish are heaped in shelves.

Conclusion

All the fishing gears has unique fish harvest composition hence utilizing different variety of fishing gears help to keep the diversification of the fish market. In Sri Lanka, a significant amount of fish is loss both in quality and quantity due to the post-harvest losses. Post-harvest losses vary by fishing gear. According to the results commercial post-harvest loss is higher in ring net fishing. Long line fishery has the lowest commercial post-harvest loss in deep sea fishery. Poor fish storage and improper handling are key factors of post-harvest losses of fish and due to unavailability of a proper pricing system fishermen do not encourage themselves to maintain post-harvest conditions at optimum level.

Recommendation

A proper fish catch monitoring system should be introduced at the point of unloading

A competitive pricing system or an auction system should be introduced to motivate fishermen to land high-quality fish than bringing a large quantity of inferior quality fish

Boats should be modified and equipped with high tech cooling facilities and with enough space for other handling practices

Harbor management staff should be trained to quality inspection of landed fish catch

Consumer awareness on identification of fish quality should be raised to improve the consumer demand on high quality fish

Cost of production of deep-sea fishery:

Production Cost: - The production cost has positive correlation with the size of the boat because larger boats deploy more crew members, gears and sophisticated equipment that incurred higher cost than smaller ones (Table 02).

Profitability: -The highest net income of Rs. 4,025,620 was enjoyed by boats in group 33-40 ft length and the lowest Rs. 2,389,748 by the boats belonged to 28-32 ft while that of Rs. 3,899,885 for the larger boats, 41-60 ft.

Table 02: Annual Averages of Catch, Income, Variable cost, Gross and Net profit (Rs)

Description	Deep sea Fishery (Boat length categories ft.)		
	28-32	33-40	41-60
Annual total revenue (Rs.)	8,457,228	11,775,025	17,590,562
Annual total Variable cost (Rs.)	5,495,721	6,947,919	11,977,493
Annual Gross profit (Rs.)	2,961,507	4,827,106	5,613,069
Annual net profit (Rs.)	2,389,748	4,025,620	3,899,885
Average rate of return	0.62	0.63	0.33

Source: Socio-economic survey/SED/NARA/2019

Conclusion

The profitability of a fishing trip is increased with size of the fishing boats but rate of return for capital invest low for largest boats than medium size boats.

Recommendations

1.It is recommended to control the cost of production of fishing boats that in operation in deep sea fisheries through applying the low-cost concept by integrating scale of economies in operation.

2.It is recommended to introduce a program to enhance the skills of skippers to increase the efficiency of fishing operations to minimize the operational costs of the trip at the sea.

3.It is recommended to introduce standardize on board procedures in controlling quality of fish caught and on-board processing of fish to meet existing international standards.

ICT application in deep-sea fishery

Mobile phones, GPS and SSB radio are the most common ICT tools used in deep sea fishing activities. VMS and AIS (Automatic Identification System) are some of the new ICT tools can be seen in multiday boats. In our sample no boat was found with sonar and

echosounder like fish finders. There were several motives for fishermen to adopt in to new ICT tools and are shown in figure 01.

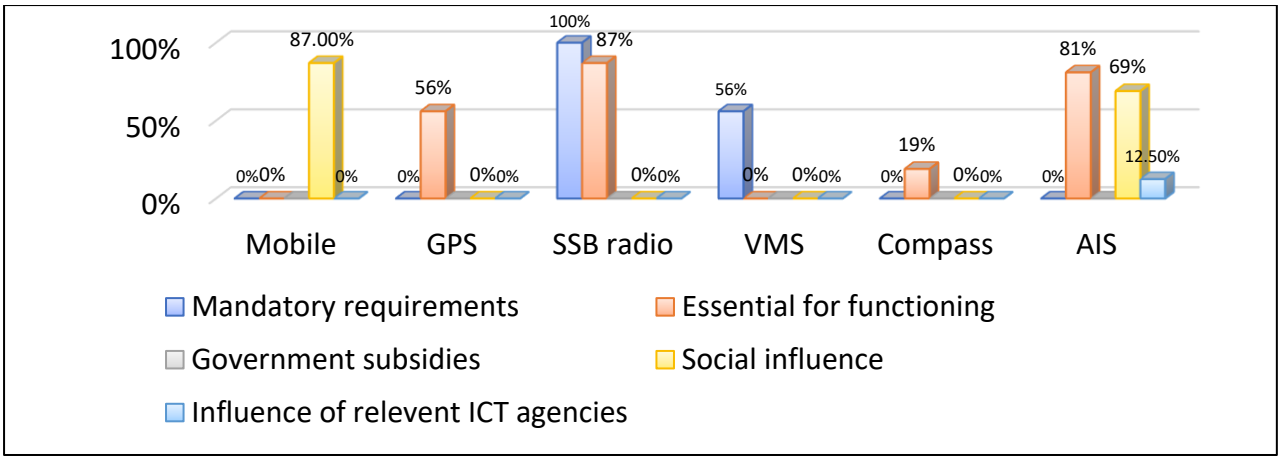


Figure 01: Different motivational factors to use ICT tools

There was a positive attitude among fishermen in using ICT tools for deep sea fishing operations. Eighty eight percent of fishers stated that ICT tools help to ensure the safety in sea and 81% were agreed with that the safety of fishing gears also has been improved with the use of new tool called AIS. Fishermen understanding about that ICT tools can increase the income per fishing trip in indirect manner were lacking. Only 31% of fishers agreed with that the ICT tools currently in used are helpful to increase their income. Fishermen stated that they do not have a reliable source for weather forecast and their awareness on weather and fish forecast services was at a lower level.

Conclusion

Fishermen awareness on ICT equipment and their uses is at an admirable level

Social influence plays an important role in ICT usage among fishermen

Government support to improve the ICT application is at lower level

Recommendation

Relevant institutions should introduce a mechanism to provide reliable weather forecast and reports timely and with minimum dissemination losses

Government should pay attention to Initiate proper subsidy schemes to support purchasing of high tech, high priced equipment such as fish finders and sonar

It is recommended to introduce a separate module for skipper training programs on ICT applications, new trends and their uses in order to keep fishermen updated with new technologies

It is recommended to improve the consistency, and the awareness of fishermen on fish forecast services and Fisheries Information Center (FIC) and should easily accessible

Community Welfare and Skills development of fishers

Project No: 8.1

Responsible Officer: Mr. K.P.G.L Sadaruwan

Introduction

This project focuses to enhance the socio-economic status of the fishing community. It is believed that the education, skill development and product development mainly help for enhancing the socio-economic status of the fishing community. Therefore, Training for fishers that help to add value to the products has been provided for the community.

Training and development of the fishing community is an educational process which involves the gaining knowledge and developing skills to enhance the performance of

employees and fisheries sector. One of the requests of the fishers was to provide training on Out Board Engine Repairing and Maintenance. Therefore, it is important to provide necessary trainings to demonstrate professionalism and human resource development of the fishers.

According to the requirement of the Ministry of fisheries and to comply with international requirements, skippers who are engaging fishing activities in OFRB boats were selected for the training. Accordingly,85 of OFRB fishing boats have successfully been completed the training programme. The training was scheduled as two day training and one resource person and NARA conducted the training programme. Four OBM training programme were conducted in Panama,Kalpitiya,and Kalmune and also 03 skill development programme were conducted in Thangalle,Kalpitiya and Kirinda for 103 fishermen.

Fishers, who use OFRB boats selected training programme on identification of the engine trouble and repairer the breakdown of the engine. As a result of breakdown the engine of OFRP boats in the sea, fishers face many difficulties in the sea. If the fishers can repairer small breakdown of the engine, it will be help them to minimize the hazard in the sea.

Photos at Kalmune workshop

Photos at Panama workshop

The fisheries information centre (FIC) of NARA

Project No: 8.3

Responsible Officer: Mrs. H.P.D.A Lakmali

Budget: 0.4 million

Socio-economic Division maintains the Fisheries Information Center (FIC) to provide necessary information for stakeholders and other interested parties of Sri Lankan fisheries industry. The end of the year 2019, a total number of 294 queries were received through the hot line 07 10 10 10 10 of fisheries information Centre from different respondents. All the queries are categorized in to five groups. Numbers of queries and the percentages under each information criteria are given bellow table.

Objectives

To promoted the information center and its activities for the betterment of stakeholders in the industry and general public

Project area: - Island wide

Promotional materials Such as leaflets distributes among fishermen and other stake holders of entire country

Stickers will be pasted on fishing boats

Banners will be displayed in fisheries harbors and landing sites

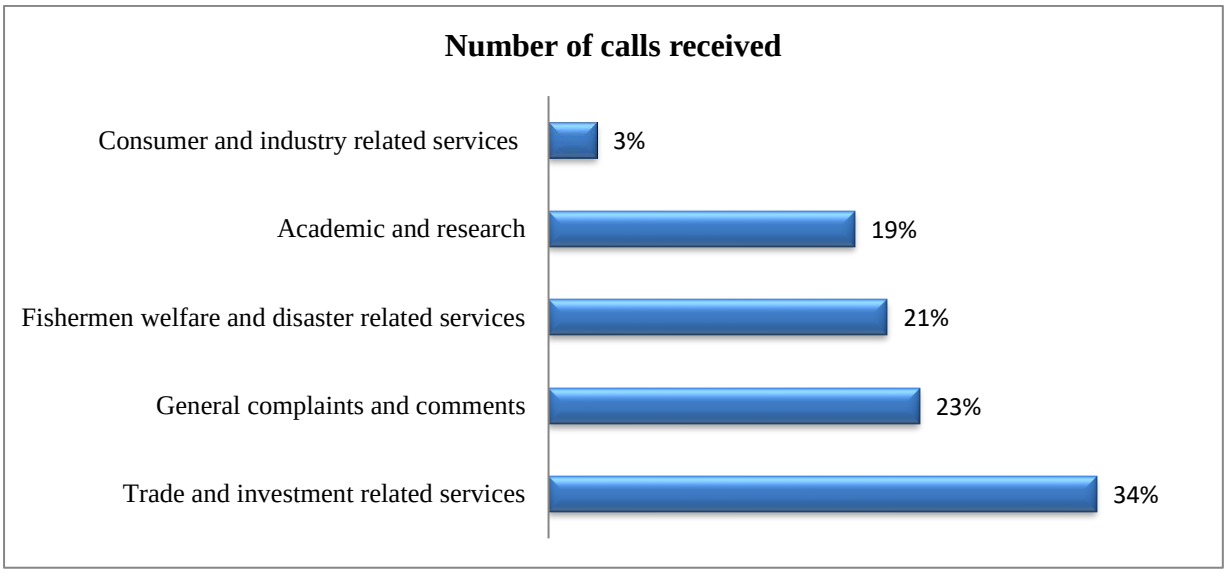
Posters will be displayed in the places where fishers are gathered (FI offices, community hall etc.)

Numbers of queries and the percentages under each information criteria

Information criterion	Number of calls received	Percentage
Trade and investment related services	98	34%
General complaints and comments	68	23%
Fishermen welfare and disaster related services	64	21%
Academic and research	53	19%
Consumer and industry related services	11	3%
Total	294	100%

Source: Socio-economic survey/SED/NARA/2019

Number of calls received



Source: Socio-economic survey/SED/NARA/2019

All queries received were successfully solved out with the assistant of NARA scientists, officials of Ministry of Fisheries and Aquatic Resources Development (MFARD), Department of Fisheries and Aquatic Resources (DFAR), National Aquaculture Development Authority (NAQDA) and other relevant officers from the governmental and non-governmental sectors.

To promote the information center among stakeholders of fisheries sector more than 10 banners were displayed in the fisheries harbors and 1000 of leaflets were distributed in harbors, landing site, fisheries inspectors' offices, and other government and non-government office premises which are located all-around the costal line of Sri Lanka.

Publications

Abstracts

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Thilakarathna, M.T.N. and Amaralal, K.H.M.L. (2019). Push and pull factors on fishers' migration to Baththalangunduwa Island in Sri Lanka, 2nd International Symposium on Social Science and Humanities (ISSSH) 2019: Development towards Sustainability, National Centre for Advanced Studies in Humanities and Social Sciences, Colombo, December, 2019.

Trainings Local

Nirukshka Abeykoon (Scientist) - Scientific approach & research methodology for agriculture. two days workshop at PGRC Gannoruwa 25.11 & 2.12.2019 organized by SLCARP

Institute of Post Harvest Technology Division

Assessment quality of fish in multi-day boats and in selected main fish sales places

Project No: 4.1

Officer responsible : Dr. G.J. Ganegama Arachchi, Mrs. Pavithra Ginigaddarage

Component 1. Assessment of quality of fish landed from three large multi-day boats (lager than 55' in length)

Recent studies conducted by NARA has found that more than 50% of large size yellowfin tuna fish (*Thunnus albacores*) unloaded from multi-day boats (MDBs) are not in acceptable quality for export markets. However, there is growing demand in international markets for yellowfin tuna caught in Sri Lanka. Therefore, in 2017, MFARD was initiated introducing large size multi-day fishing boats (> 55' in length) with chill bath compartments as one of remedial measure to reduce currently high post harvest quality losses of large size fish in MDBs while targeting to increase production of export quality yellowfin tuna in local MDBs.

Present study assessed if recently introduced large multi-day boats (> 55' in length) are producing high percentage of export quality yellowfin tuna. Five MDBs, anchored at Dickowita and Negombo were assessed in 2018 and part of results was complied in Annual progress report in 2018. Three newly constructed MDBs anchored at Dickowita Fishery Harbour were assessed in this year (2019). Information was gathered on handling practices in MDB using a structured questionnaire.

On-board handling practices for yellowfin tuna*:* Present survey found that large size yellowfin tuna was not pre-chilled in a ice-water slurry using Chill-bath immediately after hauling the fish onboard in any newly introduced large MDBs. This pre-chilling is critical unit operation in preserving export quality of large size tuna (>20 kg) fish, especially, the colour and flavour/odour of flesh since these are main quality characteristics in assessing the freshness of fish/fillets for export market. This survey was also observed that individual whole fish is wrapped with polythene sheet/pouch before storing (stacking) the fish in ice in the fish-hold of MDB.

At present, fish storing days in MDB are about 33-45 days. Fishers should be encouraged to unload fish before high level of freshness of fish is depreciated. Shelf life of highly acceptable quality Yellowfin tuna in ice is about 14 days. Presently, boats are cleaned using detergents only and disinfectants are not used. Fishing crew needs to be encouraged adopting proper cleaning practices in MDBs.

Histamine levels of flesh of large size yellowfin tuna (>25kg) unloaded from MDBs:

In 2018, sixty three (63) number of core flesh samples from large size yellowfin tuna (>25kg) which were selected for export fish processing industry (based on site assessment for sensory quality) at Dickowita and Negombo, were collected by NARA and stored in -80 °C Ultra low temperature freezer. These samples were analyzed for

histamine levels in 2019. Fifty nine (59) yellowfin tuna samples contained histamine below 50 ppm while another four out of 63 samples contained histamine levels in the range of 100-166 ppm.

In present study (in 2019), another set of core flesh samples were obtained randomly across whole lots of yellowfin tuna from three separate MDBs by NARA and these samples have been stored in -80 °C Ultra low temperature freezer. When technical staff is available these samples will be analysed for histamine levels. Number of random samples collected from each boat are given in Table 1.

Table 1. Information on randomly collected core samples of flesh of yellowfin tuna from multi-day boats (lager than 55' in length) in 2019

Date (Location of Fish landing)	Sample number (Multi-day boat, >55')	Collected Date	No. of core flesh samples of Yellowfin tuna
10/3/2019 (Dickowita)	1	09.03.2019	60
11/6/2019(Dickowita)	2	11-06-2019	80
27/6/19(Dickowita)	3	27-06-2019	100

Sanitary quality water, ice and newly introduced large size fishing MDBs (>55 feet in length):

Ice used for fish handling in MDBs and sea water (harbor basin water) used to separate fish in fish holds during unloading from fish holds of MDBs at pier, are heavily contaminated with *Escherichia coli* (*E. coli*) indicating fecal contamination of these utilities (Table 2). Fish were remained stored in faecally-contaminated chill-storage environment of fish hold of boat during the fishing trip since bilge water pumped out of fish holds were found high loads of *E. coli* (Table 2).

Table 2. Microbiological quality of utilities and fish holds of multi-day boats (> 55' in length)

Date (Location of Fish landing)	Sample number (Multi-day boat, >55')	Sample type	Results			
			Faecal coliform	*E. coli*	*Salmonella*	*Listeria monocytogenes*
10/3/2019 (Dickowita)	1	Water from harbor basin*	550	550	Negative	Negative
		Bilge water ¶	20	13	Negative	Negative
		Ice from Gantry 1	110	110	Negative	Negative

		Ice from Gantry 2	11	11	Negative	Negative
11/6/2019 (Dickowita)	2	Water from harbor basin*	550	70	Negative	Negative
		Bilge water ¶	1800+	900	Negative	Negative
		Ice from Gantry 1	1600	550	Negative	Negative
		Ice from Gantry 2	550	350	Negative	Negative
27/6/19 (Dickowita)	3	Water from harbor basin*	900	900	Negative	Negative
		Bilge water ¶	1600	900	Negative	Negative
		Ice from Gantry	900	80	Negative	Negative

*Harbour water is used to clean fish during unloading from fish hold
¶ Bilge water (melting ice and oozing out fish soluble) retained in fish hold

Average amount of export quality fish produced by newly introduced large size MDBs (>55feet in length):

By performing onsite sensory evaluation (assessment of freshness) of core flesh samples of each fish, each Yellowfin tuna is selected from MDBs by export fish processing industry when fish is unloaded from MDBS at Fishery Harbour. Based on catch data of three new MDBs, the average weight of large yellowfin tuna accepted for export fish processing industry, is about 50% of total fish unloaded from MDBs. This indicate that better fish handling practices need to be encouraged using the existing infrastructure facilities at optimum level such as use of chill bath etc. in order to reduce high post harvest fish quality losses in MDBs.

Recommendations

Encourage fishers to use chill baths to pre-chill fish before storing fish in fish hold with ice in MDBs, Use cotton cloth cover to warp fish instead polythene cover that hamper the rapid chilling of fish in fish holds.

Shorten the fishing trip duration of MDBs

Use of food grade water and ice for cleaning boats and fish

Use of food grade disinfectants to clean in boats

Provide training programs for MDB fishers

Component 2. Investigation of quality of ice produced in Ice Plants

This investigation was continued from 2018 as per the request made by MFARD to expand this study in 2019 across other Ice Plants in located in other areas including Southern area of Sri Lanka also. Therefore, quality of ice and ice making water samples from another 29 Ice Plants located in Galle, Matara, and Hambantotoa areas, were assessed in 2019.

Table 3. Summary of total Ice Plants investigated for microbiological quality of ice making water, ice stored in cold room and ready for dispatching (crushed ice) from 2018 to 2019

Total # of Ice Plants	#of Ice Plants produce acceptable quality/ Unacceptable quality ice	Sample types	Number of Ice Plants		
			Faecal coliforms (MPN/100 ml) present	*E. coli* (MPN/100 ml) present	*Salmonella* present (100 ml)
72	**66** (Unacceptable quality ice)	Water/ Tube well	48 (1 to 1800+)	38 (1 to 1600)	4
		Ice from Store (-18°C)	56 (1 to 1800+)	53 (1 to 1800+)	5
		Ice from Crusher	62 (1 to 1800+)	57 (1 to 1800+)	7
	6 (Not contaminated): Faecal coliform, *E. coli* and *Salmonella* are not found in any of three sample types from six Ice Plants.				

Table 4. Summary of different serotypes identified among fifteen *Salmonella* isolates found from ice making water, ice from store or crushed ice across 72 Ice Plants from 2018 to 2019

#	Date	Location	Sample type	*Salmonella* serotype
1.	7/4/2018	Trincomalee	Ice making water	*Salmonella* Brunei
2.		Trincomalee	Ice from Cold Store	*Salmonella* Kentucky
3.		Trincomalee	Ice from Ice Crusher	*Salmonella* Tananarive
4.	21/05/18	Mulathive	Ice from Cold Store	*Salmonella* Edinburg
5.	23/06/2018	Kalpitiya	Ice making water	*Salmonella* Kentucky
6.		Kalpitiya	Ice from Cold Store	*Salmonella* Wilmington

7.		Kalpitiya	Ice from Cold Store	*Salmonella* Agona
8.	8/7/2018	Oluwil & Kalmune	Ice from Ice Crusher	*Salmonella* spp.
9.	12/8/2018	Mannar	Ice making water	*Salmonella* spp .
10.	26/12/18	Galle	Ice from Ice Crusher	*Salmonella* Graba vi
11.		Galle	Ice from Ice Crusher	*Salmonella* Graba vi
12.	11/2/2019	Tangalle	Ice from Ice Crusher	*Salmonella* Braenderup
13.		Tangalle	Ice from Cold Store	*Salmonella* Sekondi
14.		Tangalle	Ice from Ice Crusher	*Salmonella* Spp.
15.	12/5/2019	Beruwala	Ice making water	*Salmonella* Hvittingfoss

Acceptable quality ice was found in only four Ice Plants. Results of ice quality have been notified to respective Ice Plants.

Outputs

A consultative meeting was conducted on March 14, 2019 for stakeholders in order to find remedial measures required to produce acceptable quality at economical price. This meeting was based on scientific information generated by NARA on quality of ice produced Ice Plants located in Trincomalee, Batticola, Jaffna, Mulathive, Anuradhapura, Dambulla, Puttalam, Chillaw, Kalpitiya, Mannar, Polonnaruwa, Ampara, Monaragala, Galle, Matara, Hambantotoa during 2018 and 2019. A report on the consultative meeting has been submitted to DFAR. This report included following main suggestions given by stakeholders: Create awareness among stakeholders on GMPS; introduce and implement Standards/regulations; and Upgrade infrastructure of Ice Plants.

A concept note was submitted to MFARD to seek Cabinet approval in 2019 for obtaining LKR 52 million targeting to upgrade 30 Ice Plants. This funding will be utilized to provide financial and technical support for improving basic infrastructure of main ice handling facilities together with staff safety equipment in 30 Ice Plants for in one year period.

Recommendations:

Conduct intensive technical training programs for stake holders in of Ice Plants with regular monitoring of sanitary quality of Ice Plants

Appoint NARA as part of legislative competent authority to inspect sanitary quality of Ice Plants

This report should be make available as base line data for strategic plans for upgrading Ice Plants in Sri Lanka as an urgent task. Therefore, this report/data on present status of sanitary quality ice in Ice Plants in Sri Lanka, should be submitted to competent authorities responsible for food safety in Sri Lanka

Collaborate similar research programs with other institutes and food safety authorities to contribute towards effective and efficient national food safety programs since analysis of samples incur high costs.

Component 3. Assessment of sanitary quality of fish sales placers in Dedicated Economic Centers

Four field visits were made to fish retailing stalls of Dedicated economic centers in Ambilipitiya (02), Pilayandala (01) and Veyangoda (01).

Ambilipitya Dedicated Economic Center:

Nine fish samples were collected from fish stall located Ambilipitya Dedciated Econmic Center in two sampling visits analysed for *E. coli*, *Salmonella* and *Listeria monocytogenes. Salmonella* and *L. monocytogenes* were not detected in all fish samples. *E. coli* were present in the range of 43->1100 MPN/g. Acceptable limit of *E. coli* in fish is <500 MPN/g and this was exceeded in six samples out of nine fish samples (66%). Water samples collected from the fish stall did not contaminated with *Salmonella* and *L. monocytogenes.* However, *Salmonella* Tripoli was detected in one ice sample. Samples of ice, water and swabs from three fish contact surfaces (cutting board, fish storing bin and fish displaying tray) collected in first field visit were found contaminated with *E. coli* and *Salmonella* Senftenberg was also detected in surface cutting board. However, *E. coli*, *Salmonella* and *L. monocytogenes* were not found in the same sample types that were collected in next field visit (Table 5A). This indicate that an effective communication of NARA technical staff with stall owner about the unacceptable sanitary quality data fund by first investigation (field visit) might have made fish stall maintain cleanliness.

Pilyandala Dedicated Economic Center

Five fish samples from this stall was analysed for *E. coli*, *Salmonella* and *L. monocytogenes.* Four samples found *E. coli* positive (3.6- 93 MPN/g). Ice and three fish contact surfaces (cutting surface of wood log, fish storing bin and fish displaying tray) were contaminated with *E. coli* at levels of >1800 MPN/100 ml and 45-1600 MPN/cm^2, respectively (Table 5B).

Veyangoda Dedicated Economic Center

E. coli contamination in four fish samples found in the rage of 3.6-23 MPN/g and Salmonella were not detected in these samples. Fish washing water found in potable

quality. However, *E. coli* were found in ice and fish contact surfaces (cutting surface of wood log, fish storing bin and fish displaying tray) at levels of 900MPN/100 ml and 8-1600 MPN/cm^2 , respectively.

Table 5A. Microbiological quality of fish , ice water and fish contact surfaces in Ambilipitiya Dedicated Economic Center

Date	Location	Sample type	Sample codes	Results		
				E. coli	*Salmonella* serotype	*Listeria*
25/08/19	Ambilipitiya	Fish	Yellow fin tuna (MPN/g)	1100	Negative	Negative
			Skipjack tuna (MPN/g)	460	Negative	Negative
			Marlin (MPN/g)	1100	Negative	Negative
			Herring (MPN/g)	43	Negative	Negative
			Indian Scad (MPN/g)	93	Negative	Negative
		Water	Water from fish washing tap (MPN/100 ml)	20	Negative	Negative
		Ice	Ice (MPN/100 ml)	1800+	*Salmonella* Tripoli	Negative
		Swab	Cutting board (MPN/cm^2)	1800+	*Salmonella* Senftenberg	Negative
		Swab	Fish container (MPN/cm^2)	1600	Negative	Negative
		Swab	Fish displaying tray (MPN/cm^2)	1800+	Negative	Negative
12/10/2019	Ambilipitiya	Fish	Yellowfin Tuna fish (MPN/g)	>1100	Negative	Negative
			Skipjack (Balaya) (MPN/g)	>1100	Negative	Negative
			Sail fish (MPN/g)	>1100	Negative	Negative
			Indian Scad (MPN/g)	>1100	Negative	Negative
		Water	Water from fish washing tap (MPN/100 ml)	ND	Negative	Negative
		Ice	Ice (MPN/100 ml)	ND	Negative	Negative
		Swab	Fish cutting wooden log (MPN/cm^2)	ND	Negative	Negative
		Swab	Fish container (MPN/cm^2)	ND	Negative	Negative

		Swab	Fish displaying tray (MPN/cm^2)	ND	Negative	Negative

Table 5B. Microbiological quality of fish , ice water and fish contact surfaces in Pilyandala and Veyangoda Dedicated Economic Center

Date	Location	Sample type	Sample codes	Results		
				E. coli	*Salmonella* serotype	*Listeria*
15/09/19	Piliyandala	Fish	Squid (MPN/g)	0	Negative	Negative
			Indian Scad (MPN/g)	7.4	Negative	Negative
			Bigeye scad (Bolla) (MPN/g)	3.6	Negative	Negative
			Sardinella (Salaya) (MPN/g)	3.6	Negative	Negative
			Sardinella albella(Sudda) (MPN/g)	93	Negative	Negative
		Water	Water from Fish washing water tap (MPN/100 ml)	0	Negative	Negative
		Ice	Ice (MPN/100 ml)	1800+	Negative	Negative
		Swab	Fish cutting wooden log (MPN/cm^2)	1600	Negative	Negative
		Swab	Fish container (MPN/cm^2)	45	Negative	Negative
		Swab	Fish displaying tray (MPN/cm^2)	1600	Negative	Negative
26/10/2019	Veyangoda	Fish	Yellowfin tuna fish (MPN/g)	9.2	Negative	
			Skipjack (Balaya) (MPN/g)	3.6	Negative	
			Indian scad (Linna) (MPN/g)	3.6	Negative	
			Sail fish (Thalapath) (MPN/g)	23	Negative	
		Water	Water from fish washing tap (MPN/100 ml)	ND	Negative	
		Ice	Ice (MPN/100 ml)	900	Negative	

		Swab	Fish cutting wooden log (MPN/cm^2)	120	Negative	
		Swab	Fish container (MPN/cm^2)	1600	Negative	
		Swab	Fish displaying tray (MPN/cm^2)	8	Negative	

Recommendations

Fish stall staff should be make aware of good sanitary practices with regular training programs

This report should be make available for competent authorities responsible for food safety and provide collaborative support to create awareness on better fish handling sanitation of fish stalls.

Collaborate similar research programs with other institutes and food safety authorities to contribute towards effective and efficient national food safety programs and avoidance of replicating same study since analysis of samples incur high costs.

Component 4. Investigation of toxigenic radioactive residues (radio nuclides) in imported fishery products in Sri Lanka

This is the first on investigation of the potential -presence of toxigenic radio nuclides using a large number samples of fish products in a single study in Sri Lanka. The study was commenced in 2018 and continued in 2019 also since sample analysis could not be completed as planned in 2018 due to a delay in entering into an Agreement with Sri Lanka Atomic Energy Board (SLAEB) for obtaining their technical support in sample analysis in their laboratories. As A collaborative work, SLAEB analysed samples for radio nuclides in fish samples at a concessional Testing fees. This study investigated if harmful radioactivity levels of five radio nuclides in most common imported fish and fishery products available in local market. A total of 300 numbers of random samples comprising 100 dried fish, 100 canned fish and 100 frozen fresh fish which were purchased from local retail market were analyzed for radioactivity of five Radio Nuclides (K^{40}, Cs^{137}, Pb^{210}, Ra^{226} and Th^{232}).

Dried fish samples were purchased from were collected from whole sale and retail places in Colombo 11. Canned fish samples were purchased from Supermarkets and Sathosa retail outlets and other whole sale places. Frozen fish were purchased from main fish importing wholesalers and Ceylon Fisheries Corporation (CFC). In addition, 09 frozen fish samples were provide by fish collected by fish stock assessment in Nansen-Research vessel in 2018. Information on imported fish products analysed are given in Table 6.

Table 6. Information on imported fish products including name of fish, country of origin and Brand names

#	Sample Name	Brand	Origin country	Imported Stage	Fish variety	No. of samples
01	Canned Fish	Appollo	China	Canned	Mackerel-*Scomber japonica*	15 (45 Tins)
		Rasa Malu	China	Canned	Mackerel-*Scomber japonica*	20 (60 Tins)
		My choice	China	Canned	Mackerel-*Scomber japonica*	20 (60 Tins)
		Ship	Chile – south America	Canned	Jack mackerel – *Trachurus murphyi*	15 (45 Tins)
		Renuka captain	Chile – south America	Canned	Jack mackerel – *Trachurus murphyi*	10(30 Tins)
		Blue bird	Chile – south America	Canned	Jack mackerel – *Trachurus murphyi*	07(21 Tins)
		Captain	Chile – south America	Canned	Jack mackerel – *Trachurus murphyi*	08 (24 Tins)
		Diamond	Chile – south America	Canned	Jack mackerel – *Trachurus murphyi*	05 (15 Tins)
02	Dry Fish		Oman	Salted	Queen Fish	03
					Shark (Short Fin)	01
			Maldives		Sail Fish	02
			Indonesia		Shark (Silky)	02
			Oman	Dry	Shark (Short Fin)	04
					Shark (Silky)	01
					Queen Fish	06
			Pakistan		Queen Fish	06
					Giant cat fish	02
			India		Shark (Short Fin)	01
					Queen Fish	04
					Giant cat fish	06
			Maldives		Sail Fish	13
			Indonesia		Shark (Silky)	08
					Shark (Short Fin)	39
					Queen Fish	02
03	Frozen fresh fish		Spain	Sea frozen	Marlin	01
			Yemen			08
			Netherland			03
			Taiwan			18
			Yemen	Land frozen		03
			Sea shells			01

			Yemen	Sea frozen	Sail Fish	13
			Taiwan			24
			Yemen	Land frozen		15
			Taiwan			03
			Yemen	Sea frozen	Yellow fin tuna	02
			09 samples of raw fish were provided by stock assessment project by Nansen-Research vessel and fish types to be identified.			09

Frozen fresh fish: Hundred frozen fish samples (100) included Sail fish, Marlin, Yellowfin tuna fish. Presence of Cs^{137} radionuclide at level of about 1±0.1 Bq/Kg radioactivity was detected in 21 fish samples of these three fish types. Radioactivity of Ra^{226} at level of 2.60±0.8 Bq/Kg was detected in one sample of Sail fish.

K^{40} which is a naturally occurring ubiquitous radio nuclide, was detected in the range of 40.0± 2.0 - 742.0± 96.0 Bq/Kg among the total of 100 frozen fish samples. Pb^{210} and Th^{232} were not found in all frozen fish.

Dried fish samples: Hundred dried fish samples (100) included Shark, Queen fish and sail dried fish and giant cat fish. Presence of Cs^{137} radionuclide was detected in eleven dried fish samples. About 1 ± 0.1 Bq/Kg of Cs^{137} radioactivity was detected in ten samples (Shark, Queen fish and sail dried fish) while 2.3± 0.3 Bq/Kg radioactivity level of Cs^{137} was detected in one dried fish sample (Shark dried).K^{40} which is a naturally occurring ubiquitous radio nuclide, was detected in the range of 33.0± 27.0 - 279.0± 28.0 Bq/Kg among the total of 100 dried fish samples. Pb^{210} and Th^{232} were not found in all dried fish

Canned fish samples: Hundred dried fish samples (100) included Jack mackerel (*Trachurus murphyi*) and Mackerel fish (*Scomber japonica*) as retorted in metal cans. Radioactivity of Ra^{226} at level of 2.0±0.4 Bq/Kg was detected in one sample of Jack mackerel. K^{40} which is a naturally occurring ubiquitous radio nuclide, was detected in the range of range of 102.0± 8.0 - 408.0± 60.0 Bq/Kg among the total of 100 canned fish samples. Other three radionuclides (Cs^{137}, Pb^{210} and Th^{232})were not found in all canned fish.

Present study found that dried fish, canned fish and frozen fresh fish which imported were imported and available in retail markets during 2018-2019 acceptable for consumption.

Recommendations

This report should be making available as base line data for relevant investigations in future. Therefore, this report/data on present status of toxigenic radio active residues in

imported fishery products, should be submitted to competent authorities responsible for food safety in Sri Lanka

Collaborate similar research programs with other institutes and food safety authorities to contribute towards effective and efficient national food safety programs and avoidance of replicating same study since analysis of samples incur high costs.

Sanitary survey of shellfish and monitoring of antimicrobial resistance in aquatic environment

Project No: 4.2

Officer responsible : **K.W.S. Ariyawansa, Pavithra Ginigaddarage**,

Component 1 Assessing microbiological quality of bivalves

Oysters and water samples were collected from harvesting areas (Gangewadiya, Kandakuliya and Kalpitiya), and analyzed for microbiological parameters such as aerobic plate counts, total coliforms, faecal colifoms, *E.coli*, *Vibrio cholerae*, *Vibrio parahaemolyticus* and *Salmonella* spp. The microbiological quality of the harvested oysters (n=30), clams (n=5) and the surrounding water (n=15) was tested using standard techniques. Bivalve (Oyster and clams) samples contained Aerobic Plate Count (APC) in the range of 3.0 x $10^3$to 4.1 x10^6cfu/g and 71% of samples had less than 5 x 10^5cfu/g. Faecal coliforms varied between not detected (ND) to 23 MPN/g whereas *E.coli* ranged from ND to 9.3 MPN/g. Faecal coliforms were not detected in 49% bivalve samples. *E.coli* were not detected in 71% of bivalve samples while unacceptable levels (>2.3 MPN/g) were detected in 20% of these samples. APC of water samples ranged from 2.0 x 10^2 to 2.4 x 10^4 cfu/ml. *E. coli* varied from ND to 1800+0 MPN/100ml. Faecal coliforms and *E.coli* were not detected in 33% and 40% of water samples respectively. *Salmonella* spp. *Vibrio cholerae* and *Vibrio parahaemolyticus* were not detected in any of bivalve or water samples from growing areas.

Water samples were collected from Puttalam lagoon and microbiological quality of water was monitored (n=19). Parameters. Aerobic plate counts (Range 1.2 x 10^2–2.2 x 10^3), total coliforms(ND – 110 MPN/100mL), faecal colifoms(ND – 80 MPN/100mL), *E.coli*(ND–35 MPN/100mL), *Faecal streptococci* (ND - 2.3). All water samples were free from *Vibrio cholerae*, *Vibrio parahaemolyticus* and *Salmonella* spp. Faecal coliforms and *E.coli* were not detected in 58% and 74% of water samples respectively.

Output and Recommendations:

Monitoring data were submitted to quality control unit of DFAR in order to promote bivalve exports and local sales

All 12 sampling points in Puttalam lagoon were comply with US FDA restricted areas classification and suitable for culturing and natural relaying of bivalves.

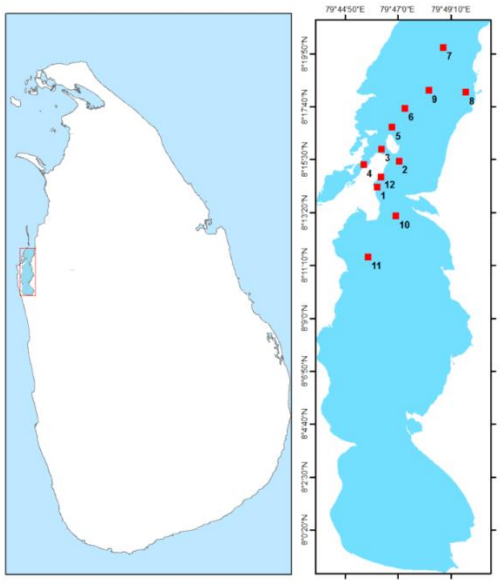


Figure: Sampling points of Puttalam Lagoon

Component 2 Antimicrobialresistance of *Vibrio* species isolated from shrimp culture environment

Antimicrobials are a precious group of medicines which are used to treat infections caused by bacteria, viruses, fungi and parasites. Currently there is a global effort in combating antimicrobial resistance. Sri Lanka has initiated combating antimicrobial resistance (AMR) with multi sectoral collaboration, under one health concept. Bacterial, viral, fungal and parasitic diseases are the major causes of shrimp /ornamental farm mortality and production losses in hatcheries and culture systems. Antibiotics are commonly used to control the bacterial populations in hatcheries and farms. However, these antibiotics are applied in *ad hoc* manner with consequences leading to alteration of microbial communities and the generation of drug-resistance strains of bacteria. Hence it is important to be aware about the gravity of the situation in Sri Lanka and to take prompt action. Therefore, studies were undertaken to test prevalence of antimicrobial resistant microorganisms and antimicrobial residuals in shrimp culture environment in Sri Lanka.

Shrimp (n=27), sediments (n=27) and water(n=27) samples were collected from 3 different shrimp farms in Thoduwaya, Arachchikattuwa and Madurankulia in Puttalum district.Samples were analyzed in Quality control laboratory IPHT, NARA (ISO/ IEC 17025 Accredited laboratory).All shrimp, sediment and water amples were analyzed for *Salmonella* spp. and *Vibrio* spp.Different type of *Vibrio* species wereisolated by culture on thiosulfate-citrate-bile salts-sucrose (TCBS) agar plates and identified using biochemical tests according to Bergey's manual and FDA manual (Oxidase, Indole, Salt Tolerance Test, Triple Sugar Iron (TSI), ONPG Test).Antibiotic sensitivity was determined using Mueller-Hinton agar (MHA) plates by disk diffusion method for following Antibiotic impregnated discs

Chloramphenicol (30 µg) , Amoxicilin (10 µg), Tetracycline (30 µg, 10 µg), Nalidixic acid (10 µg), Oxytetracycline (30 µg), Nitrofuronton (30 µg, 10 µg)

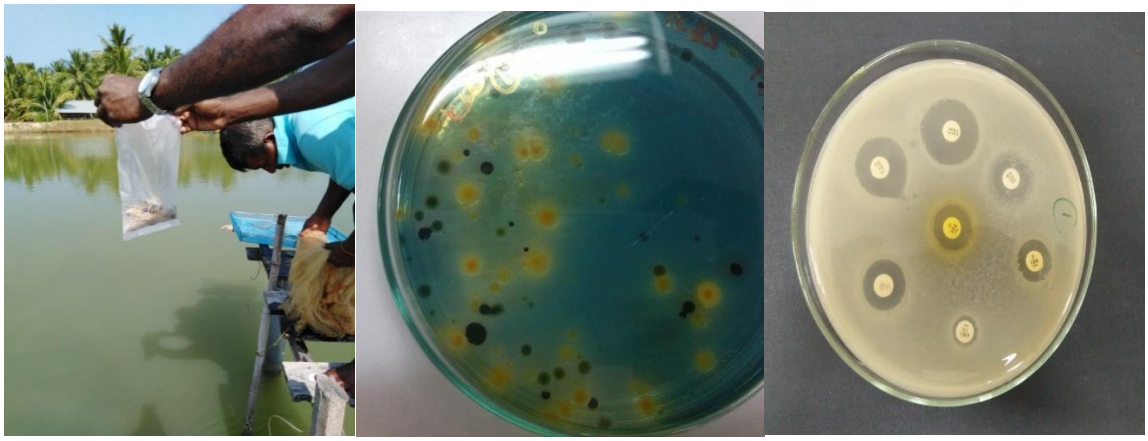
During the study,146 isolates belonging to the family Vibrionaceae identified as, *Aeromonas hydrophila, Vibrio metschnikovii, V. anguillarum, V. parahaemolyticus, V. harveyi, V. vulnificus, V. damsel, V. mimicus*and *V. fluvialis*

Microorganisms isolated from samples were categorized as susceptible, intermediately resistant or resistant based on the size of inhibition zones around each disc as per the interpretive criteria of CLSI guidelines (CLSI, 2010a).

Antimicrobial agent	**Concentration (µg)**	**Interpretative criteria**		
		Susceptible	**Intermediate**	**Resistant**
Amoxicillin	10, 30	5.50%	25.98%	68.50%
Chloramphenicol	30	76.11%	19.40%	4.48%
Nalidixic acid	30	43.70%	35.29%	21.0%
Tetracycline	30	82.96%	11.85%	5.18%
Tetracycline Oxytetracycline Nitrofurontone Nitrofurontone	10 30 30 10	76.64% 82.35% 28.46% 27.80%	11.68% 5.88% 48.78% 46.96%	11.68% 11.76% 22.76% 25.20%

This study showed that *Vibrio* species which are resistant to antibiotics are prevail in shrimp culture environment and are more resistant to amoxicillin in comparison with other antibiotics used in this study.

Results also indicated that the application of antibiotics for the control of Vibriosis in shrimp farms has limited effectiveness due to the development of resistant bacterial strains.



Figures Collection of samples and testing of antibiotic resistance

Component 3 Study on Prevalence of selected antibiotic residues in shrimps*(Penaeus monodon)*, water and sediments of shrimp farms in Puttalam District, Sri Lanka

The present study was carried out to evaluate the current residuals of five commonly used antimicrobials; Chloramphenicol (CHL), Nalidixic acid (NAL), Nitrofurazone (NIT), Oxytetracycline (OTC) and Malachite Green (MG) from three shrimp farms from the Puttalam district. Triplicate samples of each shrimp, water and sediment were collected from Toduwawa, Arachchi kattuwa and Madurankuliya of each three ponds per farm. Analyses were done according to competitive Enzyme-linked Immunosorbent Assay (ELISA) testing protocol, using MaxSignal Chloramphenicol (CAP)-1013-2, Nalidixic Acid-1204-01, Nitrofurazone (SEM)-1069-01, Oxytetracycline-1081-01D, Malachite Green-1019-06A and Thermo Scientific SKANIT software for Microplate Reader. MG showed the highest residuality (138.289 ± 52.998) followed by NIT (6.308 ± 2.340) and CHL (1.516 ± 0.750) in the farms respect to sediments and shrimps. Water had the significantly ($F(2,24) = 6.43$, $p<0.05$; One-way ANOVA test) highest NIT concentration (13.328 ± 7.764) than the sediment (6.980 ± 2.581) and shrimp (5.636 ± 1.989) samples. The MG concentration found in water (3.09 ± 2.05) was significantly lower ($F(2,24) = 31.12$, $p<0.05$; One-way ANOVA test) than the sediment (123.44 ± 65.71) and shrimp (153.14 ± 33.98) samples. OTC was found to be lower (<1.5ppb) than the lowest detection limit (LDL) in all samples. Detected highest concentration (ppb) of NAL was 24.663 ± 12.710 (based on wet sediment weight), and 28.460 ± 5.549 in water, but all the shrimp and all three sample types in two other farms were low (<5ppb; LDL). In Sri Lanka, CHI, NIT and MG are illegal to treat in aquaculture. The results also suggest that there were many active antibiotic residues in the study biota and the environment while causing harmful effects on ecosystems. Antimicrobial residues are prevailing in the shrimp culture environment and evident the use of antimicrobial agents during shrimp farming.

Figures: Collection and preparation of samples for analysis

Component 4 Study on prevalence of ciguatera fish poisoning

The ciguatoxin produced by *Gambierdiscus toxicus* causes ciguatera fish poisoning (CFP) in humans. This phenomenon is in direct link to food web associated with reef fishes. Though several reports on CFP in Sri Lanka, data is tenuous. Thus, this study was done to study present status of CFP in the country: Quantification of ciguatoxin (CTX) as there were some fish based food poisoning cases were reported in Eastern region of the country. 27 samples of reef fish were randomly collected (triplicates of 09 species per site) in Northwest, Northeast and East coasts during March to August 2019. Sample analysis was done according to competitive Enzyme-linked Immunosorbent Assay (ELISA) testing protocol, using Genemed Synthesis IncsQ, USA (GSI) Ciguatoxin (CTX) ELISA Test Kit. (Catalogue#: DE-100680). and Thermo Scientific SKANIT software for Microplate Reader. All the samples were detected with lower than the lowest detection limit (0.06ppb) of CTX through the kit.

All the three regions had no significant ($p>0.05$, Pearson Chi-Square) association between the educational levels and the awareness of CFP. There was no significant ($p>0.05$, Pearson ChiSquare)association between the coastal regions and availability of reef fish in the market. The resultsreviled CFP is not so critical in the three regions. Most of Northern people preferred the taste, color and texture of reef fish and overall likeliness than others. Both Northern and Northeast people showed the, highest fish meat consumption per diet than Northwest. Male had the highest meat consumption than female. People of three coastal regions did not well aware of the CFP. Each region had the highest availability of reef fish in local markets. Ciguatera toxin (ciguatoxin) was not detected in all fish samples (lowest detection limit using ELISA Test kit - 0.06 ppb). Results indicated reported seafood poisoning was not due to CFP.

Fish Type	Location	Fish Type	Location
Jack fish	Silathurai	Jack fish	Mulathiv, Kokilai
North West		North East	
Grouper	Paalakuda, Silathurai	Grouper	Kokilai
Lawaya	Palakuda	lawaya	Nilaweli
Snapper ranna	Palakuda	Snapper	Nilaweli
Snapper (irithambuwa)	Pukkulam	Snapper (irithambuwa)	Nilaweli
Barracuda	Mannar	Barracuda	Kokilai
Jack fish	Silathurai	Jack fish	Mulathiv, Kokilai
Seabass	Silawatura	Seabass	Nilaweli
Emperor	Palugahathurai	Emperor	Kokilai
Parrot fish	Kalpitiya	Parrot fish	Kokilai

Figure: Preparation of samples for Ciguatera analysis

Investigation of incidences of histamine forming bacteria in chilled Yellow fin tuna (*Thunnus albacares*) in export fishery industry of Sri Lanka

Project No: 4.3

Officer responsible : Mrs. Pavithra Ginigaddarage, Dr. G.J. Ganegama Arachchi, Dr. K.W.S. Ariyawansa

Field samples from multi-day boats (MDB) and fish processing factories. From multi-day boats samples comprised of ice (n= 30) from fish holds, swabs (n=30) in fish holds, swabs (n=30) on decks; swabs (n=30) on skin of yellow fin tuna. Ice (n=30) samples from chilled transport vehicles were collected at Dikkowita and Negombo fishery harbors and ice (n=30) from chilled trucks which transport fish to the processing plant were also collected. From the processing plants swabs (n= 18) from fish skin surface, fish loin samples (n=15), swabs (n=17) from floor of processing plant, ice (n=18) from processing plant, swabs (n=17) from chilled transport vehicles and swabs (n=6) from surface of fish rejected from the processing plant were collected. Background data such as area of fishing, number of days of fishing, Amount of ice used, method of icing, weight of fish, temperature of fish and cleaning procedures were also gathered at the time of sampling.

Presumptive histamine forming bacteria were isolated by inoculating the samples on Nivens medium and Violet Red Bile Glucose (VRBG) agar. Plates were incubated at different temperatures (37, 25 and 15 °C) in order to isolate bacteria that have the ability to form histamine at different temperatures. Histamine forming ability of bacteria isolates were confirmed by measuring histamine levels in broth cultures grown in trypticase soy broth (TSB) supplemented with 1.0% L-histidine at different temperatures. Histamine content was measured by using AOAC 977.13 method. PCR was done for those isolates to amplified histidine decarboxylase gene (709 bp) as described in Takashi *et al*., 2003. API 20E test kit was used to identify the isolates biochemically and further confirmation of the identities were done by amplifying and sequencing approximately 1400 bp of the 16S ribosomal DNA (rDNA) for bacteria. PCR product samples were sent to Macrogen Korea for DNA sequencing.

From the samples collected from multiday boats following results were obtained. Out of 21 ice samples collected from chilled transport vehicles, histamine forming bacteria were isolated in 11 instances and they were identified as *Klebsiella aerogens, Enterobacter aerogens, Pseudomonas* spp., and *Serratia rubidaea.* While *Bacillus* spp. was found in an ice sample collected from the fish hold of a MDB. From the 18 swab samples collected from boat decks histamine producing bacteria were isolated at three occasions. They are *Pseudomonas* spp. and *Morganella morgani*. One swab sample collected from fish holds of MDB contained *E.coli* which produced histamine. Two swab samples taken from fish surface were positive for histamine producing *Pseudomonas* spp. and *Aeromonas salmonicida*. From the isolated organisms *Enterobacter aerogens* and *Klebsiella aerogens* isolated from ice samples collected from chill transport vehicles, *M. morgani* isolated from

boat deck formed histamine levels more than 500 ppm in the TSB supplemented with 1% histidine at 15 °C.

From the samples collected from fish processing factories histamine forming bacteria were isolated from fish loin samples, surfaces of rejected fish, surface of fish selected for processing and swabs from chilled transport vehicles. They are *Aeromonas* spp., *Psychrobacter* spp., *Citrobacter* spp., *Shewanella* spp., and *Pseudomonas* spp.,. Weight of fish which loin samples were obtained was in the range of 30 – 64 kg and histamine content was ranged from 4 – 49 ppm.

From this study it can be seen that the histamine forming bacteria were present in ice which used to chill fish, boat deck, fish hold, fish skin (at the harbor), fish loin samples, surfaces of rejected fish and surface of fish selected for processing and swabs from chilled transport vehicles. Therefore, it is necessary to control the occurrence and growth of these bacteria by adopting proper handling and cleaning practices.

Sample analysis is in progress.

Extraction and characterization of bioactive peptides from Tuna fish waste

Project No : 4.4

Officer responsible : Mr. Suseema Ariyarathna

There are about 30 numbers of fish processing factories around Sri Lanka mostly scattered around Colombo and Gampaha districts which focus on export market. Tuna

fish is one of main fish varieties processed for the export market. Considerable amount of waste (skin, bone, head, viscera, black meat) generation occurs during the processing steps. Discarding fish skin, bones and viscera without using leads to environmental pollution while other type of waste selling for lower price. Usage of this waste for a value added product will be important for the industry and the fishermen as well.

“Development and storage condition optimization of tuna fish powder and shelf life enhancement using lemon grass powder as an antioxidant” was study done at Aquatic Product Development Laboratory at IPHT. Tuna fish powder has been prepared using hot air oven and lemon grass powder has been prepared using vacuum oven under low temperature condition. Two type of packaging methods, polypropylene and vacuum packaging was tested and two types of storage conditions, room temperature and freezing conditions was also tested. From this study it has been found that using 10% (W/W) lemon grass powder to tuna fish powder, shelf life of tuna fish powder can be extended in terms of microbiological (APC and Y & M), chemical (TVBN, FFA) and sensory parameters. Vacuum packaging was found as the optimum packaging method and there was no significant quality difference between frozen tuna fish powder and fish powder stored at room temperature. This fish powder can be used as a protein rich ingredient in any food item, including soup mixes, bakery items, snack products etc.

Different trials on protein extraction from tuna fish skin have been conducted using two different methods.

pH shifting method

Salting out method

The amount of protein obtained from salting out method is 65% and it is 35% in pH shifting method. The protein content of Tuna fish skin is around 15-20%. After extracting proteins, it should be freeze dried or spray dried to keep long for peptide analysis.

Recently we have conducted some trials on enzymatic hydrolysis of fish skin waste to obtain peptides. Here pepsin and papain like proteolytic enzymes can be used and fish gut itself is an another source of pepsin enzyme. Therefore, some trials are going on to analyze whether mixing gut and skin can breakdown skin proteins or not. And also trials are going on to extract protein hydrolysates using dried papaya powder as it is the source of papain enzyme. Once finalize the best method for making protein hydrolysates from fish waste, bio-activity tests have to be conducted.

Due to delay in chemicals in 2019 bio-activity tests were unable to conduct and hope to complete during 2020. Further we plan to conduct some product development research studies using protein hydrolysates extracted from fish waste.

Extraction steps of protein

Innovation of seaweed based value added productandanalysis their bioactive compounds

Project No: 4.5

Officer/s responsible: Mrs. Pradeepa Jayasinghe

Effect of incorporation of seaweeds on quality of noodles

Noodles is a staple food in many parts of the Asia and becoming popular around the world because of convenience, less time for preparation and desirable taste and properties. Seaweed play important role in the human nutrition as functional food. The incorporation of seaweed into noodles also been shown improved the nutritional and functional properties.

To meet the objectives of this study it was evaluatedthe sensory quality of noodles by incorporating different seaweed percentages. Therefore in the initial step 1 five different *Ulvalactuca*and *Gracilaria verrucosa* percentages (5%,7%,10%, 15% and 20%)were incorporated and replaced of wheat flour content in the noodles dough mixture. According to the sensory evaluation results 7% Gracilaria and 5% *Ulva*resultedmaximum score level. The selected best treatment in step 1 was used to further formulate noodles with improved textural properties. In the step 2 smoothness of the noodles were improved bymixing with2% and 3% xanthine gum using round and ribbon shape noodles machines.

In step 2 Gracilaria 7% incorporated, 2% xanthene gum and round shape noodles showed significantly highest quality by sensory score. In the same time same highest score observed 3% xanthine, Gracilaria 7% ribbon shape noodles to giving significant effect to the quality. There wasn't significant difference betweensensory quality of market available noodles samples and above noodles mixtures.

Compare to the market noodles the laboratory develop *Ulva* based noodles samples was showed 18% higher mineral content while Gracilaria based noodles showed 13% improvement. All the samples showed protein content in the range of 1.3-4.35% level. *Ulva* based noodles sample showed 2% oil content while *Gracilaria* based products observed zero levels. It can be observed that seaweed based noodles were nutritionally richer than market available noodles.

Experiment 2:

The *Kapphaphycusalvarezii* raw seaweed was collected at 10 days intervals, and extracted the carrageenan content. Initial sample obtain 38.5 % carrageenan yield and 65cm^3/g gel strength. After 10 days carrageenan content increased to yield 56.35% and gel strength also increased up to 162.5c cm^3/g. The gel strength of sample after collected twenty days was found 50% reduction in the yield than sample obtain ten days before,whereasat the same time 74% increased in thegel strength.

Figures : Seaweed based noodles

Application of Bio nanotechnology in Value Addition to Aquatic Resources

Project No : 4.6

Responsible Officer/s: Mr. S. Thiruchenduran (Officer has resigned from NARA with effect from August 2019)

The current study explored three seaweed species, *Caulerparacemosa*, *Sargassumcrassifolium* and *Ulva reticulata*.

Extraction protocols were followed for the phytochemical screening and DPPH scavenging activity separately.

Sequential extraction was followed for the assessment of antioxidant activity. Terpenoids, steroids, phenolic compounds, flavonoids, saponins and alkaloids were present in all three species in detectable levels.

Considering DPPH radical scavenging activity, methanolic extract of *C. racemosa*has shown significantly higher activity with a mean of 54.41±0.85 % and methanolic extract of *U. reticulata*has shown a significantly lower activity with a mean of 21.06±0.04%.

Methanolic extracts of *C. racemosa*and *S. crassifolium*and ethyl ether extracts of *U. reticulata*and *S. crassifolium*have shown significantly higher radical scavenging activity.

Water has shown poorer radical scavenging activity for all three species. Based on the results obtained, all three species have active compounds. Polar fractions of *C. racemosa* and *S. crassifolium*and non-polar fractions from *U. reticulata*suitable to use for isolation of bioactive compounds.

Testing Services of IPHT

New Scope of accreditation
Heavy metals
Hg,Cd,As,Pb
Fatty acid profile
Poly Aromatic Hydrocarbon
Amino acid profile
Total protein

Quality Control Laboratory (Microbiological and Chemical units) of IPHT which has obtained accreditation status for several analysis parameters as per ISO/IEC 17025: 2005

Standards. Technical Assistance were obtained from UNIDO for extending scope of accreditation.

Testing Services of laboratories have been obtained by industry, especially, fish exporting companies; ministries, academic institutes and other stake holders. Total of 1161 samples were analyzed for microbiological (702) and chemical (459) quality. Relevant to these samples, 397 Test Reports were issued by IPHT and total testing income to NARA were LKR 4,278,450.00. Forty percent (40%) of total revenue will be remitted to NARA as royalty payment.

Sensory evaluation of 134 No. of canned fish samples (134X20Tins) under IPHT mini projects (V5115) and paid Rs. 1,420, 400.00 as analyzing charges by SLSIto NARA. IPHT hasissued 27 nos. of test reports to SLSI for above evaluation.

Extension programs conducted:

For 29 employees of " HelaBojun "- Pambala (හෙළබොජුන්හළ,පම්ඹල)on 09/05/2018
For 35 selected employees of " HelaBojun "- Puttlum (හෙළබොජුන්හළ,පුත්තලම)on 05/07/2018

For 20 stake holders on 18/08/2019 at NARA/ IPHT product development laboratory

For 10 stake holders on 18/09/2019 at NARA/ IPHT product development laboratory

For 20 selected participants engaged with sea weed culture at Kalpitiya on 10/10/2019





Technology Transfer Programmes for stake holders

Success stories

Production of seaweed based Jelly and puddings at sales outlets of “Helabojun hala” at Pambala and Chilaw




Training/Awareness programmes conducted during year 201**9**

Date	Name of the progrmme	Aim	Participants	Place
17/06/2019	Workshop for CFC Staff	Proper handling and quality management of seafood	120 CFC staff	Negombo
22/07/2019	Awareness forPublic Health Inspectors from Ampara District	Seafood Quality and Safety	PHI	NARA
08/09/2019 to	Awareness on Post Harvest Technology and production of Value added fish products	To upgrade the livelihood of	Fisher community	Wankaanai - Mannar

11/09/2019		the community		
22/09/2019 to 25/09/2019	Awareness on Awareness on Post Harvest Technology and production of Value added fish products	To upgrade the livelihood of the community	Fisher community	Wankaanai - Mannar
07/11/2019	Awareness on Post Harvest Technology and production of Value added fish products	To upgrade the livelihood of the community	Fisher community	Pitipana - Negombo
18/08/2019	Awareness on Production of develop raw materials &production of Value added sea weed based products	To upgrade the knowledge & To provide technical support	Stake holdersengaged with Production of sea weed based products	Processing unit - NARA
10/10/2019	Awareness on production of Value added sea weed based products	To upgrade the livelihood of the community	Selected participants engaged with sea weed culture	Kalpitiya
25/11/2019	Safety issues in bivalve farming	To enhance awareness	Hoteliers	Negombo

Visit to the Maligawaththe CFC Stall on 27th May 2019 and a report was submitted to CFC with observations and recommendations

Other activities

Participation of "Widhu Soba (විදුසෝභා)" Exhibition on Identification of fresh fish at Sri Rahula school Malabe on 16/09/2019

Attending to meetings at the ministry of fisheries and aquatic resources, DFAR, Ministry of health, SLCARP, MRI etc representing IPHT NARA.

Involvement for degree curriculum development at Ocean University

Local trainings attended

Training Programme	Date	Venue	No. of participants
Molecular biology training	16th -18th January, 2019	Genetec	05
Workshop on understanding the CODEX process	25th and 26th February	Colombo	02
Proposed biosafety regulatory procedures for Living Modified Organisms (LMOs) in Sri Lanka	28th February 2019	Colombo	02
Workshop in HACCP/ISO 22000:2018 standard and implementation of food safety management systems	09th and 10thMay, 2019	SLSI	02
Method validation	01st -03rdJuly, 2019	HARTI	01
Media quality control and reference culture maintenance	26th-28thAugust, 2019	ITI	02
Fleming fund fellowship-AMU/C servillance training workshp programme	03 rd Octomber,2019	Marino Beach Hotel	01

Overseas trainings attended

Training Programme	Date	Venue
Pavithra Ginigadderage Aquatic animal disease management of fisheries products in the production stage	27th October – 14th November, 2019	Busan, South Korea
Maduni Pattuwe Arachchi Protocols for the production of high value secondary products from fish and shellfish processing	25thNovember-22nd December,2019	Central Institute of Fisheries Technology, Kochi, India

Supervision of undergraduates

Following undergraduates were supervised by Principal Scientist, Senior Scientists and two Scientists attached to IPHT

L.D.K. Perera,BSc **(**Biological Science), University ofKelaniya

B.V.D.K. Abeyrathne,BSc (Biological Science**),** University ofKelaniya

P.W. Nishadi, BSc (Biological Science), University ofKelaniya

W.D.L.Samidu, BSc (Biological Science), University of Kelaniya

E.M.T.Kulasinghe, BSc (Zoology), University ofKelaniya

S.B.Sahan, BSc(Zoology), University ofKelaniya

M.P. Liyanage, BSc(Zoology), University ofKelaniya

A.N.H. Silva, BSc (Zoology), University of Kelaniya

M.H.P.Lakmali, BSc (Zoology), University of Kelaniya

S.P. Vijayarathna, BSc (Zoology), University of Kelaniya

S.M.P.D. Senanayake, BSc (Microbiology), University ofKelaniya

T.A.N. Gunarathna, BSc (Aquatic Resources), Uva Wellassa University

K.H.G.T. Sandamini, BSc (Aquatic Resources), Uva Wellassa University

N.G.S. Perera, BSc (Applied Sciences),University of Sri Jayawardhanapura

S.K.M.R.J. Athurupana, BSc (Animal and Food sciences),Rajarata university

R.H.Ukwatta, BSc (Animal and Food Sciences),Rajarata university

H.P.K.E.Gunarathne, BSc (Animal and Food Sciences),Rajarata university

Publications

Jayasinghe P.S., Pahalawattaarachchi V., Ranaweera K, K., D., S.Perera R. (2019) "**Dietary fiber content, fatty acid and starch digestible rate of seaweed and seaweed based products in Sri Lanka.** Journalof Acta scientific nutritional Health, Vol.3 Issue 7,pp 143-146.

Jayasinghe P.S., G. Ganegamaarchchi, Perera R. (2019) "**Formulation of nutritionally rich seaweed based palmyrah jam.** Journal of ACTA scientific nutritional Health, Vol.3 Issue 8, pp 54-59

K. W. S. Ariyawansa, S. Gallage, P. Ginigaddarage, K. Hettiarachchi, and G. P.Roshan, (2019). Microbiological quality of water from Puttalam Lagoon to find suitability for natural relaying of bivalves. Proceedings of the National Aquatic Resources Research and Development Agency, pp. 65.

P.H.Ginigaddarage, G.J.GanegamaArachchi, K. W. S. Ariyawansa, K.S.Hettiarachchi,G. P.Roshan,S. Gallage, S. Abhayaratneand C. Nanayakkara (2019). Isolation of histamine producing bacteria from multi-day boats landed at Dikkowita fishery harbour. Proceedings of the National Aquatic Resources Research and Development Agency, pp. 66.

S. Gallage,K. W. S. Ariyawansa, P.H.Ginigaddarage, K.Hettiarachchi and G. P.Roshan (2019). Antibiotic resistance of Vibrio species isolated from shrimp culture environment in Puttalam District Sri Lanka. Proceedings of the National Aquatic Resources Research and Development Agency, pp. 67.

Ganegama Arachchi, G. J., Ginigaddarage, P. H., Gunasekara, A. M. G. U., Roshan, G. P., Gallage S., Senevirathna, S., Pathirage, M.(2019). Microbiological quality of ice at different stages of production in Sri Lanka. Proceedings of the National Aquatic Resources Research and Development Agency, Scientific Sessions 2019, Sri Lanka. pp. 69.

National Hydrographic Office

National Charting Programme

Project No: 7.1

Responsible Officer/s: Mr.Roshan,Mrs.Nilupa

Objective/s: To supply necessary charts and maps to variety of end- users, not limited to the marine and maritime trade, but also for ocean and seabed research, environment protection, exploration activities and naval requirements etc.,

According to the NARA Act No. 32 of 1996 the NHO/NARA has a national responsibility to provide updated hydrographic information of our water for safety of navigation. The NHO also has an international responsibility and obligation to make all hydrographic information available to mariners under Safety of Life at Sea Convention (SOLAS) Chapter V, Regulation 9 ofInternational Maritime Organization (IMO).

The importance of this has led NHO to initiate **National Charting Program(NCP)** to fulfil the requirement for Chapter V, Regulation 9 of SOLAS convention and the maritime development of the country and the region. Under NCP following Nautical and Coastal Charts were planned.

1. Nautical Chart from Trincomalee to Kudremalai Point

2. Bathymetric data acquisition for Little Basses Reef to Pulmoddai Roads

3 .Bathymetric data acquisition for Coastal Chart Weligama to Colombo.

4 .Upgrading existing charts

Methodology: As National Hydrographic Office of Sri Lanka, data acquisition in National Charting Program is been carried out according to specifications given by S-44 (IHO Standards of Hydrographic Surveying) of International Hydrographic Organization (IHO).

Considering the availability of financial, physical resources and weather constrain, especially Monsoon pattern in Sri Lanka, and Surveys for nautical charting were planned as follows

Activity	Total Area belongs to the Chart (Sq.km)	Target Area for Year 2019(Sq.km)
1.Bathymetric Data Acquisition for Costal Chart Trincomalee to Kudremalai Point (1:300,000),Nautical Chart Mannar Island (1:75,000)	30,000	14,985

2.Bathymetric data acquisition for Little Basses Reef to Pulmuddai Roads(1:300,000)	33769	4565 (Up to 200m Isobath)
3 Bathymetric Data Acquisition for Costal Chart Weligama to Colombo (1:150,000)	8792	1926 (Up to 200m isobaths/0

Table 1: Target areas of Nauticaland Coastal Charts for year 2019

1.0Costal Nautical Chart Trincomalee to Kudremalai Point

NHO has planned to produce a coastal chart from Trincomalee to Kudremalai Point (Scale-1:300,000) covering about 550 km coastal stretch from East to West of Sri Lanka. Total sea area covering from this chart is about 30,000 km^2.Necessary surveys were planned in two phases. 40% of the total area was covered during the year 2017 and could not continue Offshore surveys in year 2018 due to unavailability of RV"Samuddrika". Anyhow northern island area was surveyed using small boat and fair sheet of the Northern Island was completed.

During the year 2019 NHO has planned to complete the 98% of the chart including Nautical Chart for Mannar Island as a separate chart. Due to unavailability of RV"Samuddrika" for a long period of time NHO could completed only 60% of the targeted area.

Surveys for Nautical Chart "Mannar Island" could not start due to permission issue from the Sri Lanka Navy.

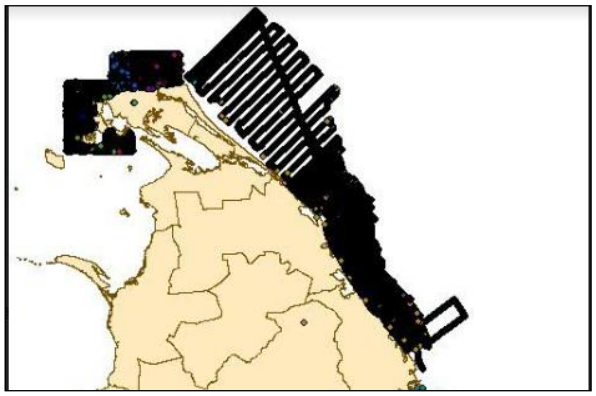


Figure 4: The area covers in Coastal Chart "Trincomalee to Point Pedro"

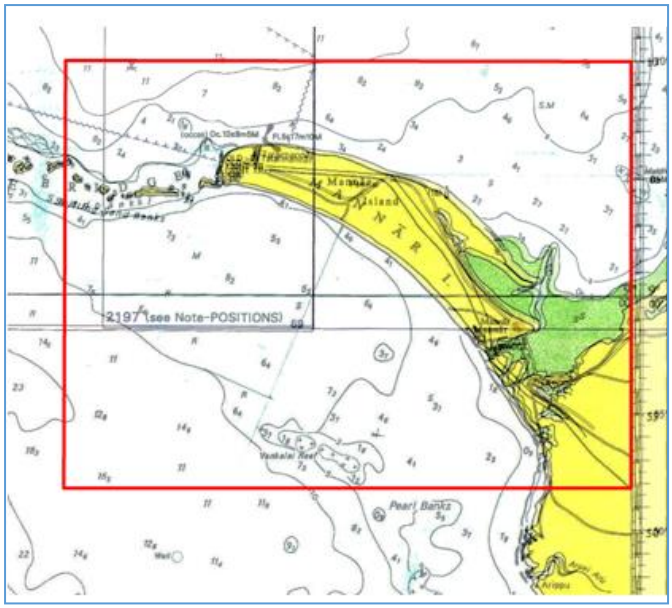


Figure 1:1 Nautical Chart “Mannar Island” intended to complete year 2019

2. Coastal Nautical chart “Little Basses Reef to Pulmudai Roads”

According to the National Nautical Chart Index, the total coastal belt of Sri Lanka intended to cover with five small scale charts. Nautical Chart “Little Basses Reef to Pulmoddai Roads” is one of those. This covers 250 km long coastal stretch from South to East of the island. The total area intended to survey in two phases. During the phase one NHO has planned to complete surveys up to 200m isobath using RV”Samuddrika”. Due to unavailability of RV “Samuddirka”, the data collection couldn’t completed as planned.

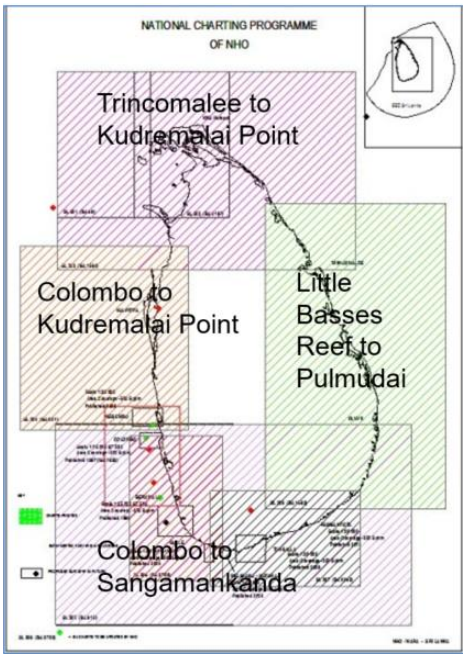


Figure 1.3: Nautical Charts covering the entire coastal belt

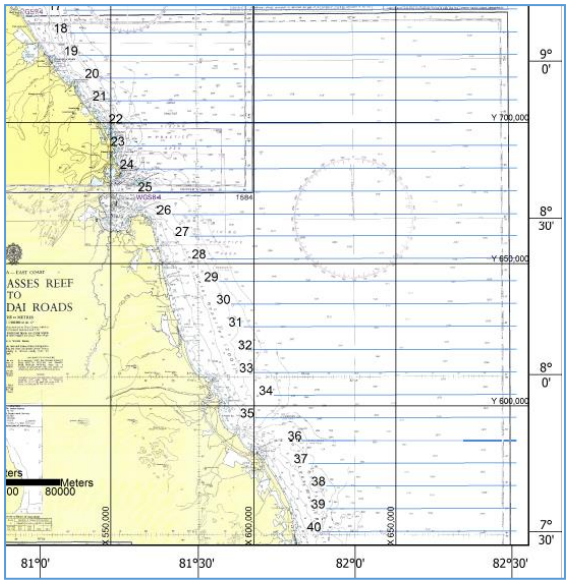


Figure 1.4: Nautical Chart "Little Basses Reef to Pulmuddai Roads"

3. **Costal Nautical Chart Weligama to Colombo (1:150,000)**

60% of the chart was completed at the end of year 2018 and NHO /NARA has intended to complete surveys up to 200m isobath .Only 10% of the planned area could completed during the year 2019 since unavailability of RV"Samuddrika" for a considerable time period. Sri Lanka Navy hydrographic unit assure to provide bathymetric data beyond the 200m isobath up to the chart limit

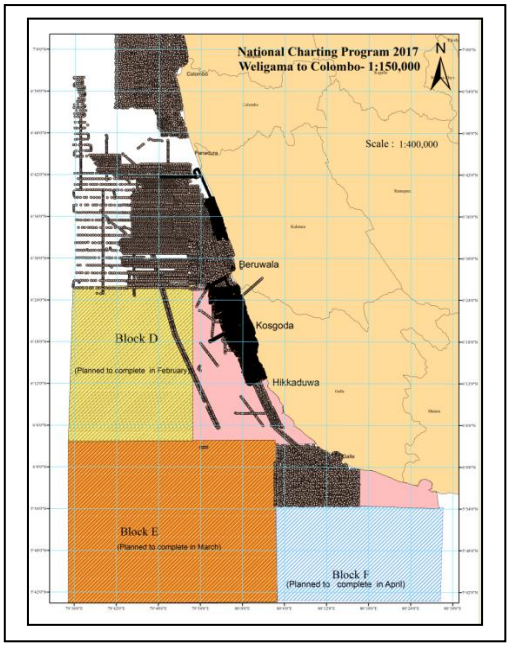


Figure 2: Coastal Nautical Chart "Weligama to Colombo"

4.0 Upgrading Existing Charts

The published charts should be maintained to ensure the validity of existing data as the sea bed is subjected to change due to natural phenomena such as Tsunamis, storms or any other extreme weather condition or by other manmade hazard. Any changes of bathymetry are needed to be applied timely. Necessary communication links has been maintained with the relevant authorities (Sri Lanka Port Authority, Director/ Merchant Shipping).

2. Coastal Nautical Chart Little Basses Reef to Pulmudai

Activity	Chart	Total Area belongs to the Chart (Sq.km)	Target Area in Year 2019 (Sq.km)	Physical Progress in Year 2019 (Sq.km)
1.Bathymetric Data Acquisition for Costal Chart Trincomalee to Kudremalai Point	1.Coastal Nautical Chart Trincomalee to Kudremalai Point(1:300,000) 2. Nautical Chart "Mannar Island"	30,000	14,985	8900
2.Bathymetric data acquisition for Little Basses Reef to Pulmuddai Roads	2.Coastal Chart: Little Basses Reef to Pulmudai Roads (1:300,000)	33769	4565	0
3 Bathymetric Data Acquisition for Costal Chart Weligama to Colombo	3.Coastal Chart: Weligama to Colombo	8792	1926	100

Out puts:

Expected Outcomes:

Nautical charts to ensure safety navigation around Sri Lanka and also to make available hydrographic data for blue economy.

1. Fair Sheet of Trincomalee to Kudremalai Point with the scale of 1:300,000

Fair sheet for covering 50% of coastal nautical chart from"Little Basses Reef to Pulmuddai Roads with the scale of 1:300,000

Fair sheet of Coastal nautical chart of Weligama to Colombo with the scale of 1:150,000

Modeling the spatial variability of tide in the Jaffna archipelago

Project No: 7.2

Responsible Officer/s: Mr.Roshan,Mrs.Nilupa,Mr.Rathnayake

Objective: The objective of this study is to develop a tidal prediction system for the Jaffna archipelago.

Methodology:Autonomous sea level stations were established and collected water level data at Mandativu, Kayts, Kurikadduwan, and Point Pedro. Tidal characteristics of these locations were determined from harmonic analysis of collected sea level data.Tidal inversion software (OTIS) developed by Oregon State University (OSU) was used for modelling the tide for the study area. Modelled tides were validated using the observed tides.

Activity	Progress
1.Installation of autonomous tide gauges	Installed autonomous tide gauges at Mandativu , Kayts, Kurikadduwan and Point Pedro
2.Levelling installed tide gauges to MSL	levelled tide gauges at Mandativu and Point Pedro to MSL (Tide gauges at Kurikadduwan and Kayts couldn't be connected to MSL due to unavailability of appropriate Benchmark nearby)
3.Maintenance of tide gauges	Done
4.Acquisition of current data	Collection of current data couldn't be done because of instrumental failure of the current meter
5. Processing bathymetric data	Done
6. Tidal data analysis	Done (harmonic analysis of collected sea level data)
7. Tidal modelling and validation	Done
8. Report writing and documentation	Done

Table 4. Progress of activities

Progress: 80%

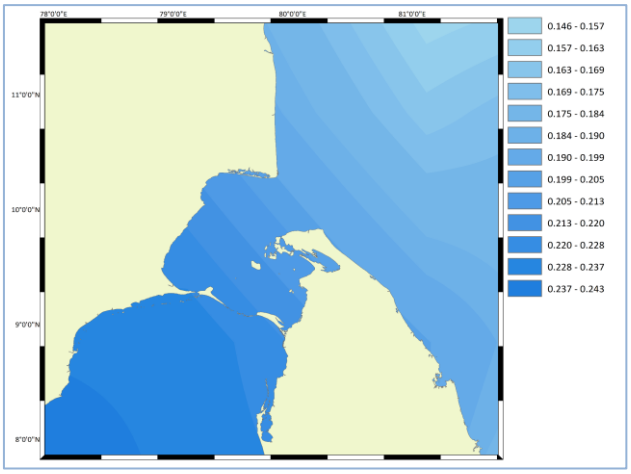


Figure 6. Amplitude of M2 constituent (Amplitude in meters)

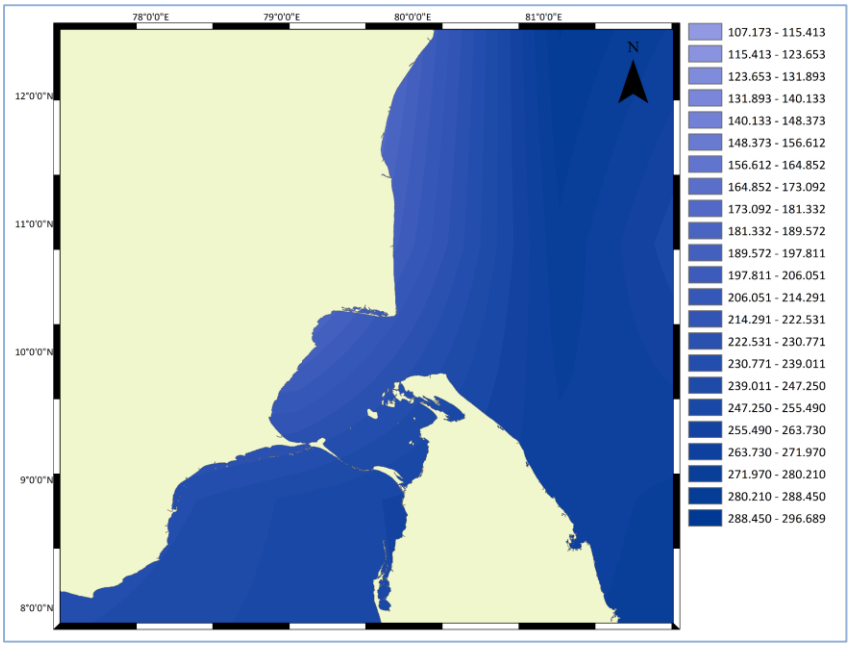


Figure 7 Greenwich phase lag of M2 constituent (in degrees)

Output: Co-tidal charts (Co-amplitude and Co-phase charts)

Reson Seabat 8101Multibeam backscatter data as a tool for sea bed characterization

Project No : 7.3

Responsible officer/s : Mr.Roshan,Mrs.Nilupa

Objective - Creation of detailed map of seabed topography and acoustic backscatter data;these data have been used to infer sediment and habitat types

Methodology: - Multibeam backscatter data provides information on the hardness of the sea floor and is used to differentiate between different types of sea floor such as hard rock or soft sediment. Thisdata; backscatterdata; can be used as a proxy to understand the characteristics of the sea floor and also provide information on the sediment grain size and sea floor roughness.

Activity	Progress
1.System Preparation and software Installation	Done
2.Data Acquisition	Could not continue due to system failure. Found that system need upgrading
3.Grab Sampling	- stopped the project-
4.Data Processing	
5.Data Analysis	
6. Mapping & Report Writing	

Outputs - Map indicating sea bed texture (mud ,sand ,rocks etc.)

National Institute of Oceanographic and Marine Sciences Division

Tuna fishing ground advisory and fisheries information service

Project No : 6.1

Responsible Officer/s : Mr. S. S. Gunasekara

Introduction

Total marine fish production of Sri Lanka in 2017 amounted to 449,440 tons while offshore and high seas fishery contributed 189,720tons, 40 % (MFAR, 2018).Coastal fishery is still the major contributor to fish production of the country which is contributed around 60% to the total marine fish production while 51.6% to the total fish production of the country. The fisheries sector contribution to the Gross Domestic Production (GDP) at constant price in year2017 was 1.3%. Operated fishing boats have been 4,447 and 1500 boats have been equipped with VMS. Sri Lankan offshore high seas fishery sector operated with by long line, gillnets and ring net or combination of them. Long line fleets mainly targeting large pelagic species such as yellow fin tuna (*Thunnusalbacares*), big eye tuna (*Thunnusobsesus*). Major target of the gillnet operators is skipjack tuna (*Katsuwonuspelamis*) and ring net targets for Indian scad (*Decapterusrusselli*).

Development of fishing ground forecasting system for offshore fishery in Sri Lanka was started in 2007 and implemented in 2008 on experimental basis. Experimental forecasts were released in weekly basis to selected fishing fleets and the validation results of the forecast have shown encouraging results. Hence, the forecast dissemination was expanded to all major fishery harbors via fax, email and radio communication. Since November 2015, fishing ground forecast provide twice a week. Forecasting area has been increased to cover almost area where Sri Lankan fishing vessels fishing. During 2019, fuzzy logic base forecasting model was developed and accuracy assessments with VMS verified fisheries logbooks shown 67% accuracy of improved forecasts.

However, there were several challenges have been found to be overcome in order to enhance the fishing efficiency ~~to~~ that will ensure the high catch rates. Migratory behavior of tuna species is one of the major challenges; it can be horizontal as well as vertical. Vertical migration is a slow process with the thermo cline variability influenced by mixing which depends on seasonal monsoons winds. However, horizontal migration is more complex and related to the biological life stages.

Usages of near real-time satellite information are therefore important and providing information on swimming depth of yellow fin tuna can make a considerable impact on the fishing efficiency. As the mixed layer of the Indian Ocean is heavily influenced by its monsoonal wind reversals, the tuna vertical migration due to thermo cline variability is significant. As a result, depth of deployment of tuna long line is uncertain and experienced low catch rates. The existing fishing ground forecast system has incorporated with fishing depth to ensure the fishing efficiency of long line. The developed model predicts temperature vertical profiles to determine swimming temperature of tuna enabling to maps the depths of tuna resources.

Thus, the fishing depth is found to be an important element to be accompanied with forecast information to ensure high catch rates. Yellow fin tuna are known to preferentially occupy the surface mixed layer above the thermo cline (Dagorn et al., 2006). As the mixed layer of the Indian Ocean is heavily influenced by its monsoonal wind reversals, the tuna vertical migration due to thermo cline variability is significant. As a result, long line deployment is uncertain and experienced low catch rates. Therefore, predictions of temperature vertical profiles were a challenge. Thus, a methodology was developed to predict temperature vertical profile of the ocean using sea surface temperature and sea surface height information from satellite and incorporated into the existing fishing ground forecast system (Rajapaksha*et al*., 2014). This methodology has several limitations such as ocean surface conditions affect by wind forces and mixed layer dynamics. Therefore, a new method was developed based on the temperature profile data provided by Copernicus Marine Environment Monitoring Service (CMEMS). The CMEMS provides model based regular information on the physical state and dynamics of the global oceans in ¼° spatial resolution. It has more advantages due to its high spatial and temporal resolution as well as based on multiple data sources.

Objectives

To enhance the economic efficiency of offshore/high seas fishery by providing information on potential fishing ground advisory to multi-day fishing vessels

Outputs

Potential fishing ground advisories for tuna multi-day fishery boats.

Outcomes

Increased economic efficiency of offshore fishery sector and reduce the fishing pressure on coastal fishery resources.

Project areas

Project area consist of the Indian Ocean where large pelagic fishing operations conducted by Sri Lankan fishermen from all coastal districts.

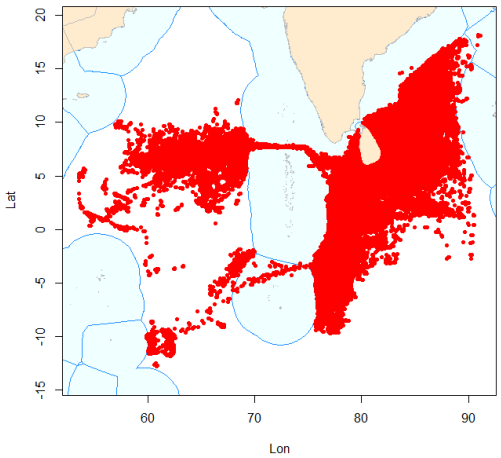


Figure 1: Fishing extent of Sri Lankan fishing vessels in Indian Ocean

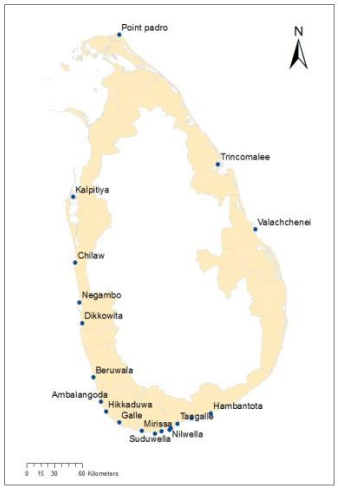


Figure 2: Fisheries harbors for data collection

Methodology

Fishing ground forecasting

Satellite data, model data were downloading and processed three times a week. Multi-criteria model developed under previous project is used to predict potential fishing areas for tuna. This output is coupled with depth prediction model and produce final maps for dissemination.

Fishing Depth Prediction

The operational Mercator global ocean analysis and forecast system is providing high resolution 10 days of 3D global ocean forecasts which are updated daily. This product includes daily mean of temperature, salinity, currents, sea level and mixed layer

parameters from the top to the bottom. It also includes hourly mean surface fields for sea level height, temperature and currents.

Fishery data from logbooks have been collected by DFAR is available since January 2016. Temperature Depth data of long lines were collected using TDR sensors for 6 months and the data are available from June 2012.

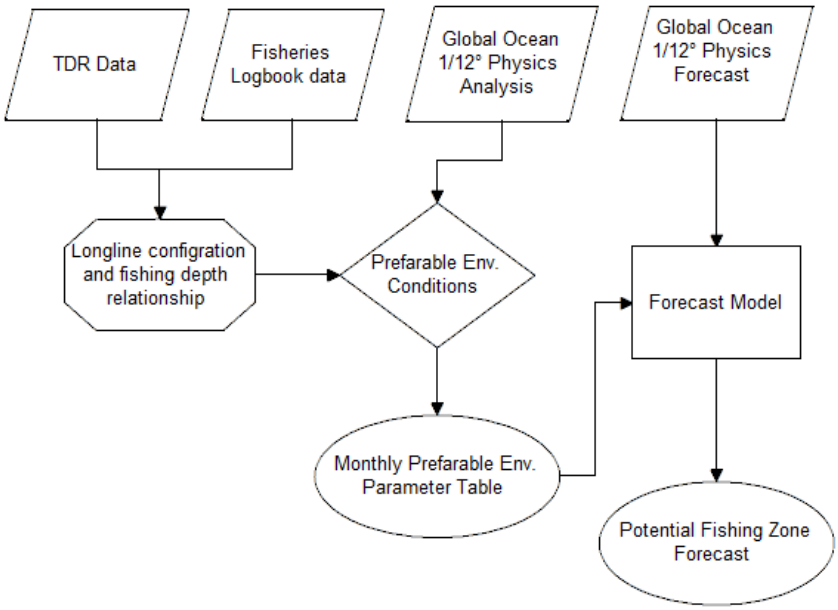


Fig.1 Flowchart of the Methodology

TDR and related fisheries data will be used to obtain relationship between long line configuration and fishing depth. This relationship can be used to predict fishing depths that useful to adjust long line configurations. Thus, the hooks will be reached to the predicted fishing depth. Ocean environmental conditions of the entire water column will be obtained from CMEMS modeled data. Generalized Linear Model (GLM) and Empirical Cumulative Distribution Function (ECDF) will be used obtain monthly preferable ocean parameters for tuna aggregations. This parameter table can be used as input for the forecast model to predict potential fishing zones and fishing depth prediction based on CMEMS ocean status forecast. To validate the fishing ground forecast, logbooks and VMS data will be used. Flowchart of the methodology is show in Figure 1.

Activities

CMEMS ocean model data download and analysis

Fishery data collection: VMS data fisheries data

In-situ data collection (TDR, oceanographic data)

Model development

Generating fishing ground forecast maps

Validation of results

Disseminate information by TP, fax and internet to the users

Awareness programs for fishermen, vessel owners and other stakeholders

Results

Tuna fishing ground forecast

109 potential fishing ground forecasts were produced and disseminated via fax, telephone and email, during 2018. Since February 2017, forecast map was disseminated with ITN *Puwathsatahana* program on every Thursday and Saturday on 0700 am.

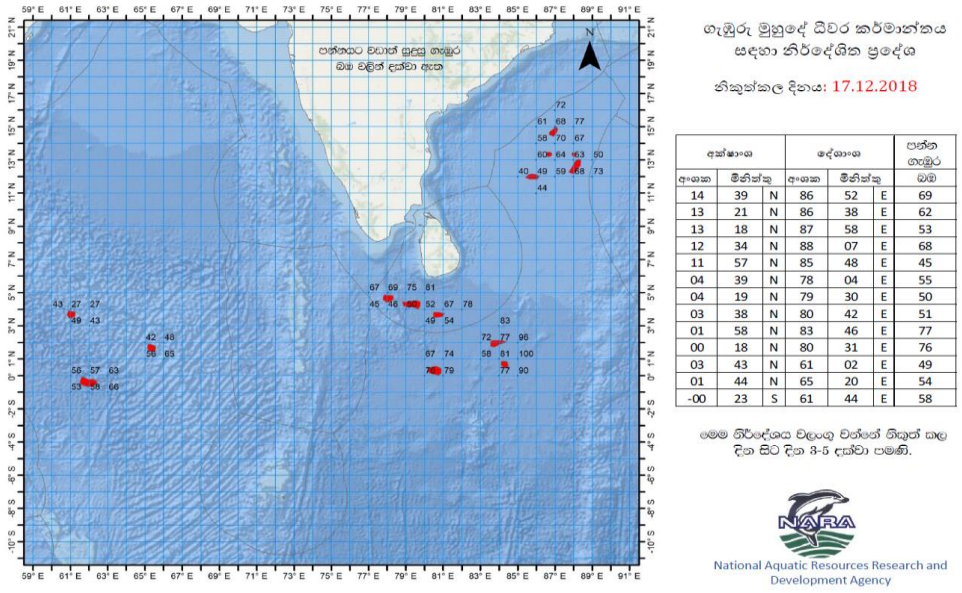


Figure: Forecast map (Potential areas are shown in red color)

75% of forecast production and dissemination target was achieved during 2018. There were several limiting factors such as technical failures of computers, unavailability of external data, internet connection and unavailability of human resources.

Operational fishing ground forecasting depends on availability of near real-time satellite data and global physical forecast products. There were several events due to service

provider's maintenance and breakdowns caused to interrupt project activities. Those events can't be avoided as NARA haven't capacity to receive direct satellite data and processing at NARA. Also, NARA has limited capacity to develop NARA own physical ocean models for ocean state forecasting.

Fisheries database was updated with VMS data from January 2018 to May 2018 and Fisheries log book data of 2017. Due to technical limitations of DFAR, VMS data were not received since May 2019.Availability of accurate fishery data is crucial for success of this project.

Fisheries awareness interviews have been conducted on Dikowita, NegamboChilaw and Kalpitiya fisheries harbors.

E-mail user community has been improved twice since 2016 and more than 210 fishermen and fisheries officers are receiving fisheries advisory.

The accuracy of predictions can be improved significantly with in-situ data collection by temperature, depth sensors attached to longline fishing gear. It is highly recommended to give a priority to purchase these sensors directly from manufactures during 2020.

The fisheries information web portal is essential for dissemination of fisheries information to a wider group of stakeholders. Department of fisheries has agreed to provide web facilities to disseminate fisheries information through their website from 2020.

Recommendations

Incorporate ocean physics models and in-situ information to improve prediction. As our current fishing ground advisory based on near real-time data, it would be highly advantageous, if we could provide fishing ground advisory based on forecasted ocean conditions few days ahead. Thus, fishermen will be able to plan their cruise based on advisory and ultimately receive more economic benefits than just roaming for fishes here and there in the ocean.

Awareness of Skippers and owners of multiday fishing boats about PFZF of Nara will be key factor to success of project. Therefore, awareness programs should conduct frequently.

VMS and logbook dataset need to process and analyses for accuracy assessment of fisheries logbook data and improvement of Tuna fishing ground forecasting system of NARA.

Conclusions

Fishing ground forecasting and fisheries information service project has been successfully conduct its activities with few limitations.

Modeling of Coastal Sediment Dynamics and Coastal erosion on the North-eastern Coast of Sri Lanka.

Project No: 6.2

Responsible Officer/s: Mr. R.M.R.M. Jayathilaka

Introduction

The study aims to trial a cost-effective modeling approach to derive a reasonably accurate sediment transport along the natural sand dune along the coastline between Point Pedro and Mullathivu.

Natural sand dunes play a vital role in protecting our beaches, coastline and coastal developments from coastal hazards such as erosion, coastal flooding and storm damage. Sand dunes protect our shorelines from coastal erosion and provide shelter from the wind and sea spray. Sand dunes also provide a future supply of sand to maintain the beach. The wider the band of dunes, the larger the reservoir of sand. The height of natural dunes also provides protection from coastal flooding from storm surge and wave action.

Figure 1: The sand-dunes of Kudathanai (Jaffna), photographed in early 2012s [Image Courtesy: Wikipedia].

The Vadamaraadchi sandbar (silica-rich sand) is located in this coastal stretch. It is believed that the sand bar was formed by sand that comes from the mouths of the east-flowing rivers of India. This sand that comes to Jaffna through long-shore drift within the continental shelf that links India and the island is deposited as sand dunes along the northeast coast of the peninsula, by the northeast wind. Therefore, to understand the coastal sediment transport and near-shore wave climate, the coastal stretch between Point Pedro and Chundikkulam has chosen for the case study.

The coastline erosion/accretion of the coastal stretch between Nakarkoyil to Aliavalai has studied under NIOMS-NARA project in 2016. In data poor environments, such as commonly found in developing countries, numerical modelling is a promising method to derive a qualitative regional sediment transport, and to identify the environmental forcing/human interventions that govern the sediment budget.

Objectives :

1.Establish a calibrated sediment transport model and to provide a methodology to minimize the identified contemporary coastline erosion problems in the area.

2. To determine the near-shore waves, currents, sand transport rates and morphology on adjacent coastal environment.

Methodology :

Numerical simulations were carried out by means of the process-based model Delft3D to obtain state-of-the-art estimates of the annual longshore sediment transport rates. Delft3D combines a short-wave driver (SWAN), a 2DH flow module, a sediment transport model (L. Van Rijn & Boer, 2006), and a bed level update scheme that solves the 2D sediment continuity equation. In particular, the hydrodynamic and sediment transport module Delft3D-FLOW, and the wave module Delft3D-WAVE were used (G. R. Lesser, 2009). Delft3D-WAVE module is based on SWAN (Simulating Waves Near shore), a third-generation wave model that uses action density (equal to energy density divided be the relative frequency) to describe development of the wave spectrum.
ERA-interim from the European Centre for Medium-Range Weather Forecasts (ECMWF) were used to determine offshore wave climate. ERA-Interim is the recently published data and re-analysis dataset which covers the period from 1979 to present (Uppala et al., 2005) (Dee, 2011). The schematized offshore wave scenarios will be transformed towards the coast with the Simulating Waves Near shore (SWAN) model to obtain the representative wave climate in near shore (Walstra, 2013).

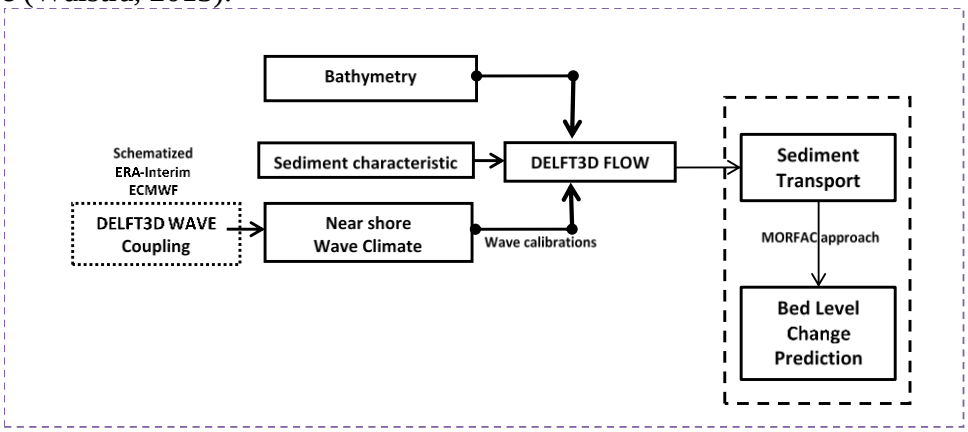


Figure 2. Flow chart of morphodynamic modeling.

Bed level update in coastal morphodynamic models is facilitated via the sediment continuity equation. However, as the time scales associated with bed level changes are generally much greater than those associated with hydrodynamic forcing, to enable reasonably fast computations, these models have until recently adopted the approach of updating bed levels and feeding them back into the hydrodynamic calculations only every few hydrodynamic time step (Lesser, 2009). The MORFAC approach departs from this traditional way of thinking and essentially multiplies the bed levels computed after each hydrodynamic time step by a factor (MORFAC) to enable much faster computation (Ranasinghe, 2011) (Benedet, 2016). The significantly up scaled new bathymetry is then used in the next hydrodynamic step.

Study Area:

Figure 4. Map showing the study area for the proposed project. The transacts (red line) along with the proposed locations for beach sampling (yellow triangles), suspended sediment concentration (blue dots) and deploying current meter (red stars).

The study area extends approximately 60 km along the coastal stretch from point Pedro to Chundikkulam.

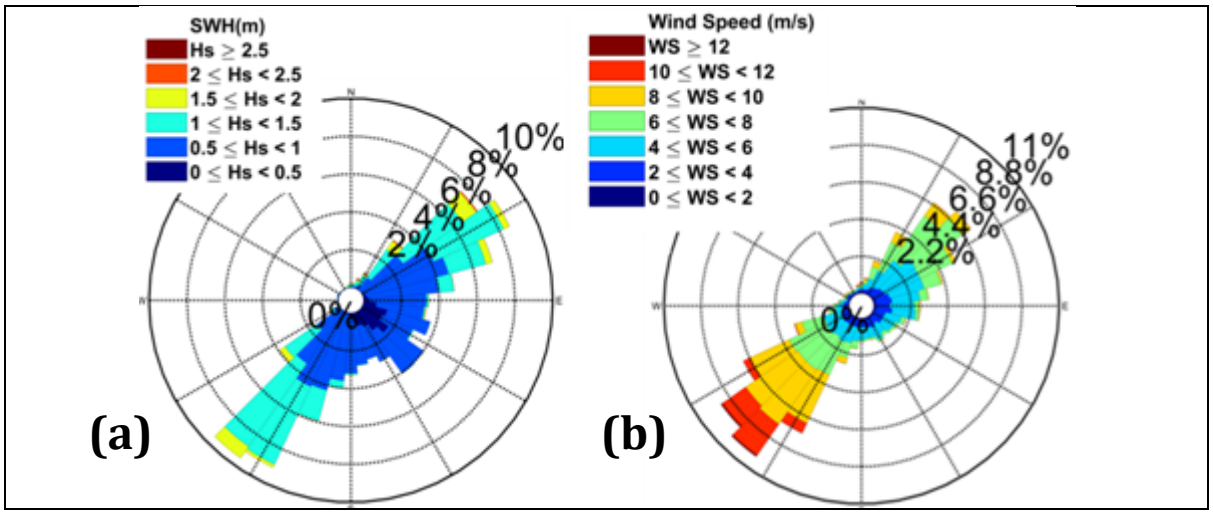
Expected Output

1. Potential sediment transport pattern along Northeastern coast of Sri Lanka.
2. Erosional and depositional areas for the Northeastern region of Sri Lanka.
3. Spatial/temporal changes of grain size of beach profiles.

Results

Wind-Wave Climate

Sand sediment characteristics and total suspended sediment concentration between Point Pedro and Chundikkulam has been studied. Boundary conditions (wave-wind climate, water level and sand characteristics etc.) for said coastal stretches were set up for modeling and to be finish by 2019.



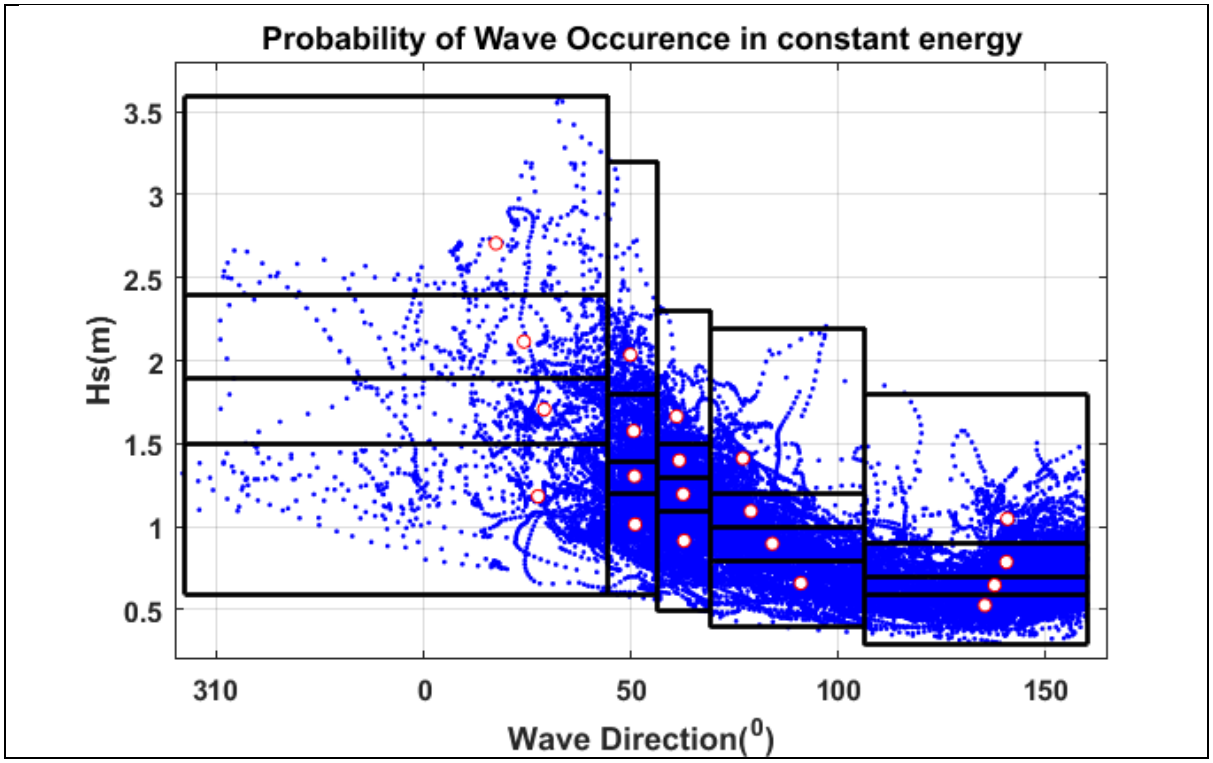


Figure 2: Annual wave(a) and wind(b) climate of Chundikulam, Jafffna and representative wave conditions (black lines: boarder of the bins, blue dots: individual waves red dots: representative wave conditions) for Offshore Wave boundary Chundikulam.

The northern Indian Ocean is characterized by bi-annually reversing monsoon winds resulting from the seasonal differential heating and cooling of the continental land mass and the ocean. The SW monsoon generally operates between June and October, and the NE monsoon operates from December through April (Tomczak and Godfrey, 2003). The transition periods are termed the first inter-monsoon (May) and the second inter-monsoon (November). We studied 40 years (from 1979 to 2019) of ERA-5 data to schematize the wind/wave climate for boundary conditions. Figure 3 shows the wind/wave roses off Chundikulam, Jafffna. In which the length of the arms of the roses represents the percentage of occurrence of the situation and the color of each cell represents the magnitude. The alignment of each the arm gives the direction of wind/wave.

According to the wind climate in the study area, wind is coming from NE direction from November to March with the angle 40-70 while it changes to SW direction with the angle 220-240 from May to September. During SW monsoon, the wind speed varies between 7-12 m/s while it varies between 1-8 m/s during NE monsoon.

Analysis of wave climate indicates that the significant wave height varies between 0.25 m to 2.0 m having most probable wave heights around 1.25 m. The distribution of wave direction is mostly from 40-80 (NE) and from 200-240 (SW). Important to notice that wave heights are also smaller near the near-shore area, in fact waves which exceeded 1.5 meters in the near shore section are hardly visible, while in the waves greater than 1.5 m

are observed in off-shore. The NE monsoon experiences the highest probability of occurrence of higher wave events than in SW monsoon.

Extreme Wave conditions

A separate wave study is performed, taking into account the extreme wave climate which can be used for maintaining dune height. The study took 46 years of ERA-Interim/ERA-40 data of pressure fields on the ocean between the period 1971 and 2017. It is also calculating wave heights on the ocean and then a second wave model was used to calculate wave heights at 14 m Water Depth off the coast Chundikkulam. Graph with significant wave heights (Hs) versus peak wave period (Tp) is given in fig 3.

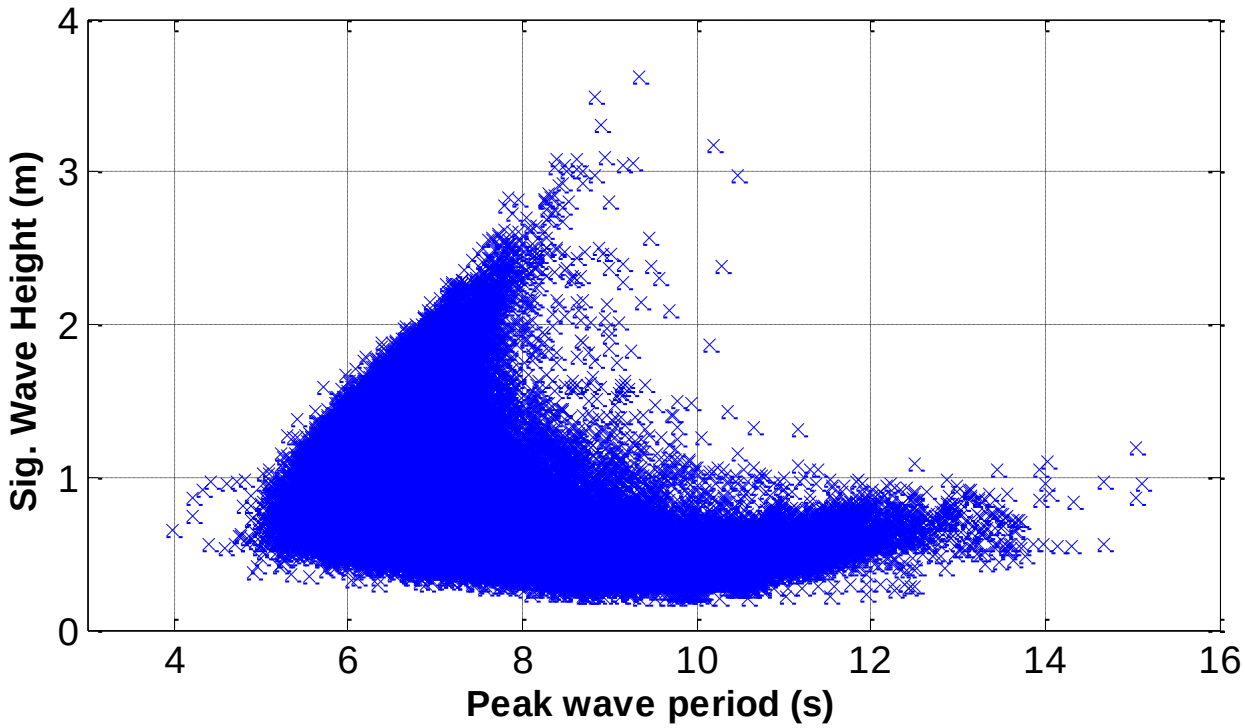


Fig 3, 46 years re-analyzed data ERA-Interim data off the coast of Kokilai, 81.3 E 9.1 N.

From these 46 years of hind cast, 19 most extreme conditions drawn at 14 m water depth are listed for the coast off Chundikkulam. Table 1 and 2 give the most extreme waves occurred during 46 years of re-analyzed data at 14 m water depth off the coast of Chundikkulam.

Table 1 Most extreme Significant Wave Height and their return periods occurred during the period between 1971-2017 off the coast of Chundikkulam.

Number	Hm0-14 m (m)	w = n/46	Return Period (yr) = 1/w	Tp (s)
1	3.6251	0.022	46.00	10.47
2	3.4857	0.043	23.00	10.18
3	3.3095	0.065	15.33	9.33
4	3.1736	0.087	11.50	9.26
5	3.0974	0.109	9.20	9.16
6	3.0787	0.130	7.67	8.94
7	3.0767	0.152	6.57	8.89
8	3.0542	0.174	5.75	8.82
9	3.0459	0.196	5.11	8.82
10	3.0379	0.217	4.60	8.70
11	3.0265	0.239	4.18	8.68
12	3.0176	0.261	3.83	8.62
13	3.0093	0.283	3.54	8.62
14	3.0013	0.304	3.29	8.51
15	2.982	0.326	3.07	8.49
16	2.9771	0.348	2.88	8.45
17	2.9267	0.370	2.71	8.40
18	2.92	0.391	2.56	8.39
19	2.9058	0.413	2.42	8.38

Table 2: Probability of Exceedance of Significant Wave Height of 46 year re-analyzed data off the coast of Chundikkulam.

No	Hs(m)	Wave Range (m)	Occurance(%)	Probability Exceedance (%)
1	0	0	0	100
2	<0.5 m	0.0-0.5	20	80
3	<1.0m	0.5-1.0	62	42
4	<1.5m	1.0-1.5	84	12
5	<2.0m	1.5-2.0	85	1
6	<2.5m	2.0-2.5	99.8	0.2

The Probability exceedance curve for significant wave height over 46 years re-analyzed data at 14 m water depth is shown in the Fig. 4 below.

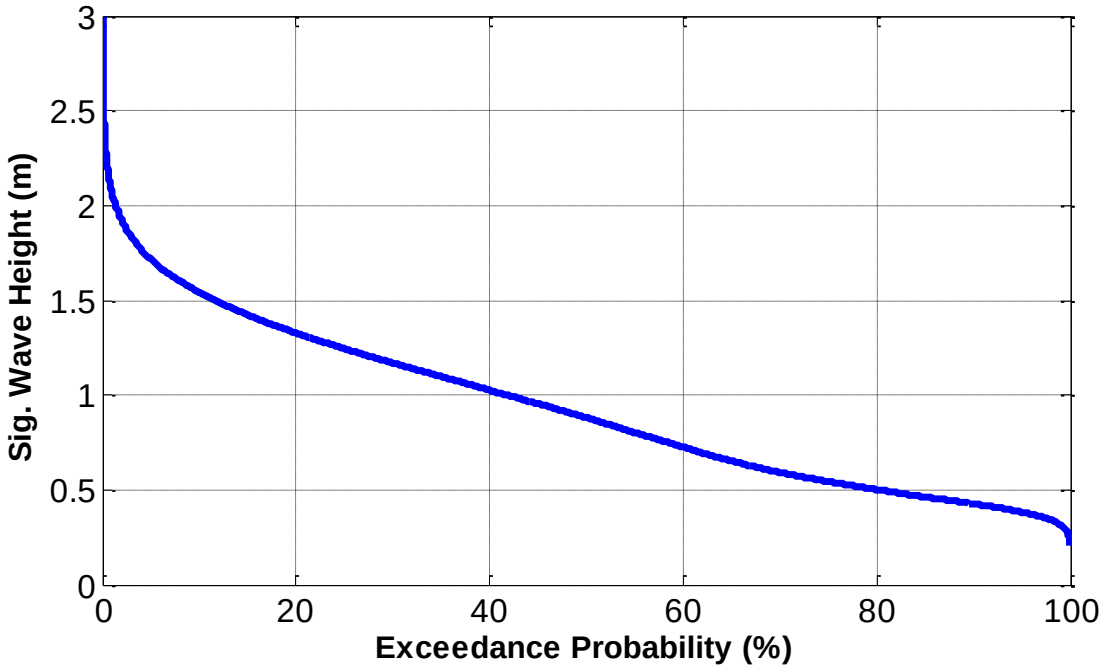


Fig. 4 Probability exceedance of significant wave height of 46 year re-analyzed data off the coast of Chundikkulam.

The extreme wave condition at 14 m water depth for various return periods is calculated for the project site (for 46 years).

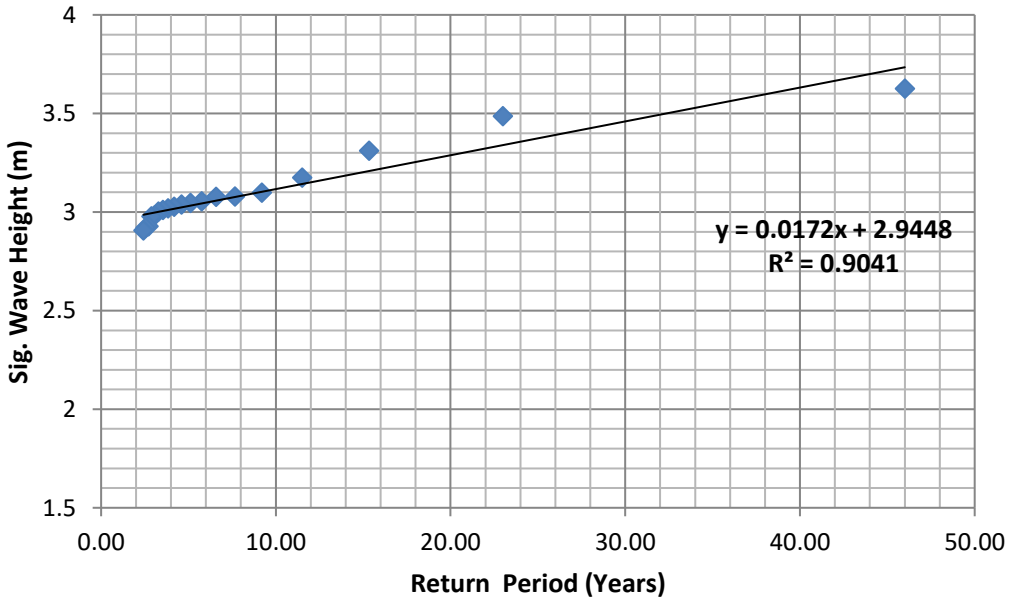


Fig. 5 Return period of significant wave height of 46 year re-analyzed data off the coast of Kokilai.

Design wave climate (Hs) is determined by using statistic distributions and it is important to select a conservative return period. We try to get the best fit distribution on it and the fitted distribution is Log Normal distribution based on the extreme value data at the 14-m water

depth. The trend line formula will be used to estimate the significant wave height for some time period. From the Normal Distribution analysis, the significant wave height for particular return time period can be estimated at 14 m water depth off the coast of Chundikkulam. For example 3.8 m significant wave height can be expected for 50 years return period at the project site.

Sediment transport and morphological evolution

Fig. 7 shows the computed yearly sand transport rates through cross-shores transects at Point Pedro to Chundikkulam coastal area. The transects run from approximately - 20 m to the +3 m MSL contour in order to integrate all transport magnitude within the closure depth, which is computed by Hallermeier equation (Hallermeier 1981, 1983). The transport rates through the cross shore transects are in general larger than the transport rates through the alongshore transects that are in general directed outwards the coasts. In this study, we discuss only the transport rates through the cross shore transects i.e. longshore sediment transport rates. Longshore drift plays an important role on the evolution of a shoreline, as if there is a slight change of sediment supply or any other coastal influence, longshore drift can change dramatically, impacting on the formation and evolution of adjacent beach.

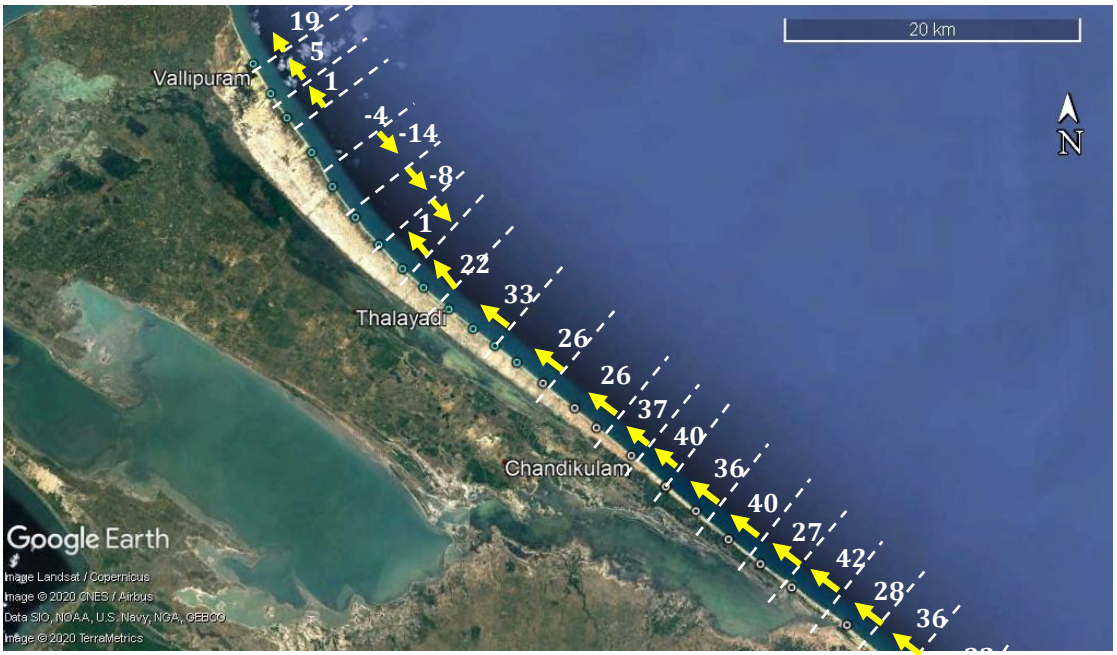
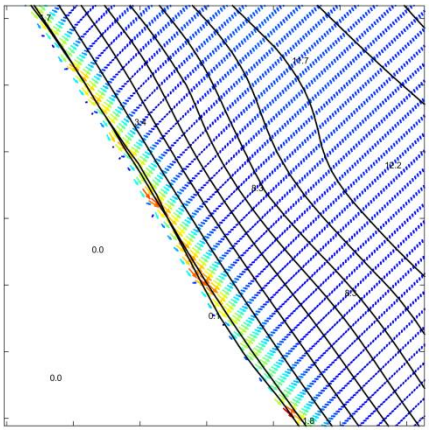
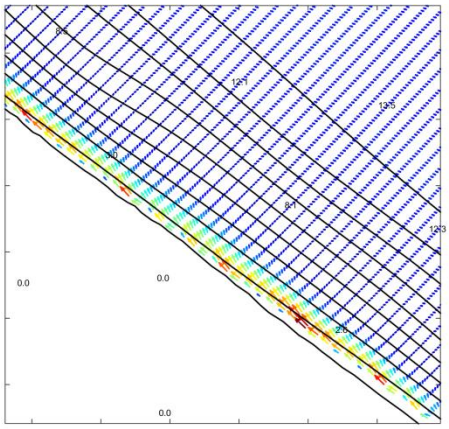


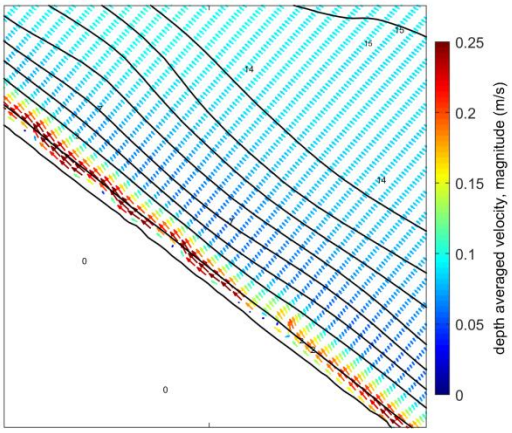
Fig 6 Sediment transport rates along the study area, yellow arrows show net longshore transport. in 1000m3/year.

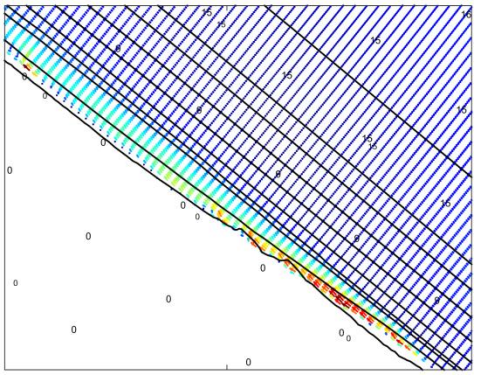
In overall, the net transports rates through the cross-shore transect are directed Northward. Numerical results of the alongshore sediment transport clearly indicate variable characteristics in magnitude along different sections of the case study.

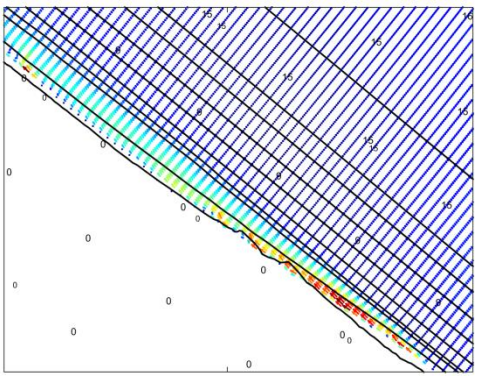
The net sediment transport capacity computed between Chundikulam (S1) and Thalayadi (S28) shows the maximum value of the transport capacity for the whole studied area is reached, 45 000 m3/year (S15) and then gradually decreased to 1 000 m3/year near Thalayadi (S28).











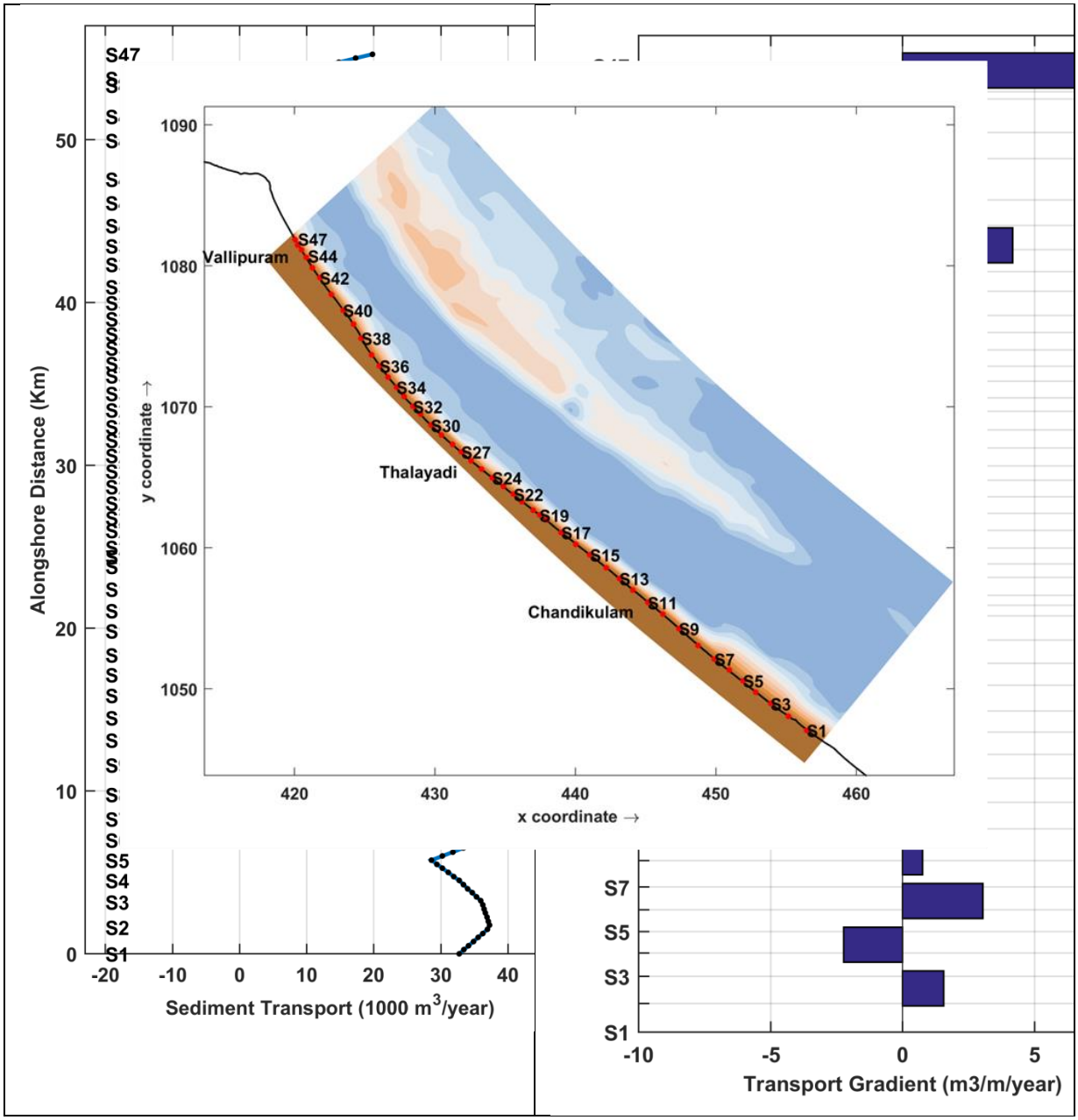


Fig 8 :Net alongshore sediment transport through the cross-shore transects up to 25 m depth contour (S01-47). (b) Sediment transport gradient (m3/m/year), negetive gradient shows the accretion and positive gradient shows the erosion.

Figure 8 shows negative values in sediment gradients between S1 to S28. This region is identified as an accretion coastline. A nodal point, the transport direction changed and building is observed north of Thalayadi. Thereafter, 5 000 m3/year rate of transport shown in S40 with a milder gradient along the straight coastline. Then the coastline bends slightly extending to S47 and afterwards the coastline exhibits in a convex manner. In the area between S47 and S40 the transport is increasing with a steep gradient, suggesting intense erosion.

Prospecting sand resources in offshore, Galle

Project No: 6.3

Responsible Officer: Mrs. Dileka Samaranayake

Introduction

Due to rapid development in construction industry since 2009 the demand for the construction materials including sand has grown up enormously resulting shortage of the supply. The crisis led to illicit sand mining in major river banks which arise many environmental issues.

Therefore there is an urgent need for an alternative for river sand.

Sri Lanka, being an island nation possesses large exclusive economic zone (EEZ) that runs up to 200 nautical miles which is more than eight times the land area of the country. Currently Sri Lanka Land Reclamation and development cooperation use offshore sands for constructions after purification. As the demand for the sand arises day by day they seek for other locations to extract sand which is suitable for construction purpose.

Since the extraction process in deep ocean is not economically feasible, this study intended to study the construction sand resources in the continental shelf in Galle area.

Objectives:

- To prospect the sand resources in Galle area
- To study the chloride, shell and heavy mineral content in offshore sand
- To study the surface geology of the area

1. **Sample/Data collection:**

   1.1 Sediment(Grab Sample collection)

   The offshore field visits from Galle to Rathgama were carried out from February to September 2019. The samples were collected from the predetermined sampling locations(FIG 01). The Van-Veen grab sampler was used for the sampling and approximately 1kg of each sample was collected from the surface of the sea bed. Thirty sediment samples were collected and transported to NARA laboratotry for further analysis after recording the physical observations.

   1.2 Sub bottom profiling

   Sub bottom profiling could not completed as the instrument was out of service

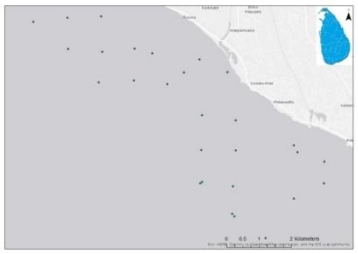


FIG 01: Sampling locations

2. Results

a. Grab samples

2.1 Grain size and distribution characterization

Particle size is a fundamental property of any sediment which can provide important clues on energy and provenance. The samples were analyzed for grain size distribution, statistical and textural parameters.

The best range for mean grain size for quality sand is 0.5mm to 2 mm. The mean grain size of the study varies from 0.073-1.25 mm(FIG 02). A median size (D50) of sand around 0.6 mm is most suitable for concrete production (Dias et al., 2008). The median size of sand in this study varies from 0.07mm to 1.8mm(FIG 03). Sorting level of the sand demonstrates the strength and suitability for different usage. Most of the samples of the area are in moderately well sorted range.

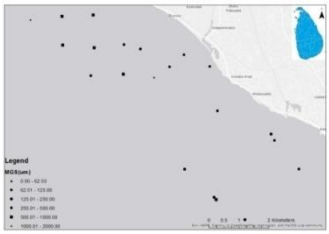


Figure 2: Mean Grain Size

Figure 03: D 50

2.2 Shell and coral percentage

The shell and coral percentage of the sand found in the area was under 5%.

3. Discussion and conclusion

Bathymetry of the mining area is an important factor in sea sand mining. Bathymetry of the study area varies from 0m to 9m within the 500m from the coastline and within 2.5 km from the coast line 0-38 m depths recorded (Based on bathymetry map generated by NARA). However, the depth of the continental shelf around the Gin River shows much shallower, showing the influence of the sediment carried by the river.

Some of the collected samples contained excess amount of coral and shell fragments and they were not processed further. However, a patch of shell bed was identified which lays next to the sand layer. Although there is sand layer from Rathgama to Galle the suitable sand range (considering mean grain size, sorting and D50 values) could be found near the mouth of the Gin Ganga.

Further studies should be done to confirm the quality and quantity of the sand including the chemical properties of the sand.

Way Forward

Since the sub bottom profiling study, the chloride content and the heavy mineral study could not completed due to failure of the sub bottom profiler and lack of the chemicals , the study will be continue for 2020.

Plastics and Polythene Debris In and Around Sri Lanka

Project No: 6.4

Responsible Officer/s: Me. W.R.W.M.A.P. Weerakoon

[1]. Introduction

Over the past decade, plastic debris, as a major marine and coastal litter have become an emerging issue all over the world. Plastics and polythene have been used over the last six decades without proper recycling but with a dramatic increase in production resulting in the majority of those wastematter ending-up into the oceans. Plastics and polythene fold into several categories, and have a variety of chemical and physical properties which determines their impact on the environment. Categories such as micro-plastics (particles smaller than 5.0 mm in size) are generated from a variety of sources, including industrial waste, cosmetics, personal care products and plastic litter etc. Although, plastics and polythene are useful in an array of applications, the increasing loads of those waste has become a serious problem as they are buoyant and are being dispersed over long distances, and may persist for centuries when settle in the ocean as sediments.

[2]. Materials and Methods

2.1. Study Area

The Bar Reef is a system of coral reefs just offshore from Sri Lanka's Kalpitiya peninsula. It has the greatest biodiversity of any coral reef in the waters around India and is one of the few pristine coral reef systems in Sri Lanka. It is a complex of reefs which stretch parallel to the coast from the northern end of the Kalpitiya peninsula to the islands which separate Portugal Bay from the Gulf of Mannar. It has high ecological, biological and aesthetic significance, being home to 156 species of coral and 283 species of fish. Due to this significance, the above site was selected as a key area for the study.

Location	Coordinates	Description
1	N: 8.36726, E: 79.73671	Shallow
2	N: 8.37091, E: 79.74546	Shallow
3	N: 8.37821, E: 79.74976	Shallow
4	N: 8.38373, E: 79.73602	Deep
5	N: 8.37635, E: 79.72771	Deep
6	N: 8.34707, E: 79.70753	Reference point, Deep

2.2. Collection of Samples

Surface water sampleswere collected from selected positions. At each position, the surface layer was sampled with a floating trawl-net (mesh-size = 300 µm)with two floater buoys. Trawls were hauled horizontally at the surface at a speed below 2 $ms^{-1}$to a distance of nearly 100 meters. The counts of a flow-meter attached to the lower part of the trawl opening were recorded at the start and the end of each trawl. Trawling was performed at a few meters away from the boat as an attempt to avoid the wake of the vessel/ boat. Once the trawl-net was recovered, the water samples were taken in to bottles and stored until transported to the laboratory.

2.3. Analysis of Samples

Surface water sampleswere washed in fresh filtered water over a sieve (mesh-size= 180 µm). All residuals were subjected to a wet peroxide oxidation (WPO) using 20 mL of aqueous 0.05 M Fe(II) (i.e. $FeCl_2$) and 20 mL of 30% hydrogen peroxide (H_2O_2), and heating to 75^oC until no natural organic material is visible. Suspicious particles were sorted from the sample under a microscope, and each sorted sample was checked once more to reduce the risk of overlooking the smallest plastic particles. All assumed particles were placed on a purified gridded Petri-dish for the examination under the microscope, photographed and, to the extent possiblemeasured and described (*e.g.*width, length, shape, type and colour). Simultaneously, the visually identified material was confirmed as plastic material (plastics or polythene) by performing a 'hot-needle test' and further accessing via microscopy imaging, followed Masura, *et al* (2015). Each sample was checked against two blank containers (controls); a filtered fresh water sample and (2) a container with known contaminants accumulated in control samples to reduce the risk of contamination and to remove all possible contaminants from samples.The sorted particles were washed in freshwater and dried in pre-weighed aluminium foil in a drying cabinet at 30^oC.After sufficient drying, the contents were packed in glass bottles and stored in roomtemperatureuntil further analysis. Those particles were subjected to Fourier Transform Infrared spectroscopy (FTIR) to identify the chemical composition. After removing the plastics, the remaining parts of the sampleswere preserved in 10% ethanol for further studies. The seasonal abundance of plastic and polythene litter was calculated in terms of (i) number of particles per m^3 (N) and (ii) weight of particles (W); g m^{-3} whereas the above values were compared with different categories of plastics and polythene.

[3]. Project Progress

During the study in 2018, a total of 160sea surface water samples were collected for the analysis of plastics and polythene from 40 sampling locations. In addition to the visual analysis, selected samples were subjected to an advanced laboratory analysis using Fourier Transform Infrared Spectroscopy (FTIR-ATR). A total of 130sea surface water samples (81.2% of the collected) were analysed, and the rest were preserved to be used and analysed in the future (Table 3.1).

Table 3.1. Summary of collection and analysis of Surface water samples

Region	No. of Locations	No. of Samples Collected	No. of Samples Analysed (Visual)	No. of Samples to be Analysed(Visual)	No. of SamplesAnalysed (Chemical)
North-west	06	42	32	10	18
South	12	36	20	16	11

Key Performance Indicators (KPI's): In line with the project charter, the KPI's of the project on both physical and fiscal progress are given in Table 3.3.

Table 3.3. Performance Indicators

Indicator	KPI Description	Scheduled	Performed	Performance
Field visits	Number of visits; scheduled vs. performed	08	12	150 %
Sample Collection	Number of samples collected; planned vs. performed	160	240	150 %
Analysis of Samples	Number of samples analysed; planned vs. performed	240	191	79.6 %
Reporting	Number of documents planned vs. produced	04	04	100 %
Budget Coverage	Expenditure vs. finance allocation (LKR. Mn.)	0.75	0.70	93.3 %

[4]. Results and Discussion

4.1. Abundance and Size of Plastic and Polythene Debris

The results disclosed that the waters in the West coast in general, aremore polluted with plastics and marine debris compared to the North coast, especially due to the highest abundance of debris found in the North-western coastal waters, especially around the bar-reef coral system.

The total number of plastic debris in surface waters around the Bar Reef coral reef system varied in a range from a minimum of 1.21 PSM in NEM to 3.55 PSM in SWM.

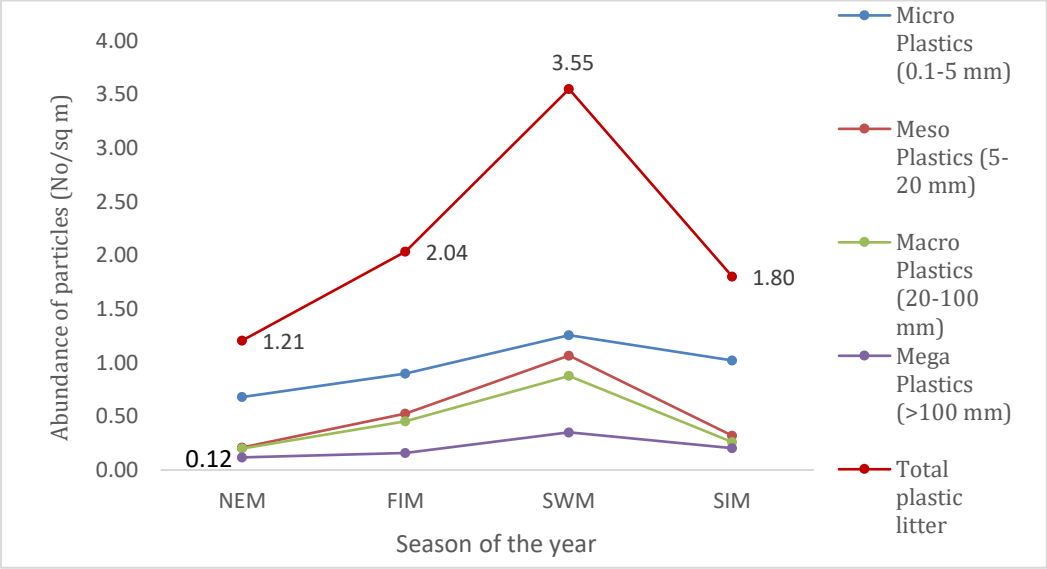


Figure: Seasonal variation of the abundance of different categories

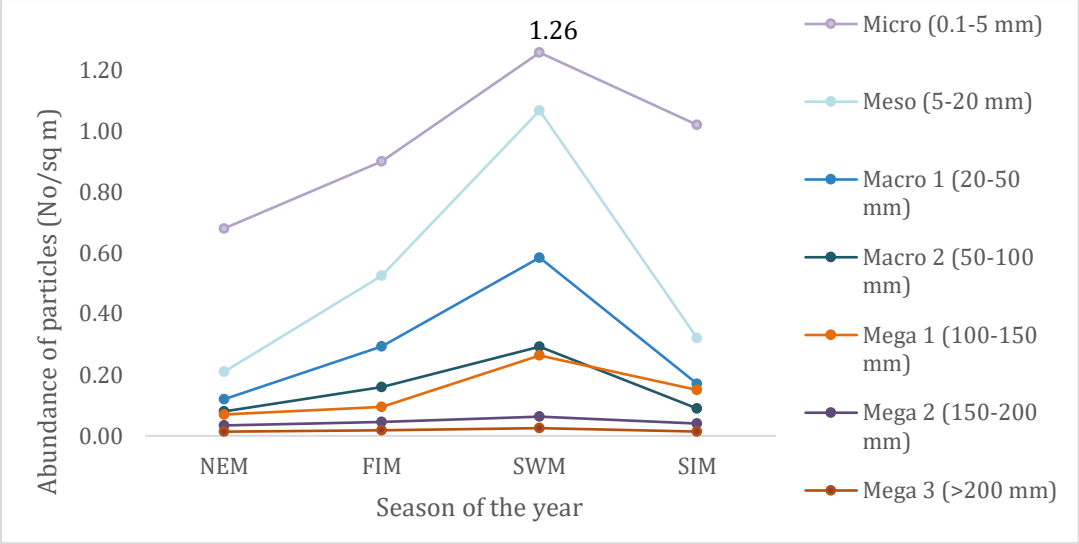


Figure: Seasonal variation of the abundance of different sub-categories

Seasonal Changes in the distribution of plastic litter

During the both the NEM and the SWM, the abundance of micro-plastics at the reference site (6), is low compared to the coral reef system, meaning that the coral area is contaminated with micro-plastics, compared to the deep sea. The relatively higher concentration of micro-litter in SWM may be due to the shallowness and the turbulence caused by weather. As well, the deep sea (reference site 6) more polluted with micro-plastics in SWM (1.2368 – 1.2583 particles/ m^2), compared to that in the NEM (0.4300 – 0.4600 particles/ m^2).

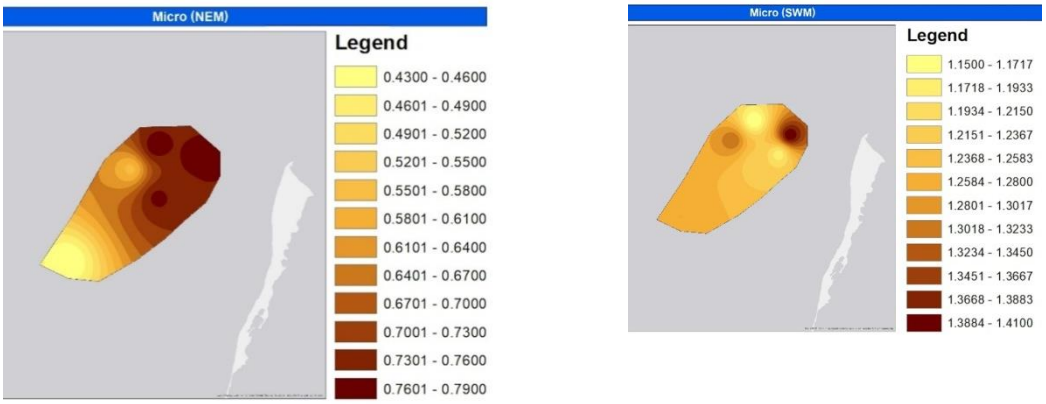


Figure: Spatial distribution of micro-plastics in the study area (particles/ m^2)

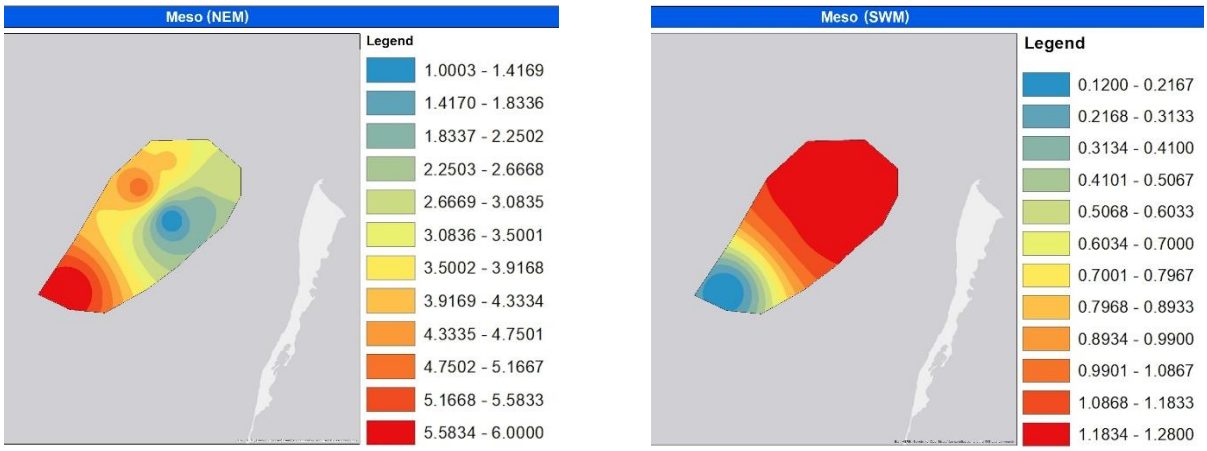


Figure: Spatial distribution of meso-plastics in the study area (particles/ m^2)

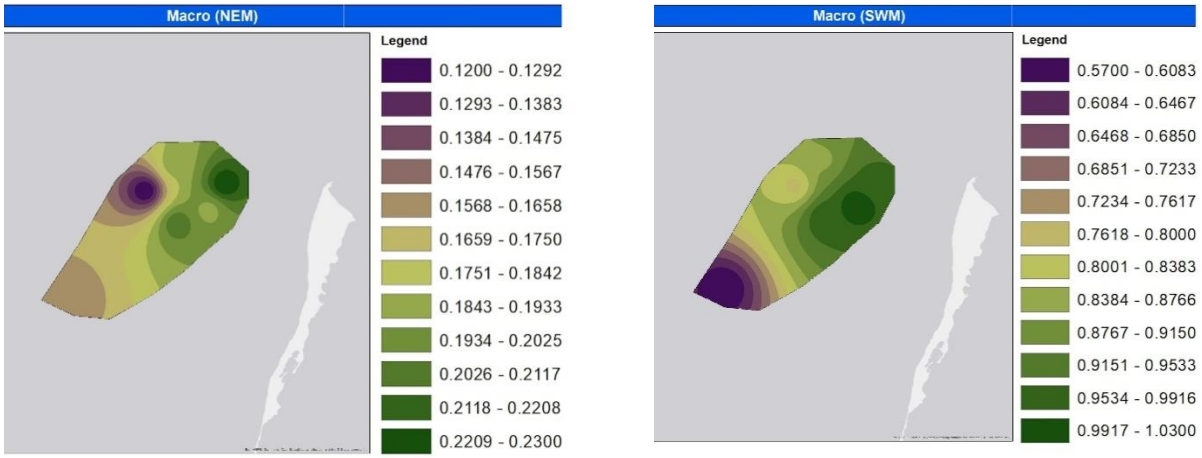


Figure: Spatial distribution of macro-plastics in the study area (particles/ m^2)

4.2. Categorical Distribution of Plastic and Polythene Debris

In reference to all locations in Both Bar-reef and Southern waters, the majority of plastic and polythene debris found in surface waters were fragments whereas the second major contaminant was thread-like micro-plastics. Foams were the third major abundant category of micro-plastics, where thin fibers and films were least found in the survey. A large number of fragments were recorded from the North Western locations.

4.4. Physical Size of Plastics and Polythene Debris

The average sizes of plastic and polythene particles were 1.26±1.18 mm and 1.87±1.24respectively. This reveals that the vast diversity in the size of plastic and polythene particles. There were micro-plastics smaller than 0.1 mm and the majority among those smallest particles belonged to filaments, many thread-like and thin fiber micro-plastics were lengthier, but were small in width. The majority of micro-plastics were around 0 – 0.5 mm in width, and around 0 – 4 mm in length.

4.5. Surface Properties of microplastics

The majority of micro-particles of plastics and polythene (>65%), contained had rough surfaces at the time of observation, meaning that those particles have been exposed to factors that contribute weathering of particles.Many fragments, and foams contained rough surfaces while many particles in the form of films contained a smooth and shiny surface. Thinn fibers and thread-like microplastics varied in this charatcristic, and this surface property may vary with their origin.

4.6. Hardness of Plastic and Polythene Debris

Most of the microplastic particles contained a hard structure, and are debris of hard plastics. A nearly equal proportion (49.6%) comprised of soft structured plastics, and are debris of soft plastics or the plastic particles that have been partially degrated into fragile structures.

4.7. Geometric Shapes of Microplastic Particles

The majority of plastic and polythene particles were irregular shaped (74.13%), whereasfilement type was the second most abundent shape.

4.9. Chemical Composition of Microplastics

The chemical composition of selected plastic and polythene particles was assessed by subjecting them to a FTIR-ATR analysis. Accordingly, the polymer and plastic categories abundent in the debris in surface water and beach were roughly estimated. The results revealed that the debris in surface water at a majority, contains Polypropylene, Polyethylene, Polystyrene, Nylon, PETE and HDPE, and the virgin pellets (primary plastics) were least observed in all samples. This indicates that the majority of microplastics were originated from secondary plastics, and the results indicate that the majority of microplastics are from packaging materials, and industry used material and fishing gear.

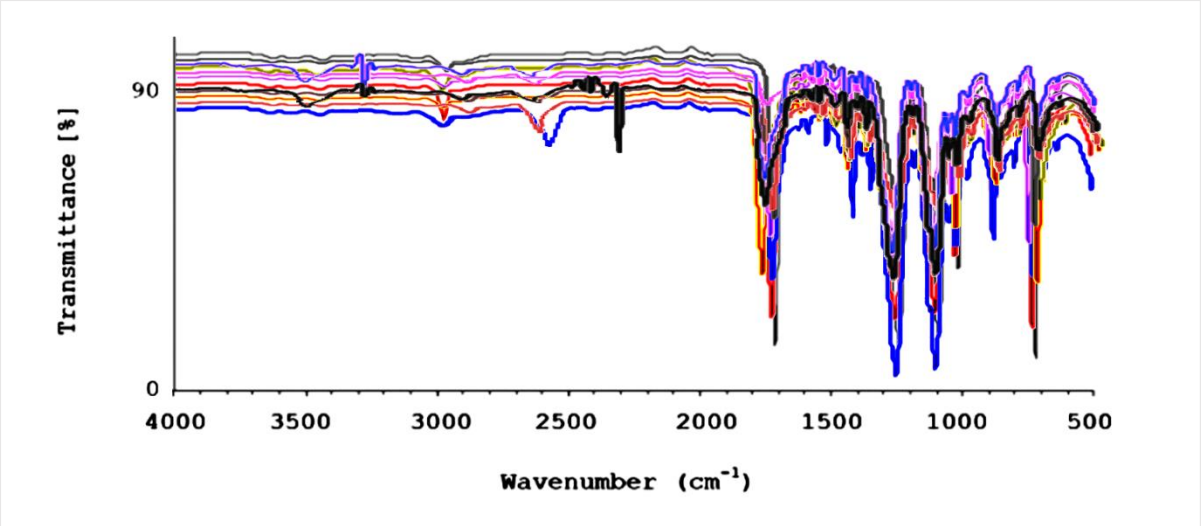


Figure: Spectra of selected particles identified as PETE

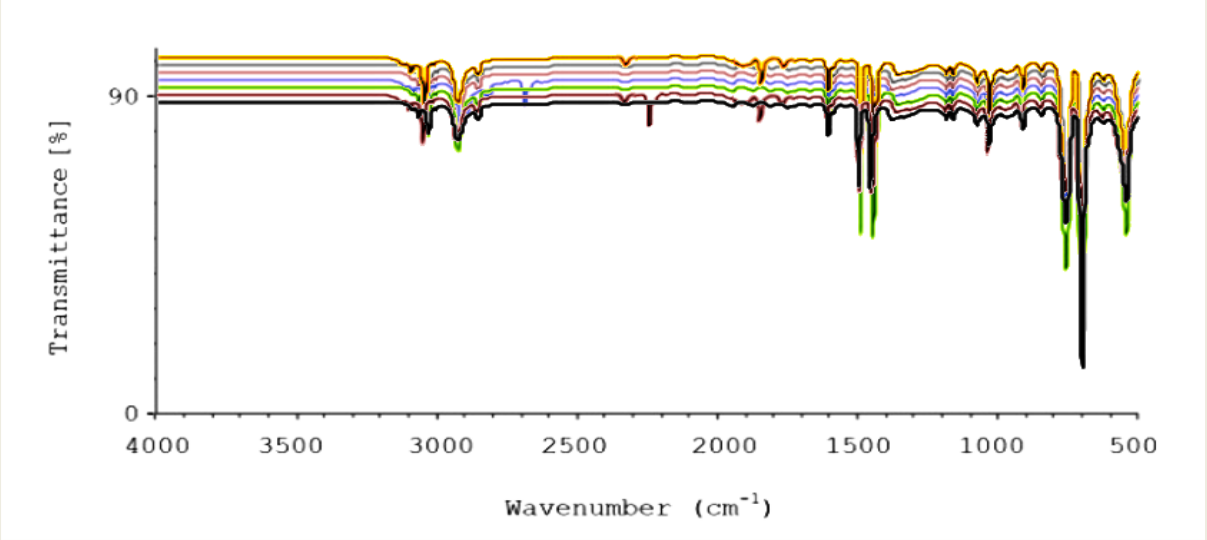


Figure: Spectra of selected particles identified as Polystyrene

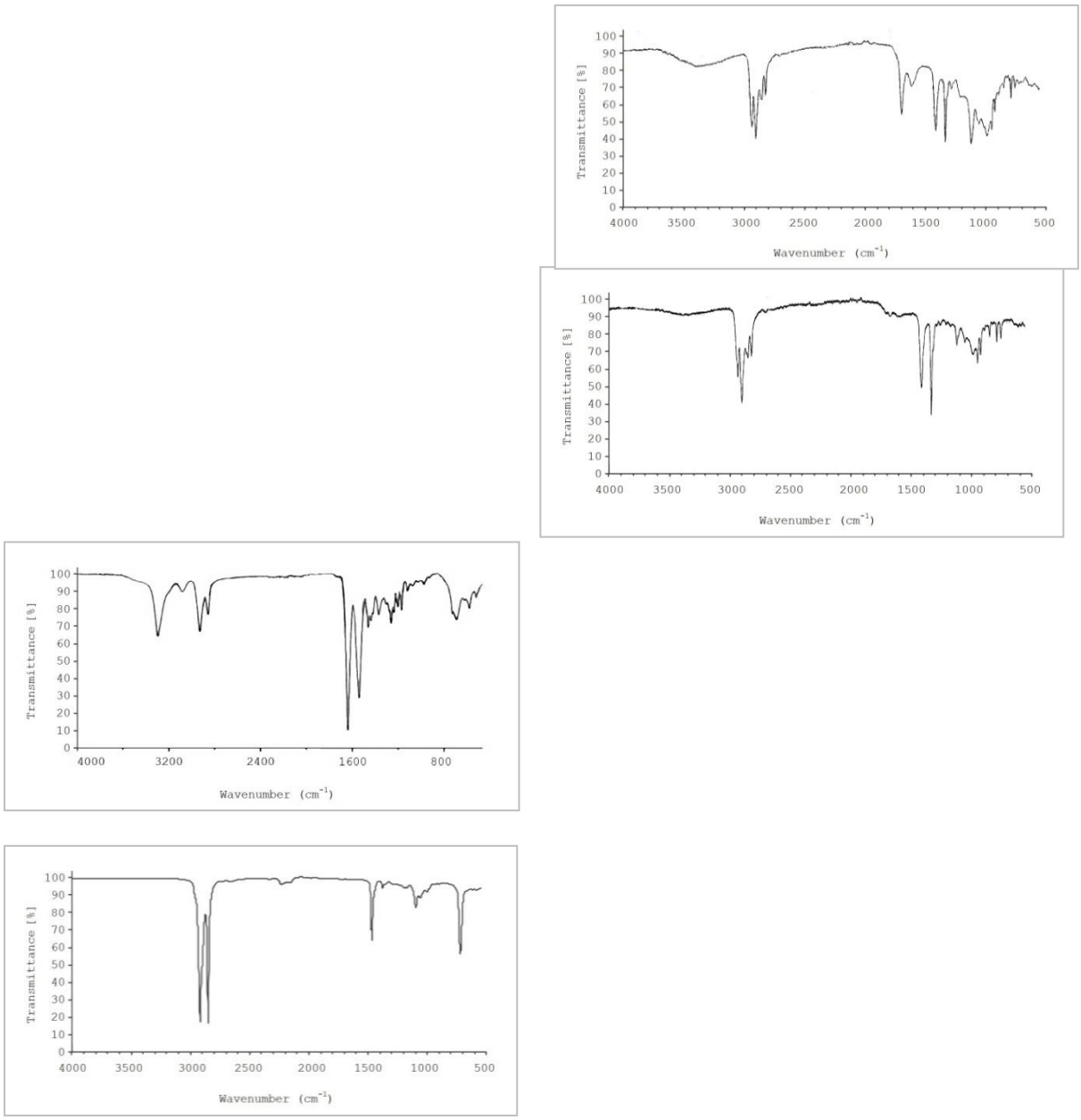


Figure: FTIR-ATR Spectra of Selected plastic and polythene litter particles from selected samples

[5]. Status of Degradation

One of the reasons for the great versatility of many synthetic polymers is their high resistance against environmental influences. However, this fact leads to extremely low degradation and long residence times for synthetic polymers once they enter the environment. Degradation of synthetic polymers can generally be classified as biotic or abiotic, following different mechanisms, depending on a variety of physical, chemical, or biological factors. During the degradation process, polymers are converted into smaller molecular units (e.g., oligomers, monomers, or chemically modified versions) and possibly are completely mineralized. The most important processes for the degradation of synthetic polymers can be divided into (1) Physical degradation (abrasive forces,

heating/cooling, freezing/thawing, wetting/drying), (2) Photodegradation (usually by UV light), (3) Chemical degradation (oxidation or hydrolysis), and (4) Biodegradation by organisms (bacteria, fungi, algae).

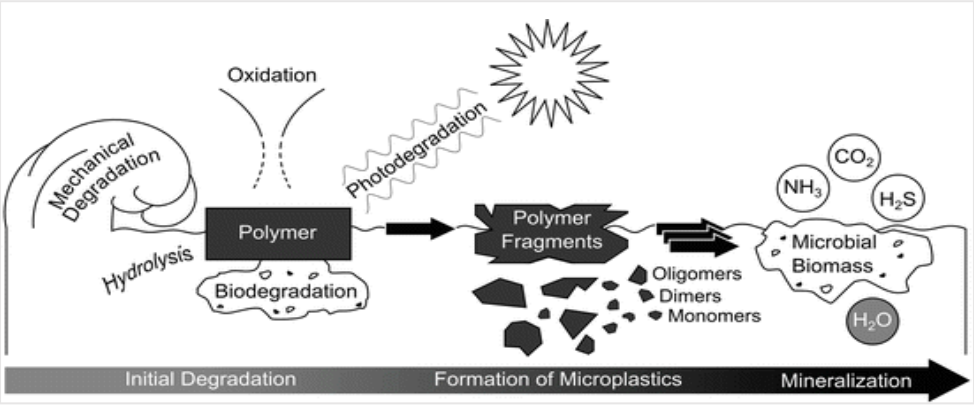


Figure: Degradation pathways of synthetic polymers in the aquatic environment with degradationprocesses involved and intermediate steps until complete mineralization

Mechanical degradation is an important factor with regard to plastics in the aquatic environment. In most cases, aging of the polymer by environmental influences, such as photodegradation or chemical degradation of additives, changes the polymer properties and leads to embrittlement of the polymer. The recalcitrant material is then shredded into smaller particles by friction forces occurring during the movement through different environmental habitats (also see Kooi et al. of this volume for a discussion on microplastics fate and transportation). This degradation generally leads to smaller plastic particles, which can result in particles with sizes between 1 and 5,000 µm. Such particles are classified as microplastics. However, the mechanical degradation does not stop if the particles are within the size range of microplastics. Thus, the formation of even smaller particles, so-called nanoplastics, is very likely. These nanoplastics could have different properties compared to the original macroplastics or microplastics (for a discussion on nanomaterials, see Rist and Hartmann of this volume). In both cases, the mechanical degradation leads to a decrease in particle size and consequently to an increase in the surface area of the polymer particles, which results in faster degradation due to higher reactivity.

Under normal environmental conditions in aquatic systems, the temperature is not high enough to start chemical changes of synthetic polymers; thus, thermal degradation is not significant.

The degradation of synthetic polymers in the environment on a molecular basis is usually initiated by photooxidation (with UV radiation) or by hydrolysis and is eventually followed by chemical oxidation. The predominant mechanisms strongly depend on the type of polymer, as there are numerous different compositions of synthetic polymers produced (i.e., polyolefins, polyesters, polyamides). After the initial reactions, the molecular weight of the polymer is decreased, and the reacted groups become available

for microbial degradation. Photooxidation is usually a fast process, but the degradation rate also depends on the extent of additives in a particular polymer that could prevent oxidation processes (i.e., antioxidants). Moreover, the photodegradation of plastics floating in the aquatic environment is slower compared to degradation in terrestrial exposure. Experiments on the disintegration of PE and PS showed faster degradation on the water surface compared to plastics that partially or completely submerged, likely related to the decreasing intensity of light and thus to the lower rate of photooxidation. For this reason, many plastics can stay in the aquatic environment for decades or hundreds of years.

Biodegradation of synthetic polymers can occur in two different environments (aerobic and anaerobic). The extent of the degradation of polymers into CO2, H2O, N2, H2, CH4, salts, minerals, and biomass (mineralization) can be full or partial. Partial or primary degradation of the polymer chain leads to stable or temporarily stable transformation products. Biodegradation is coupled to three essential criteria:

1.Microorganisms must be present that can depolymerize the target substance and mineralize the monomeric compounds with enzymes of an appropriate metabolic pathway.

2.The environmental parameters, such as temperature, pH, moisture, and salinity must provide conditions that are necessary for biodegradation.

3.The morphology of polymer particles must render the attachment of microorganisms and the formation of a biofilm, while the structure of the polymeric substrate, e.g., chemical bonds, degree of polymerization, degree of branching, and parameter, such as hydrophobicity or crystallinity, must not hinder microbial actions.

Since the size of synthetic polymers is generally too large to penetrate the cell membranes of microorganisms, the first step of biotic degradation is the cleavage of side chains or the polymer backbone and the formation of smaller polymer units (monomers, oligomers) by extracellular enzymes. In most cases, this first step of depolymerization involves an enzymatically catalyzed hydrolysis of amides, esters, or urethane bonds. These smaller molecules can then be absorbed by microorganisms and metabolized. Of course, abiotic hydrolysis can also result in intermediates that are then further metabolized by microorganisms.

The complete biotic degradations of poly(ε-caprolactam) and water-soluble polyethylene glycol are well described in literature. However, most of the plastics occurring in the environment are water insoluble, and many of the synthetic polymers present in the aquatic environment, such as PE, polypropylene (PP), PS, and PET, degrade very slowly or not at all. The degradation of these polymers is usually a combination of abiotic and biotic degradation pathways.

Polyolefins, such as PE and PP, represent a class of substances with high industrial production volumes and are determined frequently in environmental samples. These polymers are usually not biodegradable, as the alkyl backbone is not accessible for microorganism and must undergo an abiotic transformation. The alkyl backbone of polyolefins offers a high resistivity against hydrolysis but is usually susceptible to oxidative degradation. To prevent this, additives are added during the production process, and the oxidative or photooxidative degradation of the polymer is delayed until the antioxidants are consumed. After the initial oxidation of the surface of polyolefins, the degradation could occur in several weeks but results in the formation of microplastics as possible intermediates. These smaller and oxidized plastic fragments are more susceptible to microbial attack, e.g., biodegradation of PE is described for pre-oxidized fragments of the original material by Pseudomonas sp..

[6]. Conclusions and Recommendations

The results reveal that the waters around Sri Lanka are contaminated with plastics and polythene. In reference to micro-plastics, the vast majorityof those were in the secondary category, indicating that the packaging material, industrial applications and fishing gear are major reasons. The waters in the West coast in general, are more polluted with plastics and polythene compared to the East coast, especially due to the highest abundance of debris found in the North-western and the Western coasts. The average size of plastic particles in surface water was smaller than the average size of polythene debris.Most of the plastics both in sea water and beach sand had rough surfaces at the time of observation. Many fragments and foams contained rough surfaces while many particles in the form of films contained smooth and shiny surfaces.Irregular and filament type were the most abundant shapes of plastic and polythene particles.Waters in the North western and the Western coasts were highly polluted compared to the southern coast (moderately polluted) and to the Northern and the East coasts (least polluted compared to others). Several categories of foreign-born plastics were found from north western, southern, eastern and northern coasts. Those were found during July – October, 2018. The preliminary results revealed that the samples at a majority, of plastic and polythene debris contain poly propylene, poly ethylene, poly styrene, nylon. PETE and HDPE types were notable in the results, and the virgin pellets (primary plastics) were least, but notably observed in samples, meaning that, without the existence of manufacturing plants, the occurrence of primary plastics indicates the transport of foreign originated marine debris through ocean currents. The chemical composition of selected plastic and polythene particles was assessed by subjecting them to a FTIR-ATR analysis. Accordingly, the polymer and plastic categories abundant in the debris in surface water and beach were roughly estimated. The identification methods for aging, time of exposure, and chemical changes of particles were recognized to conduct advance analysis on micro-plastics

Since the study, coveredmerely one-year, further monitoring and research is required to reveal the changes in composition, pollution level etc. must be done. Spatial variations in

the distribution of plastic particles with regard to the presence of fishery harbors, popular tourist destinations, river openings and coastal currents may be further studied. Furthermore, the effects and impacts of plastics and polythene, especially of micro-plastics on marine ecosystem components may be studied.

Assessment of Climate Change Impacts on the Ocean Environment: Impacts of Temperature, Salinity and Water Level on Coral Reefs in the East and the West Coasts of Sri Lanka (Phase-1)

Project No: 6.5

Responsible Officer/s: W.R.W.M.A.P. Weerakoon, H.B.U.G.M.Wimalasiri

[1]. Introduction

Climate change is amidthe primeglobal threats to coral reefs. Findings ofscientific research irrefutablysignify the changes of the atmosphere, the ocean, and theeffects of anthropogenicactivities.Climate change affects coral reef ecosystems, via sea level rise, changes to the frequency/ intensity of tropical storms, and altered ocean circulation patterns.All of those theatrically alter eco-system functions, whereas the goods and services that coral reef eco-systems could provide to people.The warming of ocean,roots thermal stress to corals and cause bleaching and infectious diseases.Rising sea levels results in a surge in sedimentation on reefs located near-off-shore where the sediment run-off cause smothering of corals.The changes in storm patterns cause stronger and frequenttempests,disastrous to corals.Changes in precipitation, increased freshwaterrunoff, sediment, and land-based pollutants trigger algal blooms and cause fogs that reduce light.Changed ocean currents cause changes in connectivity and temperature regimes that contribute to food scarcity for corals and hampers dispersal of coral larvae.Ocean acidification declinesthe growth, structural integrityand the survival of corals.

Justification

The major coral bleaching around Sri Lanka was caused by the *El Niño* and *La Niña* effect in 2015-2016. A similar catastrophe befell in 1998, but the corals healed over time, as the milieushaven'tdisturbed. Regrettably, with climate change, it's likely that these incidences may re-occuroften, and on a recurrence, the chances of survival are bleak, due to the disturbed environment. The coral reefs are yet having a challenging time recovering on its own, given the swelling impact of human activities and climate change. Thus, so as to protect the existing corals and to predict on an imminentchange, analysis of time-series data is vital. Yet, instead of using a global forecast product, it's desirable to use a regional forecast product to simulate the ocean temperature and compare with in-situ data. Thus, application of a local data monitoring network is crucial so as to safeguard the coral reef eco-systems in Sri Lanka.

2.2. The Area of Study

Based on the requirement, two major sites were selected as the area of study: The first study area; the Bar Reef is a system of coral reefs just offshore from Sri Lanka's Kalpitiya peninsula. It has the greatest biodiversity of any coral reef in the waters around India and is one of the few pristine coral reef systems in Sri Lanka. It is a complex of reefs which stretch parallel to the coast from the northern end of the Kalpitiya peninsula to the islands which separate Portugal Bay from the Gulf of Mannar. It has high ecological, biological and aesthetic significance, being home to 156 species of coral and 283 species of fish. Due to this significance, the above site was selected as a key area for the study.The second study area; the Pigeon Island National Park is one of the two marine national parks of Sri Lanka. The national park is situated in the near-off-shore from Nilaveli, Trincomalee.The national park contains some of the best remaining coral reefs of Sri Lanka. Both study sites provide home to a number of endemic species residing in the crucial coral reef-based eco-systems, that are sensitive to climate change impacts such as changes in temperature and salinity. The work done in phase 1, during FY 2019, specifically focused on the first study area; the Bar Reef coral system (Figure 2.2).

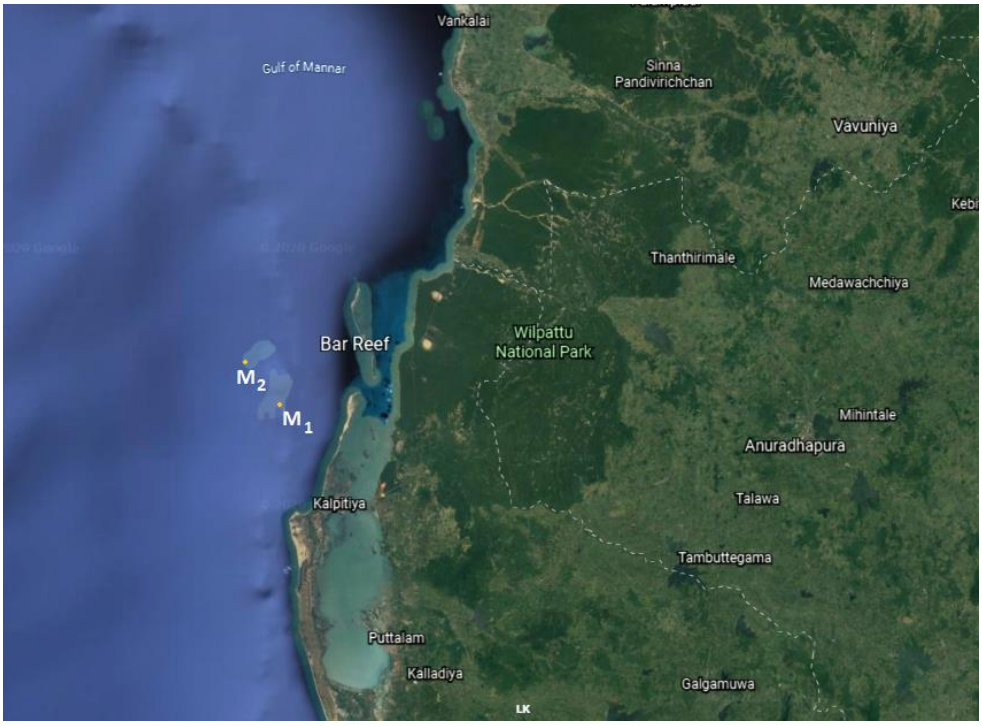


Figure 2.2. *The study area: Data logger mooring points (M_1 and M_2)in the Bar Reef coral system*

2.3. Expected Objectives:

- To study the temporal (hourly, daily, weekly, monthly, inter seasonal, intra seasonal,annual or decadal) temperature variability at two coral reef hot spots in Sri Lanka.

- To understand the impact of temperature and salinity variability on coral reefs of these sites.
- Improve predictability of coral mass bleaching during El-Nino periods.

2.4. Expected Outputs and Benefits:

- **Phase 1 (2018) and continuous:**In-situ temperature dataset in the East coast of Sri Lanka.
- **Phase 1 (2019) and continuous:**In-situ temperature dataset in the West coast of Sri Lanka.
- **Phase 2 (2020) and continuous:**In-situ salinity and conductivity dataset in the East and the West coasts of Sri Lanka.
- **Phase 2 (2021) and continuous:**In-situ water level, pH and pressure dataset in the East and the West coasts of Sri Lanka.
- **Phase2 and continuous:**Major coral reef species composition in those two sites and their growth rate in natural environment.
- **Phase 2 and continuous:**Reports and scientific publications based on temporal and spatial ocean temperature variability around Sri Lanka and its impact on coral growth rates.
- **Phase 3 (2022) and continuous:**Coral mass bleaching prediction system for Sri Lanka.

[3]. Materials and Methods

3.1. Collection of Data: At Bar Reef, the temperature data loggers were implemented in 2018, and the retrieval for FY 2019 was initiated on March the 14th. Data recording was set-up and programed to one-hour interval to the internal memory. Data retrieval was ended up for FY 2019, on December the 5th. In addition to the temperature data obtained, a series of parameters of the water surface including dissolved oxygen, salinity and conductivity was measured seasonally.

3.2. Analysis of Data: In-situ data comparison with ancillary data was performed.Hourly temperature data were averaged to find out the daily temperature values. The averaged values were compared with Global-HYCOM forecasting products and with NOAA- AVHRR OISST temperature data.

[4]. Annual Work Progress

Number of field visits scheduled was 6 for FY 2019, whereas the number of field visit made was 8. The number of samples proposed to collect: Hourly ocean temperature values from two depths (5m and 10m) at two sites (Bar reef and Pigeon Island). Although the data could not be retrieved regularly, data have been recorded from sensors at all locations throughout the year.Number of samples collected:Assessed 18436 hourly ocean temperature data fields from Bar reef site and 8960 hourly ocean temperature data from Pigeon Island.

[5]. Results and Discussion

5.1. Findings from the Two Temperature Data Loggers Moored in Bar Reef
Based on currently available data, the minimum temperature recordedduring 2019 was

recorded as 27.95°C, whereas the maximum figure was 32.31 °C (Figure 5.1). Notably, this reveals a minute rise in the maximum temperature 30.99 °C(at 5m depth; on 2018.10.16, 06 p.m.), and 31.01 °C (at 10 m depth; 2018.10.12 at 06 p.m.). The results also indicate a slight change in the minimum temperatures, compared to the minimum figures of 28.25 °C(at 5 m depth, 2018.02.03, 09 a.m.), and of 25.98 °C (at 10 m depth; 2018.02.04, 21 p.m.). During several time periods, temperature in the shallow area became lower than the temperature recorded at 10m depth. The recorded highest cooling (-0.9°C) during 2018 was on 2018.10.26, 07 a.m. This surface cooling occurred all over the year during night time, but stronger day time cooling events observed during May and November months in both 2018 and 2019, following, and demonstrating the typical seasonal characteristics of monsoonal effects on water masses (Figure 5.2).

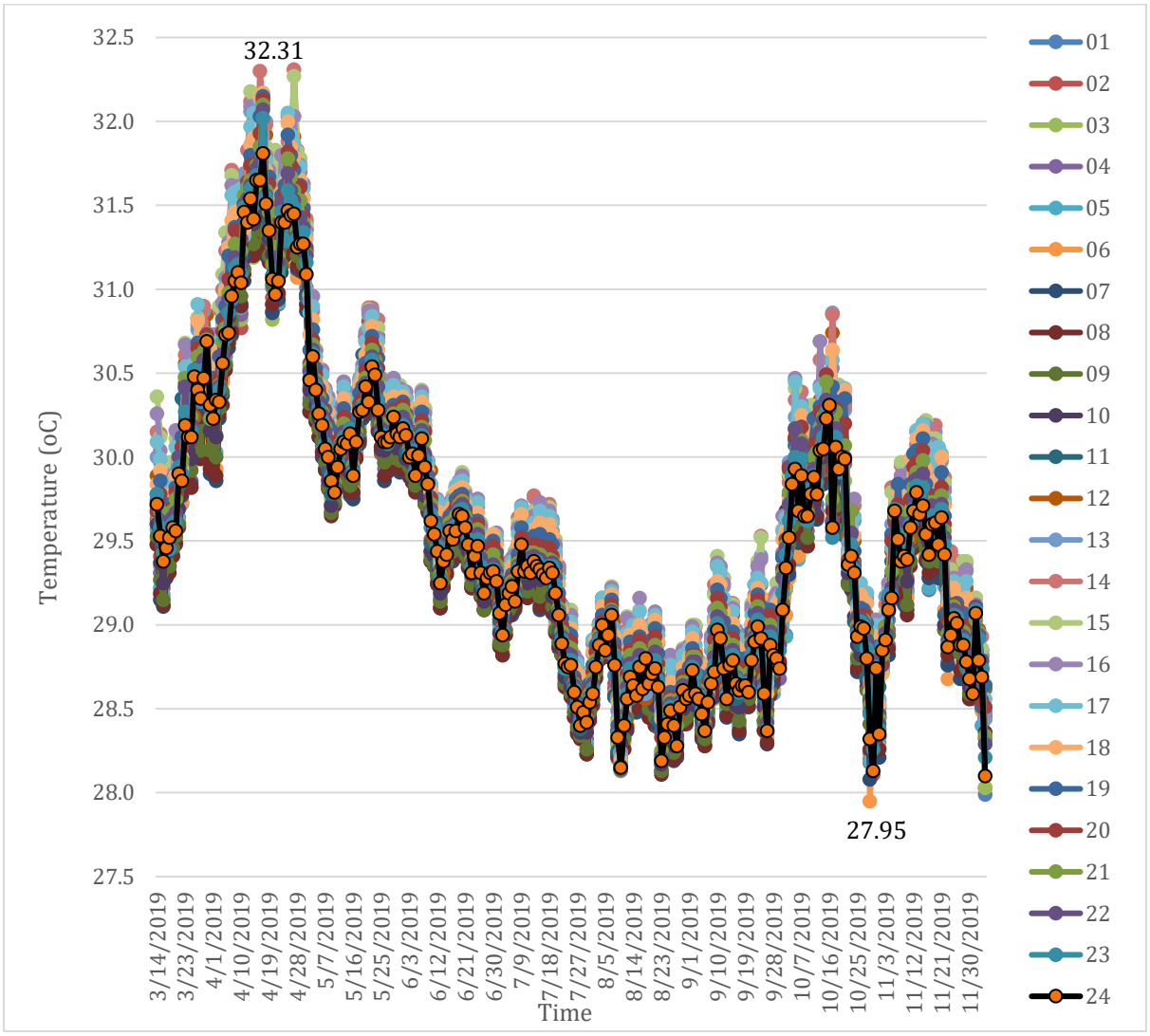


Figure 5.1.*Variation of water temperature at Bar Reef, 5m depth*

The water temperature varied between a minimum of 27.95 °C (2019.10.29, ≈06 am) and a maximum of 32.31 °C (2019.04.15, ≈14 pm) in a range of ≈4.36°C. Two prominent peaks were noticeable during the months of April and October. Similar pattern was observed in 2018 (Figure 5.2).

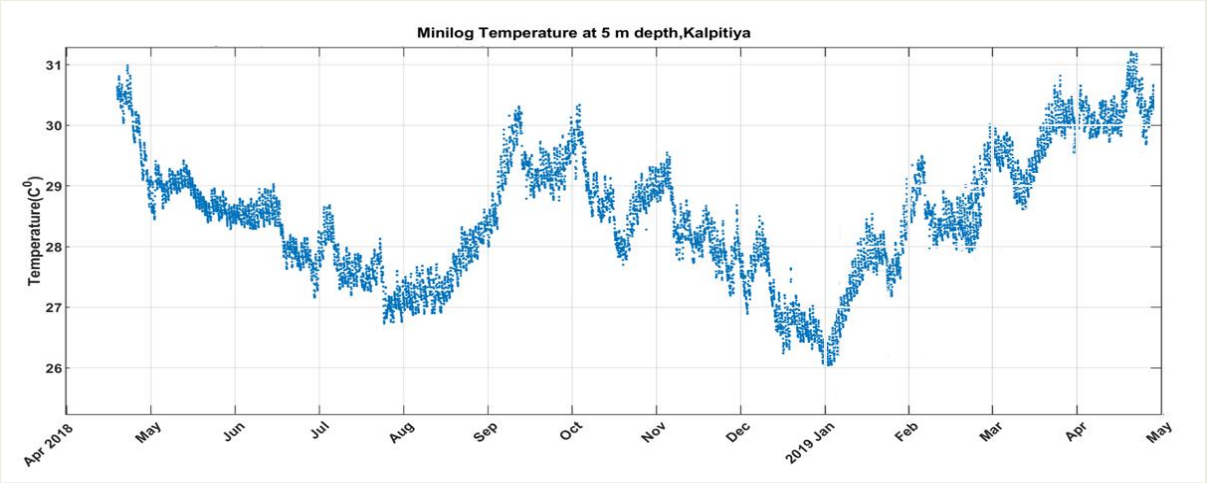


Figure 5.2. *Variation of water temperature at Bar Reef, 5m depth in 2018, and early 2019*

In terms of the average figures, the lowest mean temperature during the year 2019 was calculated as 29.38 ^{o}Cat 07 am and the highest temperature was calculated as 29.84 ^{o}Cat 15 pm (Figure 5.3). In fact, the average daily temperature was fluctuating in between 29.38 ^{o}C to 29.84^{o}C in a range of 0.46 ^{o}C in general, where from 07 am onwards up to 15 pm, the temperature rises and from 15 pm onwards up to 07 am next dawn, the temperature drops gradually.

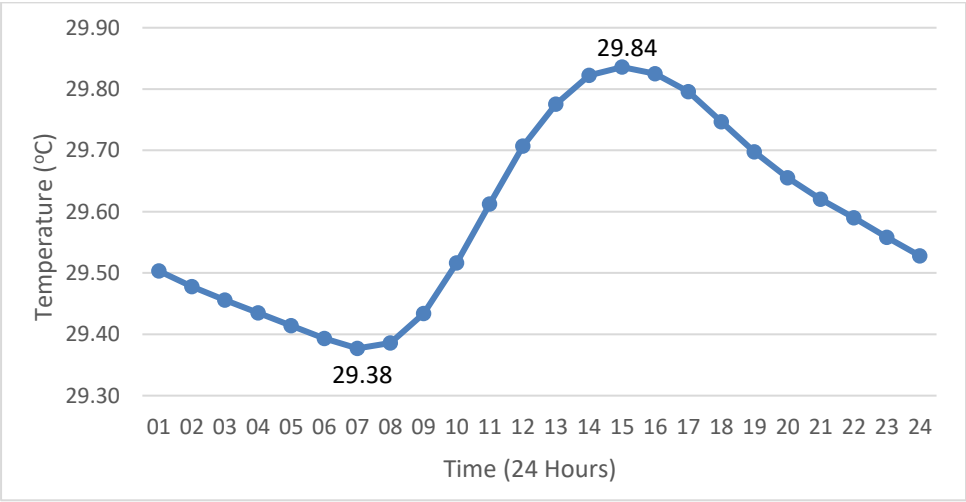


Figure 5.3.*Hourly mean temperature during year 2019*

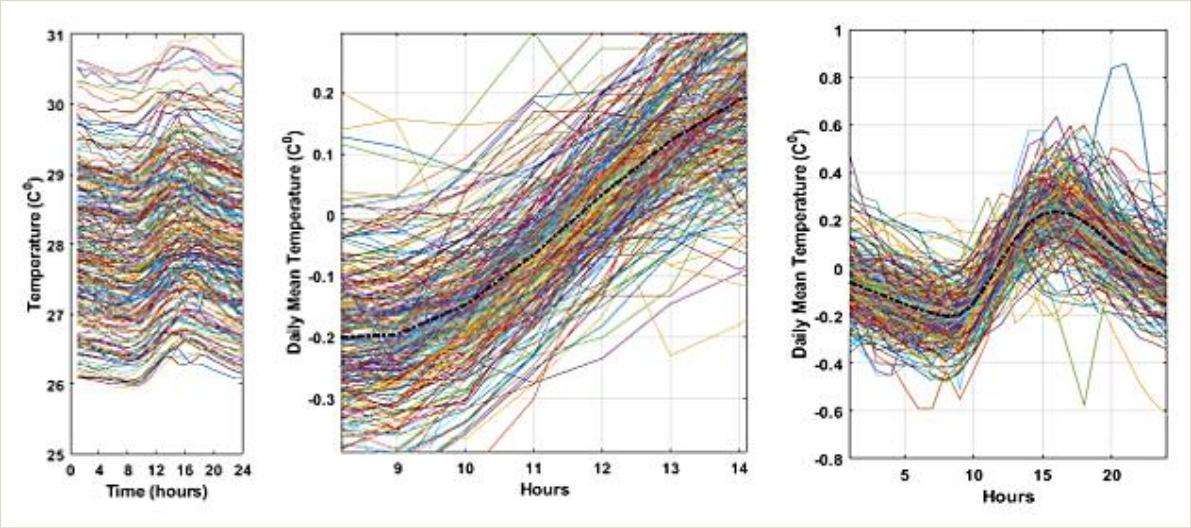


Figure 5.4. *Daily mean temperature during year 2019*

Importantly, as revealed by the SD ≈ 0.8, the average figures are considerably different from the actual monthly (individual) figures as the daily and hourly temperature values changes in accordance with the seasonal effects, prominently seen in the Figures 5.1 and 5.2 above.

Table 5.1. *Hourly mean temperature figures during 2019, at Bar Reef*

Hours	MeanT (°C)	SD (°C)	Change (°C)*	Hours	MeanT (°C)	SD (°C)	Change (°C)*
01	29.50	± 0.84	- 0.02	13	29.78	± 0.89	0.07
02	29.48	± 0.83	- 0.03	14	29.82	± 0.90	0.05
03	29.46	± 0.82	- 0.02	15	29.84[2]	± 0.90	0.01[a]
04	29.44	± 0.82	- 0.02	16	29.83	± 0.89	- 0.01[a]
05	29.41	± 0.82	- 0.02	17	29.80	± 0.89	- 0.03
06	29.39	± 0.82	- 0.02	18	29.75	± 0.88	- 0.05
07	29.38	± 0.81	- 0.02	19	29.70	± 0.88	- 0.05
08	29.39	± 0.82	0.01[a]	20	29.66	± 0.87	- 0.04
09	29.43	± 0.83	0.05	21	29.62	± 0.87	- 0.04
10	29.52	± 0.84	0.08	22	29.59	± 0.86	- 0.03
11	29.61	± 0.86	0.10[b]	23	29.56	± 0.85	- 0.03
12	29.71	± 0.88	0.09	24	29.53	± 0.85	- 0.03

Note:*Change in temperature from the previous hour, [a]minumum, [b]maximum*

5.2. Findings from Seasonal Data Collection

5.2.1. Changes in Surface Temperature

The surface water temperature at the Bar Reef coral system, varied from a minimum of 27.24 °C to 28.03 °C during the first inter monsoonseason (2019) in a range of 0.79 °C (Figure 5.2.1).Furthermore, during the North-east monsoon season, the temperature fluctuated between a minimum of 29.19°C and a maximum of 29.27°C in a range of 0.08 °C. In the South-west monsoon season, the water surface temperature changed between

a minimum of 28.33 ^{o}C to and a maximum of 28.57^{o}C, in a range of 0.24^{o}C.Accordingly, the highest fluctuation in temperature in the surface waters around the Bar Reef coral system was recorded during the South-west monsoon season, whereas the minimum surface temperature fluctuation was observed during the North-east monsoon season.

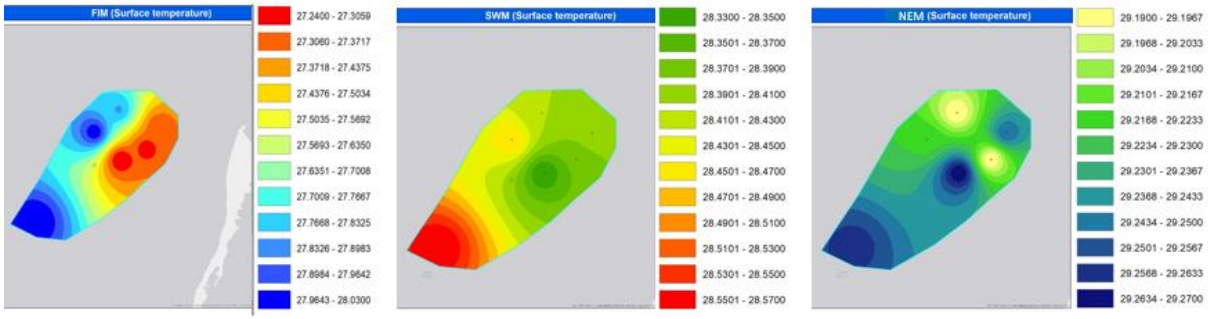


Figure 5.2.1. *Surface water temperature variation during the First inter-monsoon, the North-east monsoon and the South-west monsoon seasons in 2019.*

5.2.2. Changes in Salinity

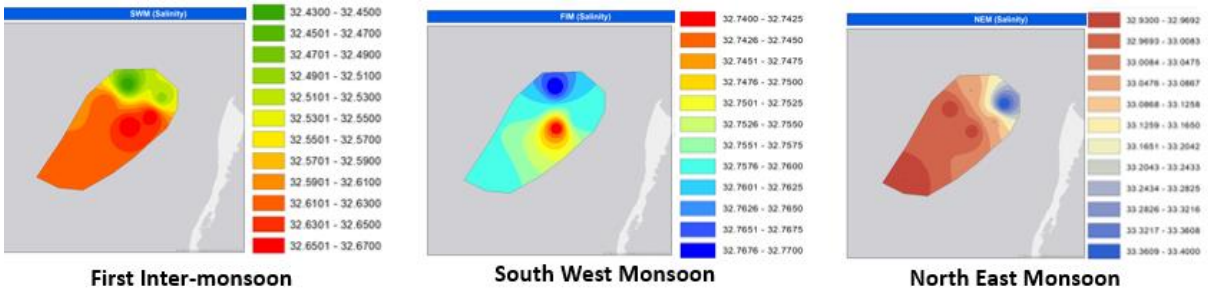


Figure 5.2.2. *Surface water salinity variation during the First inter-monsoon, the North-east monsoon and the South-west monsoon seasons in 2019.*

5.2.3. Changes in Dissolved Oxygen

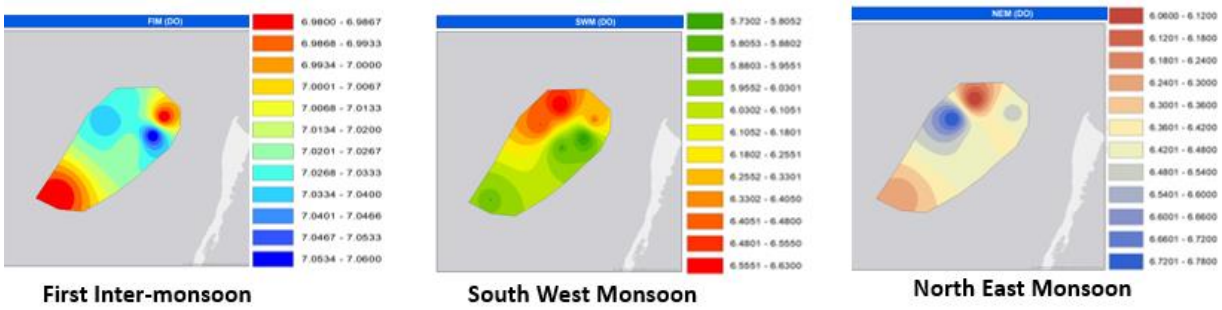


Figure 5.2.3. *Surface water dissolved oxygen variation during the First inter-monsoon, the North-east monsoon and the South-west monsoon seasons in 2019.*

5.2.4. Changes in Conductivity

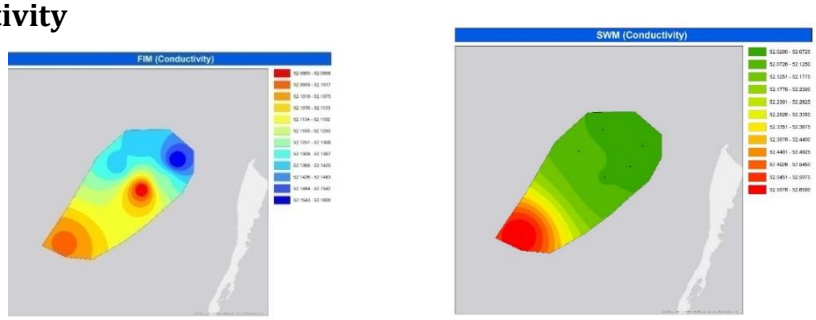


Figure 5.2.4. *Surface water conductivity variation during the First inter-monsoon and the South-west monsoon seasons in 2019.*

[6]. Conclusions

Initial results demonstrateseasonal and spatial variations in temperature, salinity, conductivity and dissolved oxygen in the area of coral reef systems reside. Temperature, surface salinity, dissolved oxygen and the water quality parameters in the shallow areas change often compared to deep waters, and the remaining corals residing in the shallow area is more prone to seasonal changes of temperature, salinity, oxygen demand and conductivity, and are the most vulnerable. However, the data is not yet sufficient enough to reveal any long-term change of oceanographic parameters in the reef residing in the deep-sea area. Since, there is no local data records in the times of recent El-nino or La-nina effect, the predictions cannot yet be done. However, in such case the corals residing in the shallow area are the most vulnerable, even thoughboth deep sea and shallow coral reef systems can be affected eventually.Furthermore, the HYCOM data looked much compatible (R=0.8) with the in-situ data thus, the 7-day HYCOM products can be used to predict the temperature variability at 5m depth level at these two sites.

Ocean Acidification and the Changes of Marine Carbon System in Sri Lankan Waters

Project No: 6.6

Responsible Officer/s: W.N.C.Priyadarshani, W.R.W.M.A.P.Weerakoon, and K. Arulananthan

Background:

Ocean acidification causes a shift towards pH-neutral conditions due to increased H+ ion concentration resulted by dissolved excess CO_2 from the atmosphere as a response to strike balance in the chemical equilibrium.During last two decades, the acidity has increased significantlyand impacts on both biogeochemical cycles, particularly on marine carbonate cycles and calcified organisms which actively engage in photosynthesis (biological pump) and calcification (carbonate counter pump).

Meantime, Sri Lankan coastal waters are enriched with some marine ecosystems such as coral reefs, mangroves and other biological hotspots which generate tourist revenue have to be protected while those resources protective measures should be taken based on continuous monitoring of ocean environment. Thus, to monitor the real status of acidity and alkalinity around Sri Lankan waters will be crucial for stakeholders in their conservative decision making and enacting some rules and regulations to ensure the recreational values and reduce habitat degradation.

Here, similar to other biogeochemical cycles and processes, ocean acidity/alkalinity is also expected to have temporal and spatial changes together with seasonal (monsoon induced current patterns and non-seasonal oceanic processes mesoscale eddies, El Niño events and horizontal particle transportation) while seasonal and interannual variation of marine carbon system will be brought. Hence, ocean acidification influence on the changes in marine carbon systems in Sri Lankan waters will be useful ocean-research locally and regionally.

Objectives:

In current study, several objectivessupposed to be fulfilled during the study period such as: to assess the level of acidification using data obtained from RV Dr Fridtjof Nansen cruise around SL, to assess the contribution of inorganic carbon compounds to acidification, to construct a time-series data set on ocean acidity/alkalinity, to study variations of p^H with regard to seasonal physical oceanic processes, to study the response of calcified phytoplankton (Coccolithophore and foraminiferans) to ocean acidification etc.

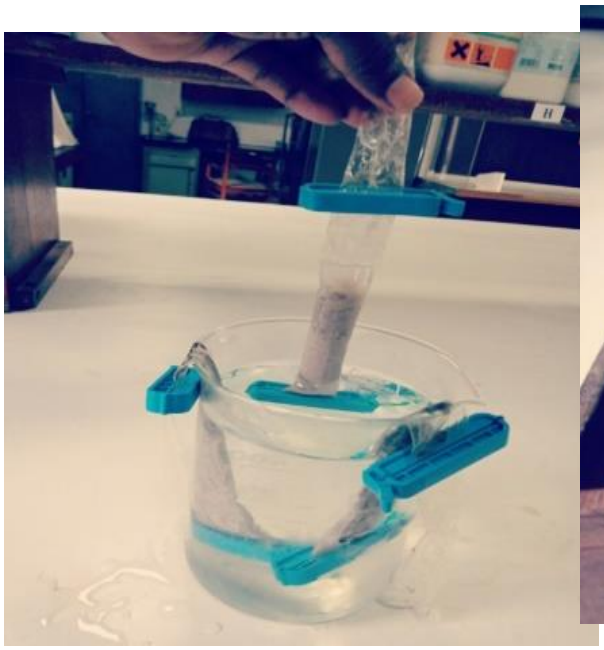
The study aimed to assess acidity, nutrients, chlorophyll a, carbonate, dissolved inorganic carbon, total alkalinity, and several physical parameters such as temperature and salinity parameters of water in selected sites of western, north-western, southern and eastern coastal stretches surface and deep-sea water in different seasons. To study the response of calcified phytoplankton (Coccolithophore and foraminiferans) to ocean acidification

and assess the contribution of inorganic carbon compounds to acidification will be proposed to carry out with continuing in 2020.

Results

Compiling the available pH data around Sri Lanka

The latest measurementdata on p^H variations in surface waters around SL from 10 transects carried out byR/V DR Fridtjof Nansen (June- July, 2018) were used to indicate the current status of acidification around Sri Lanka (Figure 1). Here, low pH values were observed in western side of the country.



In situ Parameters observed/analyzed

eastern coastalsite (12 points)was subjected to collect water samples for acidity measurement and other oceanographic parameters (Figure 2).

Under this oceanographic survey, in situ data collection for physical parameters (Temperature, Salinity and CTD - Conductivity, Temperature, Depth) water sample collection for chemical parameters (P^H, Dissolved Oxygen, Nutrients - Nitrate, Nitrite, Phosphate and Silicate and Total suspended solids) and biological parameters (Chlorophyll a, Phytoplankton, and Zooplankton) were carried out. The survey was carried out using R/V Samuddrika atGalle and Trincomalee.

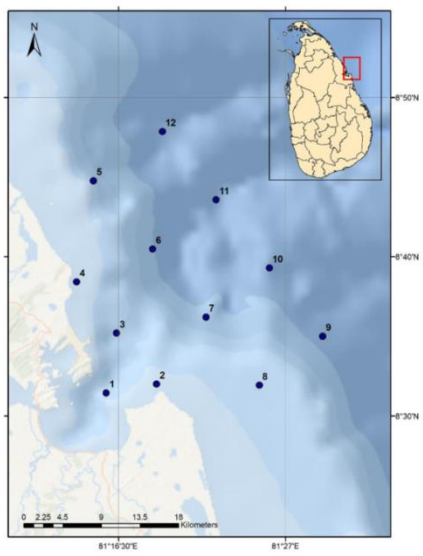


Figure 2.c. Sampling sites at Eastern coastal waters

Figure 3.0 Sampling at Trincomalee coastal waters using R/V Samuddrika

Figure 4. Laboratory analysis of chemical and biological parameter

a. p^H variations and other oceanographic status in Trincomalee Bay & Adjacent Sea

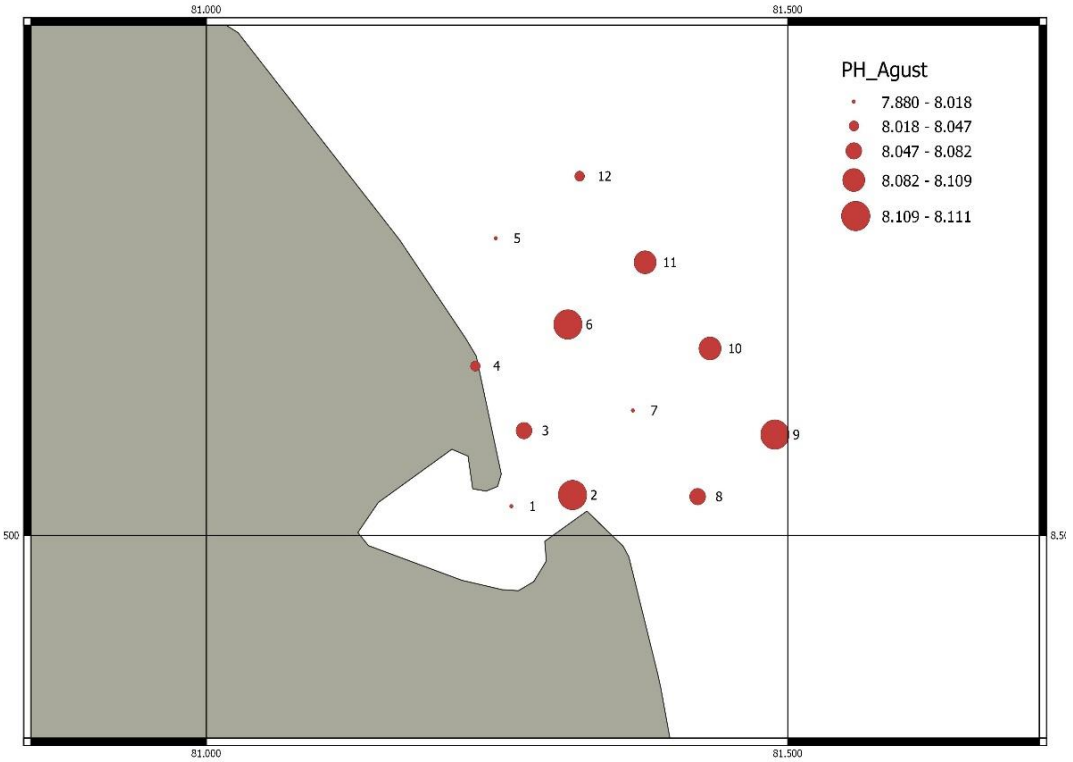


Figure 5.1 p^H Variations in eastern coastal waters during month of August.

P^Hvalues ofTrincomalee coastal waters during August varied between 7.064to 8.121 while those values are lower than standard sea water P^H value (8.200) which indicated that ocean acidification is on going in eastern coastal waters, (Figure 5.1 and Figure 5.2).But this cannot be directly linked to climate change as Trincomalee coastal waters

are refresh with land-based discharges through Mahaweli river run off. Normally,P^H value of fresh water discharges could be varied between 6.00-8.00. However, August and September months are dry season for Trincomalee area andhigh load of discharge cannot be expected from Mahaweli River during this time. Sri Lanka Dome condition in eastern coastal waters during summer time can be another possible reason for this low p^Hdue to coastal upwelling happening in this area. This assumption can be further convinced by P^Hvalue variation in month of September. During September the acidic condition has increased in offshore area rather than coastal waters.However, this study has to be continued and should be correlated with prevailing weather condition and actual river run off measurements.

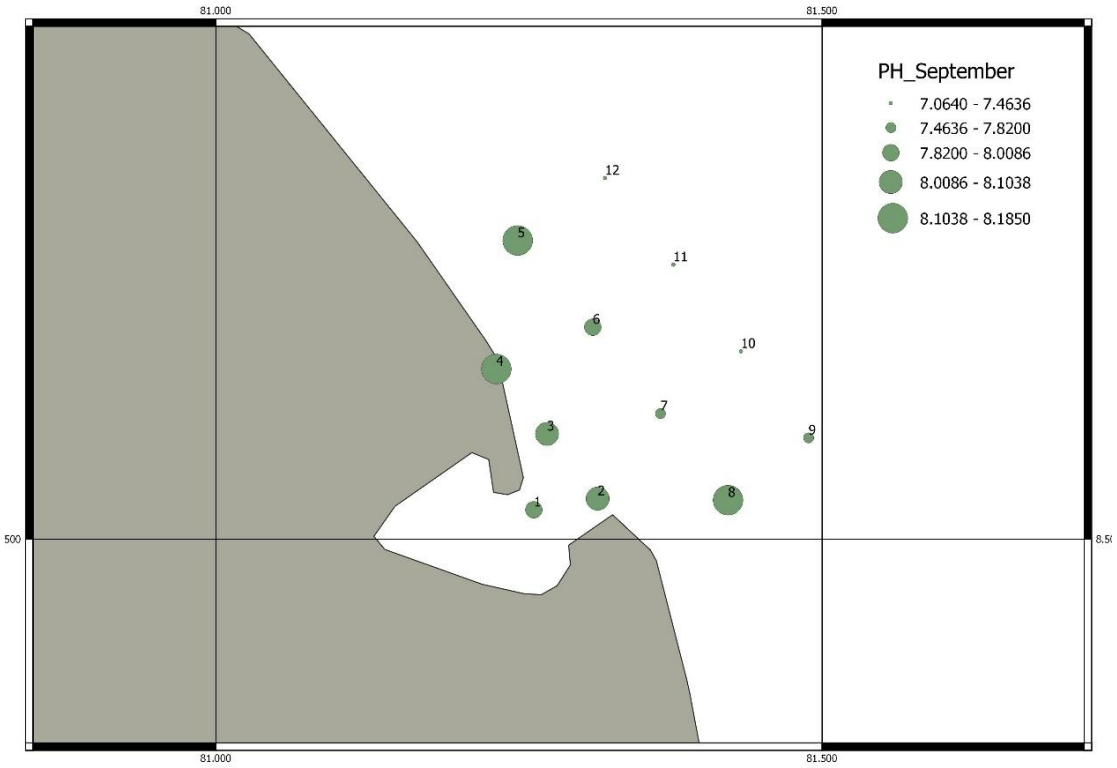


Figure 5.2 p^H Variations in eastern coastal waters during month of August.

Physical properties of eastern coastal waters

Salinity and Temperature

Salinity and Temperature in all 16 locations were inversely correlated with each other during summer time (August and September), (Figure 6). Low salinity and high temperature were recorded in northern side (Nilaweli area) of Trincomalee coastal region during August which indicated that fresh water river plume dispersed towards northern side from the Bay while high salinity water enters from southern side of the Bay mouth. Then during September, high salinity water with low temperature dispersed to Bay area while fresh wetter with low salinity and high temperature water spread towards

offshore areas. However, in general salinity of all locations were > 32.00 PSU while temperature remained over 27.24 ^{0}C.

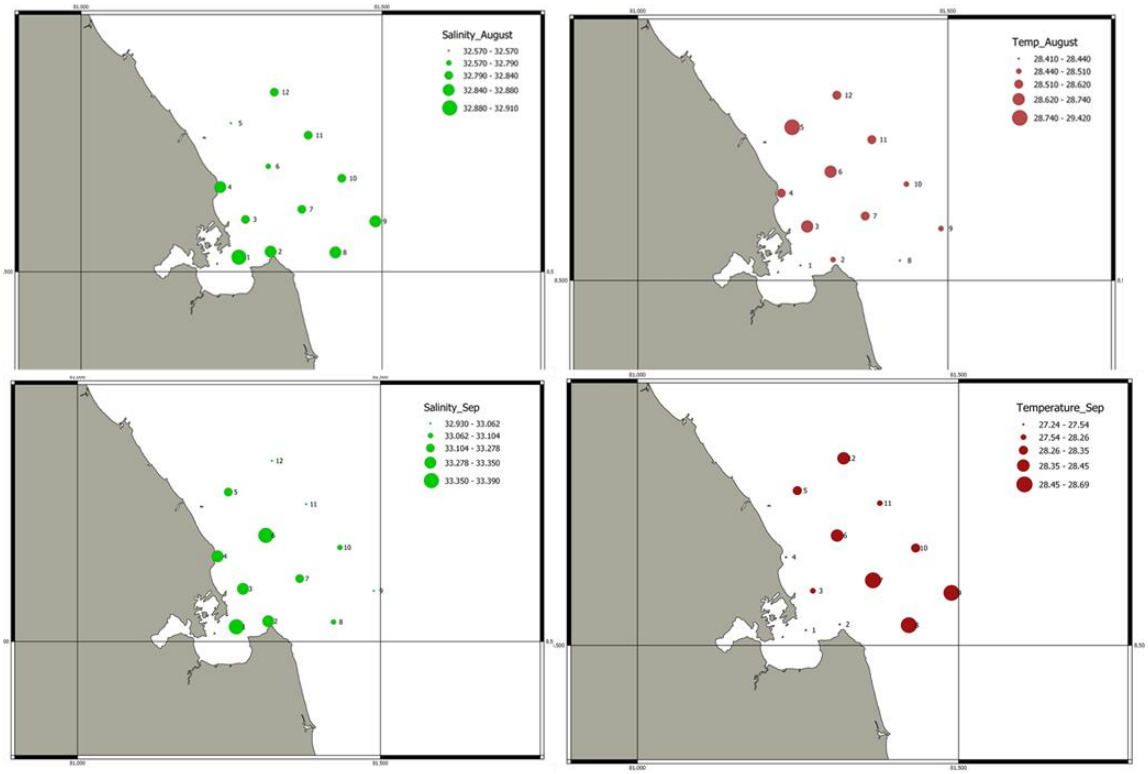


Figure 6.0Temperature and salinity variations in eastern coastal waters during month of August and September.

Dissolved Oxygen

Dissolved Oxygen in Trincomalee area varied 6.20 mg. l^{-1} to 6.55mg. l^{-1}in August while it varied 5.95 mg. l^{-1} to 6.76 mg. l^{-1} during September, (Figure 7. A and Figure 7.b). Here, high values were related with prevailing wind speed during the sampling day.

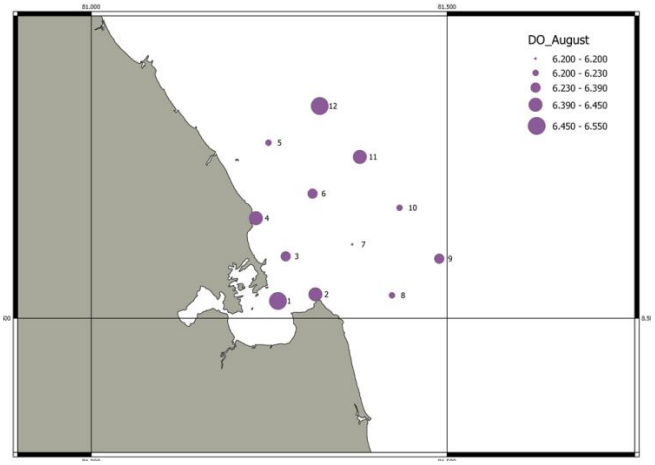


Figure 7.aDissolved Oxygen variations in eastern coastal waters during month of August.

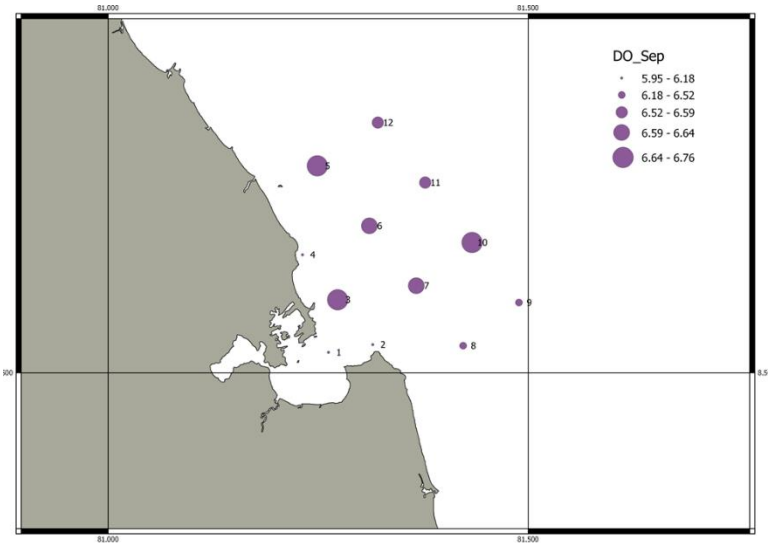


Figure 7.bDissolved Oxygen variations in eastern coastal waters during month of September.

Nutrients

The nutrient (Nitrate, Nitrite, Phosphate and Silicate) variations in Trincomalee coastal area during summer (August and September) varied very similarly except Silicate concentrations in September, (Figure 8.a and 8.b) which indicated that diatoms with silicate shells could be higher during that time.

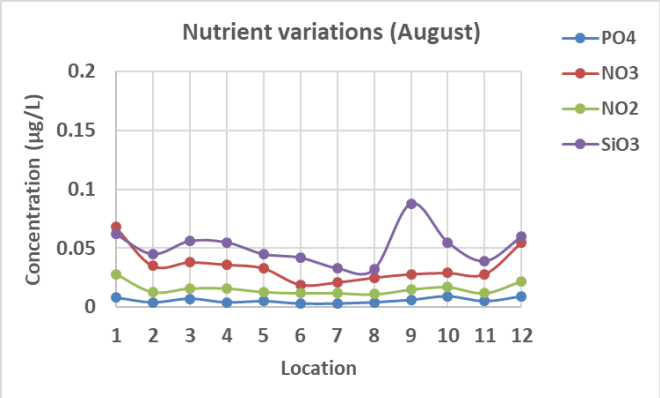


Figure 8.aNutrient variations in eastern coastal waters during month of August.

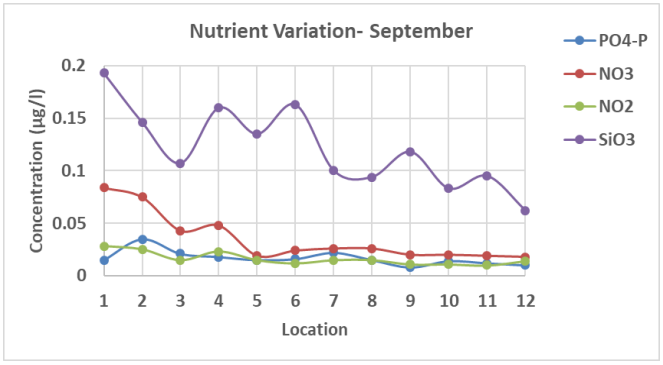


Figure 8. Nutrient variations in eastern coastal waters during month of September.

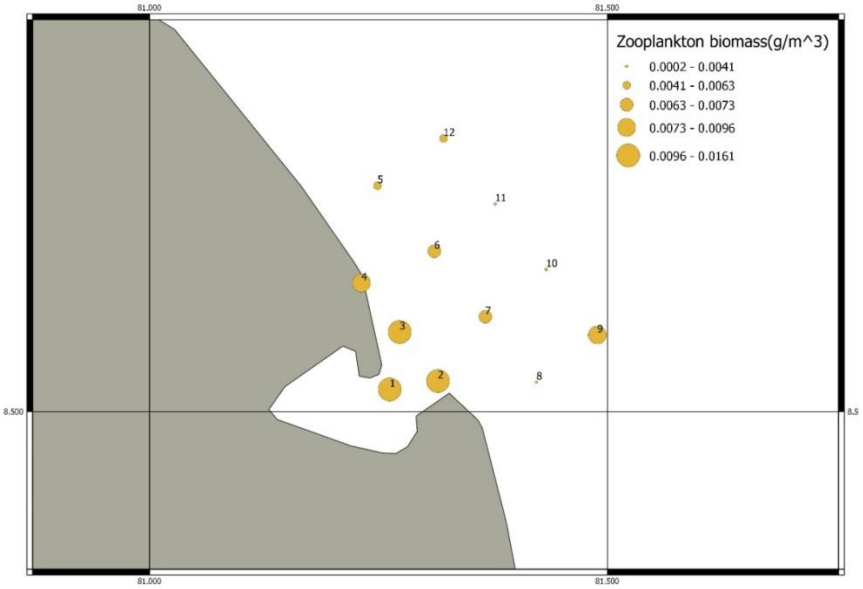


Figure 9. Zooplankton biomass in eastern coastal waters during month of August.

Biological Properties

Zooplankton Biomass variation in eastern coastal waters during summer time is higher in month of September compared to that values in August. According to higher silicate, it is suggested that high population of diatoms would be present in September. According to higher phytoplankton production, biomass of Zooplankton can be expected which suggests that primary production is higher during end of summer in eastern coastal waters. However, this work has to be continued for other seasons during 2020 to get clear idea about carbon system and its interactions with the time.

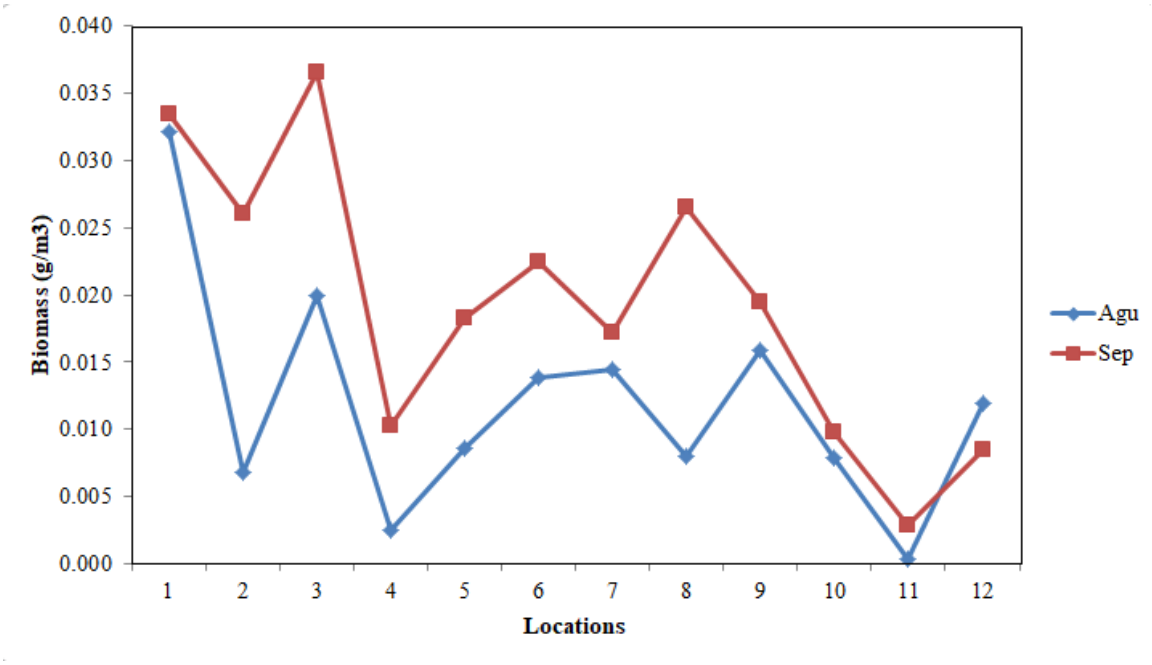


Figure 10. Zooplankton Biomass Variation in eastern coastal waters during summer, 2019

Conclusion and recommendation

According to the R/V DR Fridtjof Nansen survey, P^Hvalues were over than 8.00 in Trincomalee area during June-July 2018. But, in current study, P^Hvalues sometimes dropped up to 7.06 offshore areas due to Sri Lanka Dome upwelling during month of August. Thus, high nutrient pump especially Nitrate, Nitrite and phosphate could be noticed in August resulting higher biomass of Zooplankton and phytoplankton production in month of September. Hence carbon system behavior is quite unique in summer time at Trincomalee coastal areas. But, further studies are required to compare with other seasons

Output:

To improve the institutional capacity for conducting comprehensive ocean acidification research, some equipment (P^H meter, ADCP) and chemicals (m- Crisole purple) were purchased.Report on ocean acidification status in Sri Lankan eastern waters is produced while documentation on Seasonal variability of calcified phytoplankton with response to ocean acidification status have to be conducted in 2020 with proper technology improvement.

Sea level Observation and formulation of Oceanographic data base

Project No : 6.7

Responsible Officer/s: Dr. K. Arulananthan and K.W. Indika

Introduction

Sea-level increase is being accelerated during the last four decades; especially in the Indian Ocean, the rate of increase is higher than the global average. Monitoring indicates that Sri Lanka is one of the areas where the sea-level rise is fastest in the world. Economic growth of the coastal areas is faster than the inland. Because of the population growth and faster urbanization, the coastal areas, with the higher population growth and urbanization, the coastal community is increasingly prone to ocean disasters induced by sea-level rise such as storm surges, salt water intrusion and coastal erosion. To protect the social and economic development, reliable monitoring, better understanding of the process of the sea-level change, prediction of the impending disasters based on science, suitable planning and adaptation are essential to device effective strategies to reduce the potential damages induced by sea-level changes.

Oceanographic data, including sea-level data is vital for the management of coastal regions. The data give insights into the dynamics of the ocean and coastal regions. Properly managed and preserved data can be used and re-used by future researchers, exploited commercially or used by educators and the general public. Such further uses will make an additional contribution to scientific advance and knowledge

Activities completed

Housing for the fifth sea level monitoring station of the country was constructed at Point Pedro (PPT) fisheries harbor premises. The equipments are expected to be fitted in April 2020. The new sea level station will fulfill the long standing requirement of establishing a station to monitor hydrological and meteorological parameters of northern peninsula. Ceylon Fisheries Harbor Cooperation (CFHC) was kind enough to make available its premises to establish the sea level station. The station is constructed such a way that, if the harbor undergoes expansion, the station could be easily shifted.

A temporary bench mark was established at the proximity of the PPT sea level station, and reference is made to the permanent bench mark, located at Point Pedro hospital with the assistance of National Hydrographic Office of NARA,

Long term sea level data (2006-2017) from Mutuwal sea level station is analyzed to estimate sea level trend. The total sea level rise during the 12 years is 37.752 mm, the sea level is being raised at the rate of 3.146 mm per year.

The sea level data of 2018-19 is treated separately, as the Mutuwal Station is shifted to the Colombo Harbour premises at the later part of 2017. The data from Mutuwal and

Colombo need to be synchronized to analyze as a single set of data. In order to synchronize, Colombo Sea level station need to reference to the permanent bench mark at the Eli House Park.

Data from the international cruises are incorporated into the Oceanographic Data Base;

2019

China RV MIRAI Bay of Bengal

China RV Hems_Leeuwin East Seri Lankan Water

USA RV Sally Ride MISO BOB

2017

USA RV Thomas Thompson Bay of Bengal Project: ASIRI 03

2015

USA RV Roger Revelle Bay of Bengal Project: ASIRI 02

2013

USA RV Roger Revelle Bay of Bengal Project: ASIRI 01

Mooring

USA Mini mooring Kalpitiya

USA Pressure Inverted Eco Sounder (PIES) East Coast Sri Lanka

Sea Glider No 530

Meteorological Data

- Beruwala ?????
- Mirissa
- Colombo
- Maldives
- Singapore
- Seashells

An icon named 'Sea level Data' is created on the NARA web page 'http://www.nara.ac.lk/?page_id=4018' to make available public access to the sea level data. The data could be visualized on graphical form and down loaded as per the user's requirement. The user is requested to fill a 'contact form', made available on NARA web page. In total, 68 requests by the public, including students, academics and researchers via email is served.

Constraints

Request is made to incorporate Dr. Fridtjof Nansen survey data around Sri Lanka (2017), however the data is not provided.

Repeated request is made from Oceanography Divisional staff of NARA to provide data or at least metadata (information on the parameters gathered), collected using the treasury fund, however none of the staff provided any data to update the Oceanographic Data Base.

The ultimate goal is establishing an Oceanographic Data Centre, where all the 1) data is archived, 2) processed, 3) stored in a data base and 4) makes it accessible to the users.

However, the project is still in the early phase, the data are being archived in hierarchical folder system and some of the data are being quality controlled.

Conclusion

The establishment of the Point Pedro (northern coast) sea level station, will complete the objective of establishing sea level station at the different sides of the Sri Lanka; Colombo (western coast), Mirrissa (Southern coast), Trincomalee (Eastern coast).

More stations shall be established in between the above main sea level stations, to build up a comprehensive sea level monitoring network.

Recommendations

During the existence of NARA, nearing four decades, NARA has gathered extensive data on various environmental, fisheries, and socio-economical parameters. However, NARA does not maintain a common data base, which is accessible academics, researchers and general public. Moreover, most of the data are not available as the researchers, who collected the data are left NARA.

Furthermore, Lack of trained human resources and unwillingness of the NARA officers to provide the data for a common data base is major hurdle for the successful implementation of the project. Data sharing policy need to be developed.

Publications

Research papers /Conference Proceedings

1. H.B.U.G.M.Wimalasiri, P.Dalpadado, R.P.P.K. Jayasinghe Zooplankton biomass variation in relation to temperature and salinity for upper 30m around Sri Lanka. *Proceedings of the National Aquatic Resources Research and Development Agency (NARA), International Scientific Sessions* 2019 (50).

2. D.G.T.C.Balawardhana, H.B.U.G.M. Wimalasiri and S.S.K. HaputhanthriAbundance and reproductive seasonality of Stomopneustesvoriolaris (Black sea urchin) in East and South coasts of Sri Lanka. *Proceedings of the National Aquatic Resources Research and Development Agency (NARA), International Scientific Sessions* 2019. (3)

3. A.G.G.C. Bandara, M.I.G.Rathnasuriya, H.B.U.G.M.Wimalasiri, R.P.P.K. Jayasinghe, P.Dalpadado. Abundance, Distribution and species composition of ichthyoplnkton in surface coastal waters of Sri Lanka. . *Proceedings of the National Aquatic Resources Research and Development Agency (NARA), International Scientific Sessions* 2019.(7)

4. K.W. Indika, Ranjana U.K. Priyadasa, E.M.S. Wijerathne, H.B.U.G.M. Wimalasiri, Determination of Climate Change Impact to the Coastal Community in the Northern Indian Ocean, 24th International Forestry and Environment Symposium, 11 - 12 October 2019, Jetwing Blue, Negombo, Sri Lanka.

5. M.I.G.Rathnasuriya, R.Skern-Mauritzen, A.Mateos-Rivera,. H.B.U.G.M Wimalasiri,. R.P.P.K. Jayasinghe,. J.Krakstad and P. Dalpadado, Species composition and diversity of fish larvae in sri lankan waters from a combined morphological and dna barcoding approach. *43rd Annual larval fish conference At: Palma De Mallorca, Spain*

6. H.B.U.G.M. Wimalasiri, D.G.T.C.Balawardhana and S.S.K. Haputhanthri (2019) Sea Urchin Abundance and Diversity at Selected Locations in Southern and Eastern Coasts of Sri Lanka. *International Research Conference of Uva Wellassa Universit,y* 7th – 9th February, UvaWellassa University, Badulla, Sri Lanka. p 4

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1. Project completion report on "*Modelling of Coastal Sediment Dynamics and Coastal erosion on the North-eastern Coast of Sri Lanka*." National Institute of Oceanography & Marine Sciences, NARA, 2019.

2. *Coastal erosion investigation along Negombo-Wadduwa coastal stretch*, Report submitted to Chairman, NARA as per the request of the Ministry of Fisheries and Aquatic Resources, 30th of May 2019.

3. *Side Scan Sonar Survey on Proposed Fish Aggregation Devices Deployment Sites off Trincomalee*, Report submitted to the Ministry of Fisheries and Aquatic Resources, 29th of August, 2019.

Environmental Studies Division

Study on effect of bio accumulation and integrating ecological, carbon and water footprint to tracking anthropogenic pressure on Mangroves, Sea grass beds and salt marshes, wetlands in coastal, lagoon and fresh water bodies (rivers & Reservoirs) to enhance ecosystem conservation (Malala Lagoon)

Project No: 5.1

Responsible Officer/s: A. A. D. Amaratunga, W. K. Suwandhahannadi, M. G. C. R. Wijesinghe, S. R. C. N. K. Narangoda, M. D. S .R. Maddumage ,J. K.P. C. Jayawardane

Justification:

Coastal lagoons are highly productive ecosystems. They contribute to the overall productivity of coastal waters by supporting a variety of habitats, including pelagic phytoplankton, benthic macrofauna,intertidal salt marshes, seagrasses, and mangroves. They also provide essential habitat for many fish and shellfish species (Bertness, 2007). And also lagoons are transition habitats for catadromous and anadromous finfish and shrimp species while providing temporary accommodation for sedentary and sessile shellfish species.

About 82 *lagoons* are found around the1,338 km of Sri Lankan coast covering about 1520 km^2. From these, 62 are located in the dry zone while 15 and four lagoons are on the wet and intermediate zones, respectively (Silva et al., 2013). Several natural and anthropogenic factors cause for the health of the lagoons worldwide. Lagoon salinity regime may also change by streamflow regulation by constructing dams, trans-basin diversions and interlinking rivers. This is one of the most common land-based human interventions in Sri Lanka.Damming and diversion of the Walawe River gives severalimpacts on some downstream brackish water lagoons.

Malala lagoon (650 ha) is the largest of the five enclosed shallow lagoon situated within the Bundala National Park in the south eastern arid zone of Sri Lanka, and it is one of the most productive fifteen lagoons in Hambantota District.This ecosystem receives freshwater from MalalaOya. It is located close to the ocean and opens to the sea through nearly a 300 m wide mouth during the rainy season. During the dry periods, the mouth is closed by a naturally formed sand bar which is about 2m high from the lagoon water level. Embilikala is a low saline lagoon and is located nearly 1.7 km away to the Northeast of Malala lagoon and these two are interconnected through the natural canal, which is about a 40 m wide that runs for about 3.1 km meandering between the two water bodies (Banu and Balasooriya, 2014). After the completion of the KirindiOya Irrigation and Settlement Project (KOISP) large scale discharges of agricultural water caused to dropped the salinity of the lagoon up to 1-7ppt (Cumaranatunga and Titus,1998). This has changed the quality of water in these lagoons and may lead to adverse impacts on aquatic animals and finally for the whole ecosystem (Matsuno et al., 1998).

Project Objectives

To identify level of anthropogenic stress on Malala lagoon.

Methodology

Before the sampling programme, the awareness programme was conducted to with the help of Fisheries Inspector (FI), Department of Fisheries – Hambanthota. He was arranged a meeting with Fisheries Society at that area (Palle Malala Grameya Dewara Sanvidanaya).



Fig.1: Awareness programme with FI and fisherman's in the area and the lagoon

The study was carried out in selected 13 sampling points located within the lagoon from July to December 2019. The outlets of the Lunugamwehera reservoir for supply water to paddy cultivation are the primitive inflows to the lagoon. Four different water inlets were used to collect water samples. Physical, chemical and biological parameters of water quality were measured. In-situ parameters such as water temperature, pH, salinity, electrical conductivity, dissolved oxygen, turbidity were measured. Ammonia, Ortho-phosphorus, Nitrate and Nitrite concentrations (ppm), Total suspended solids, Biochemical Oxygen Demand (BOD), chlorophyll-α, primary production and plankton diversity were the tests carried out in the laboratory. All the tests were performed according to the standard methods for Water and Waste Water Analysis given by American Public Health Association (APHA).


Fig. 2: Sampling at the Malala lagoon

Results

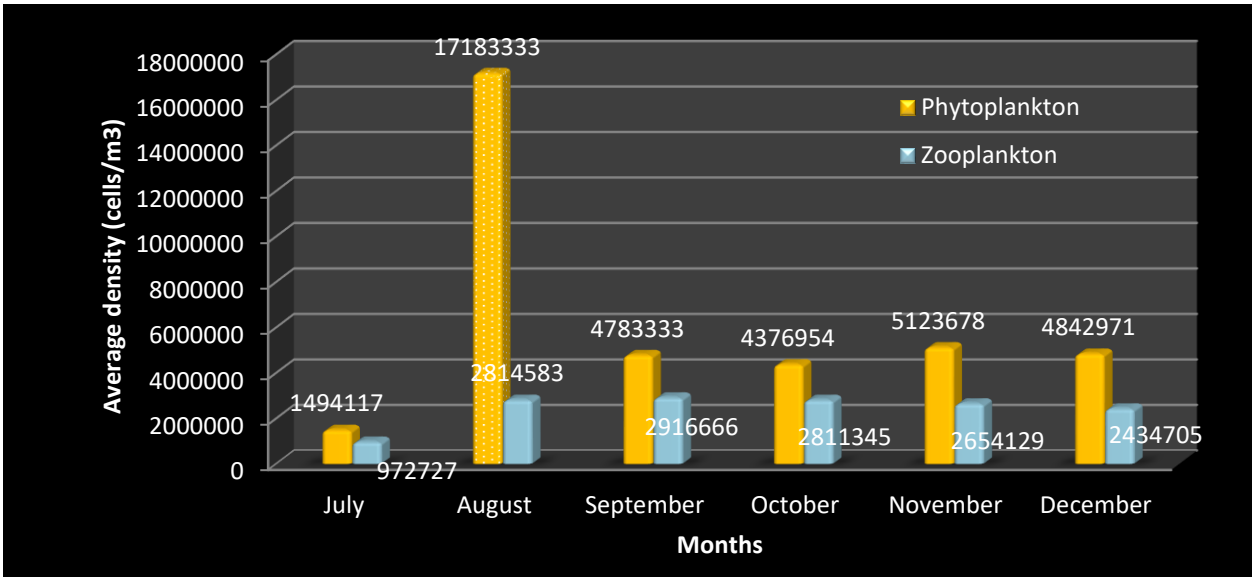
The results of the study revealed that the average monthly salinity of the lagoon system varied between 0 - 0.3 ± 0.09 ppt. This salinity is very low than the previous salinity of that lagoon before the Kirindi Oya Irrigation and Settlement Project (KOISP) project. This may be due to receive huge fresh water influx from KOISP project to these two inter-connected lagoons.And also due to the water dilution, high value brackish water fish species were replaced by the lower value fresh water species, principally the Tilapia (*Oreochromismossambicus*). According to catch data most dominant fish species in the lagoon was Tilapia. Not only that brackish water species like *Liza dussumieri, Tachysurus sp., Gerressetifer*, *Chanoschanos* and fresh water species like *Macrobrachiumrosenbergii*, *Channastriata*, *Glassogobiusgiuris* were observed within the fish catch in Malala lagoon.

Lagoon system was highly covered with fresh water aquatic plants like *Nymphaeanouchali, Nymphaeapubescens ,Typhalatifolia, Aponogetoncrispus, Najas marina* and *Nitella* sp.Nutrient like Ammonia, Ortho-phosphorus, Nitrate and Nitrite concentrations in lagoon water was very low amount (Table 1). These nutrients may utilize by these aquatic plants in the lagoon. The results reveal that, highest fresh water flow rate of 1.06 ms^{-1} was observed in freshwater input from irrigation channel which bring water from Lunugamwehera Reservoir irrigation draining channel. The total discharge of the drain channel was 30.8 m^3s^{-1} and it directly drain to Malala & Ambilicalala laggon complex.

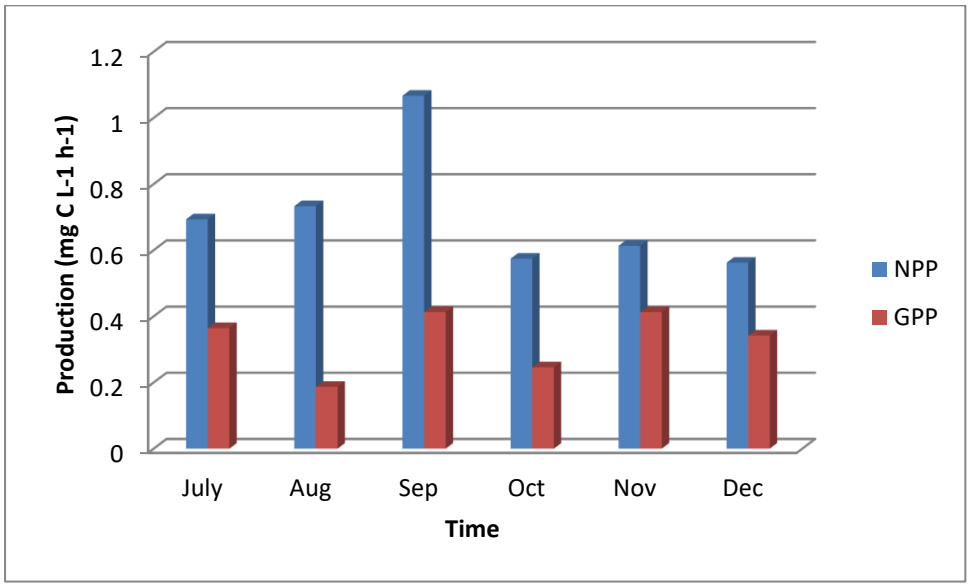
Month	NPP (mg CL-1h-1)	DO (mg-L)	NO_3^- (ppm)	NO_2^{-1} (ppm)	PO_4^{-3} (ppm)	Chl ()	Ammonia (ppm)	Turbi (NTU)	PH	EC (mS cm^{-1})	Salanity (ppt)	WT (C^0)	TDS (mg-L)
July	0.73 ±	7.80 ±0.9	0.004 ±0.001	0.003 ±0.002	0.02 ±0.006	0.07 ±0.02	0.01 ±0.009	19.88 ±7.7	1.98 ±0.28	1.98 ±0.69	0.15 ±0.05	28.82 ±0.27	657.23 ±229.5
Aug	0.69 ±	8.08 ±0.6	0.002 ±0.003	0.002 ±0.001	0.07 ±0.008	0.12 ±0.03	0.08 ±0.121	17.65 ±7.4	8.74 ±0.16	1.40 ±0.41	0.34 ±0.09	26.86 ±0.27	610.15 ±172.1
Sep	1.06 ±	6.51 ±1.7	0.006 ±0.002	0.001 ±0.001	0.01 ±0.008	0.18 ±0.02	0.08 ±0.047	18.21 ±7.9	8.12 ±0.35	1.62 ±1.71	0.23 ±0.1	28.04 ±0.47	482.31 ±178.7
Oct	0.57 ±	6.92 ±0.9	0.005 ±0.002	0.002 ±0.001	0.01 ±0.011	0.19 ±0.23	0.06 ±0.059	16.88 ±6.6	8.43 ±0.35	1.37 ±0.32	0.13 ±0.05	27.03 ±0.49	555.85 ±165.4
Nov	0.61 ±	4.99 ±1.3	0.004 ±0.001	0.002 ±0.001	0.01 ±0.012	0.21 ±0.02	0.04 ±0.008	8.09 ±8.7	7.73 ±0.28	0.86 ±0.11	0±0	27.92 ±0.37	429.77 ±67.7
Dec	0.69 ±	0.73 ±0.9	0.003 ±0.003	0.002 ±0.001	0.02 ±0.011	0.20 ±0.01	0.06 ±0.06	14.56 ±6.4	8.63 ±0.27	1.56 ±0.42	0.17 ±0.05	28.47 ±0.35	453.71 ±165.4

Table 1: Variation of physicochemical parameters of Malala lagoon (Mean ± SD)

Average density of phytoplankton in August was somewhat higher than the other months. Within June, July and August very little rainfall was observed for the study site. Most of the phytoplankton species observed within the lagoon were fresh water species like *Chroococcusminimus, Merismopediaglauca, Pediastrum duplex, Scenedesmusquadricauda, Synedra sp., Navicula sp., Anabaena sp., Nostoc sp., Nitzschia sp., Mcrocystis sp*., etc.



Average Net Primary Production (NPP) and Gross Primary Production (GPP) changed according to below chart.



Variation of physicochemical parameters of Malala lagoon over the period from 1991 to 2019 (Mean ± SD, minimum to maximum or range)

Physicochemical Parameter	1991/1993 IIMI (1995)	1995/1997 Titus et al.(1998)	1999/2000 Piyankarage et al.(2004)	2019 Present study
Depth (m)	1.0 – 2.2	1.33 ± 0.38	1.27 ± 0.39	1.35 ± 0.45

		0.55 – 2.00	0.28 – 2.25	0.3 – 2.13
Temperature (^oC)	-	27.69 ± 1.62 25.6 – 31.30	28.8 ± 1.93 25.2 – 34.7	27.73 ± 0.81 26.4 - 29.3
Conductivity(mS/cm)	-	5.14 ± 3.88 1.22 – 14.08	3.04 ± 2.35 1.84 – 13.62	1.45 ± 0.9 0.68 – 3.97
Salinity (ppt)	14 41(high level) 7-15(low level)	2.18 ± 1.61 0.59 – 6.21	-	0.17 ± 0.13 0 – 0.4
pH	-	7.93 ± 0.46 7.00 – 8.60	8.08 ± 0.35 6.86 – 8.65	8.3 ± 0.4 7.34 – 9.04
PO_4^{-3} (µg/L)	-	11.72 ± 5.39 3.33 – 28.33	48.80 ± 22.9 16.3 - 88	25.63 ± 25 2.4 – 84.1

Results revealed that the lagoon system was totally changed from brackish water to fresh water.

Also, large amount of fresh water inflow to the Malala lagoon directly affect for the water quality, sediment quality benthic lives of the lagoon ecosystem. Sediment samples were collected from thirteen sampling locations of the lagoon. Highest nutrient inflow to the lagoon was recorded from inlet near to the Tissa road of Hambantota district. Recorded mean nitrite nitrogen, nitrate nitrogen, dissolve phosphate and ammoniacal nitrogen values of the inlet water systems are 0.005 mg/l, 0.012 mg/l, 0.006 mg/l and 0.119 mg/l respectively. Also, mean sediment nitrate nitrogen, sediment bound phosphate and ammoniacal nitrogen values were 0.019 ± 0.010, 0.789 ± 0.024 and 0.004 ± 0.024. In every location, high abundance of benthic macro invertebrates was recorded. Nearly seven different Mollusca species were identified. Abundance of polycheates was low in the lagoon. Benthic macro invertebrates were primary nutrient in takers of the lagoon.

Recommendations

Need a suitable mechanism to remove drainage water from Kirindi Oya Irrigation and Settlement Project without entering to Malala and Embilikala lagoons with the help of Wild Life Department and Irrigation Department. Prior to this project, Initial Environmental Examination (IEE) process should be conducted to elucidate the impact from the project.

To address this excess water in the lagoon, in 1992 the government put up a canal close to right side of the lagoon mouth, in order to drain out the excess water to the sea. After the implementation natural lagoon mouth was not opened instead of heavy flood. So need a management activity to keep the natural lagoon mouth functions.

Stoking of planktovorous fish species in the reservoir and try to balance the nutrient balance with food web manipulation

Regular monitoring of nutrient & salinity of the lagoon

Prohibit the usage of mono filament nets within the lagoon

Increase awareness programme for fishing communities

Remarks

Request letter on permission from Wildlife department was sent on 16 January 2019 to and permission granted letter was received on the 27 June 2019. So the research was conducted from July.

Study of Marine Litter inputs from North Western, Western, Southern and Eastern Marine Coastal areas of Sri Lanka.

Project No: 5.2

Responsible Officer/s: B.R.C. Mendis, A.A.D. Amarathunga

Problem Statement/Justifications:

This study was focused on marine debris (plastic and polythene) which is recognized as a worldwide threat to marine organisms, ecological processes and economies. Marine habitats are contaminated with man-made debris and represent the major categories of marine debris by material type on a global basis. The sea around the Western, Southern and North Western province of Sri Lanka is composed of a large coastal community and is highly affected by the increasing urbanization and industrialization activities. These anthropogenic activities were increase the amounts of organic and inorganic waste input into the system and would have an impact on the overall coastal ecosystem. Therefore, dumping plastic and polythene waste into marine environment harm the aquatic biota. Thus, identification and quantification of waste input status helps in management and conservation biological and fisheries aspects.

Project Objective/s:

To identify and classify dumping of plastic and polythene waste inputs around coastal belt of Sri Lanka

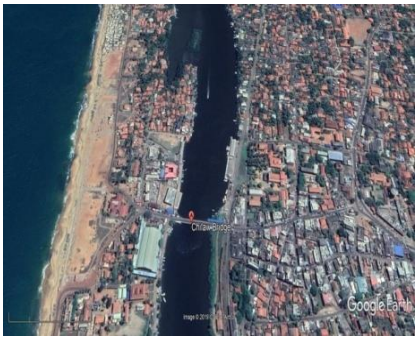
To give recommendations to implement conservation measures to plastic waste management.

Methodology:

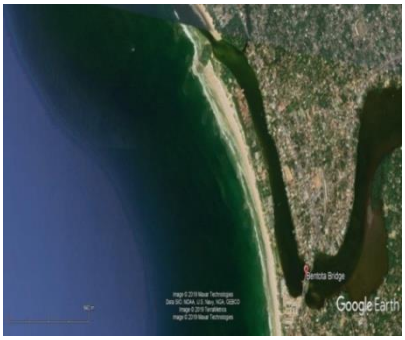
Marine debris was surveyed on selected sites mainly focus on river discharge outlet, estuary mouths and tourist destination sites as North - Western (Negombo and Chilaw) coastlines and Southern (Bentota, Horathota river basin and Kalido Beach) during study period from January to December 2019. Debris cover was estimated in 100 x 10 m net using the sample collected in each site on monthly basis for macro debris (> 2.5 cm). The collected debris particles were quantified and categorized by material type. During next year (year 2020) this study will be continue to the study sites in Eastern coastline and in-depth analysis of pollution sources.

Sampling Sites

Negombo Lagoon Sea Mouth

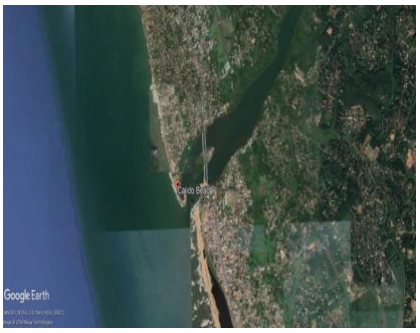


Chilaw Lagoon



Bentota River

Horawala Thotupola



Kalido Beach

Moratuwa Bridge

Results and Observations

Throughout the whole study period, marine debris was collected mainly from anthropogenic activities such as domestic waste dumping and boat operations. They were mostly comprised of plastic and polythene waste which was observed at Negombo sea mouth area and Kalido beach. Significantly higher amount of debris were found in Negombo sea mouth area and Kalido beach. The composition of debris by material types indicated as packaging material (45%) dominated the debris, followed by consumer products (20%) and fishing items (20%) plastic bottles (10%), while caps/lids and food wrappers/containers contributed only 5% respectively.

Observations

Project Highlights

Conclusions

The study revealed that the urbanized Negombo area was highly polluted with marine debris and their impacts on water pollution is also high. Negombo sea mouth areas are highly polluted with marine debris compared to Chilaw and Bentota areas. Thus, it is recommended to make remedial measures to reduce the debris accumulation on sediment to conserve these valuable coastal habitats.

Recommendations

Conduct public awareness programmes to minimize usage of plastic and polythene to reduce plastic pollution. It is important that the awareness of the society is re-checked and an ecology-concerned society is build via timely dissemination of knowledge and apposite policy reforms.

Strong marine debris management program is needed for Sri Lanka with sound policy measures to address the debris issues.

Implement strong rules & regulations and carry out continuous monitoring programmes to minimize/overcome marine debris pollution.

Encourage recycling of plastics such as polyethylene, polypropylene, polystyrene without causing the environmental degradation.

Identification of most appropriate fresh water fish species as bio-indicators in lower and upper catchments of the Kelani river basin for Environmental pollution Assessment. (Continuous Project)

Project No: 5.3

Responsible Officer/s: S. R. C. K. Narangoda, A. A. D. Amarathunga, K. A. W. S. Weerasekara, M. D. S. R. Maddumage, J. K. P. C. Jayawardhena

Justification:

Pollution in aquatic environment has become a worldwide problem during past few decades and both natural and anthropogenic activities may alter the physical, chemical and biological processers associated with water resources and industrial activities (Chovanec, Hofer and Schiemer, 2003). In water quality assessments, biological information is more important in many of the same reasons ecologically and economically. Although, depend on series of chemical testing is the widely used method to determine and predict the degree of contaminants in a water body and chemical measures only present a static picture and give no indication of the underlying damages done to the ecosystem. Therefore, studying biological indicators reveals effect of bio-accumulated and even quickly metabolized contaminants (McLemore and Keeler, 1995).

Fish are one of the animal species often used as a naturally occurring environmental bio indicator out of plants, planktons, invertebrates, and microbes to assess the health of the environment and are an important tool for detecting changers in the environment and subsequent effect from human society. In addition, fish reflect the state of the pollution very well because of their limited ability to eliminate contaminants (Sucman, Vavrova, Gargosoava and Mahrova, 2010). Therefore, it is useful to find out more economically viable alternative when compared with other specialized measuring systems.

According to the available literature fresh water fish have not been extensively use as a bio- indicator to evaluate the level of contamination in the fresh water ecosystems in Sri Lanka (Sucman, Vavrova, Gargosoava and Mahrova, 2010). Furthermore, Kelani river basin is one of the most polluted river basins in Sri Lanka and the gravity of water pollution status of Kelani river basin is apparent due to land based sources, agricultural runoff, domestic effluents and municipal effluents (wijesinghe, 2015). In addition to that, heavy metal, organic waste and microbial pollution also present in some places of Kelani river basin. Furthermore, some other problem arises due to saline water intrusion from the sea making the water non-usable mostly due to sand mining of lower catchments of river basin making severe salt wedges on several occasions (Wijesinghe, 2015). Therefore the fish species found in the river basin with the presence of different types of pollutants are more vital and several pollutant sensitive bio-indicatory fish species also can be found in both lower and upper catchments. Therefore, it is a challenge and valuable

to find out most appropriate and suitable fish species that can serve as bio-indicator in Kelani river basin.

Project Objectives

This was a three year research project consisted with two main phases and phase one consists of discovering the fish diversity, abundance and biology and some other bio indicatory characteristics of the fish species found along the lower and upper catchments of Kelani river basin. And also, pollution assessment also was carried out in the same locations which were used to identify the fish species to compare with their diversity. The sub objectives covered within the year 2019 are as following;

Identification of the collected fish specimens up to the lowest possible taxonomic level.

Finding of fish species diversity, Relative Abundance and Species Richness for collected species to see their suitability to serve as a biological indicator.

The main objective of the phase two is to investigate the suitability of selected fish species (within the year 2019), as biological indicators by laboratory experiments to see their relationships either at the individual or population level, on selected pollution pressure. Fish identification for the upper catchment of Kelani river basin was completed along with the pollution assessment in the same locations selected.

Methodology

One of the most widespread method for select bio-indicatory species according to the principles recommended by Stork and Samway (1995), Caro and Doherty (1999) is score the each listed potential indicator species against eight key selection criteria that captured both biological and geographic criteria. For the biological and geographical criteria the following attributes should be selected respectively;

Well known biology

Relatively high abundance

Easy to locate, identify and monitor in the field

Clearly measurable

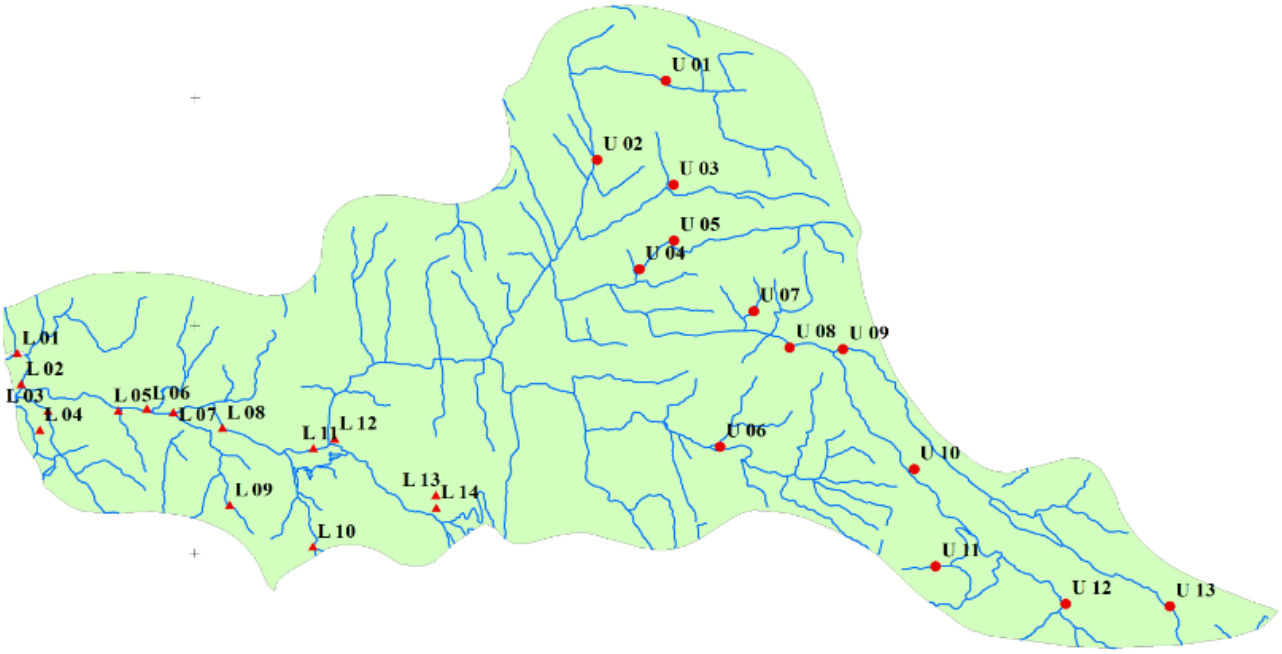
Resident within the ecosystem of interest prior to environment change

Sensitive to environmental changers within the period of measurement

Occurs on a scale relevant to the threat processors

Widespread

Using the above eight key selection criteria, each species will be scored against the each attribute. As a summery, each attribute will be scored between zero (poor) and three (high).



Map of the sample locations of upper and lower catchments of Kelani river basin

Study locations were identified based on the preliminary studies carried out and information gathered from available literature. Basically whole river basin was considered as upper catchment and lower catchment depending on the topography of the whole basin. The lower peneplains extending to about 300 meters of elevation as described in detailed by Cooray (1984) consisting of different degree of erosions and pollution. The upper peneplains consist of mountain chains which is more than 300 meters elevation. Locations were selected by considering the two major facts such as pollution level and availability of fish species. Thirteen sampling locations were selected for upper catchment and fourteen locations were selected for lower catchment including some reference sites which known as very low pollution status from literature.

Sampling was done for the water sample collection for physic-chemical parameters and freshwater fish identification from January to December 2019 for selected locations of upper and lower catchments of Kelani river basin. Freshwater fish species identification and their distribution were recorded.

Upper catchment	Lower catchment

code	Location name	code	Location name
U 01	Lahupana Ella	**L 01**	Mattakkuliya
U 02	Kotiyakumbura	**L 02**	Thotalaga
U 03	Pannala (Bulathkohupitiya)	**L 03**	Wallanpitiya bridge
U 04	Parussalla	**L 04**	Kolonnawa
U 05	Wee oya	**L 05**	Ambathale bridge
U 06	Panakoora/ Noori road	**L 06**	Biyagama
U 07	Kithulgala	**L 07**	Kaduwela
U 08	Malwaththa	**L 08**	Nawagamuwa
U 09	Kalugala palama	**L 09**	Panagoda
U 10	Koththallena	**L 10**	Padukka
U 11	Nallathanniya	**L 11**	Hanwalla bridge
U 12	Goverawela B division	**L 12**	Wak oya
U 13	Bagawanthalawa	**L 13**	Thunmodara

Sample locations of the upper and lower catchments



Kolonnawa Wallanpitiya Biyagama



Nawagamuwa Panagoda Thunmodara

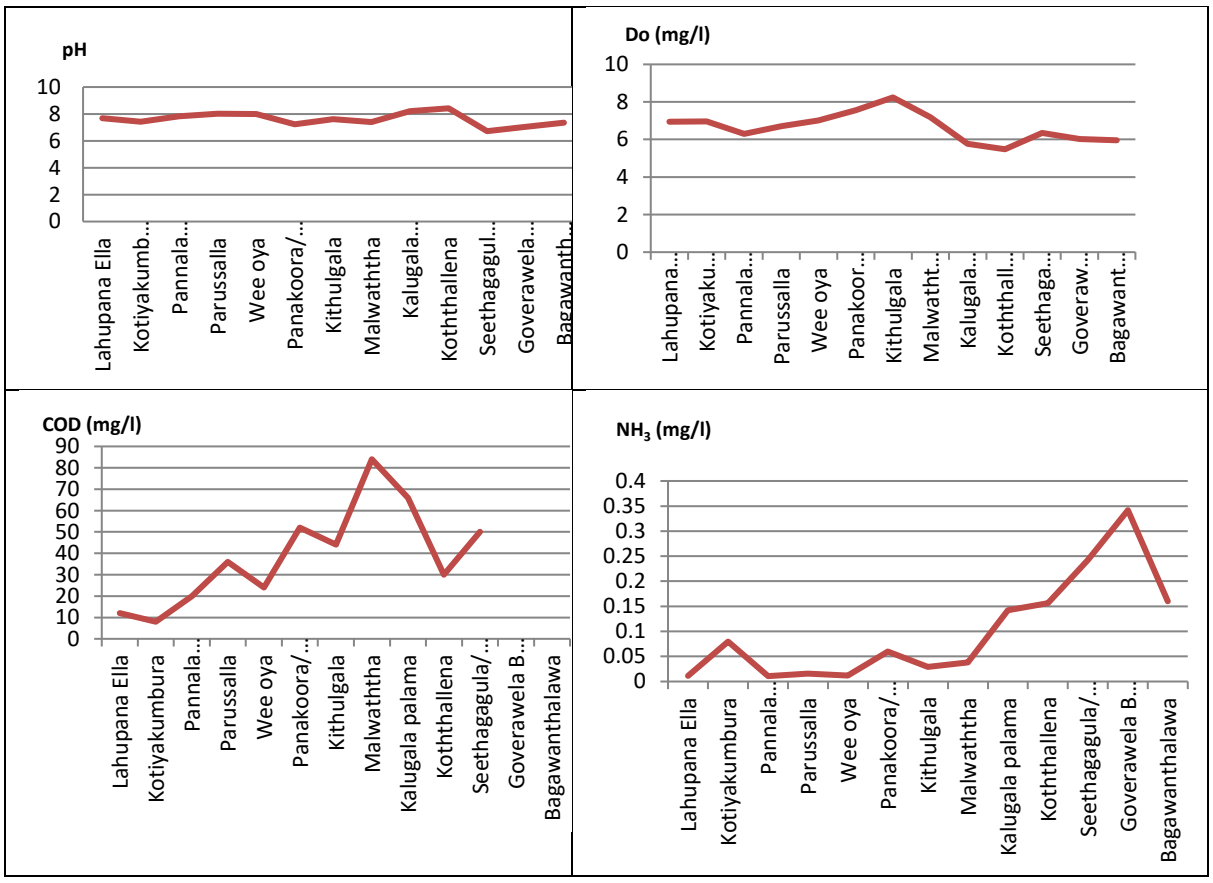
Some photographs of the sampling locations of the Kelani river basin lower catchment

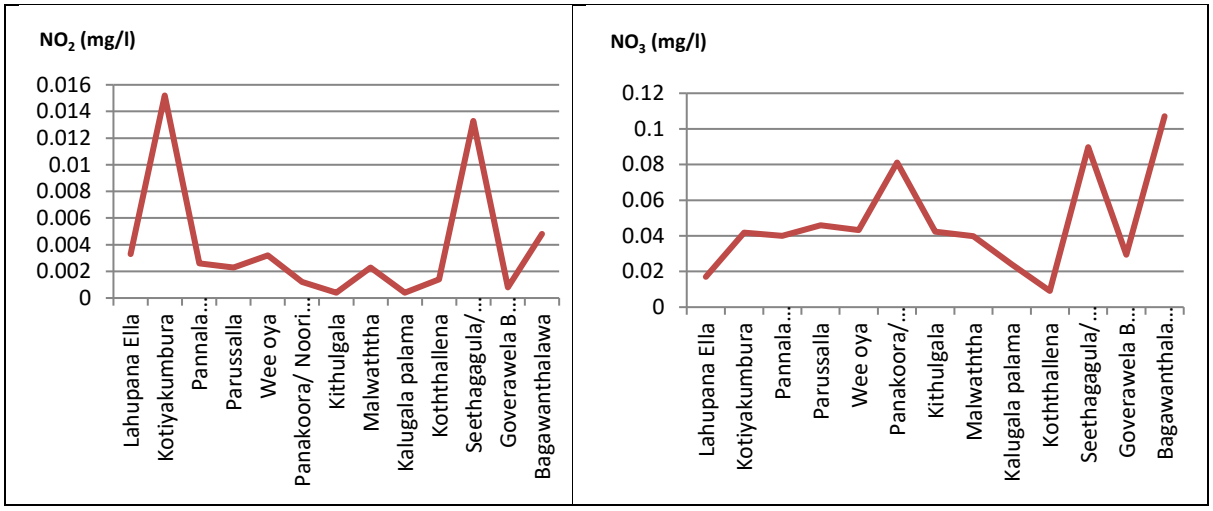
All the data collected in a Microsoft Excel Spreadsheet and this additional information will provide context for designing sampling schemes and for reporting and interpreting trends. Fish species for which basic biological knowledge is poor will not be considered

as indicators as in the selection criteria. Summarized traits information and the highest scoring taxa were only used to identify the initial selection of taxa as potential indicators. Those selected taxa, the top ranked fish species can be used to serve as the best bio-indicatory species for the selected ecosystem. Data collection and analysis for all the criteria except no: 6 and 7 were completed during the year 2019. All the field sampling for the pollution analysis of upper catchment of Kelani river basin was also completed.

Results

When considering the pH variation along the sampling locations, no any locations were exceeded the recommended pH range (6.5-8.5) published by CEA drinking water standards. Although, Parussalla, Koththallena and Kalugala palama were exceeded the 8.0 pH value, which is very close to the maximum recommended value. And also, high nitrite value was received for the Kotiyakumbura and Nallathanniya area respectively 0.015 mg/l and 0.013 mg/l when compared to the maximum recommended value which is 0.001 mg/l. All the other values received for tested parameters were within the range of acceptable levels published by Central Environmental Authority and SLS 614, 2013, 1983 drinking water standards. According to the water quality results received for Kelani river basin upper catchment indicated that the most of the locations were not highly polluted and still remain in the non polluted state. Further statistical analyses are continuing to check the relationship between pollution and fish species present those locations.





Variation of water quality parameters in different sampling locations of Kelani river upper catchment

Four major fish species were identified as most suitable bio-indicators after analyzing the bio indicatory characteristics as described earlier. They were as *Rasbora daniconius* (Dandiya),*Garra ceylonensis* (Galpadi), *Puntius filamentosus* (Pethiya), and *Tor khudree* (Lehella). Further studies for those selected species will be carried out in year 2020 to see their suitability to serve as possible bio-indicators.

Rasbora daniconius *Garra ceylonensis* *Puntius filamentosus* *Tor khudree*

Some photographs taken during the field visits

Outcome

Current water pollution status of upper and lower catchment of Kelani river basin.

Increased institutional strengthening for proper environmental management.

Scientific publications

Expected output

Number of identified fresh water fish bio indicators for proper environmental pollution assessment.

Investigation of causes for emergency incidents such as oil spills, algal blooms and fish kills (Emergency Studies)

Project No: 5.4

Responsible Officer/s: K.A.W.S. Weerasekara, A.A.D. Amarathunga, B.R.C. Mendis, M.D.S.R. Maddumage, J.K.P.C. Jayawardhane and S.R.C.N.K. Narangoda

Problem Statement/Justification:

An environmental emergency can be defined as a sudden-onset disaster or accident resulting from natural, technological or human-induced factors, or a combination of these, that causes or threatens to cause severe environmental damage as well as loss of human lives and property. Examples include fish kills, oil spills, chemical accidents, harmful algal blooms, surface water or ground water pollution with toxic chemicals etc. Also, about 300 commercial vessels travel in the Indian Ocean around Sri Lanka thus there is a huge possibility for occurrence of emergency situations such as oil spills and environmental problems due to discharges of oil and waste into ocean waters. All this could cause problems of water pollution resulting in degradation of aquatic resources leading to environmental and economic damage as well as public concern and the potential for social unease. Impacts of such incidents may be harmful and long lasting, thus immediate action should be taken to minimize the damage to ecosystem and human lives. Therefore, investigations are carried out by NARA as per the public or government official request, to study and provide scientific reports based on the site inspection and field/laboratory experiments. Environmental Studies Division conduct the project continuously collaborating Officers from the other divisions of NARA (IARAD, MBRD & FTD) were for field investigations & reporting according to the relevancy of the emergency situation.

Project Objective:

Main objective of this project was to identify and investigate the major causes for environmental emergencies and provide recommendations to the relevant authorities to overcome those situations.

A total of twelve (12) emergency studies were carried out throughout the year 2019. The summary of each incident is given in the following table(Table 1).

Table 1: Summary of the emergency studies in 2019

No.	Date of Investigation	Incident	Causes for emergency	Output
1.	February 2019	Pollution of Chilaw Lagoon buffer zone by solid waste	Improper waste disposal by the Municipal council	Investigation was done and reports submitted to relevant authorities
2.	March 2019	Fish kill in a Pond in Sri Subodhirajaram a Viharaya, Bombuwala	Due to lack of oxygen for fish at night caused by eutrophic condition and high population density of fish in the pond.	Investigation report
3.	March 2019	Fish kill in a water body at Wallampitiya "Kalu Palama" area	Due to lack of oxygen for fish at night	Investigation report
4.	March 2019	Public nuisance complaint from neighbourhood of the dry fish processing plants at North Pitipana, Negombo	Bad odour generated and improper waste water disposal in to Negombo lagoon	Two Field inspections, Investigation report for case No: L 83926 and L 83927
5.	April – May 2019	Fish mortality in Hamilton Canal	Canal water is highly polluted due to waste discharges from both point and non point sources. Water quality is unfavourable for fish and aquatic life.	Preliminary report was forwarded to Ministry of Mahaweli Development and Environment; Ministry of Fisheries & Aquatic Resource Development; Wattala Divisional Secretariat; and CEA

6.	July 2019	Fish kill in Negombo Lagoon	Low dissolved oxygen levels in lagoon water	Observations and recommendations were reported to Marine Environment Protection Authority
7.	July 2019	Oil patches along sea shore from Wellawatte to Mount Lavinia coastal stretch	Spilled oil from a marine vessel in sea had reached to coastal waters and sea shore.	Investigation report with recommendations was submitted to Ministry of Fisheries
8.	July 2019	Public complaint on solid waste accumulation in Ambalammulla, Seeduwa area in Muthurajawela wetland/Negombo Lagoon	Dumping of solid waste from the Seeduwa-Katunayake urban council	Investigation report was sent to Central Environmental Authority (CEA)
9.	August 2019	Public complaint on a fish kill in Kirulapana Canal	A fish kill incident was not reported during the investigation	Observations were reported to CEA and Colombo Municipal Council
10.	October 2019	Solid waste accumulation along Dikkovita coastal area and banks of Hamilton Canal	Improper waste disposal of public. Harmful to scenic beauty, and cause coastal water pollution and harmful health impacts	Investigation report was submitted to CEA, Ministry of Agriculture, Committee office (parliament), MEPA and CCD
11.	September-December 2019	Study on water pollution condition and renovation work of the moat at the Sri Dalada Maligawa, Kandy	Poor water quality of the moat	The catch-hold-translocating of the fishes in the moat. All fishes were released back to the identified safe places within the Mahaweli river reach from Gatambe to Thenne-kumbura
12.	August 2018 – August 2019.	Mapping of shrimp trawl grounds in the coastal waters around Sri Lanka	Illegal trawl fishery affected the livelihoods of fishers in the northern and eastern provinces of Sri Lanka	Demarcate the trawlable areas for shrimps in the coastal waters around the country.

Pollution of Chilaw Lagoon buffer zone by solid waste

An investigation was conducted by Environmental Studies Division together with Marine Biological Resources Division as per the request of Marine Environment Protection Authority. It revealed that solid waste dumped by Chilaw Urban Council near the Chilaw lagoon mouth at 'Kurusa Paduwa' area was directly affected badly to the water quality of the lagoon and aquatic organisms as well as a nuisance to fishing community and general public. The preliminary report was produced based on the results of field investigations and laboratory tests and report was submitted to relevant authorities.

Solid waste dump site | Eutrophication of water near the dumping site | Electronic waste

Figure 3: Photographs of open dump of waste in Chilaw lagoon buffer zone (February 2019)

Fish mortality in Hamilton Canal

The preliminary investigation study of the fish kill in Hamilton Canal was carried out by Environmental Studies Division together with Inland Aquatic Resources and Aquaculture Division of National Aquatic Resources Research and Development Agency (NARA), on 29th April 2019 as per the request of general public and the instructions given by Chairman / NARA. According to the observations during the study, canal water has become black in colour, contaminated and smelly in the study area (from Elakanda to Pitipana). Dead fish were observed at the edges of the canal and all were belong to the *Oreochromis* spp (Thilapia). The study concludes that the major reason for the fish kill incident was due to heavy water pollution of the canal which leads to low dissolved oxygen, high Chemical and Biochemical Oxygen Demand, high turbidity, high oil & grease level and high sedimentation with the prevailing heavy rain conditions. The investigations revealed that, Hamilton canal is currently degraded and subjected to water pollution due to organic and inorganic pollutants owing to waste discharges from both point and non point source pollutants.

Investigation of the Oil Spill incident  at Wellawatta to Mount Lavinia Coastal belt

Research team from Environmental Studies Division (ESD), NARA were carried out a field inspection on 3rd June 2019 to find out the causes for the oil spill occurred at sea and the beach between Wellawatte to Mount Lavinia. Oil and Grease measured in the water samples collected from all the sites were higher than the permissible threshold limits for the coastal water quality standards. It was noted that all the parameters except oil and grease lies with the acceptable limits which is suitable for survival of fish and aquatic life. The study revealed that some spilled oil from a marine vessel in sea had reached to coastal waters and sea shore. Investigation report with recommendations was submitted to Ministry of Fisheries.

Figure 4: Some photographs taken during Hamilton canal fish kill investigation (April-May 2019)

Oil patches along the shore in Mount Lavinia

Beach sand contaminated by Oil and Grease

Beach sand contaminated by Oil and Grease

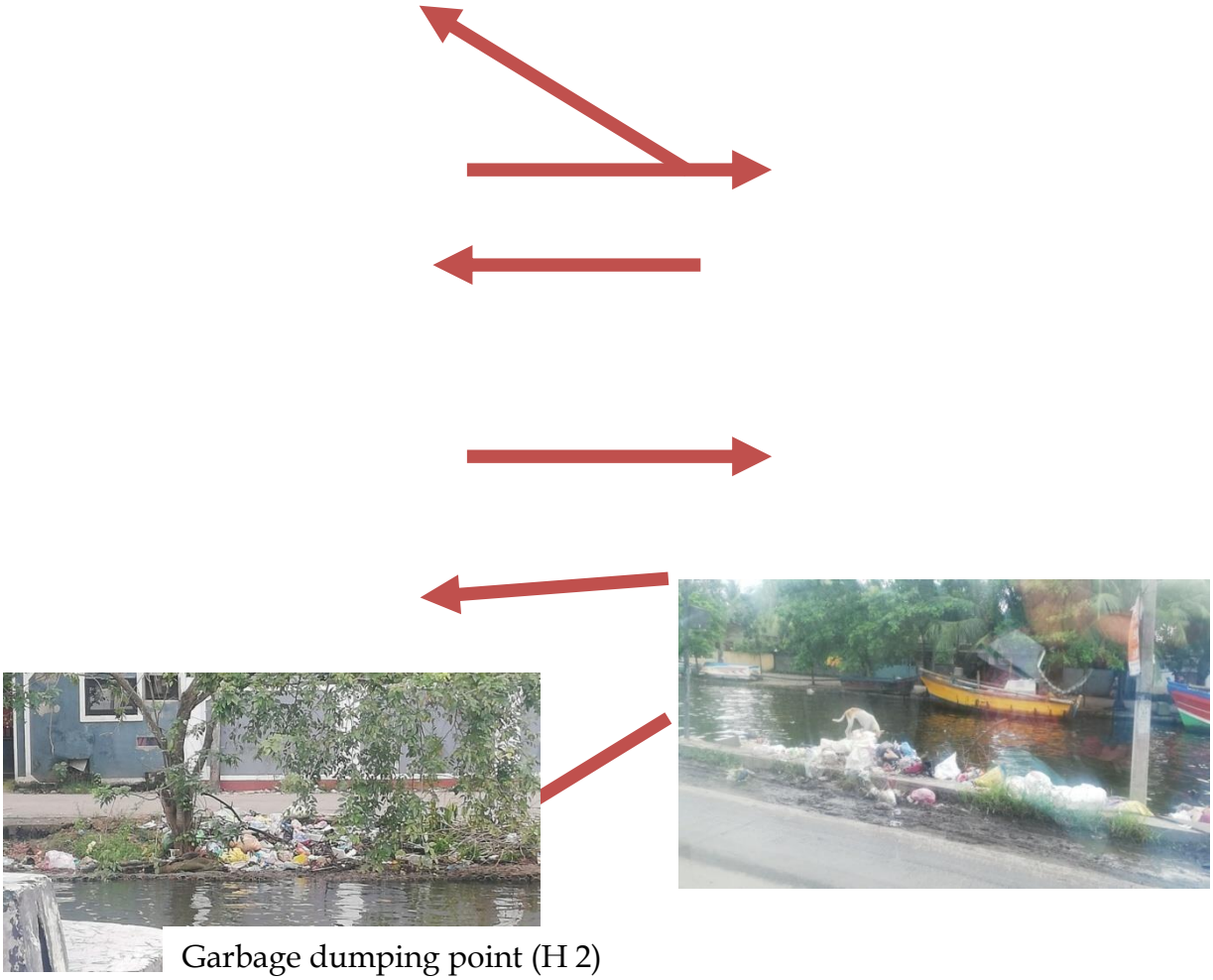
Formation of black oil residue

Figure 5: Some photographs taken during Oil spill incident on coastal water and shoreline in Wellawatta – Mount Lavinia (July 2019)

Solid waste accumulation along Dikkovita coastal area and banks of Hamilton Canal

Improper waste disposal by public along Dikkovita coastal area and banks of Hamilton Canal was recorded. Several locations of Dikkowita coastal stretch can be seen the collection of waste varying from plastic bottles to electrical appliances, and the list of what ends up along the coast as litter is endless. It gave unpleasant scene to those areas with occupying with unhealthy smell. The following photographs in different locations of Dikkowita coast line and Hamilton canal showing the dumping of waste in different ways. The investigation revealed that it was harmful to scenic beauty, and cause coastal water pollution and harmful health impacts to public as well.

Figure 4 : Waste dumping points at Dikowita coastal stretch



Garbage dumping point (H 2)

G.P.S. Coordinates:

6° 59.771'N/ 79° 52.399'E

Garbage dumping point (H 1)

Figure 5: Waste dumping at banks of the Hamilton canal

Study on water pollution condition and renovation work of the moat at the Sri Dalada Maligawa, Kandy

The objective of the study was to enhance the quality of water at the Sri Dalada Maligawa moat through phytoremediation technique. The catch-hold-translocating of the fishes in the moat was carried out from 6th September 2019 to 17th December 2019. All fishes were released back to the identified safe places within the Mahaweli river reach from Gatambe to Thenne-kumbura.

The fish translocation was base on the NARA pre-study carried out in 2018 on the water pollution in the moat and Kandy Bogambara Lake. There were several meetings to discuss the moat renovation work and later on base on NARA recommendation made in 2018, Sri Dalada Maligawa and Urban Development Authority of the Central Province decided to start the moat renovation work under technical support of NARA and Department of Irrigation and made a request from NARA to undertake the fish removing task. As per instruction given by the Secretary of the ministry, IARAD and ESD divisions jointly carried out the relevant work over two months period.



Figure 6: Highlights of catch-hold-translocating of the fishes in the moat at the Sri Dalada Maligawa, Kandy

Mapping of shrimp trawl grounds in the coastal waters around Sri Lanka

In Sri Lanka, the main shrimp harvesting technique in practice by fishers is bottom trawling. The trawling practices, at present, are confined to limited areas in the West coast; North of Colombo (Hendala), North of Negombo, Portugal Bay off Kalpitiya, Mannar off Pesalei and Jaffna peninsula (Kareinagar, Gurunagr and Velwetithurai). In the recent past, Sri Lankan fisheries industry has faced a burden issue, especially in the northern waters of Sri Lanka, due to illegal trawling conducted by Indian fishermen. This has caused a massive destruction not only for the marine environment and biological resources but has also had an impact on the fishing community living in the north.

Further, trawl fishery has become a focal point of geo-political landscape in the Indian subcontinent due to mass transgression of Tamilnadu trawlers into Sri Lankan waters. The economic loss due to illegal trawl fishery (shrimps and bycatch) has been estimated by Ranasinghe (2008) as being over 20 million USD, despite the massive environmental

impacts on the surrounding seas and socio-economic marginalization impacts to the respective local communities.As a result, livelihoods of fishers in the northern and eastern provinces were largely affected and they put pressure on the Sri Lankan government to diplomatically interfere and solve the issue.

Under this scenario, department of fisheries made a request from NARA to demarcate the trawlable areas for shrimps in the coastal waters around the country considering as an urgent requirement. Table 02 summerizes relevant information with regard to identified trawl grounds. The extent of identified trawl grounds which is recommended under the study remains unchanged except in Mannar (Pesalai). The maps of respective trawl grounds are given in Figures 07.

Table 2: Summary of identified areas for bottom trawling

Trawl Ground	Fisheries District	Existing Area (km^2)	Recommended Area (km^2)	Perimeter (km)		Remarks
				Existing	New	
Handala	Negombo	43.46	43.46	36.62	36.62	Unchanged
Negombo	Negombo	13.17	13.17	19.70	19.70	Unchanged
Kalpitiya	Puttalam	14.98	14.98	15.98	15.98	Unchanged
Pesalai	Mannar	575.89	427.87	109.31	87.83	Revised
Jaffna -01	Jaffna	139.90	139.90	47.61	47.61	Unchanged
Jaffna -02	Jaffna	228.86	228.86	61.63	61.63	Unchanged

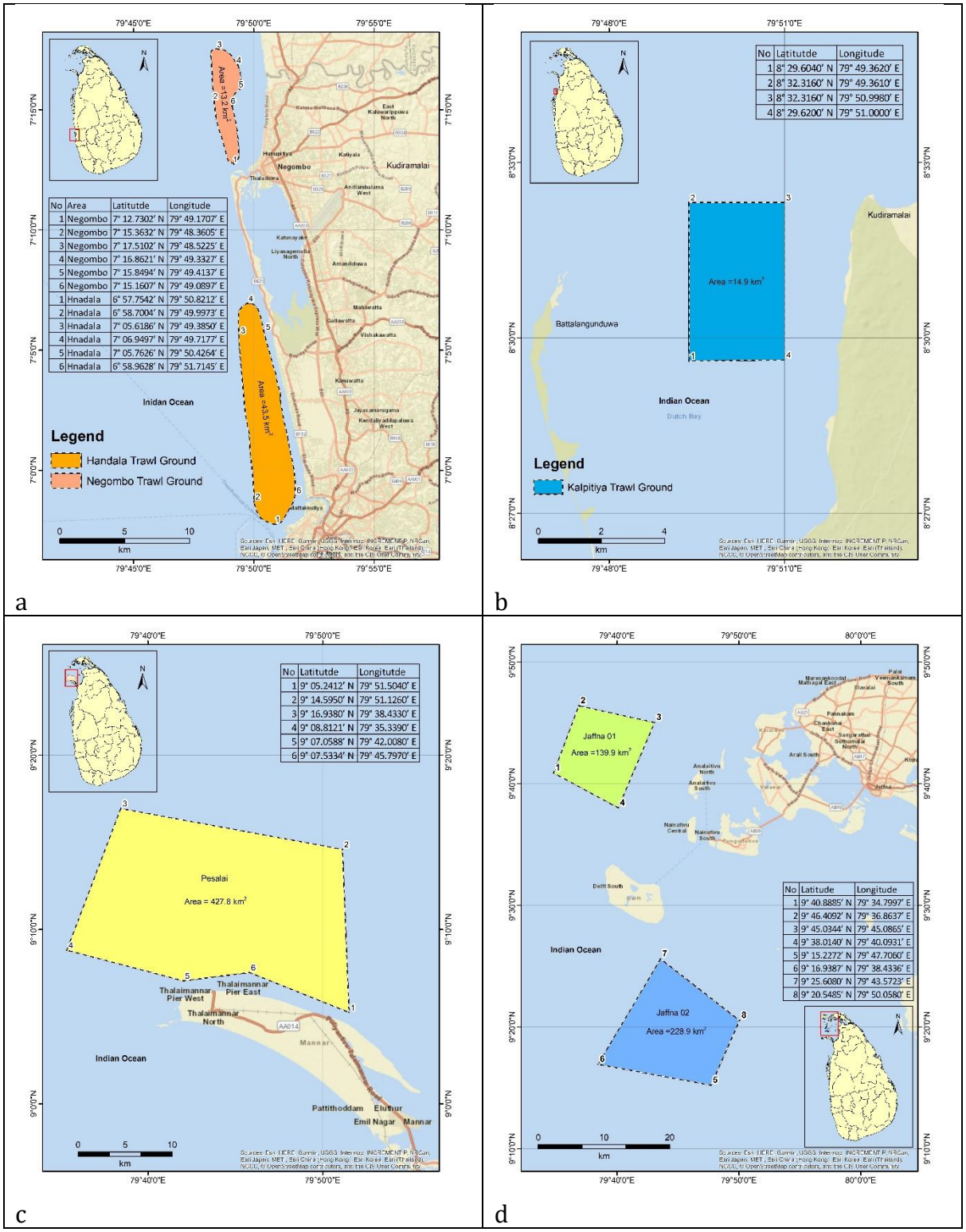


Figure 7: Maps of trawl grounds

Outcome:

Investigation reports have been submitted to relevant government/non-government authorities/agencies in order to minimize any negative impacts and also to avoid recurrence of incidents in future.

Recommendations:

It is important to inform any incidents of fish kills/oil or chemical spills, algal blooms, ground water or surface water pollution to National Aquatic Resources Research and Development Agency (NARA) for an investigation as soon as possible.

Publications

Abstracts

1. Nandasena, W.T.C.N., Amarathunga, A.A.D., Narangoda, S.R.C.N.K. (2019). Pollutant levels in upper catchment of Kelani river basin: A case study in Maskeliya reservoir. Proceeding of the International Symposium on water and air pollution: Recent trends in research. University of Peradeniya. Pp 21.

2. WDTN Nandasena, AAD Amarathunga, S.R.C.N.K. Narangoda, GY Jayasinghe, (2019). Study on pollutant levels in upper catchment of the Kelani river basin: A case study in Maussakelle reservoir. International Conference on Water & Air Pollution – Recent Advances in Research" 29th & 30th March 2019, Postgraduate Institute of Science, University of Peradeniya, Sri Lanka.

3. Weerasekara, K.A.W.S., Pathiratne, A. and Kithsiri, H.M.P. (2019). Assessing potential toxicity of drinking water from selected dug wells in Medawachchiya, Anuradhapura District, Sri Lanka, using plant and fish bioassays. In proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2019. p 43.

4. Chathurani, S.H.U., Ranathunga, R.R.M.K.P., Amarathunga, A.A.D.,Hettige, N.D., and Weerasekera, K.A.W.S., 2019. Present status of the water quality in Beruwala Fishery Habour, Sri Lanka. Aquatic Research to Nurture the Nation. Scientific Session - 2019, National Aquatic Resources Research and Development Agency (NARA), Sri Lanka.p.46

5. Ranasingha K.M.G.G.N.S. , Amarathunga A.A.D., Jayawardana G.D.M.N., Jayasinghe G.Y., Weerasekara K.AW.S. and Narangoda S.R.C.N.K.(2019). Experiment on Development of a Model Treatment System for Fish Effluent in Small Scale Fish Stall. National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2019.p 51

6. Ranasingha, K.M.G.G.N.S, Amarathunga,A.A.D., Jayawardena,G.D.M.N., Jayasinhahe,G. Y., Mendis, B. R. C., Maddumage, M.D.S.R. and Jayawardena, J.K.P.C (2019). Assessment of the perception of owners on waste water discharge from their small –scale fish stalls in Sri Lanka. NARA Scientific Sessions. p. 58.
7. Oshadi, H.D.C.L., Mendis, B. R. C. and Jayawardana, J.M.C.K., (2019). Sediment Characteristics and Status of Water Quality in North Region of Negombo Estuary, Sri Lanka. 7th International Conference of Sabaragamuwa University of Sri Lanka, Belihuloya. (p. 138).

8. Supith, E., Amarathunga, A.A.D. , Jayasinghe, G. Y., 2019. A study on the adsorption and photo degradation of chlorpyrifos pesticide with natural absorbentmaterials. Proceedings of the 7th SURF International Workshop, 20-22 September 2019, Galle, Sri Lanka.

9. Liyanage, H.D., Amarathunga, A.A.D., Mendis, B. R. C., Jayasiri, H.B., Thushara H.K.R., and Rathnayake, V.I.,(2019). Phytoplankton Community structure in relation to physico chemical parameters in coastal waters from Colombo fort to Panadura. First research symposium of the Ocean University of Sri Lanka.p. 36

Journal Publications (Full Papers)

1. Hettige, N.D., Weerasekara, K.A.W.S., Chandrasiri, E.G.D.N. and Jayawardene, J. M.C.K. Manuscript titled "Plankton Diversity in Bomuruella Reservoir, Nuwara-Eliya: A preliminary survey" was accepted for publication in Journal of Environmental Professionals Sri Lanka; Volume 8; Issue No. 2.

2. Weerasekara, K.A.W.S., Pathiratne, A. and Kithsiri, H.M.P. Manuscript titled "Cadmium and Arsenic levels in edible fishes, Oreochromis niloticus (Nile Tilapia) and Ompok bimaculatus (Butter catfish) from Padaviya Reservoir, Sri Lanka and Human Health Risk Assessment associated with their dietary exposure" was submitted in December 2019 to consider publishing in journal of National Science Foundation, Sri Lanka.

3. Narangoda S. R. C. N. K., Weerasekara, K.A. W. S., Amarathunga, A. A. D., and Hettige N.D. Completed manuscript titled "A Review of Marine litter Pollution in Coastal Waters of Sri Lanka" Submitted in December 2019 to consider publishing in Journal of Environmental Professionals, Sri Lanka.

Monitoring and Evaluation Division

Zonal Plan for Mariculture in Northern Province

Project No: 9.4

Responsible officer/s: Dr. V. Pahalawattaarchchi, Mr. A.B.A.K Gunarathne, Ms. D.D.D. Weragodatenna

Mariculture can be recognized as important development opportunityfor coastal communities for their well-being by providing income, food security and employment. Large-scale Mariculture that can be provided foreign exchange and investment opportunities as well. Therefore, this study intended to identify potential areas for the Mariculture Development with considering environmental parameters. In order to demarcate the potential zones, Geographic Information Systems (GIS) technology was applied.

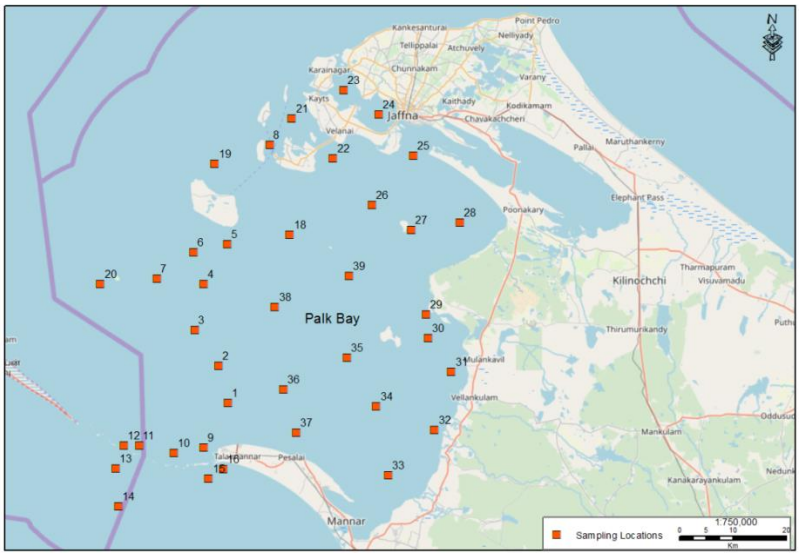
Main Objective of this study included;

- Identify the potential area for Mariculture in Northern Province
- Demarcating and mapping of the most suitable areas for Mariculture
- Maintain the database relevant to the Mariculture

The considered environmental parameters to the study are given below. Palk Bay was selected as the study area as it is most viable for the Mariculture when considered to the natural environment.

- Salinity
- Turbidity
- PH
- DO
- Temperature
- Bottom condition
- Current velocity
- Water depth
- Access to transport route
- waste disposal facilities
- Existing coverage on mariculture
- Natural Land cover
- Land use pattern

The multi-criterion site suitability modeling was applied usingGeographic Information System (GIS) in order to choose suitable sites for the Mariculture. Sampling locations, which were selected to measure water quality and bottom condition is given in following map. Historical data that is available in NARA also considered.



Site suitability analysis was done by Weighted Overlay Analysis (WOA). Totally 13 thematic layers for each parameter as describe abovewere generated using ArcGIS 10.2.2 andused them for the overlay analysis.Weighted Overlay Analysis can be performed by overlaying classified layers of selected parameters in order to identify the most suitable areas as below. Steps involved in Weighted Overlay Analysis are given below.

During weighted overlay analysis, a weight was assign for each individual parameter as obtained by Analytical Hierarchy Process (AHP) technique as shown in following table. Suitability classes were classified as most suitable, moderately suitable and not suitable.

Scale of Priority derived from AHP

Parameter	Normalized Score	Scale of Priority %
Salinity	2.65	24
Ph	1.79	16
Temperature	1.36	12
Do	1.07	10
TSS	0.85	8
Depth	0.69	6

Current Velocity	0.63	6
Bottom Con	0.46	4
Existing coverage	0.40	4
Land cover	0.42	4
Access to the road	0.69	6
Total	11.00	100

Results

- Spatial distribution of environmental parameters

Existing condition of Salinity, Temperature, DO, Ph, TSS, Depth, Bottom Condition and sensitive habitat distribution are given from Figure 1 to Figure 6.

- Zoning of Palk Bay for Mariculture

Results of interpolates the considered parameters for the zonation using an inverse distance weighted (IDW) techniques are shown in figure7.

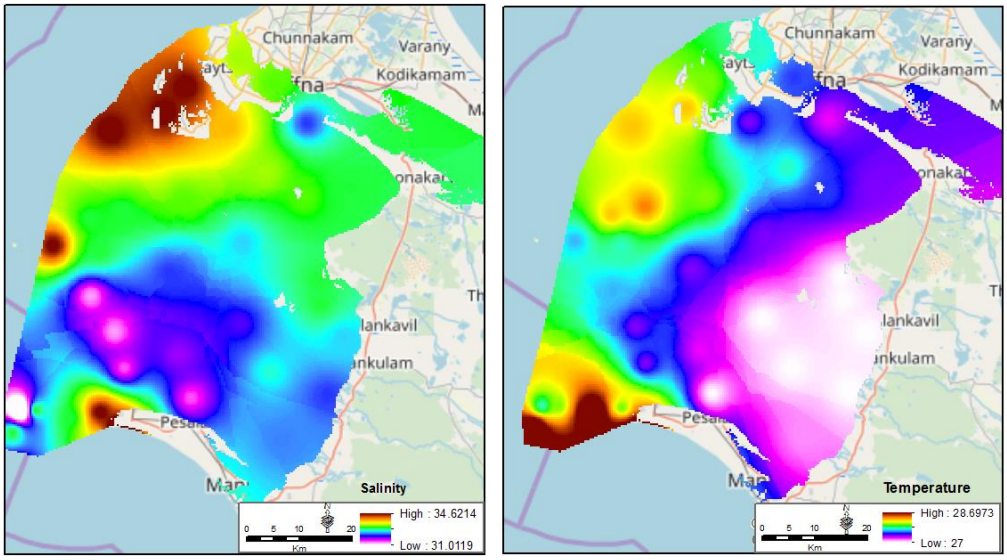


Figure1:Salinity and Temperate

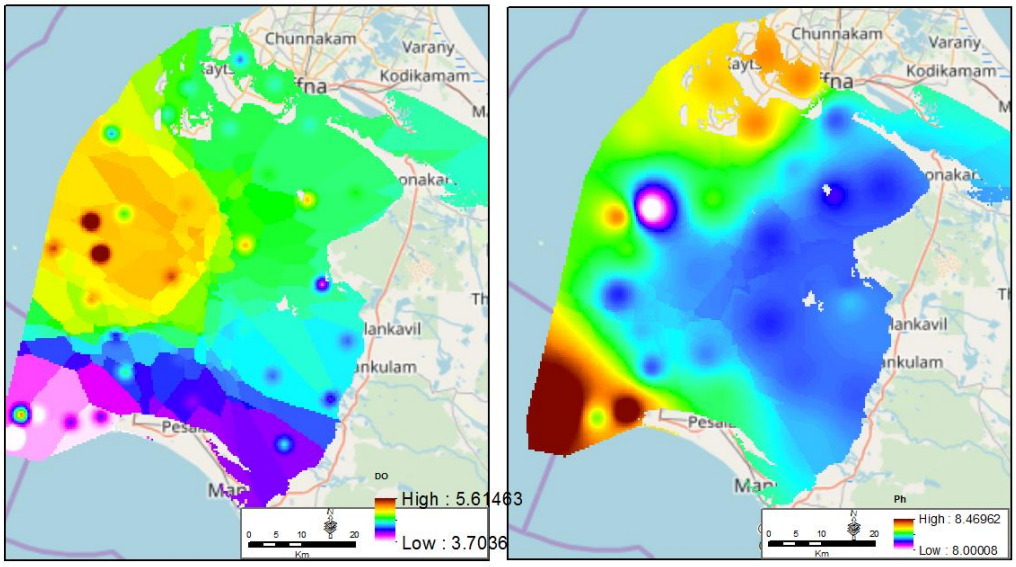


Figure 2:Distribution pattern of Physio- Chemical parameters