Performance Report

2018

National Aquatic Resources Research and Development Agency

National Aquatic Resources Research and Development Agency
Crow Island
Colombo 15
Sri Lanka

Contents

Research Highlights – 2018

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Inland Aquatic Resources and Aquaculture

Most economically viable feed with 42% protein at the cost of Rs.148.00/Kg for seabass farming introduced for the community based commercial farming at Puttalam lagoon whereas a feed with 30% protein at the rate of Rs. 102.00/Kg has been introduced for Tilapia culture. The ornamental fish farming community in the district is getting several benefits out of the center which provides awareness, trainings, fish feeds and broodstock. Panapitiya center has generated self income from promoting 2.393 tones of 03 types of experimentally improved ornamental fish feed with gross value of Rs. 450,607.75. Moreover the center has supplied 367 good quality brooders of Koi Carp, Tin Foil Barb (Golden), Angel and Gold Fish to the fish farmers.

Polycheates (*Nereis* sp.) which was a need in shrimp hatcheries could be cultured successfully in tanks using lagoon soil and kitchen waste mixed substrate. *P.menalomaculata* could easily be bred under captive condition following environment manipulation method while dropping water level at their breeding tank while low fecundity compare to other endemic *Pethia* fish species and poor colour development in F1 offspring were identified as the issues. Maximum spawning characteristics of *Barbonymus schwanenfeldii* can be obtained 0.5ml/kg of BW concentration of ovaprim in induced breeding method under Sri Lanka captive breeding condition.

Biofloc technology using locally available carbon sources as rice bran (RB), wheat flour (WF), molasses (MOL) can successively be adopted to grow guppies without changing water for 60 day with 96.6 % of highest survival at MOL and MIX treatments.

Java fern tissue culture initiation was successful using 4 mg/L 2,4- Dichlorophenoxyacetic acid with MS medium with 1g/LActivated charcol. Tissue culture protocol developed for *Anubias* suggests that the best sterilization method(70% ethanol 30sec; 6% clorox for 15 min ; 4% clorox 10min followed by five times washed with strilized distilled water)and the best shoot initiation suplement(2 mg/LBAP and 0.5 IBA). The best method for Protoplast isolation of *C.wendtii* (Athu dian) was the enzyme digestion method using 0.2% (w/v)pectinase and 2% (w/v) cellulase of 1 month old tissue cultured leaves.

Division has involved in science based detection of suitable sites to expand sea cucumber industry in Northern Province considering special characters such as micro habitat conditions other than the conventional site selection parameters. Poly culture experiments of seaweeds, oyster and seacucumber revealed that the autochthonous organic matters accumulates inside the pens due to decayed seaweeds and excretion substances of oysters lead to better growth of sea cucumbers. *K. alvarezii* (seaweed) seed bank at Dondra, Southern Province could be recomended as national seed bank to provide good quality seeds for seaweed farming. The best culture protocol for seaweed seed rearing at rectangular net cages with 100g propagate at 20cm distance between each propagule.

Over 5000 spat were collected using developed PVC, plastic spat attachment structures in Gangawadiya area and distributed among the farmers during the year. Four types of reef structures are being testing for reef construction. The investigation on effectiveness of the stockings in perennial reservoirs Karawita and Mahauswewa recommend that the best stocking density for fry stocking in cages is 450/m^2. Identifying flood affected areas in Nilwala river basin was carried out for development of flood plain aqua cultureas there is a vast area left without any development**.** As a transboudary disease causative agent Tilapia Lake Virus has been given recent attention and the surveillance programme is in progress. On site awareness programmers keep the farmers vigilant about the potential threat from the new disease to the tilapia industry

Marine Biological Resource

The large pelagic fishery database (PELAGOS) and the small pelagic database was updated for year 2018. Research showed that, the catch of oceanic tuna is dominated by skipjack tuna followed by Yellow fin and Bigeye tuna. The diversity and the abundance of pelagic and demersal fish was significantly high in the West coast of Sri Lanka. Beach seine fishery studies recommends to limit the length of the beach seine to 2.8 km. Further, the use of winches for hauling the beach seine is not recommended unless a proper mechanism for monitoring the fishing operations is implemented. Furthermore, the beach seine operation should be confined to the daytime between 6 a.m. to 6 p.m as to avoid interferences with other fishing activities. Assessing the genetic stock structure of *Amblygaster sirm*found that the *A. sirm* population distributed in coastal waters in Sri Lanka to be considered as a single stock in future management of the resource. Demersal fishery survey recommends to discourage the use of No: 10 and No: 11 hook sizes for bottom set long lines for reef fishes. It is also recommended to have the highest L_{50} value of 36.3 cm (TL) as the minimum allowable size for *Cephalopholis sonnerati*, if the prevailing ban is meant to be lifted. Further, it is recommended to discourage the capture of *Cephalopholis sonnerati* in the months of November, December and January in order to ascertain the survival of brood stock and thus the population. Study carried out for sea urchin studyindicated that there is a spatial variation in GIS values. This type of variation could be due to the difference in populations of the same species and environmental conditions. Egg removal of the berried females and illegal fishing during the closed season are identified as main reasons for the depletion of the lobster stocks. At Dondra and Polhena lobster conservation sites which are maintained under this project, 28 females belonging to different species released approximately 7.5 million larvae. Of the studied four sites namely; Hikkaduwa, Pigeon Island in Trincomalee, Bar Reef in Kalpitiya and Vankalei in Mannar, Ninety-eight (98) species of reef fish in 53 genera belonging to 26 families were recorded. The highest reef fish abundance and diversity were recorded from Pigeon Island and the lowest abundance was recorded from the Hikkaduwa marine sanctuary. The diversity, abundance and the live cover of corals have declined in Hikkaduwa when compared with the available published literature.Research in to coral reefs revealed the necessity of developing a management plan and continuous monitoring of the status of coral reefs. Research on marine mammals study indicated that they are more vulnerable for the fisheries. Through photo analyses and information collected through different sources, 21 incidents including severe damages, small damages and deaths of marine mammals were identified. Two hundred and ninety blue whales were found through photo ID analysis. In addition to the above studies, after 40 years, a marine Ecosystem survey was carried out in coastal waters of Sri Lanka using Dr. Fridtjof Nansen Research vessel and the present status of marine resources was updated.

Fishing Gear Technology Development

Submerged Fish aggregating devices were deployed in Sinnapaduwa and Weligama sea area and data collection and sites monitoring are still in progress to assess the success of the project. Total 50 FEDs were deployed in Sinnapadu and Weligama areas. Thirty two(32) FEDs were deployed in Sinnapaduwa at the first quarter of the year, before the monsoon. After the first quarter, 18 (FEDs) were deployed in Weligama area. After the monsoon in Sinnapaduwa area, (03) three trial fishing activities were conducted to assess the progress of the FEDs with the community participation. During the trial fishing activities totally 4925Kg of fish were harvested and value of the fish around 1.4 million. Carangidae species, Barracuda, Snappers, Groupers and Sri Lankan Sweetlips were significantly contributed to the catch. Other species also were recorded in small numbers. Fishing communities were harvesting fish at the locations and total benefits obtained by community is greater than the capital cost of the project.

Under the habitat enhancement for "Big Fin Reef Squid's spawners" (*Sepioteuthis lessoniana*) project bottom set structures were deployed and hold by anchors on the sea floor as an alternative for the lost habitats. Artificially developed 12 structures in Sinnapaduwa and 17 structures in Weligama were deployed before the monsoons for habitat enhancement. Observations made with aggregations of targeted species and other species for their ecological processes.

Conical shaped Structures were deployed in three depths as 10m, 15m and 20 m and attached eggs were counted. Out of the total 68% of eggs were attached on structures which deployed at 10 m depth. 21% of eggs were recorded on structures at 15m depth while 10% of eggs were observed at 20m depths. Therefore squids prefer to spawn around 10m depth habitats than other depth which were tested. Aggregated fish species were visually identified and further analyzing are carrying on for the quantification. Mangrove red snapper - *Lutjanus argentimaculatus* , Black spat snapper- *Lutjanus fulviflamma* ,Malabar Grouper- *Epinephelus malabaricus* and Lion fish, Powder blue surgeonfish, Moorish idol, Emperor angelfish, Trevallies, Yellow fin /Stripe surgeon fish, marine ornamental fish also observed during the observation trials. It could be recommended that the structures are one of best options for the habitat enhancement with low budget.

Post-Harvest Technology

Study on handling practices and quality of yellowfin tuna in multi-day boats (MDBs) larger than 55 feet in lengthindicates thatPre-chilling of eviscerated large fish which is one of most important unit operation on board to maintain export quality of large size tuna, is not practiced before storing of fish in iceand fish storing days in boat is about 35-39 days in MDBs. Histamine levels were found in the rage of 7 - 40 ppm in 18 number of large size yellow fin tuna which were accepted by fish exporting companies.

Under the Quality of fish collected from Dedicated Economic Center in Narahenpita prrojecttthirty five fish samples including Bullet tuna, Sail fish, Yellowfin tuna, Indian Scad, prawns, Skipjack, Sardinella species, Herring, and Mackerel species were collected. Five fish samples were marginally acceptable due to contamination with *E. coli* counts >500 MPN/g (900 - 1800 MPN/g). Another 9 samples which also contained both high and low counts of *E. coli* were found contaminated with *Salmonella. Salmonella* species found were *Salmonella mbandaka, Salmonella montevideo, Salmonella corvallis, Salmonella braenderup, Salmonella poona.*

Under the investigation of microbiological quality of ice produced in selected Ice Plants in Sri Lanka, Samples were collected from 44 Ice Plants located in 14 districts (Trincomalee, Batticola, Jaffna, Mulathive, Anuradhapura, Dambulla, Puttalam, Chilaw, Kalpitiya, Mannar, Polonnaruwa, Galle, Ampara, Monaragala). Ice making water and ice produced from Two Ice Plants were found in acceptable quality. Ice and ice making water from 42 Ice Plants were contaminated with fecal origin bacteria and unacceptable to be used in food industry. Faecal coliforms and *E. coli* present in the range from 1 to 1800+ and 1 to 1800+ MPN/100ml, respectively. *Salmonella* species were found in 12 samples which obtained from ice making water, ice from store or crushed ice.*Salmonella* species identified were *Salmonella brunei*, *Salmonella kentucky*, *Salmonella tananarive*, *Salmonella edinburg*, *Salmonella wilmington*, *Salmonella agon* and other two *Salmonella* isolates remaining to be characterised for species level.

Under the Investigation of toxigenic radioactive residues in imported fish and fishery productsthirteen samples of the total of 65 samples analyzed up to now, contained radio activity of Cs^{137} at level of 1.0 ± 0.1 Bq/Kg and one sample contained Ra^{226} at level of 2.6 ± 0.8 while these 14 samples radioactivity of Pb^{210}, Ra^{226} and Th^{232} were not detected. Rest of samples did not show radioactivity for any of four toxigenic radio nuclides except presence of radioactivity of K^{40} nuclide. However, all 65 frozen fish samples showed radioactivity of K^{40} which is ubiquitous in earth crust,in a range of 290 to 590 Bq/Kg. These results indicate there are no health risks due to consumption of imported fish and fishery products.

Investigation of incidences of histamine forming bacteria in chilled Yellowfin tuna (*Thunnus albacares*) in export fisherystudy investigates survival of histamine forming bacteria and potential of formation of histamine under chill storage and other controlled atmospheric conditions in fish products deemed to have export quality. Histamine forming bacteria groups belong to similar Genus have been isolated from both export quality fish loins and environmental samples collected from Fish Processing Plants. Ability to form histamine was also analysed for those isolated bacteria. Isolated bacteria are *Pseudomonas* sp., *Psychrobacter* sp., *Aeromonas* sp. ,Enterobacteriaceae sp., *Alcaligenes* sp. , *Citrobacter* sp. , *Staphylococcus* sp. , are *Shewanella* sp. These organisms will be further studied and characterized for histamine formation and at modified atmospheric conditions for next two years.

Sanitary survey and assurance of safety of edible bivalve molluscs research indicates the

unacceptable levels (>2.3 MPN/g) of *E.coli* were detected in 28% of Oyster samples collected from the lagoon environment in Gangewadiya, Kandakuliya Kalpitiya and Noradiya in North Western province. *Vibrio cholerae* and *Vibrio parahaemolyticus* were not detected in any of oyster or water samples collected from lagoon environment. There are areas in Puttalam lagoon which are free pathogenic microorganisms and are suitable for culturing and natural relaying of bivalves.
Investigation of Antimicrobial resistance studies inddicates Antimicrobial resistance to Amoxicillin(10µg) was found in 30% of Vibrio spp isolates from shrimp culture environment (shrimps, water and sediment) in Puttalam district.

In place of gelatine (animal based product), Carrageenan (seaweed based product) (2.5%) incorporated Jelly candy (jujubes) was prepared. Jujubes prepared in the laboratory incorporating carrageenan indicated lower gel strength (954 g/cm^3) than market available jujubes (2390g/cm^3). Further the experiment are required to improve the gel strength of carrageenan based candies.Fish paste was developed using flesh of Indian Scad and pulp of G*racilaria edulis.*Pharmaceutical grade glucosamine was synthesized using the and method was optimized using response surface method.

Environmental Studies

Genotoxicity screening of drinking water wells located in the North Central Province (NCP) of Sri Lanka using plant and fish based bioassays research indicates the cadmium and arsenic contents in the edible muscle tissues of most of these fishes(*Oreochromis niloticus* (Nile tilapia) and *Ompok bimaculatus* (Pena Walaya)) were within the safe limits specified by the regulatory authorities for human consumption. Bioaccumulation pattern of cadmium in the tissues of both fishes followed the order: muscle < liver < kidney, showing greater cadmium bioaccumulative capacity in the kidney tissues. Study on pollutant behaviour of Kelani River basinstudy indicates Thotalaga, Kolonnawa and Orugodawaththa were identified as most polluted locations in the Kelani river basin. Tests conducted to understand the pesticide behaviour with organic matter in the basins suggested that high amount of pesticide retaining with respect to organic carbon concentration. Assessment of current water pollution status and accumulation of heavy metals in selected edible fish species in Bolgoda Lake revealed that, relatively higher concentrations of heavy metals i.e. As, Cr, Cu, Pb and Zn were recorded in sediments. Furthermore, heavy metals As, Cd and Pb in fish tissue were below their detection limits. Mercury was detected in few *Mystus gullio* (Anguluwa) fish samples and Chromium in one *Mugil cephalus* (Godaya) fish sample.

Comprehensive study on impacts of intensive shrimp farming on Mundel Lagoon and its surroundings revealed that, mean Ammoniacal nitrogen concentration (0.13 ± 0.08 mg/l), Biochemical Oxygen Demand (>20 mg/l) and Chemical Oxygen Demand (>1600 mg/l) values in the lagoon water were in relatively higher concentrations and also hypersaline conditions (>50 ppt) in lagoon waters were recorded in dry period. Tested heavy metals (Cu), Pb, Cr, Hg) in the lagoon were below their Limit of Quantification. The Vibrio cholera and Salmonella was not recorded in the water samples collected from selected shrimp farms and the lagoon. The Disease IHHNV and WSSV identified in collected shrimps in farms surrounding of the Mundel lagoon.

Study of marine debris inputs from North Western, Western and Southern coastal areas of Sri Lanka marine debris (>2.5 cm in size) were surveyed on selected sites mainly in river discharge outlet, estuary mouths and tourist destination sites along the North - Western (Negombo and Chilaw) Western (Kalutara) and Southern (Bentota and Gintota) coastlines. Results revealed that, significantly higher amount of debris found at Negombo sea mouth. The composition of debris was dominated by packaging material (40%) followed by consumer products (25%), fishing items (15%) and plastic bottles (10%). Caps/lids and food wrappers/containers contributed 5% in each respectively.

In 2018, total of four emergency studies were investigated at Welikada, Malwana, Bundala Lagoon and Puttalam Lagoon. The major cause for first two incidents was reduction of dissolved oxygen concentration due to organic and inorganic pollutants. Bundala Lagoon fish kill was a massive one and occurred due to hypersaline condition caused by the released of brine water from a nearby Saltern. Furthermore, a sediment plume created by runoff from a deforested land was investigated at Puttalam Lagoon.

Oceanography

Potential fishing zone forecast is further improved. The spatial accuracy is 60%. Programme developed to forecast the depth of the fishing zone. Forecast is disseminated via ITN *Puwathsatahana* program twice a week. Fisheries logbook data was validated with VMS data and incorporated into the data base.

Beruwala harabour silted with fine well sored gsediment, which is an indication of siltation. The silted sediment cannot be used as construction aggregate. Hikkaduwa is silted with the moderately to well sorted sand, which shall be used as construction sand after purifications. The average water depth of Beruwala and Hikkaduwa fishery harbors are 2.96 and 2.42 m respectively. The maintenance dredging should be done in some points in both harbors

Coastal belt between Mount Lavinia and Colombo, the wave climate and, subsequently, the annual alongshore transport reach the highest values during the southwest monsoon. Colombo-Negombo coastline is subjected to erosion due to its coastal orientation and wave actions. The reduction of sand supply from Kaleni river due to extensive sand mining is a contributory factor that had accelerate the coastal erosion in that area.Seven toxic phytoplankton species reported in the coastal waters of Kirinda area.

Plastics and polythene in the coastal waters of Sri Lanka are mainly of micro-plastics. The waters in the West coast in general, are more polluted with plastics and polythene compared to the East coast. Majority of plastic and polythene debris contain poly propylene, poly ethylene, poly styrene and nylon.

Maximum and minimum temperature in the bar reef are 30.99 and 28.25 ^{o}C respectively . During several time periods shallow area temperature became lesser than the 10m temperature. This surface cooling occurred all over the year during night time, but stronger day time cooling events observed during May and November month.

The Maximum and minimum temperature in the Pigeon Island sea area was 31.1 ^{o}C and 26.25^{o}C respectively. At both locations, recorded maximum temperature at did not exceed the bleaching threshold value as per the calculations done using NOAA-AVHRR OISST data. Thus the temperature variability at ocean at Bar reef and Pigeon Island did not make harmful effects to the coral reefs in same area during 2018.

Hydrography

Under the National Charting Programme Hydrographic Surveys were carried outto ensure safe and efficient navigation in Sri Lankan waters. The nautical chart of Kalpitiya Lower is available in print on demand.According to the Memorandum of Understanding between National Hydrographic office of NARA and SL Navy, both parties were involved for the bathymetric data acquisition to produce KKS harbor chart. The fair sheet of the Nautical Chart of KKS harbor was completed during 2018 and available in print on demand. The nautical chart of Kankesanthurai to Delft Island is available print on demand.Bathymetric data acquisition for Coastal Chart Weligama to ColomboUp to 2017, 60 % of the surveys of the above chart is completed. NHO intended to complete surveys for remaining area of this nautical chart by the end of 2018. The prime objective of the Accuracy Analysis of GPS Aided Geo Augmented Navigation (GAGAN) for Inland and Offshore Surveying Applications projectis to focus to test the availability of GAGAN satellite based augmentation service over Sri Lanka for inland and offshore surveying and mapping applications. The physical progress of the year is around 50%.Surveys also conducted to support public and private Sector involvement in various development activities in Sri Lanka.

Socio - Economic & Marketing

Project on value chain analysis of lobster, crab, giant fresh water prawn and clam fisheries in Sri Lanka; results revealed that small quantities of supply and narrow markets were main barriers for competitive value chains and lack of technical programs for value chain actors on harvesting, post-harvest handling, value addition and product development hindered the sustainable utilization of those fisheries resources. It was recommended ICT based market information networks and market infrastructure facilities for the sustainable development of the fisheries. Project on cost of production in marine fishing operations; all length groups of boats were considered and results proved that multi-day boat group 33-40 ft length were enjoyed the highest annual profit while the lowest by non-mechanized traditional boats (NTRB).

Project on indigenous knowledge for coastal fisheries management; under the project beach seine fishery and stake net fishery were studied. Results revealed that over 90% of beach seines in the Mullativu district were operated using winch attached to the tractors, while 100% of southern province beach seines were operated manually. In stake net (Kattudel) fishery, utilization of craft and gear has changed over the years. Negombo and Chilaw fishers still practice traditional padu system of fishing site rotation manifests, traditional knowledge and community based management of the fishery. The fisheries information centre; centre had received 427 queries from stakeholders and general public and all the queries were successfully solved out. Project on community welfare and skills development of fishers; under this project 200 skippers of multi-day boats have successfully been trained.

Marine Biological Resources Division

MBRD

Biological and fisheries aspects of beach seine fishery in northwest coast and northeast coast in Sri Lanka

Project No	:	2.1.1.3.
Officers Responsible	:	R.A.M.Jayathilaka

Introduction

The beach seine fishery is seasonal in northwest coast and northeast coast in Sri Lanka and fishing operations are mostly confined to calmer non-monsoonal months. Most of beach seine fishermen from northwest area migrated to northeast area during the fishing season of north east area.Over the last three decades, beach seine fishery has been undergone to several changes with respect to the type of beach seine craft employed, materials used for making the net and management/ policy decisions taken regarding beach seine fishing operations (Fernando, 2001). A major change took place recently in the beach seine fishing industry due to the introduction of a winch to operate the beach seine net. This winch is becoming popular among beach seine operators since it provides an alternative solution for the growing manpower shortage for operating the beach seine net.

Objective

This study was carried out with the aim of identifying the present status of the beach seine fishery in the Northwestern region and the North eastern region and possible impacts due to the introduction of a new winch in the beach seine fishery.

Methodology

The study was undertaken in the Northwest coast from January to April and November to December 2018, and from April to October 2018 in the Northeast coast.Twenty manual operations and 31 winch operations in the Northwest coast, and 14 manual operations and 27 winch operations in the Northeast were monitored during the survey period.The selected beach seine landing sites were visited twice a month to collect information on the fish catch, fishing gear (cod net size, mesh size, number of ropes, length of net, width of net), fishing duration, distance from the coast to the operating area, number of operations per day, hauling procedure and the species composition of the catch.

Results

During the study period, a total of 87 finfish and non-finfish species belonging to 35 families were identified from the beach seine catches in the Northwest coast and a total of 71 finfish and non-finfish species belonging to 29 families were identified from the beach seine catches in the Northeast coast. *Rastrelliger kanagurta* (Indian mackerel – Kumbalawa) -21% of the total catch, *Sardinella gibbosa* (Goldstripe sardinella-Matta salaya) -19% of the total catch and *Selar crumenophthalmus* (Bigeye scad- Asgedi bolla) -12% of the total catch and Leiognathidae (Pony fish and tooth ponies-karalla) -10% of the total catch were the dominant contributors in the beach seine catch from the Northwest region whereas *Rastrelliger kanagurta* (Indian mackerel – Kumbalawa)- 22% of the total catch, Goldstripe sardinella (Matta salaya) - 21% of the total catch and *Amblygaster sirm* (Spotted sardinella - Hurulla) 19% of the total catch were the dominant contributors to the beach seine catch from the Northeast region.

The present study showed an estimated mean manual operation time of 1.98 hours ± 0.44 and 2.18 hours ± 0.75 respectively for the Northwest region and the Northeast region which was relatively lower than the estimated mean operation time for winch operation 4.04 hours ± 2.35 and 3.78 hours ± 0.62 respectively for the Northwest region and the Northeast region.

The estimated mean value of the operation distance for manual operation for the Northwest region and the Northeast region (1.15 km ± 0.16 and 1.27 km ± 0.50 respectively) was relatively lower than the operation distance for winch operation for the Northwest region and the Northeast region (2.57 km ± 1.92 and 2.73 km ± 0.53 respectively).

The results of the study further showed that the mean catch rates in terms of catch per haul per square kilometer for manual operation in the Northwest region and the Northeast region (1310 kg $haul^{-1}$ km^{-2}± 1226 and 616 kg $haul^{-1}$ km^{-2} ± 1086 respectively) was higher than the mean catch rate of winch operation in the Northwest region and the Northeast region (368 kg $haul^{-1}$ km^{-2} ± 385 and 556 kg $haul^{-1}$ km^{-2} ± 547 respectively).

Table 1: Gear hauling type, beach seine operation related parameters and estimated catches of the beach seine fishery in the northwestern region and northeastern region of Sri Lanka (2018)

Region	Gear hauling type	Sample size	Estimated mean value of hauling duration (hours)	Estimated mean value of operational length from the shore (km)	Estimated mean value of operational Area km^2	Estimated mean value of catch per haul (kg)	Estimated mean value of catch per haul (kg) per square kilometer
North western	Manual	20	1.98(± 0.44)	1.15 (± 0.16)	0.34(± 0.05)	440(±416)	1310(±1226)
	Winch	31	4.04 (± 2.35)	2.57(± 1.92)	0.77(± 0.52)	302(±448)	368 (±385)
North eastern	Manual	15	2.18(± 0.75)	1.27(± 0.50)	0.38(± 0.15)	178(±315)	612(±1086)
	Winch	27	3.78(± 0.62)	2.73(± 0.53)	0.82(± 0.16)	460(±501)	556(±547)

Conclusion

Since the introduction of the winch, manpower needed for the hauling process has been considerably reduced and the duration of the gear operation has increased. Further, the operational area has significantly widened. However, there was no significant difference in the estimated average catch between the two types of operations.

		
Manual operation		Winch Operation
		
Use tractors for hauling the beach seine		Fisheries and biological data collection

Recommendations

Since some operational procedures negatively impact the sustainability of the coastal fishery resources, the introduction of new regulations such as the maximum operational distance and the maximum operational duration are needed for the beach seine fishery. Accordingly following recommendations are made for the implementation:

- Length of the beach seine should be limited to 2.8 km (1.5 nautical miles), because too long beach seine operations may be hindrance to other coastal fishing activities.

- It is not recommended to use the tractors for hauling the beach seine unless necessary measures are implemented for protecting thehabitats on the ground (vegetation and sand-dunes etc.).

- It is also not recommended to use the winch for hauling the beach seine unless a proper mechanism for monitoring the fishing operations are implemented.

- Study recommends that the beach seine operation to be confined to the day time from 6 a.m. to 6 p.m. in order to minimize the disputes with other gear operators.

Bio-physical & socio-economic monitoring of the impacts due to coral bleaching and anthropogenic activities at selected sites (continuous project)

Project No : 2.3.1

Officers Responsible : K.G.S.Nirbadha,

Four important coral reefs (Hikkaduwa,Pigeon Island in Trincomalee, Bar Reef in Kalpitiya and Vankalei in Mannar) protected under the Department of Wildlife Conservation of Sri Lankawere selected to studythe bio-physical and socio-economic impacts due to coral bleaching and anthropogenic activities.In each study site, Thepercentage cover of corals, species composition, newly settled corals, coral bleaching percentage and composition and diversity of associated fauna and flora were assessed. A manta tow survey, 100 m line transect survey, 50 m point intercept transect method, quadrate (1 m X 0.5 m) sampling, video transect method and photo transect method were employed for these surveys. In addition, 50 m point intercept transects were deployed at shallow snorkeling areasbetween 3 and 5m depths. The following benthic cover categories were recorded to describe the benthic habitats : live hard coral (HC), dead hard coral (DC), bleached coral (BC), newly settled/ developing coral buds (CN), soft coral (SC), sponge (SP), Algae (AG), coral rubbles (CR), rock substrate (RC), sand stone substrate (SS), sand (SD), silt (SL), seaweeds (SW), seagrasses (SG), other biota (OB) and other artificial objects (OO). Furthermore, physical parameters such as depth, bathymetry, reef profile, temperature, visibility, and salinity were also monitored.

The study found that fifty hard coral species belonging to23 Genera and11Families r from the four study sites. The highest number of hard coral species recorded were families of Merulinidae (15), Acroporidae (12), Agaricidae (04), Lobophyllidae (04), Pocilloporidae (04), Poritidae (03) and Euphyliidae (03). Additionally, the hard coral species belong to families of Acroporidae, Agariciidae, Euphylliidae, Lobophylliidae and Pocilloporiae were also found from all the sites. The coral species of *Acropora muricata*, *Pavona minuta*, *Lobophyllia radians*, *Lobophyllia recta*, *Pocillopora damicornis*, *Pocillopora grandis* and *Pocillopora verrucosa* were common to all sites.Among the four study sites, Vankalei Reef had the highest abundance and diversity of hard coral species (37 species).. However, the lowest hard coral abundance was found in Hikkakuwa reef, but, interestingly this is the second highest species diversity (29 species). It was observed that the majority of the colonies of *Acropora sp.* were totally degraded in the Bar Reef marine sanctuary. In addition, in the shallow areas (3-4m) of the Bar Reef sanctuary, theseaweed species were dominated..

Among the benthic cover categories, the highest (81 ±17.25) and the lowest (21.5 ± 6.87) live hard coral (HC) percentage were recorded from Vankalei reef and Hikkaduwa reef respectively. Also,the percentage of live hard coral (HC) in Pigeon Island was 78.5 ± 12.36 and in the Bar Reef it was 42.5 ± 5.46. The highest percentage of dead corals (DC) (35.00 ± 2.65) was recoded from the Bar Reef whilethe highest percentage of silt deposition (SL) (4.50 ± 6.81) was recorded from Hikkaduwa. The presence ofseaweeds (SW) (16.00 ± 2.83) Vankalei Reef was remarkable. Furthermore, increased trends of recording of other artificial objectives (OO) were observed in all sites except in Vankalei reef. The study revealed that hard coral species in family Acroporidae including *Acropora* sp: and *Montipora* sp: family Merulinidae including *Echinopora lamellose* weredominant in the Vankalei Reef. Similar situation wasdetected at the Bar Reef during the past, Representation of *Acropora* sp:in the live coral percentagewas less than 3% in Hikkaduwa while it was recorded as 40% in Vankalei. In Hikkaduwa, *Pocillopora* sp. and *Favites* sp. were dominated and the most of the coral species were degraded. .However, it was noted that the diversity, abundance and the live coral cover of corals havedeclined in Hikkaduwa when compared with previous studies.

During the present study, ninety-eight (98) species of reef finfish belonging to 53 Genera and 26 Families were recorded from four sites. The highest reef finfish abundance and diversity were recorded from Pigeon Island and the lowest abundance was recorded from the Hikkaduwa marine sanctuary. The prominent finfish families were Labridae (15), Pomacentridae (15), Chaetodontidae (09),Acanthuridae (06), Lutjanidae (07), Scaridae (07), Balistridae (05) and Serranidae (05). The reef finfish species of *Gomphosus caeruleus* (Indian Ocean bird wrasse), *Labroides dimidiates* (Bluestreak cleaner wrasse) and *Lutjanus decussatus* (Checkered snapper) were recorded from all four sites. However, *Carcharhinus melanopterus*(blacktip reef shark) was found from Pigeon Island marine national park only. Increased anthropogenic activities releasea great pressure to coral reef environment. The results obtained under the present study clearly illustrate the degradation of the studied coral reefs.



Recommendations

- Awareness and education programmes are recommended for tourists and tourist guides. They must be educated on harmless snorkeling (touching of diving fins on corals especially on branching corals), harmless diving (unbalance bouncy and finning creates damage of corals) and adverse impacts on the coral environment due to the use of sunscreens.

- Anchoringof boats were observed closer to the coral reef bedsespecially in Hikkaduwa and Pigeon Islandindicating possible physical damages to the reefs. Also use of oil and kerosene was noted showing a risk of waterpollution. Therefore, a specific anchoring areas need to be identified.

- At Hikkaduwa, the snorkelers often usestones, to anchor their canoes.Since this activity cause coral damages, an alternative method is suggested. For an examplefixed common suitable location with a heavy concrete base attached with buoy lines, would be ideal.

- Planning and developing the tourism industry with respect to the carrying capacity of the coral reef areas is required. In addition, controllingthe dense touristsactivities at highly sensitive reef areas is also recommended.

- A continuous monitoring program needs to be implemented by NARA in order tofind out thecurrent status of the coral reefs. Accordingly, surveys needsto be carried outperiodically before and after eachmonsoon season.

- Management plans for respective coral reefs need to be formulated and implemented based on research findings.

- An onboard vigilant and security system needs to be implemented with the involvement of the Sri Lanka Navy, the Sri Lankan Coast Guard, Environmental unit of the Sri Lankan Police and the Department of Wild Life Conservation.

Study of the stock structure and biology of Amblygastersirm distributed in the coastal waters in Sri Lanka

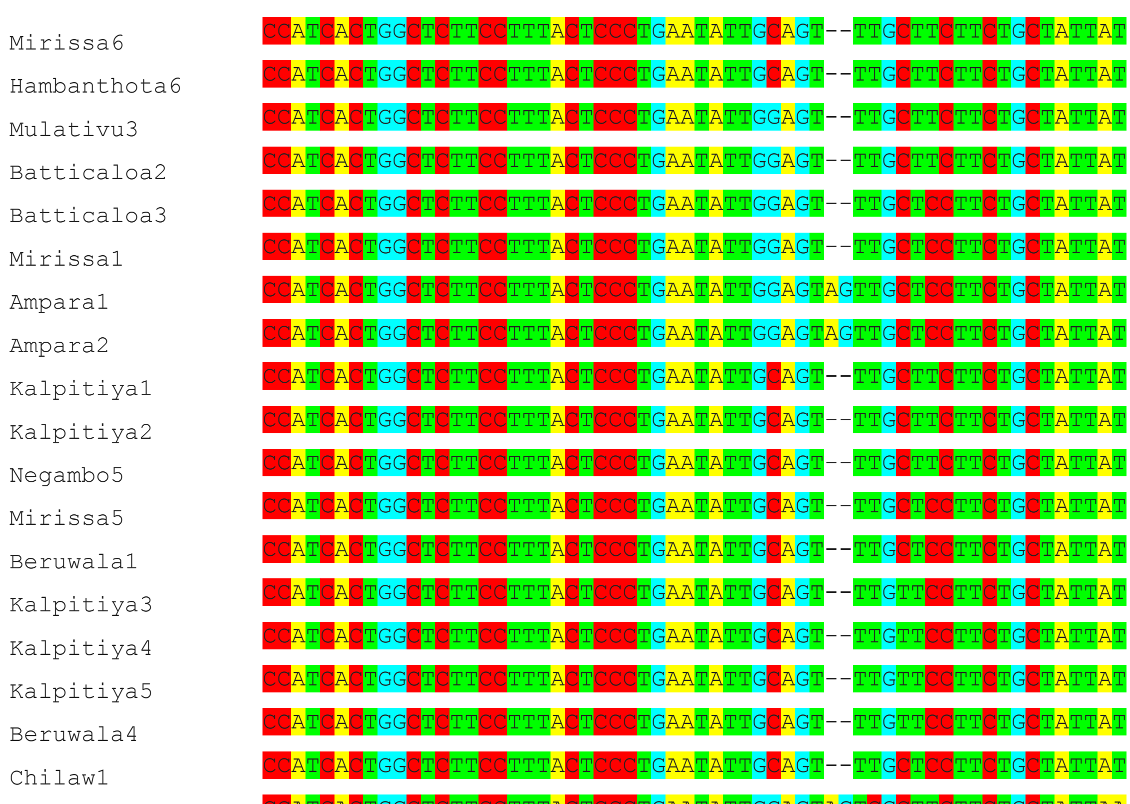
ProjectNo : 2.1.1.4.

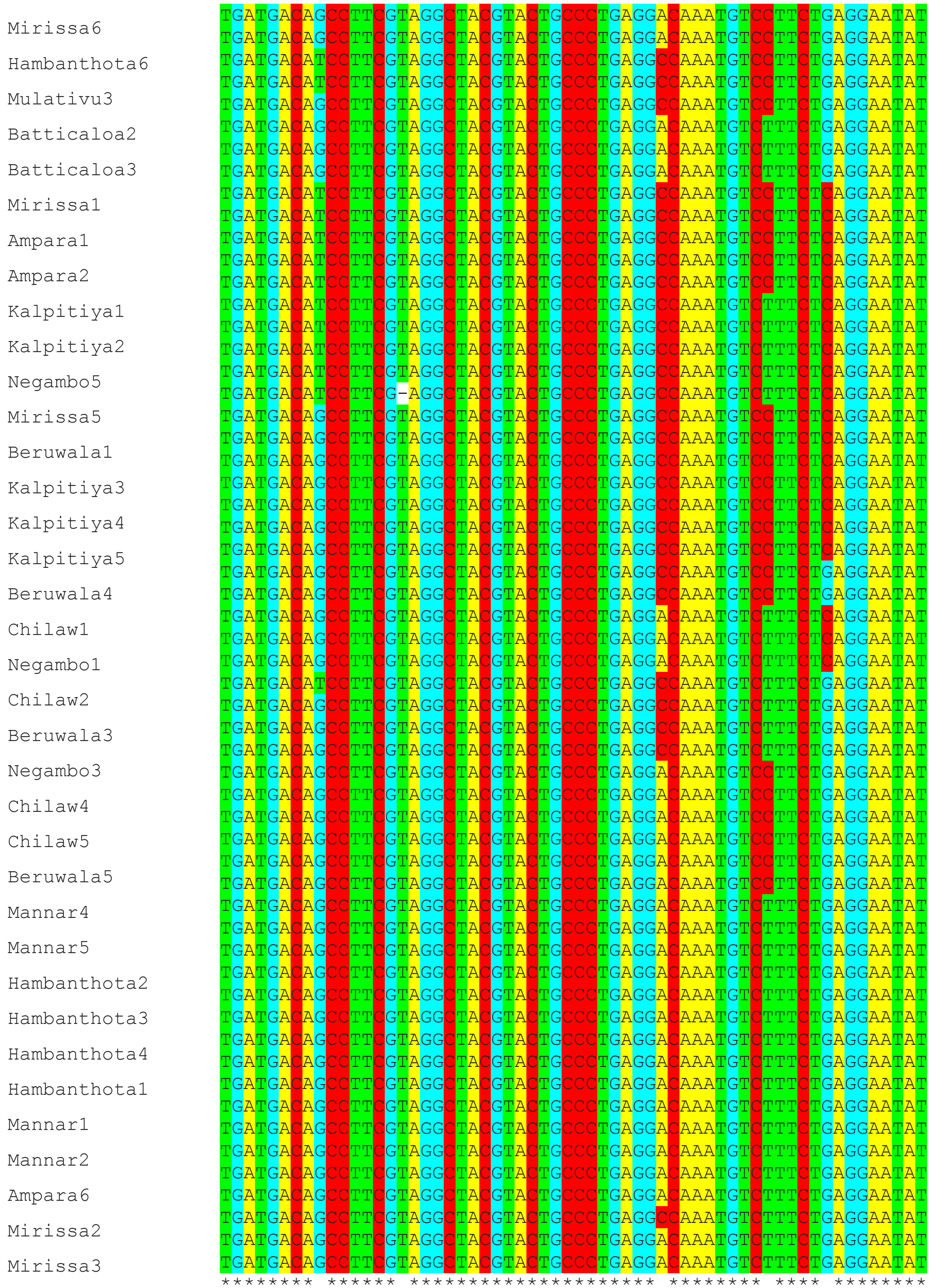
Officers Responsible : Y.C.Aluwihare

Amblygaster sirm (*A. sirm*) (Walbaum, 1792), commonly known as spotted sardinella, is the most important and the key small pelagic fish species in small pelagic gill net fisheries in Sri Lanka (BOBLME, 2015, Haputhantri, 2008).*Amblygaster sirm* contributes to 30% of the total small pelagic fish catches in the country (BOBLME, 2015), is the main income source for more than 100,000 small scale fisherman around the country (MFARD, 2017). Sustainable management of the resource is therefore needed. In this regard, stock assessment is essential to maintain the population at a sustainable level while maximizingthe harvesting. The term stock can be defined as an intraspecies group of organisms with random mating due to the temporal and special integrity.The term 'genetic stock' is described as a reproductively isolated group of species genetically different from other fish stocks. If there are separate stocks, separate fisheries management plans for the management of different stocks are needed. In addition,study of the reproductive biology of *A. sirm* parallel to the stock assessment is needed to strengthen the results and take flawless management decisions. Therefore, reproductive biology of *A. sirm* in the East coast was also studied.

For the genetic study, samples were collected from landing sites around Sri Lanka (Mulativu, Trincomalee, Ampara, Batticaloa, Hambantota, Mirissa, Beruwala, Negambo, Chilaw, Kalpitiya and Mannar) to represent the coastal waters around the country. In addition, necessary fish samples were collected from the Batticaloa and Ampara districts in order to represent the East coast of Sri Lanka, for the study of reproductive biology. In the laboratory of the MBRD, the samples were analysed in order to determine morphometric measurements, GSI, size at first maturity as well as their breeding season.In the biotechnology laboratory of the MBRD, the samples were analysed following DNA extraction, PCR and gel electrophoresis.PCR was carried out with the universal cyt b primers. C-CB280F (5’-TGC ATT TAC GCC CAC ATT GGC CGA GG-3’) and C-CB425dR (5’- CCT CAG AAD GAC ATT TGB CCT CA-3’).Genetic samples with positive PCR results were send for sequencing to Macrogen (Korea). Sequences were analyzed by using appropriate bioinformatics tools. Sequences were aligned with ClustalX Multiple Sequence Alignment Program version 1.7 (Thompson *et al.*, 1997) and the Bioedit software. Further analysis was carried out for the aligned sequences by phylogenetic tree construction.

In the multiple sequence alignment (Figure 1), single nucleotide polymorphism (SNPs), insertions and deletions were identified. Further a conserved region was observed. The insertion/deletion (INDEL) of the two nucleotides (AG) was also observed. However, this was observed in both East coast and west coast samples. A total of 12 SNPs positions were detected. They are C/A, G/C, T/C, T/C, T/C, T/G, A/T, G/T, A/C, T/C, G/C AND T/C. Further sequenced data were subjected to phylogenetic analysis by using Neighbor-Joining method in MUSCLE software in ClustalW2. Phylogenetic tree showed four major phylogenetically related groups (Figure 2).




Mirissa6
Hambanthota6
Mulativu3
Batticaloa2
Batticaloa3
Mirissa1
Ampara1
Ampara2
Kalpitiya1
Kalpitiya2
Negambo5
Mirissa5
Beruwala1
Kalpitiya3
Kalpitiya4
Kalpitiya5
Beruwala4
Chilaw1
Negambo1
Chilaw2
Beruwala3
Negambo3
Chilaw4
Chilaw5
Beruwala5
Mannar4
Mannar5
Hambanthota2
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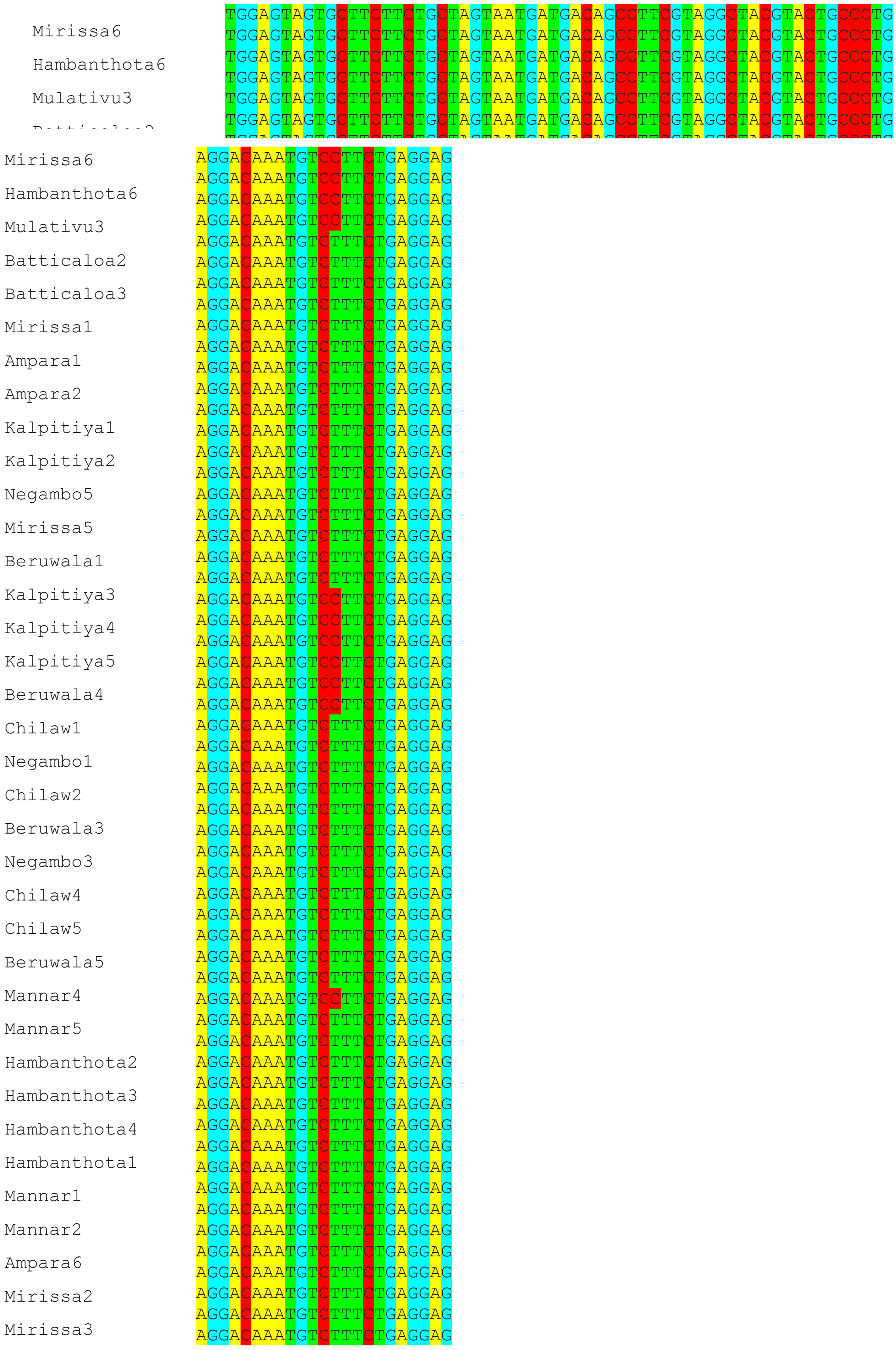
Hambanthota1
Mannar1
Mannar2
Ampara6
Mirissa2
Mirissa3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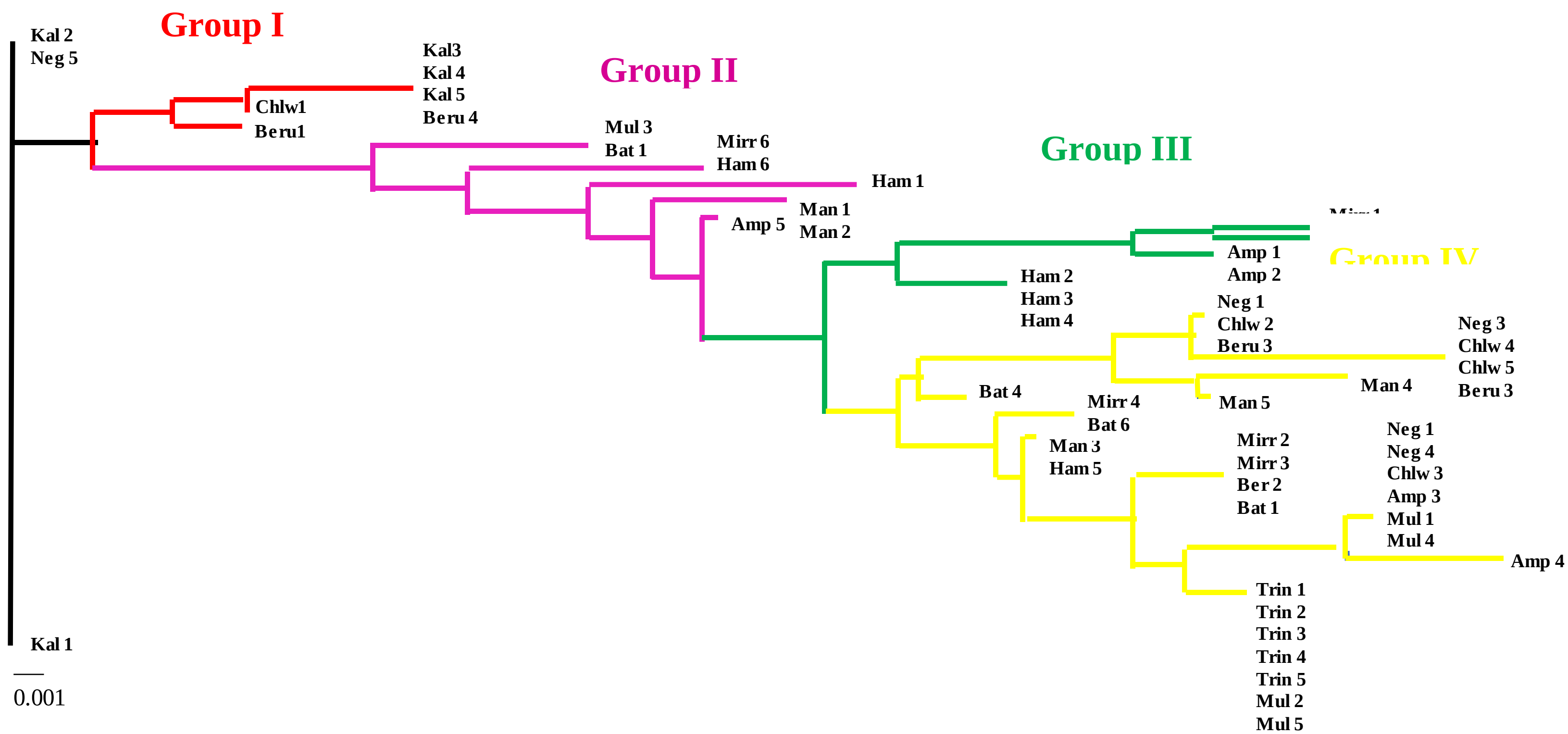
Negambo5
Mirissa5
Beruwala1
Kalpitiya3
Kalpitiya4
Kalpitiya5
Beruwala4
Chilaw1
Negambo1
Chilaw2
Beruwala3
Negambo3
Chilaw4
Chilaw5
Beruwala5
Mannar4
Mannar5
Hambanthota2
Hambanthota3
Hambanthota4
Hambanthota1
Mannar1
Mannar2
Ampara6
Mirissa2
Mirissa3



Group I
Group II
Group III
Kal 2
Neg 5
Chlw1
Beru1
Kal3
Kal 4
Kal 5
Beru 4
Mul 3
Bat 1
Mirr 6
Ham 6
Ham 1
Man 1
Man 2
Amp 5
Amp 1
Amp 2
Ham 2
Ham 3
Ham 4
Neg 1
Chlw 2
Beru 3
Neg 3
Chlw 4
Chlw 5
Beru 3
Man 4
Man 5
Bat 4
Mirr 4
Bat 6
Man 3
Ham 5
Mirr 2
Mirr 3
Ber 2
Bat 1
Neg 1
Neg 4
Chlw 3
Amp 3
Mul 1
Mul 4
Amp 4
Trin 1
Trin 2
Trin 3
Trin 4
Trin 5
Mul 2
Mul 5
Kal 1
0.001

The genetic analysis confirmed that there are nucleotide level variations and single nucleotide mutations present among individuals of *A. sirm* population in Sri Lanka. Single nucleotide mutations were seen in individuals of *A. sirm* regardless of the region they were collected. Multiple sequence alignment showed that there is a specific insertion/deletion of two nucleotides 'AG'. However, the INDEL region was not restricted to one group or individuals in one region. This clearly implies that the *A. sirm* population in Sri Lanka is from one stock and there is a mixing of populations around the coastal waters regardless of the monsoon pattern. In addition, phylogenetic analysis confirmed that all individuals have a relationship with their common ancestor and individuals collected from different regions in the East coast and the West coast are randomly distributed among the four main phylogenetic groups. In this regard, it can be further confirmed that there is only a single *A. sirm* fish stock moving around the country. Finally, from the fisheries management point of view, it can be concluded that in future, the whole population of *A. sirm* distributed in coastal water in Sri Lanka should be considered as a single stock. From the results it can be concluded that even though there are two separate monsoonal current patterns around the coasts in Sri Lanka, there is still a single A. *sirm* stock moving around the country.

The Length – Weight relationship of the *A. sirm*in the East coast waters was $\mathbf{W = 0.0066(TL)^{3.10}}$. Monthly variation of male to female ratio showed that the females dominated the natural population for many months. The breeding season of *A. sirm*in the East coast waters occurred from February to June.

Recommendations: According to the genetic study it can be recommended that the *A. sirm* population distributed in coastal waters of Sri Lanka should be considered as a single stock in future management considerations. Further, in biological studies it can be recommended to discourage the fishery for *A. sirm* in its breeding season (February to June). In order to minimize the effect due environmental changes and to strengthen the findings, it is recommended to continue this study for another year.

From the genetic study of *A. sirm,* 9 undergraduate students were trained in the Molecular Biology lab in the MBRD division.

Survey to find fish breeding, spawning and nursery grounds in West Coast of Sri Lanka

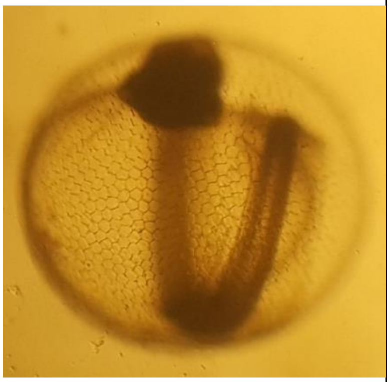
Project No : 2.1.1.2

Officers Responsible:Ishara Rathnasuriya

The fish breeding, spawning and nursery ground survey was conducted during the February to December 2018 from the coastal area between Kelani river estuary to MahaOya estuary in the west coast where human interactions are relatively high.Horizontal surface sample and a vertical sample were collected from each station using Working Party 2 (WP2) plankton net (180 µm mesh size) with help of the outboard fiberglass boat.

Collected plankton sample were sieved through the plankton sieve (180µm mesh size) preserved in 5% formaldehyde for the analysis. The preserved samples for three months i.e. March, September and October representing 1st inter-monsoon, Southwest monsoon and 2nd inter-monsoon respectively were analyzed for the abundance and diversity of fish egg and larvae.

A total of 4095 fish eggs and 465 fish larvae belonging to 23 families were collected from the study area. An average abundance of 8772 eggs and 996 larvae per 1000 m3 were recorded. Most abundant taxonomic level in each month were, Family Siganidae in March, Family Blennidae in September and Order Clupeiformes in October. Highest fish larvae abundance was found in the station (1196 larvae per 1000 m3 in vertical sample and 2537 larvae per 1000 m3 in horizontal surface sample) which is located between Negombo Lagoon and adjacent to MahaOya estuary, showing estuaries' ecological services as nursery grounds for early stages of fish. This study infers that there is a high pelagic and demersal fish diversity and abundance in the west coast of Sri Lanka.

 Family: Pleuronectidae	 Family: Engraulidae	 Family: Clupeidae

Assessment and monitoring of marine finfish fishery resources in Sri Lanka.

1.1. Assessment and monitoring of small pelagic and large pelagic fishery resources via port sampling

Project No : 2.1.1.1

Officers Responsible : Dr.Sisira Haputhantri

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 submitting 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 83% compliance rate in 2018. It is 6 % increase as compared to previous year (77 % in 2017). 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 2018, Four MBRD scientists participated for four working parties. They prepared and presented papers at the respective working parties.

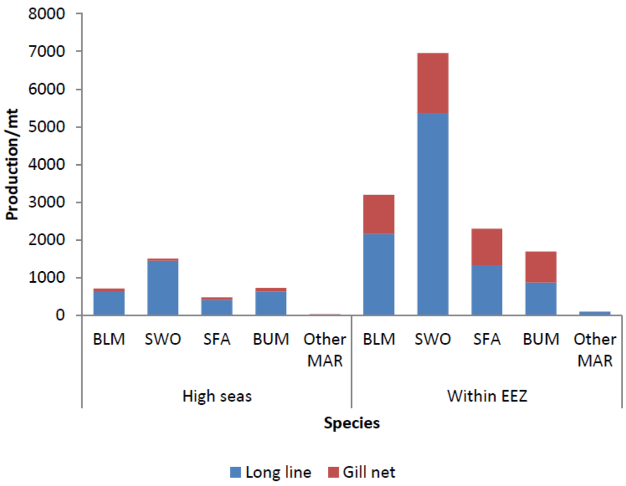
Titles and abstracts of the papers presented

Applying Generalized Linear Models (GLM) for the analysis of catch rates of Skipjack Tuna (Katsuwonus pelamis) in gillnet fishery of Sri Lanka

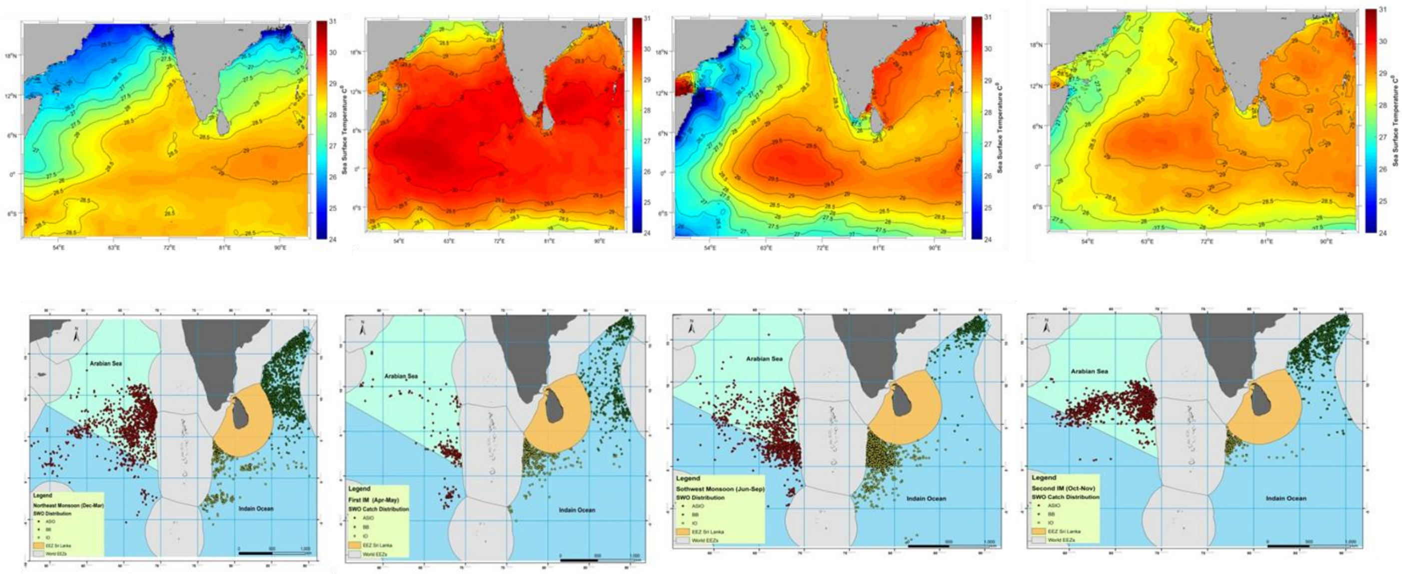
Thirteen years port sampling data (2005-2017) in the gillnet fishery of Sri Lanka was used to analyze the catch rates of skipjack tuna. Skipjack tuna is the main target species in the gillnet fishery. All gillnet catches including the catches made by popular gear combinations operate in gillnet fishery (gillnet–longline, gillnet-handline and gillnet-ringnet) were considered for this study. Five vessel types which were operated during this period in the tuna fishery of Sri Lanka have caught skipjack tuna. Fish landing data and biological data of key species in gillnet fishery are collected during the port sampling. Accordingly, the unloaded skipjack tuna catches made by the vessels are recorded and these data with other data relating to fishing operations are also recorded and entered into the national database (PELAGOS). Year, month, boat type, gear/ type, trip duration (in days) and number of net panels used for fishing operation were considered for this analysis. A monthly series of skipjack tuna Catch per Unit Effort (CPUE) in terms of catch in kg per boat per trip was derived from the catch data. A Gamma based Generalized Linear Model (GLM) was fitted to determine the relationship between the explanatory variables and monthly average CPUE. All zero-catch rates of skipjack tuna were excluded for the analysis. All main effects and their first order interactions were taken into consideration. The fitted GLM model explains 83.8% of the deviance and the vessel type was found to be the most significant factor for determining the catch rates of skipjack tuna. Among the first order interactions, year: month was found to be the key explanatory variable. The fitted GLM model comprises of main effects only explains 65.5% of the deviance.

Monsoon and temperature effects on sword fish (Xiphias gladius) catches in the high seas of Indian Ocean: A case study in high seas longline fishery of Sri Lanka

Bill fishes are normally landed as a by-catch in tuna- longline fishery of Sri Lanka. Among the five major billfish species found in the longline catches, Swordfish (*Xiphias gladius*) is dominant in terms of contribution to the total national fish production in Sri Lanka. In 2017, the production of Swordfish was 9,198mt which contributes about 46% of the total billfish catch in the country. High seas production of Swordfish was only 1,451mt where more than 90% has been harvested by longline operations. The present study was undertaken with the aim of understanding the monsoon and temperature effects on catch rates of Swordfish in high seas longline fishery of Sri Lanka. Spatial and temporal data with corresponding catch rates were obtained from the logbook data whereas Sea Surface Temperature (SST) data were obtained from ERA-interim of the European Centre for Medium-Range Weather Forecasts (ECMWF). Long line catches of Swordfish showed three distinct spatial distributions: Arabian Sea-Indian Ocean spatial cluster (ASIO) (550-700 E, 00-150 N), Bay of Bengal Region (BB) (70-170 N, 75-80E) and Sothern Indian Ocean Spatial Cluster (IO) (100S-50 N, 750-800 E). Swordfish catch rates in all three regions gradually increased during April -November while the maximum was reported from December to March during the North East monsoon prevails. Catches of Swordfish were recorded in a range of SST which varied from 27.1 to 31.2 0C. However, a clear decrease in the extent of the distribution as well as the catch rates could be observed with increased SST. Comparatively, higher catch rates of Swordfish were observed in ASIO region followed by IO and BB regions respectively. The lowest catch rates in BB reported during many months of the year may probably be due to less productive nature of the region. Catch rates of Swordfish in both ASIO and IO clusters increased during the inter monsoon and with the onset of north east monsoon while in BB cluster highest catch rates were recorded during the first inter monsoon period.



Bill fish production by species by gear in 2017



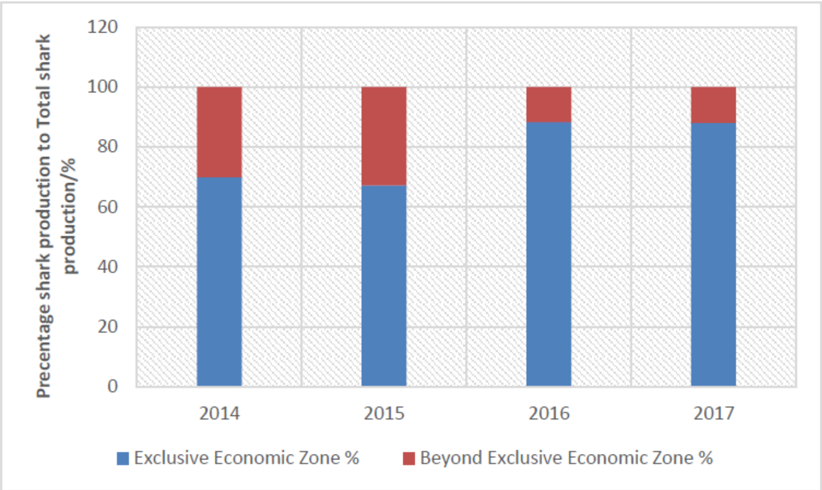
SST variation and spatial distribution of *Xiphias gladius* with respect to different monsoons: from Left to Right (as Pairs: above and below), North east monsoon (December- March), First inter monsoon (April-May), South west monsoon (June-September) and Second inter monsoon (October-November) respectively.

Temporal and operational effects on frigate tuna (Auxis thazard)Catch Per Unit Effort (CPUE): A case study in tuna fishery of Sri Lanka

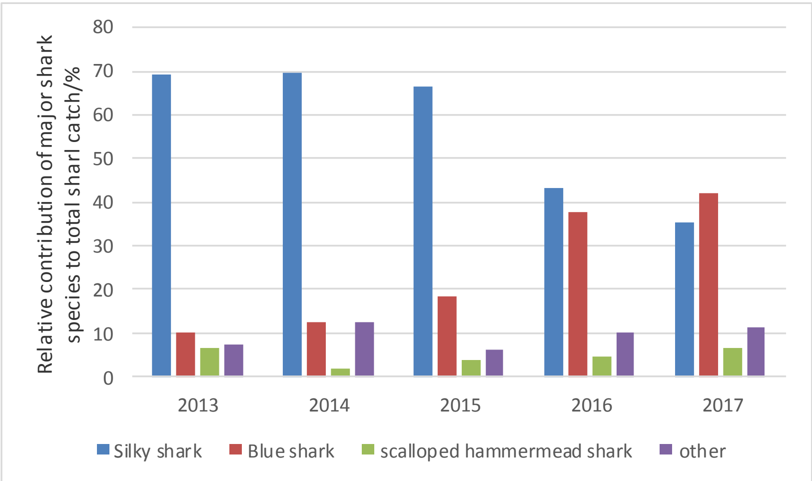
Frigate tuna (*Auxis thazard*) is a key species found in neritic tuna fish landings in Sri Lanka. Ladings of frigate tuna mostly come as a by-catch in the fishery conduct targeting tuna. Four single gears (gillnet, pole & line, ringnet and trolling line) and three gear combinations (gillnet-handline, gillnet-ringnet, gillnet-longline) catch frigate tuna in a relatively larger proportion than other gears operate in tuna fishery. Among the highly diverse fishing operations, catch rates of frigate tuna could vary with respect to different temporal and operational parameters. The aim of the study was to find out the influence of such parameters on the variability of catch rates of frigate tuna. Two temporal parameters (year and month) and three fishing operation related parameters (boat type (BT), gear type (GT) and duration of fishing trip (TD)) were used for this audit. Port sampling survey data of January, 2005 to December, 2017 were obtained from the large pelagic fishery database (PELAGOS) of National Aquatic Resources Research & Development Agency (NARA). A Gamma based Generalized Linear Model (GLM) was fitted to describe the relationship between frigate tuna monthly average CPUE and temporal & fishing operation related parameters. The fitted GLM model explains 71.5% of the total deviance and the vessel type was found to be the most significant factor for determining the catch rates of frigate tuna. Among the first order interactions, year:month was the key explanatory variable followed by year:gear type.

Reviewing effectiveness of conservation and management measures on sharks in Sri Lanka over past five years

Sharks play an important role in the marine fishery of Sri Lanka. Though shark fishery was a target fishery in the past, it has become a non-target fishery at present. Sharks are mostly caught as a by-catch in the tuna fishery. The production statistics over the last five years (2013-2017) provided by the large pelagic fishery database (*PELAGOS*) of Sri Lanka was used to analyze the recent trends in the shark fishery. Recent regulations imposed on banning of three thresher shark species with oceanic white tip shark and whale shark have resulted a considerable decline in the shark landings. At present, the percentage contribution of shark production to large pelagic fish production has become less than 2%. During the past, it remained even around 5%. The shark catches in terms of number of species at present are not diverse like reported in the past. The shark catches over the last five years are mainly comprised of silky sharks (*Carcharhinus falciformis*) (57%) followed by blue sharks (24%) and scalloped Hammerhead sharks (*Sphyrna lewini*) (5%) respectively. Though the silky shark was the dominant species in recent years, blue shark (*Prionace glauca*) landings dominated in 2017 by an increase of around 7% than silky sharks. Landings of Silky sharks were peaked in 2013 (1 247Mt) and after, there was a considerable decline in the silky shark catches reported both within Exclusive Economic Zone (EEZ) of Sri Lanka and in high seas. But, there is an increase trend in the blue shark landings mainly reported within the EEZ of Sri Lanka. During the past decade, most of the shark species have been caught mainly by longline-gillnet gear combination. During 2013 - 2017, longline has become the dominant fishing gear responsible for higher shark landings. At present, more than 80% of silky sharks are caught by longline. This study reveals that shark catches have considerably declined over last five years and recent conservation and management initiatives on sharks implemented by Sri Lanka could be one possible reason for this nature. At present, Sri Lanka is in the process of reviewing the previous National Plan of Action (NPOA) implemented with the aim of conservation and management of sharks and a new NPOA will be formulated accordingly for further strengthening the research, conservation and management of sharks.



Contribution of sharks within EEZ and Beyond EEZ: to the total shark production - 2014-2017



Shark species wise contribution to total shark production: - 2014-2017

Small pelagic fishery resources:

The small pelagic group represents over sixty marine species found in Sri Lankan waters, but, key target species in the fishery includes sardines, herrings, anchovies and mackerels. The small scale artisanal fishermen operatedwith small meshed gillnets and Outboard Engine Fiber Reinforced Plastic (OFRP) boats mostly target small pelagic fish species. Beach seines are also seasonally operated for catching small pelagic.

Marine Biological Resources Division (MBRD) of NARA monitors small pelagic fish landings with the aim of assessing the status of the resources and understanding the trends in the fishery.

The trends in the fishery till 2016 show some alarming signals especially for key species namely *Amblygaster sirm* and *Sardinella sp.* The possible reasons for such bad signals could be environmental fluctuations, overcapitalization of the fishing crafts and unsuitable mesh sizes used in the fishery. However, in 2017 there is a remarkable increase in the catchper unit effort (CPUE) both in terms of total catch per boatper operation and catch per boat per net piece (Figure 1). It was also important to note that the CPUE of key species *Amblygaster sirm* and *Sardinella sp* have increased in 2017.

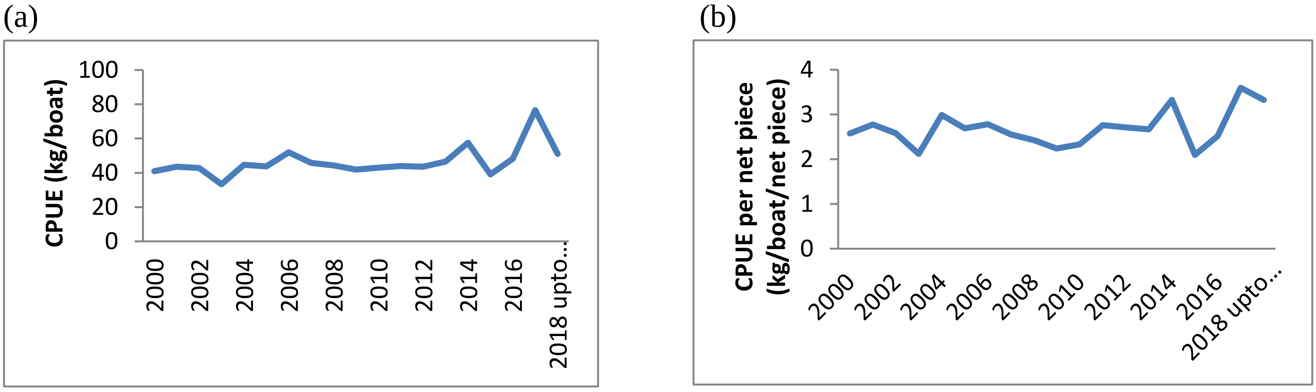


Figure 1. Annual average catch per unit effort (CPUE) (a) total catch per boat per operation (b) catch per boat per net piece

(a) (b)

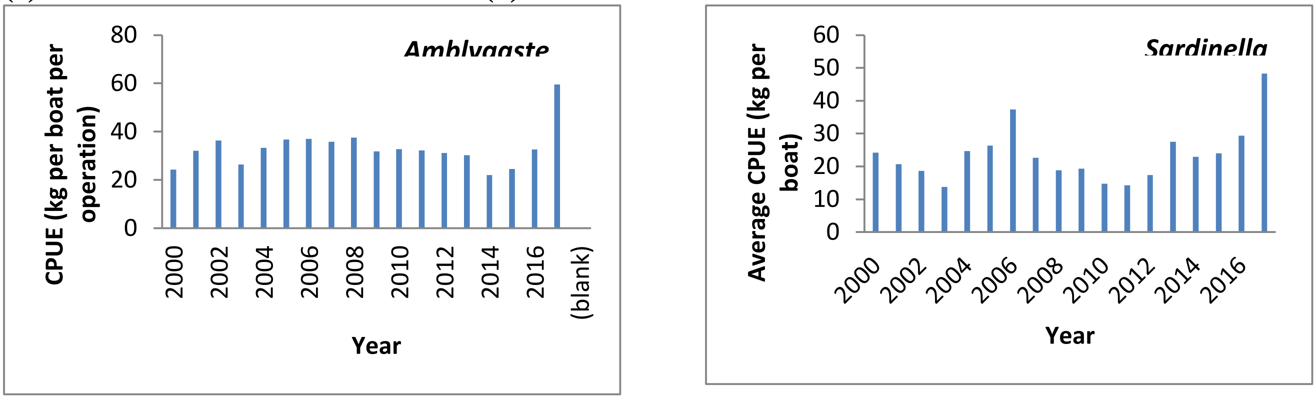


Figure 2. Annual average catch per unit effort (CPUE) of (a) *Amblygaster sirm*and (b) *sardinella sp*

The result was further confirmed by the species composition in 2017 where the contribution of both key species; *A. sirm* and *Sardinella sp* have increased throughout the year.

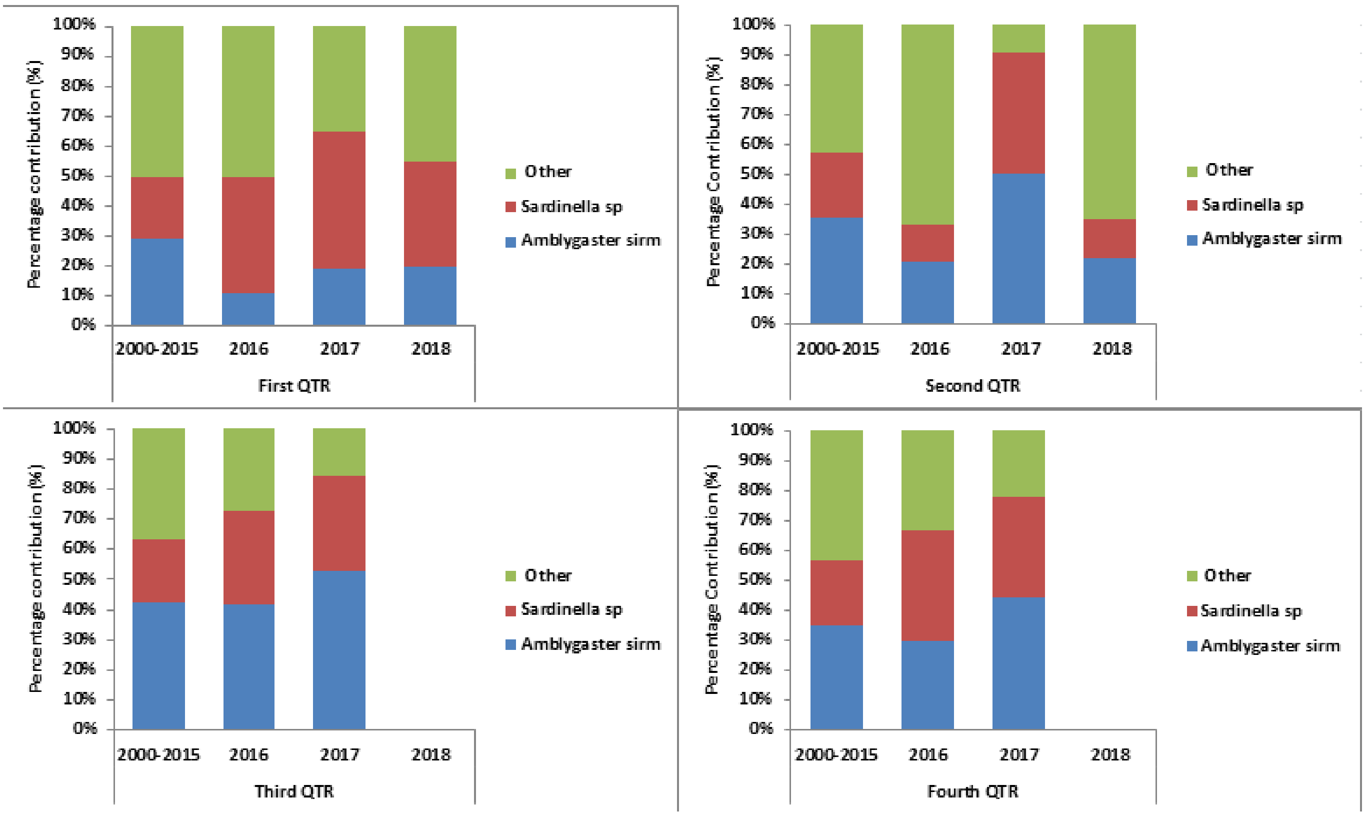


Figure 3. Catch composition of small mesh gillnets in different time periods 2000-2015;2016, 2017, 2018 up to 2nd Quarter

Catch increases of these species could be mainly due to the increased fish population depending on favorable environmental conditions occurred in the year. These kind of fluctuations could be expected periodically based on the variability in the temperature and chlorophyll contents.

However, there are many indications and evidences for unsustainable utilization of resources at present. Therefore, status of the resources should be continuously monitored in order to understand the trend of the resources and thereby to direct for proper management measures.

Recommendations

1. Effective management measures via introducing appropriate fisheries management tools need to be taken to control the small meshed gillnet fishing operations.
2. Reduction of current gillnet fishing effort in terms of number of operating boats by at least 25% is recommended in order to rebuild the depleted stocks.
3. Closed seasons during the spawning season and minimum mesh size regulations need to be introduced.
4. Conducting a comprehensive research study aiming to small pelagic fishery resources management is recommended
5. Formulation of a fisheries management plan for sustainable utilization of small pelagic fish is also recommended.

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

Project No : 2.2.3

Officers Responsible : Upul Liyanage

High exploitation rate followed by the continuous demand always make disturbances on the natural growth of wild fish populations reflecting declining catch rates, changes of the species composition in the catch, size disparity of the length classes and declining economic returns for an effort etc. This kind of observations is not exceptional for the south coast spiny lobster fishery which is subjected to high exploitation at present.

Major lobster landings sites and collecting centers in the south (Weligama, Tangalle, Hambanthota, Kirinda, Amaduwa) and east part of the island (Potuvil, Panama) were visited once a month for fisheries data collection and biological sampling.

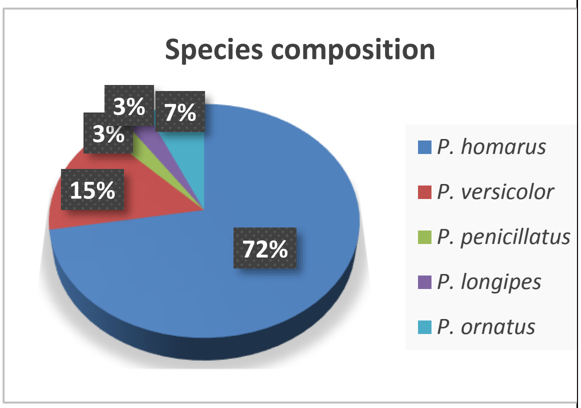
Southern coast lobster fishery

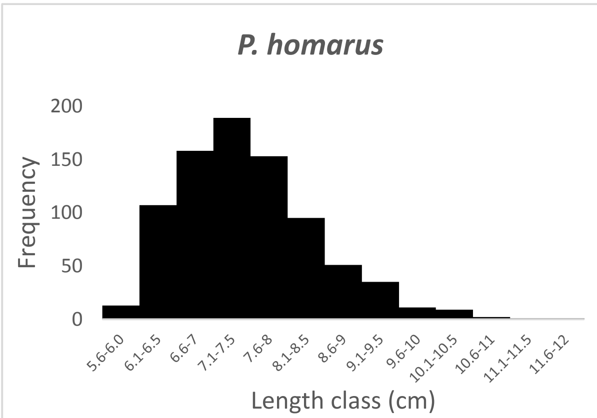
Among the five species of lobsters landed to the south coast, *P. homarus* (Scalloped spiny lobster) played an important role contributing 67 percent to the catch. But during the past decade this species continuously contributed more than 80 percent to the catch. *Panulirusversicolor*, painted spiny lobster has never been present in the catch above 5 %, but during the year 2018 it was became the second largest species in the catch contributing 15%. Catch statistics revealed that the number of undersized lobsters in the catch is negligible for all the species except *P. ornatus*. Sample size of the *P. ornatus* in the catch is too small to predict the trend. However length frequency analysis during the past few years revealed that *P. ornatus* and *P. versicolor* species reflected a good resource health. The length frequencies of the major species (scalloped spiny lobster) are quite good compare to the past years. It has been increasing the mean size of the lobsters, less number of individuals in small length classes and high frequencies of larger length classes.

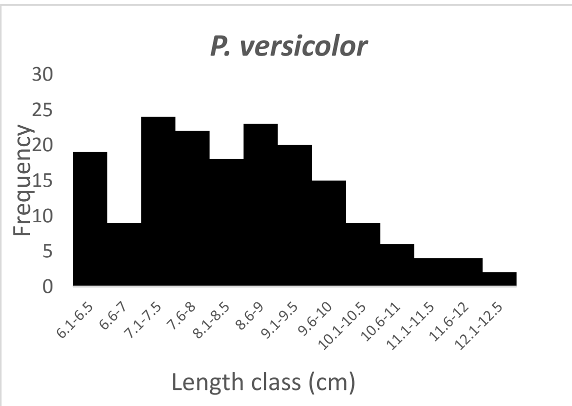
Table 1. Mean length of the lobster catch in 2018 in southern coast

Species	*P.homarus*	*P.versicolor*	*P.longipes*	*P. ornatus*	*P.penicillatus*
Female	8.15	8.49	8.22	10.78	8.53
Male	6.69	8.35	7.04	11.84	9.58
Mean	7.42	8.42	7.63	11.31	9.5

Table 1 show that means carapace lengths for male, female and both sexes separately. Estimated mean carapace length for the *P. homarus* both sexes is 7.42 cm this is 1.42 cm higher than the minimum legal size.Mean length of the catch has been increasing to significant levels and it reveals that the fishing pressure on the stock is less than the past years.







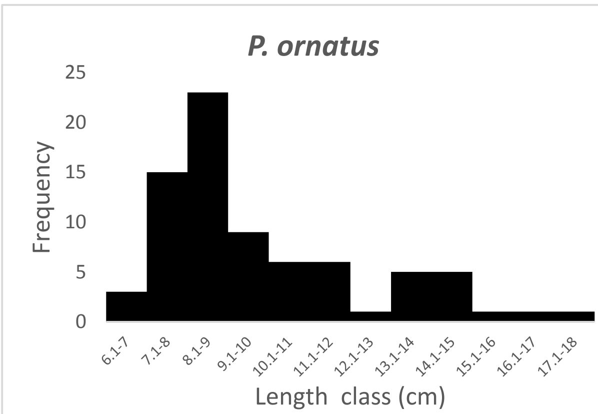
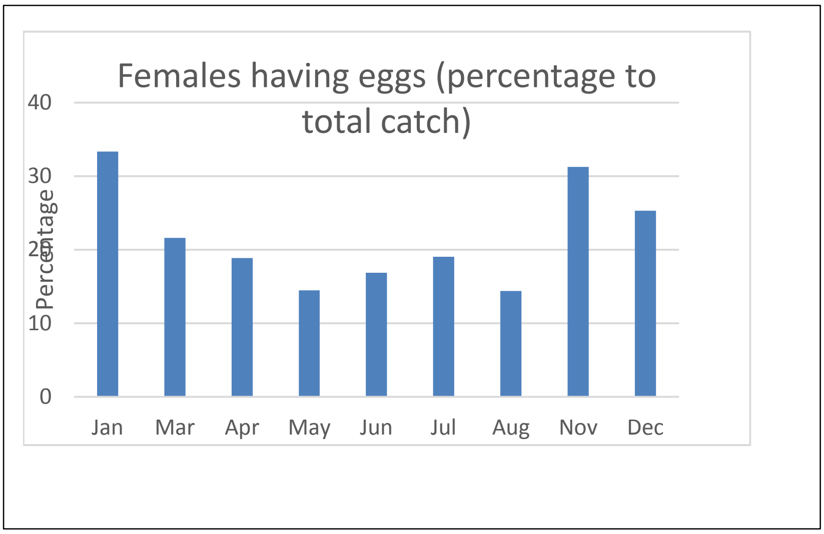


Fig 1.Species composition of the catch and length frequency plots for major species



Still harvesting of berried females are carrying out at every landing site. Fishermen practice egg removal in larger scale. During the second breeding period of the year (September-October), more than 30 percent of the commercial catch consisted of manually egg removed females.

East coast spiny lobster fishery

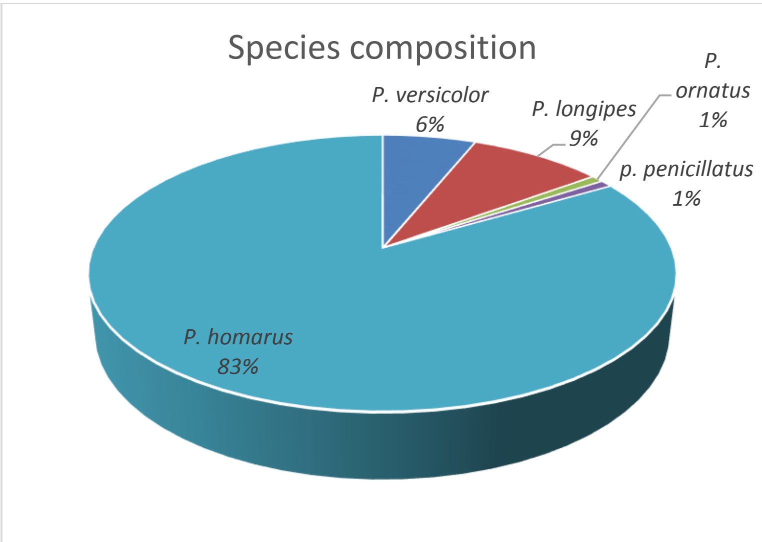


Fig 3. Species composition of the east coast lobster catch

Current species composition of the east coast region is more similar to the past results of the south coast. However, *P. homarus* is the dominant species in the catch contributing83% of the total. The number of species are same with the south coast region. Fig 4 revealed that the catch is consisted of more medium size and larger lobsters.

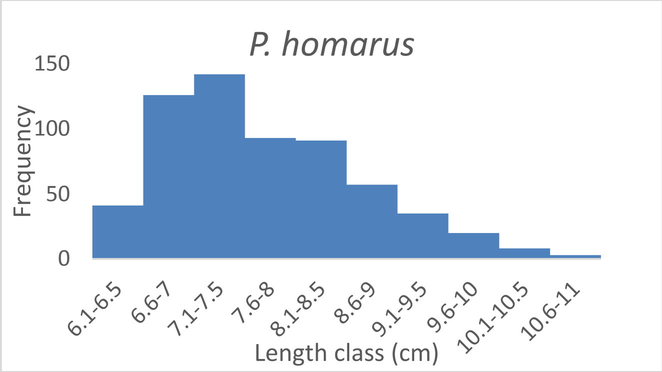


Fig 4. Mean carapace length (cm) of the major species

Table2. Mean length of the lobster catch in 2018 in eastern coast

Sex	*P. homarus*	*P. versicolor*
Male	7.53 cm	8.8 cm
Female	7.73 cm	9.0 cm
Total	7.6 cm	9.0 cm

Enforcement of lobster fishery regulations and conservation measures taken

A present, Southern Coastal Lobster Regulations implemented in 2000 are not being followed by lobster fishers and exporters. Many research revealed that female lobster release 250,000 to 2,000,000 eggs at a spawning based on their species and body size. Majority of the lobster fishermen sale berried lobsters at the market after removing their external eggs. Egg removal of the berried females and illegal fishing during the closed seasonswere identified as main reasons for depletion of the stocks.

At the Dondra and Polhena lobster conservation sites facilitated by NARA, 28 females of different species released larvae in 2018. Those lobsters were stocked by the fishermen without any NARA financial support. Approximate number of larvae released at the site during the year was 7.5 million (Assumed that no of larvae released by a female at a spawning is 300000).

Fig 5. Polhena lobster conservation site

Conclusion

A. Berried spiny lobsters rearing until releasingtheir eggswas successful

B. Length frequency analys1s revealed that lobster stocks are recovering

C. Undersized lobsters are not represent in the catch but berried females are still frequently found.

D. November, December and January months were also identified as peak breeding months

Recommendations

- Strengthening the enforcement of lobsterfishery regulations especially during the closed seasons of the year
- Declared closed seasonsin the fishery need to be reevaluated.
- Few pilot projects need to be started in the Hambanthota district with the close supervision of Department of Fisheries and Aquatic Resources.
- Further strengthening the co management mechanism and conducting awareness programmes.

Study the spatial and temporal distribution & abundance of marine mammals and their interactions with fisheries

Project : 2.3.4. 1

Officers responsible : Upul Liyanage

Sri Lanka is an Island located in the center of the Indian Ocean Marine Mammal Sanctuary (IOMMS) the first marine mammal sanctuary of the world. The marine mammal diversity of its waters is very high compared to other countries in the region, but it is not well studied their diversity, seasonality and the environmental parameters which may influence their distribution and abundance etc. Since these creatures are threatened and economically and environmentally important, a higher attentionboth nationally and internationally have been given over the past few years towards their conservation& management.

Cetacean sighting data were collected through the opportunistic platform of the commercial whale watching operators (Raja and the whale) and dedicated line transect surveys. In addition to the current surveys Dr. Fridjtof Nansen Ecosystem Survey conducted in Sri Lankan waters during 2018 provided an excellent opportunity to study on the distribution and abundance of marine mammals occurring around the island. Marine mammal stranding data are also collected throughout the coast of Sri Lanka with the support of field data collectors of NARA, Department of Wildlife Conservation and with the support of some other agencies in Sri Lanka like Sri Lanka NAVY. Further, Population assessment of the Blue whales were conducted through the visual transect survey and further studying through the photo ID techniques.

During the opportunistic survey platform,13 species of cetaceans were identified from the south coastal region.Blue whale (*Balaenopteramusculus*) was the dominant species contributed around 59%of thetotal sightings (286/485). Bryde's whales (*Balaenopterabrydei*) and Ormura's whales *(Balaenopteraomurai)*were also sighted from fifty two sightings. Ninety three sperm whales (*Physetermacrocephalus*) were sighted withineight sighting days during February, April, November and December. In addition, small pods of Killer whales*Orcinus orca* were sighted rarely during November, December, January and February. (26 whales from 12sightings). Spinner dolphins (*Stenellalongirostris)* are the most common cetacean species found in waters off Mirissa within 73 sighting 9573 individuals were recorded. Stripped dolphin *(Stenellacoeruleoalba) 430/6,*False killer whale (*Pseudorcacressidens)* 150/2, Rissos dolphin, (*Grampus griseus)* (236/6), Short finned pilot whale *Globicephalamacrorhynchus*) 493/12.

Population assessment of Blue whale

Blue whale is the most threatened and economically important cetacean species found in the waters of Sri Lanka. Distribution, abundance, population size and environmental parameters influence with those factors are important for the management and conservation. Blue whales are aggregated on the dens shipping lane from Dondra head to Galle are more dangerous and vulnerable to ship strikes and their normal behavior. Population assessment result of the blue whale during the southwest monsoon of the 2018 was as follows

Parameter	Estimate
Density (D)	0.0079 whales/km^{-2}
Cluster size (E(s))	2.64 (CV 12.34%)
Cluster density DS	0.0298/ km^{-2}
Encounter rate (n/L)	0.0272 (CV 34.13%)
Effective stripped width (ESW)	4566 m (CV11.33 %)
Detection probability (P)	0.634 (CV 11.33 %)
Abundance (N)	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.

In addition to the visual observation surveys, 290 blue whales were individually identified through the photo ID analysis. These photos were collected daily from the Mirissa area.

Fisheries interactions

Cetacean species are more vulnerable for the fisheries. Through the photo analysis and information collected through different sources found following incidents.

- 01.02.2017 Blue whale with net cut
- 01.01.2018 Bryde’s whale with recovered severe wounds due to net entanglement.
- 01.10.2016 Blue whale with possible net cut or long line
- 11.19 2016 Blue whale with entangled long line
- 18.11.2016 Blue whale with abandoned net
- 20.03.2017 Blue whale with long line attached to its fluke
- 04.04.2015 Blue whale with net entangle marks
- 28.10.2015 Net entangled sperm whale stranded to Kokilai
- 10.03.2017 10 spinner and spotted dolphins were died due to trap with beach seine
- 10.10.2018 Finless porpoise entrapped to the beach seine Jaffna
- 20.06.2017 Baleen whale carcass found at Norachchole with gillnet attached to its tail

Including above incidents, 21 incidents were recorded within past three year period.

Conclusions

- Since the blue whales inhabit in the south coastal region throughout the year there is a huge potential for further development of the whale watching industry.
- During the southwest monsoon period of the year 2018 no any single individual blue whale found in east and northeast regions of the country.
- Since blue whales are aggregated on the dense shipping route, they are more vulnerable to ship strikes.
- Fishing activities (Not only Sri Lanka) also make damages to whales (disturbances due to net and long line entanglement, net cuts, wounds and sometimes death).
- Blue whale abundance during the July 2018 was 633.

Recommendations

- Speed of the ships run through the whale habitat from Dondra head to Galle should be controlled up to below 10 knots.
- Traffic separation scheme at the Dondra head must be moved towards further south to reduce the number of ships come closer to the land
- Establishment of whale stranding network to identify the stranded whales due to ship strikes.
- Declaration of the whale sanctuary especially for the south coast
- Number of whale watching boats must be controlled in accordance to the whale density.
- Awareness programs on conservation of marine mammals need to be conducted.
- Tagging programmes onwhales need to be carried out for studying their behavior and migration etc.

Marine museum upgrade and skeleton preparation

Project No : 8.1.1.3

Officers Responsible : K.G.S.Nirbadha

All the living organisms liable to extinct with time, as a natural phenomenon. The ETP species known as Endangered, Threatened andProtected species were also found from the marine environment. Most of sea mammals and other species, including sea turtles, sharks and other marine fauna are liable to extinct with time. The main purpose ofcollecting and preservation of the ETP species in the Marine Biological Resources Division's Museum at NARA is to display specimens in public. Sharing of knowledge of ETP species has high advantages among students as well as public.To maintain and upgrade the MBRD marine museum and carried out field surveys to collect marine fauna specimens, especially ETP species that to fulfill the requirements needed to maintain the MBRD marine museum up to the standard. Further,MBRD marine museum will be conveyed massage to the public advantages of the marine biodiversity and neediness of biodiversity conservation for future generation.

In fulfillment of the project onthe Marine museum upgrade and skeleton preparation under mention works have been done. The research vessel of Dr. FridtjorfNensan was carried out ecological survey around Sri Lanka and collected many of deep sea marine species and those were preserved in formalin to prepare wet preservation. Required amount of formalin was collected and samples were preserved. 15 numbers of formalinized marine species with glass tanks (12'x8'x4) were handed over to the Dehiorvita Central Collage's laboratory.The dead body of striped dolphin, *Stenellacoeruleoalba*(Meyen, 1833) was collected from crow island, Mattakkuliya beach and stored in formalin tanks (wet preservation) to prepare the suitable tempered glass tank for public display in the MBRD museum. The specimens in MBRD museum were refilled with formalin and new specimens (collected from the field) were wet preserved using formalin. All the other dry preserved specimens (whale skeleton, Dugon's preserved dry skin and skeleton, dolphin skulls, dolphin skeletons, turtle carapaces, shark's jaws and whale's baleen plates) were painted using appropriate paints and clear varnish. The corals display board and diver's dummy were prepared to display in public. Death coral specimens (calcified exoskeleton) were collected from the field (Jaffna, Mannar, Silavathurei, Vankalei and Kalpitiya) and prepared for display after bleached processing.

Study on biological and fisheries aspects of selected edible reef fishes East coast and West coast of Sri Lanka

Project No	:	2.1.1.5
Responsible Officer	:	K.R.Dalpathadu

Introduction

A reef fishery refers to any fishery in which reefs provide essential habitat during some period of the harvested species' life-stages. It is most of the time associated with the coral reefs in the various parts of the world. Rock fishes are a part of the reef fishery resources, locally known as '*gal malu*'. It is a major part of the demersal catch from the coastal waters. Fishing activities targeting reef fish resources in the coastal waters are taken place throughout the year more or less on a continuous basis. Mostly hand line, bottom set long line ('*Bata loan'*) and bottom set gillnet ('*Elana dal'*) are used as the fishing gear to catch these rock fish species. Among the rock fish, groupers and snappers are popular marine food fish of highest market value in many parts of the world and few are currently being exported in frozen form. In addition there is a novel trend in the export market for some 'Parrot fish' species. Most of the fish product exporters are now seeking to boost up the export of these fishes especially to China and Europe.

Though, there is an increasing trend in export of rock fish in Sri Lanka, a considerable threat for the survival of these species has been raised concurrently. One of the incidents is that the banning of the *Cephalopholissonnerati* (Tomato hind) which is locally known as '*Thambuwa*'. Based on the observational records which highlighted a population decline in its known habitats, the Department of Fisheries and Aquatic Resources took actions to protect the species.

The taking of, catching, killing, transportation, sale and keeping in possession of a dead or live specimens of this fish are all banned and are offences under the Section 29 of the Fisheries and Aquatic Resources Act (FARA) and published in Gazette Extraordinary No. 2014/04 of 11.04.2017, titled “Regulations to Prohibition of Catching Fish Species ‘*Thambuwa*’ 2017”.

Making the situation more severe, there is no baseline data such as size at maturity, spawning season, fecundity…etc. and no guidelines/ regulations such as allowable sizes for capture which is a considerable challenge for Department of Fisheries and Aquatic Resources (DFAR) for taking sound management decisions. Furthermore, as several fishing methods are in use, selectivity of each gear type with respect to the size of fish varies. Also, due to lack of such information, fish stocks are currently in a threatened condition since there is a risk in harvesting a larger quantity of immature fish. Therefore, present study was conducted with the aim of identifying some important reproductive biological aspects of major rock fish species with export interest in selected areas in Sri Lanka.

Goals:

- ➢ Provide recommendations for formulation of appropriate management strategies for export oriented selected edible reef fish species as there are very few in use at present.

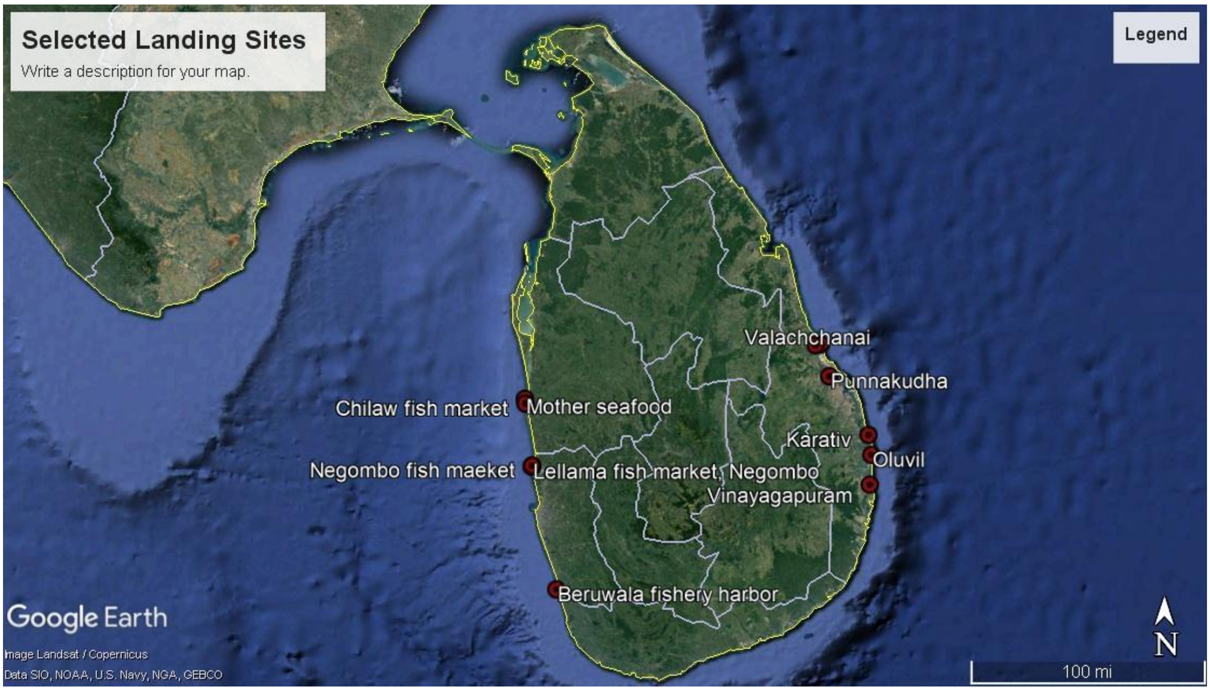
Objectives

- ✓ To study the size structure of the selected species in the catch
- ✓ To develop length-weight relationship of the selected species
- ✓ To study reproductive biological aspects of the selected species
- ✓ To estimate the size at maturity of the selected species

Materials and Methodology

A fishery dependent survey was designed in order to achieve the objectives of the research. In the west coast, Negombo, Chilaw and Kalutara fisheries districts were selected and in the east coast, Kalmunai (Ampara) and Batticaloa fisheries districts were selected as most of the rock fish production was recorded from these fisheries districts (Figure 1). In each fisheries district, several fish landing sites were selected based on the data collected during the preliminary survey in the selected fisheries districts.

In the West coast, data and sample collection was carried out from January to December, 2017. In the East coast, data and sample collection was carried out from January to December, 2018. However, sample and data collection in Chilaw fisheries district in the west coast was further carried out during 2018 too. This is because the worst case scenario in the west coast with respect to depletion of the reef fish resources was identified in the Chilaw fisheries district than other districts in the west coast.Field sampling and data collection were conducted on monthly basis thus each site was visited once a month. Before starting the field survey, a preliminary survey was conducted in respective fisheries districts in order to select the best sites for the survey and also to gather basic information such as available rock fish species from the landings, time of the boats arriving to respective sites, retail price of the rock fish species, and seasonality of the rock fish landings etc. As the Tomato hind (*C. sonneratiI*) was completely banned under the fisheries law since April, 2017, a special permission was obtained from the Department of Fisheries and Aquatic Resources for harvesting and collecting the samples of the *C. sonnerati*for this research. Accordingly, respective fishing operations were conducted in the west coast and the east coast by selected fishermen under the supervision of the NARA.



Site map.

Figure 1. A map of the study area

Following morphometric measurements were taken at the laboratory and in the field.

- Total Length (TL)

- Standard Length (SL)
- Total Weight (TW)

In the West coast, fisheries data regarding reef fishery were collected by interviewing the fishermen. Following data were collected for reef fishery.

- Boat type
- Number of fishermen per boat
- Fishing gear type (Bottom set gillnet or Bottom set long line)
- Number of hooks/length of the net per one operation
- Hook size/mesh size
- Duration of each fishing trip

A batch of *C. sonnerati* samples (n=124) caught from the southern waters which were taken into the custody by the Sri Lanka Customs Department while exporting had been provided to NARA to be utilized for this research. These specimens were also analyzed at the laboratory and used for the study. \

In the laboratory, Total Length (TL), Standard Length (SL), Total weight (TW), Somatic weight (SW), Gonad weight, weight of the liver were measured. Further the sex and the gonad development stage were determined for each specimen under consideration of methods described in earlier studies.

Results

Status of the reef fishery in the West coast.

Fishing activities targeting reef fish resources in the western coastal waters are taken place throughout the year more or less on a continuous basis. Mostly handline, bottom set longline ('*Bata loan*') and bottom set gillnet ('*Elana dal'*) are used as the key fishing gear for catching these reef fish species. Mainly Outboard engine Fibber Reinforced Plastic OFRP boats are operated with two fishermen for catching reef fish species. The fishing activities for rock fish species at sea are confined to the reef located up to about 10 – 15km away from the shore. In general, fishermen go to the sea at around 3 AM in the morning and came to the landing sites around 8 AM and then unload and sell the rock fish catch. During the period of January to December, 2017, a total number of 92 fishermen (92 boats) were interviewed. Table 1 summarises the results of the fishing activities conducted targeting reef fish in the west coast.

Table 1. Summary of the fishing operations conducted targeting reef fish in the west coast in 2017

Gear used	**Hook size/mesh size**	**Number of hooks used per operation**	**Average depth of fishing in Fathoms (1 Fathoms = 1.82m)**	**Average duration of the fishing trip**
Bottom set longline (‘*Bata loan*’)	No: 10 & No: 11	200 – 2000	10.6 Fathoms	7.09 hrs.
Bottom set gillnet (‘*Elana dal’*)	3.5 inch		6 Fathoms	5.20 hrs.
Handline	No: 10			

Catch Per Unit Effort (CPUE) was calculated in terms of catch in kg/boat/day for dominant rock fish families found in the landings in the west coast mostly based on the data obtained from Chilaw

Table 2. Catch Per Unit Effort (CPUE) for dominant rock fish families landed in the west coast during the study period.

Family	**CPUE (kg/boat/day)**
Serranidae	*2.73*
Lutjanidae	*2.68*
Lethrinidae	*11.26*

Family Lutjanidae in the catch at Chilaw

Family Lethrinidae in the catch at Chilaw

Species composition of the rock fish catches in the West coast

Chilaw fishery district recorded the highest reef fish species diversity which represents 25 species: 12 species from the family Serranidae and 12 species from family Lutjanidae and 1 species from familyScaridae. Negombo fishery district recorded the lowest species diversity with the recorded species of 18: 8 species from the family Serranidae and 9 species from family Lutjanidae and 1 species of familyScaridae.

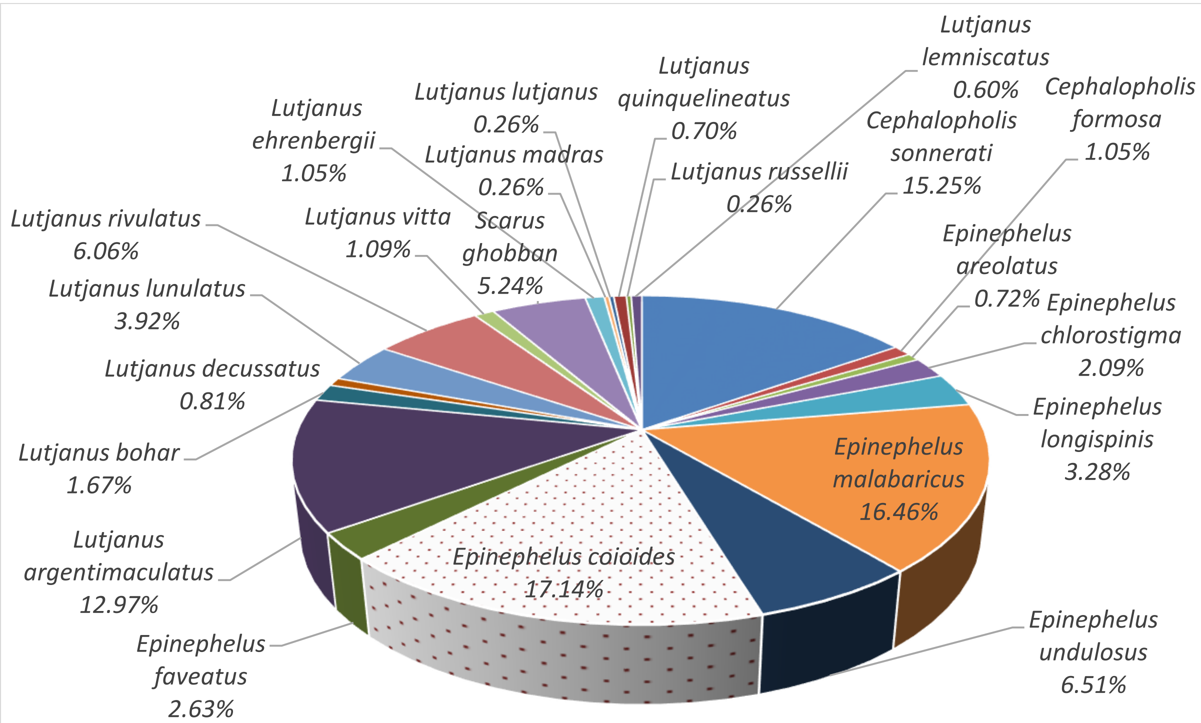


Figure 2. Recorded species composition in Kalutara fisheries district.

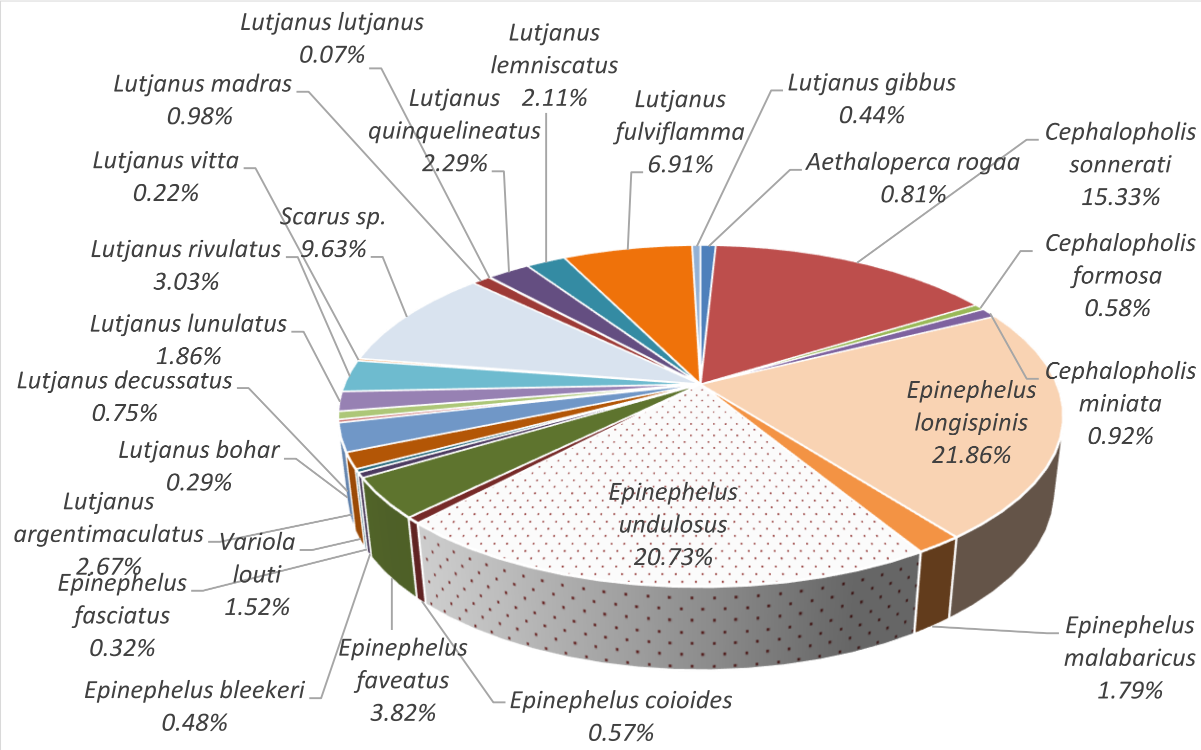


Figure 3. Recorded species composition in Chilaw fisheries district.

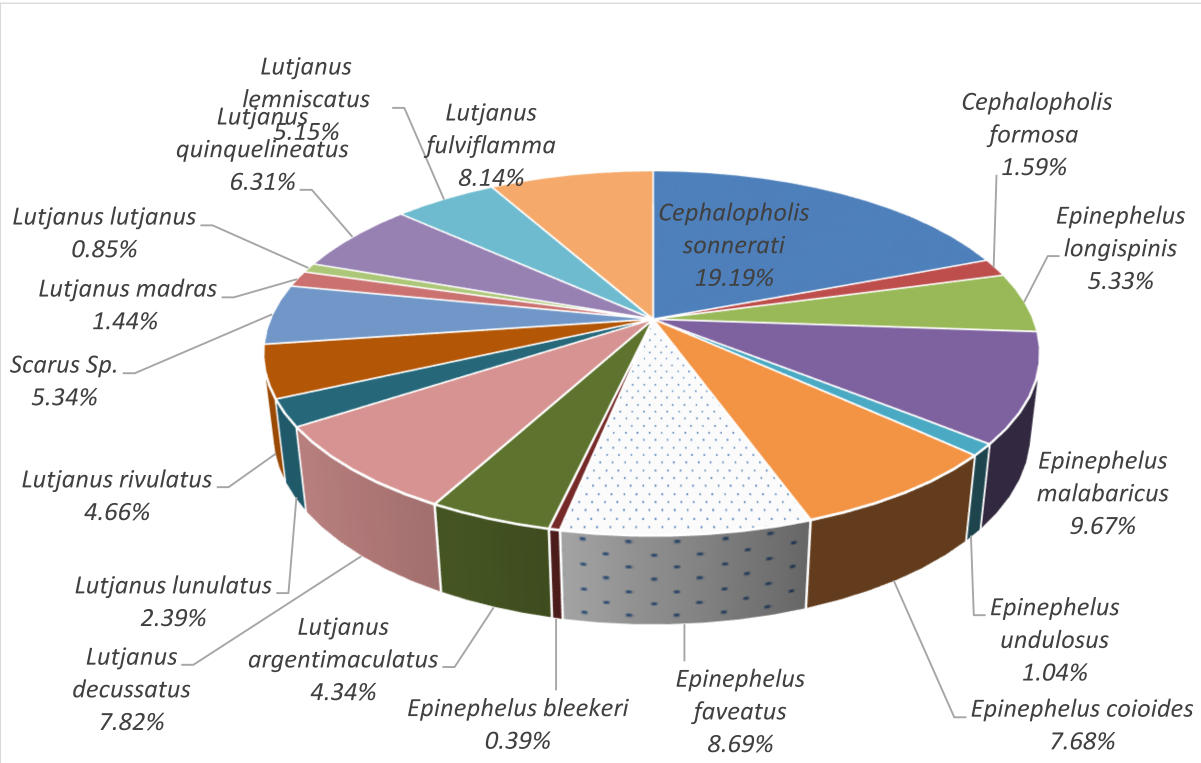


Figure 4. Recorded species composition in Negombo fisheries district.

Biological aspects of *Cephalopholissonnerati (*Valenciennes in Cuvier &Valenciennes, 1828).

During the study period, a total number of 126 specimens collected from the western coastal waters, 110 specimens collected from the eastern coastal waters and 124 specimens from the southern coastal waters were analysed in order to obtain the relevant values for biological parameters.

<u>Relative fecundity.</u>

Average fecundity was estimated at12149 ± 2404 eggs/g with the minimum of 8803 eggs/g and the maximum of 14300 eggs/g.

*Cephalopholissonnerati*in the landings at Chilaw

*Cephalopholissonnerati*in the landings at Beruwala

<u>Length – Weight relationships of *Cephalopholissonnerati.*</u>

Results of the length – weight relationships of the three *C. sonnerati*populations. (PA= Positive Allometric (*b* >3)) are presented in Table 2. .

Table 2. Length – weight relationships of three *C. sonnerati*populations

LOCATION	LENGTH – WEIGHT RELATIONSHIP	'A' VALUE	'B' VALUE	R^2	GROWTH PATTERN

WESTERN	$W = 0.01TL^{3.20}$	0.01	3.20	0.98	PA
EASTERN	$W = 0.01TL^{3.19}$	0.01	3.19	0.94	PA
SOUTHERN	$W = 0.01TL^{3.13}$	0.01	3.13	0.96	PA

Fulton's condition factor (K) of *Cephalopholissonnerati*.

The condition factor, *K* for *C. sonnerati*from three coastal regions is presented in Table 3.

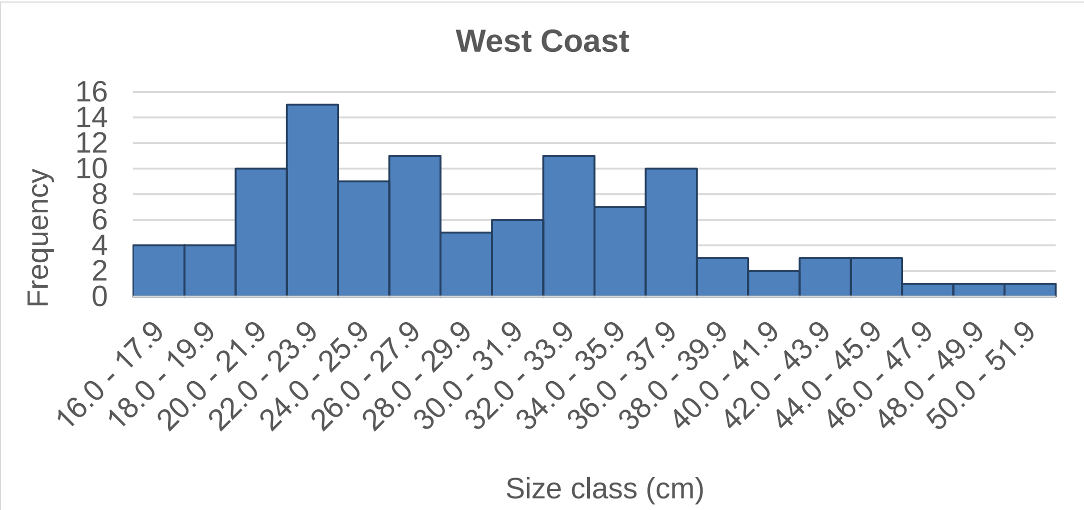
Table 3. Statistical description obtained for *C. sonnerati*in three regions. TL (cm), TW (g) and Condition Factor (K).

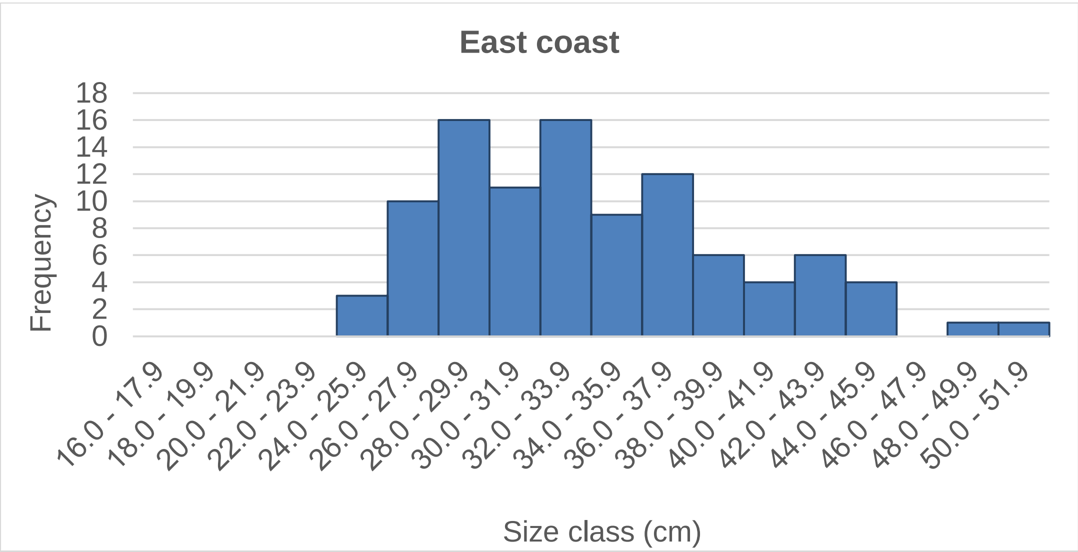
Location	**TL (cm)**			**TW (g)**			**K**
	max	**min**	**mean ± s.d.**	**max**	**min**	**mean ± s.d.**	**mean ± s.d.**
Western	50.2	17.4	29.6 ± 7.77	2300	79.92	586.017 ± 501.17	1.80 ± 0.25
Eastern	50.6	24.6	34.1 ± 5.63	2422	252.14	784.92 ± 454.57	1.79 ± 0.22
Southern	51.9	24.2	35.6 ± 5.89	2770	290.70	866.71 ± 489.15	1.74 ± 0.19

One way ANOVA test was conducted with the null hypothesis of that 'there is no statistically significant difference in the 'K' value among the three populations' in order to statistically determine the significant difference in the Condition Factor (K) among the three populations. The resulted '*P*' value was 0.132 at 95% confidential level.

<u>Length frequency distribution in the catch of *Cephalopholissonnerati*</u>

According to the results, the length modes were not consistent across the three coastal regions. Considering the west coastal waters, the most frequent size class was 22.0 cm – 23.9 cm while it was 32.0cm – 33.9 cm in the southern coastal waters. There were two dominant size classes in the east coast: 28.0 cm – 29.9 cm and 32.0 cm – 33.9 cm. The mean TL for west coast population was 29.6 cm ± 7.8 cm, for east coast population was 34.1 cm ± 5.6cm and for the southern population it was 35.6 cm ± 5.9 cm.





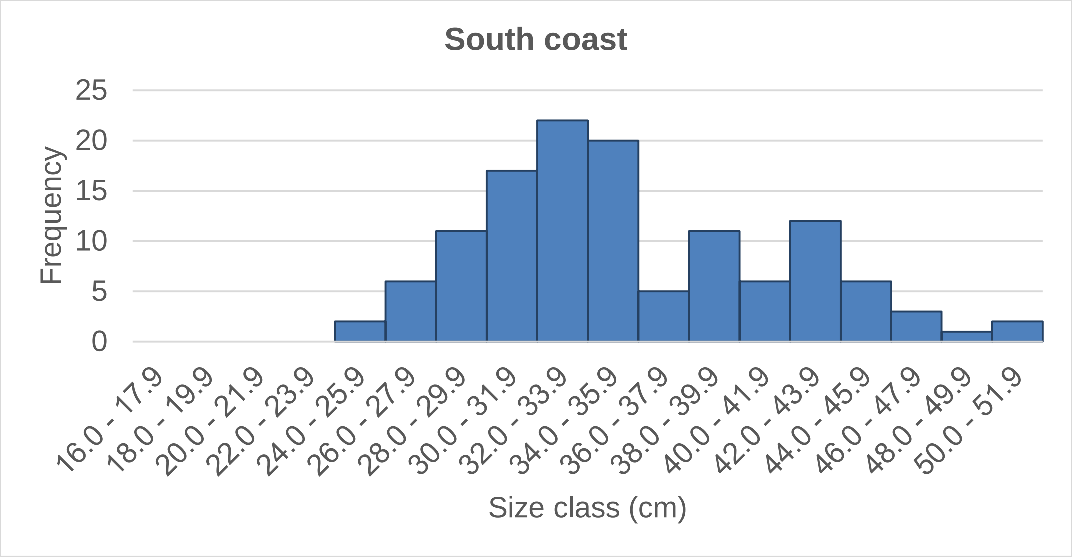


Figure 5. Length frequency distribution of *C. sonnerati*in the commercial catch in three regions

Length at 50% maturity (L50) of *Cephalopholissonnerati*.

According to the results, the L50 value for the females of western population was 33.9 cm (TL).For the females of eastern population, this was 36.3 cm (TL) and for the females of southern population, this value was 34.8 cm (TL). The mean TL for the females of western population was 29.3 cm; eastern population was 34.1 cm and southern population was 36.0 cm.

One sample t – test was conducted in order to statistically determine the significance differences between the mean TL of the females in the catch and the L50 in three coastal regions.The resulted '*P*' value at 95% confidential level was 0.00 for eastern population and the western population while 0.035 for the southern population.

Spawning period of *Cephalopholissonnerati*.

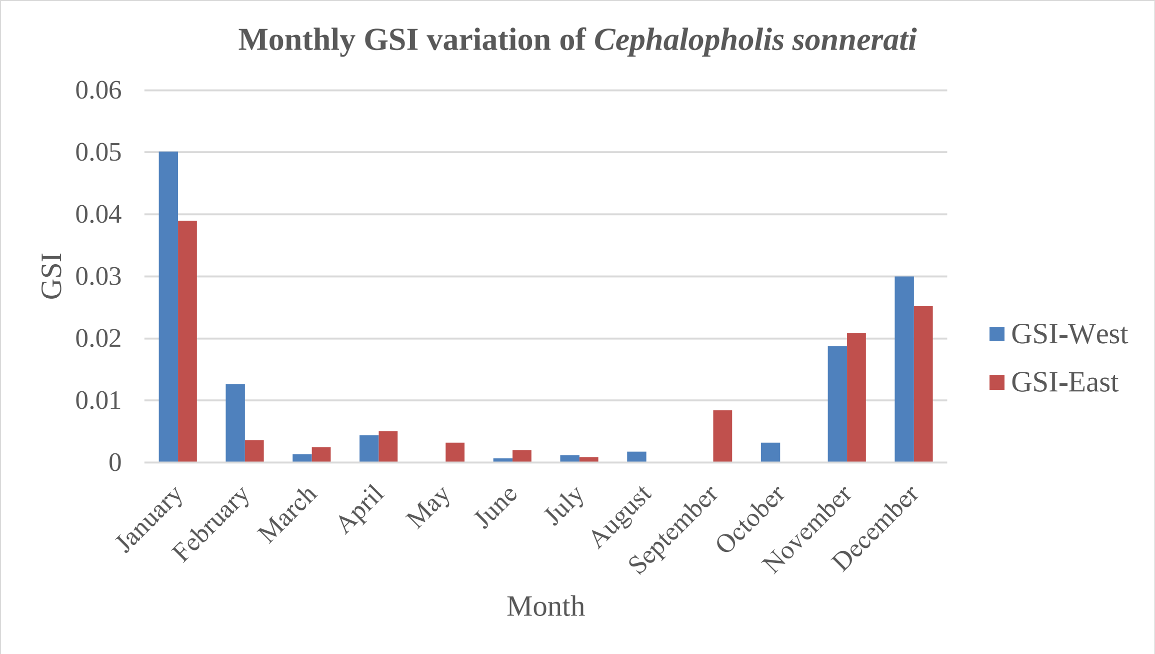


Figure 6. Spawning season of *Cephalopholissonnerati*

Some biological aspects of *Lutjanusfulviflamma*(Forsskål, 1775).

At the end of the study period, a total number of 156 specimens from the West coastal waters and 136 specimens from the East Coastal waters were analysed.

*L. fulviflamma*in the catch at Chilaw

*L. fulviflamma*in the laboratory.

<u>Length – Weight relationship of *Lutjanusfulviflamma*.</u>

Results of the length – weight relationship of the two*L. fulviflamma*populations. (NA= Negative Allometric (b<3), IS= Isometric (b=3), PA= Positive Allometric (b >3)) is presented in Table 4.

Table 4. Length-weight relationship of*Lutjanusfulviflamma*in west and east regions

Location	Length – Weight relationship	'a' value	'b' value	R^2	Growth pattern
Western	$W = 0.02TL^{2.98}$	0.02	2.98	0.97	NA
Eastern	$W = 0.03TL^{2.84}$	0.03	2.84	0.93	NA

<u>Fulton's condition factor (K) of *Lutjanusfulviflamma*</u>

The Fulton's condition factor, *K* for *L. fulviflamma*from two coastal regions is presented in Table 5.

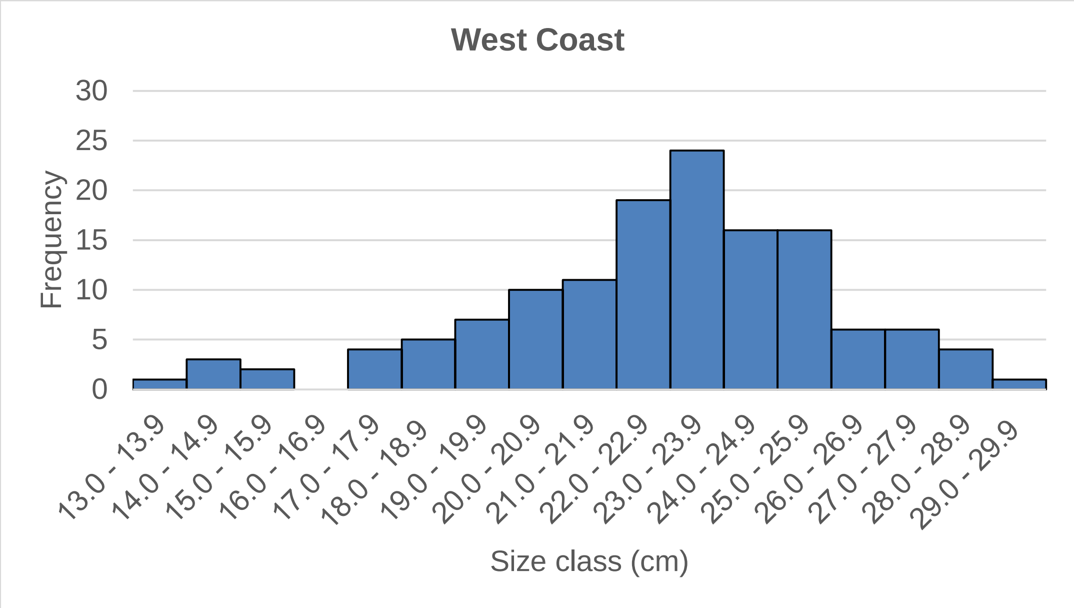
Table 5. Statistical description for *L. fulviflamma*in two regions: TL (cm), TW (g) and Condition Factor (K).

Location	TL (cm)			TW (g)			K
	max	**min**	**mean ± s.d.**	**max**	**min**	**mean ± s.d.**	**mean ± s.d.**
Western	29.7	13.5	22.8 ± 3.1	402.65	39.51	206.08 ± 76.35	1.65 ± 0.14
Eastern	27.4	17.8	22.6 ± 2.1	322.29	94.80	184.64 ± 50.27	1.57 ± 0.11

Independent sample t – test was carried out in order to determine whether there was a statistical difference between the mean condition factors (K) of the two populations. The resulted two tailed '*P*' value was 0.000 at 95% confidential level.

Length frequency distribution in the catch of *Lutjanusfulviflamma*.

According to the results, the length modes were not consistent across the two coastal regions (Figure 7). Considering the Western coastal waters, the most frequent size class was 23.0 cm – 23.9 cm while it was 22.0cm – 22.9 cm in the Eastern coastal waters. The mean TL for West coastal population was 22.8 cm ± 3.1 cm and for East coastal population was 22.6 cm ± 2.1 cm.



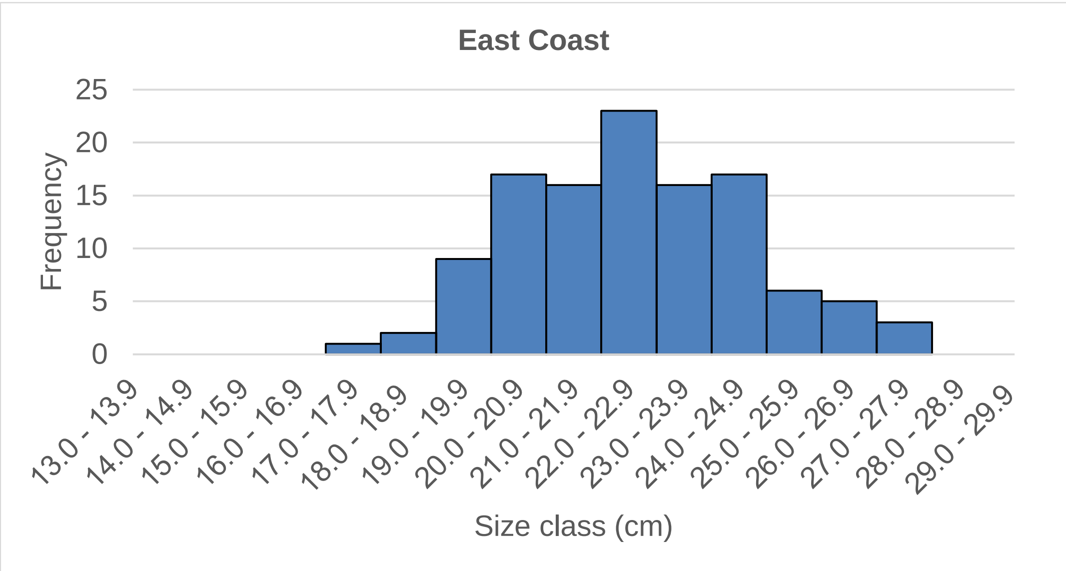


Figure 7. Length frequency distribution of *L. fulviflamma*in the commercial catch in two regions

<u>Length at 50% maturity (L50) of *Lutjanusfulviflamma*.</u>

The calculated L50 values for two *L. fulviflamma*populations are tabulated in the Table 6.

Table 6. Length at 50% maturity of *L. fulviflamma*in the two regions

L50 (cm)		
Population	**Male**	**Female**
West coastal waters	23.0	23.0
East coastal waters	22.1	22.1

One sample t – test was conducted in order to statistically determine the significance differences between the mean TL of the *L. fulviflamma* in the catch and the L50 in two coastal regions. The results are tabulated in the Table.

Table 7. Results of the t-test conducted for *L. fulviflamma*

Population	**Males**				**Females**			
	Mean TL (cm)	**L50 (cm)**	**t value**	**P value (2 tailed)**	**Mean TL (cm)**	**L50 (cm)**	**T value**	**P value (2 tailed)**
West	23.5	23.0	1.798	0.077	23.7	23.0	2.152	0.036
East	22.8	22.1	2.220	0.031	22.6	22.1	2.051	0.045

<u>Spawning period of *Lutjanusfulviflamma*.</u>

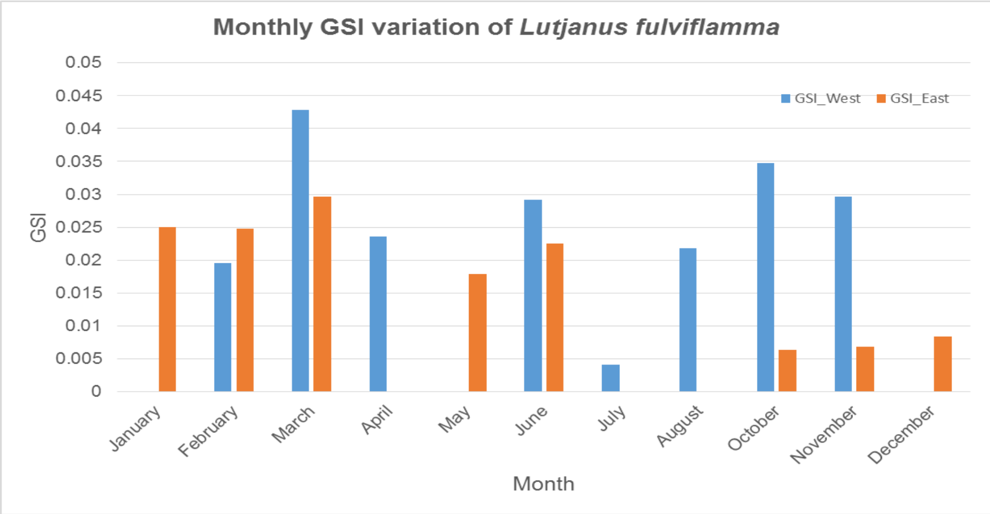


Figure 8. Spawning season of *Lutjanusfulviflamma.*

Some biological aspects of *Epinepheluslongispinis*(Kner, 1864).

Atotal number of 130 specimens from the West coastal waters and 46 specimens from the East Coastal waters were analysed.

*E. longispinis*at the Chilaw fish market

*E. longispinis*in the laboratory

<u>Length – Weight relationship of *Epinepheluslongispinis.*</u>

Results of the length – weight relationship of the two *E. longispinis*populations. (NA= Negative Allometric (b<3), IS= Isometric (b=3), PA= Positive Allometric (b >3)) were summarized in Table 8.

Table 8. Length – weight relationship of the two *E. longispinis*populations in west and east coasts

Location	Length – Weight relationship	'a' value	'b' value	R^2	Growth pattern
Western	$W = 0.01TL^{3.14}$	0.01	3.14	0.93	PA
Eastern	$W = 0.01TL^{3.02}$	0.01	3.02	0.93	PA

<u>Fulton's condition factor (K)of *Epinepheluslongispinis.*</u>

The Fulton's condition factor, *K* for *E. longispinis*from two coastal regions is presented in Table 9.

Table 9. Statistical description obtained for *E. longispinis*in two regions. TL (cm), TW (g) and Condition Factor (K)

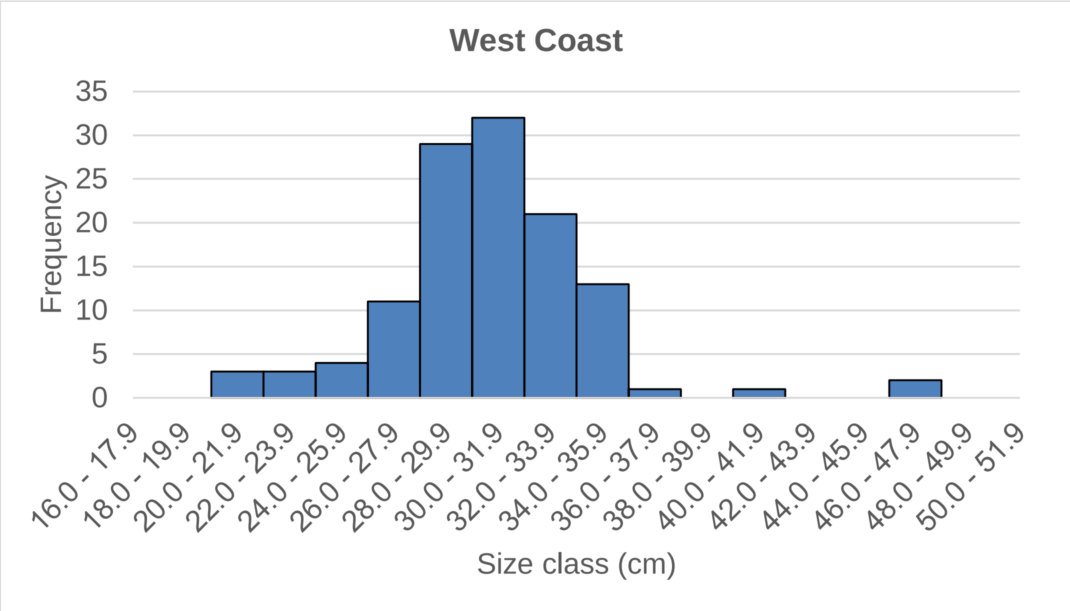
Location	TL (cm)			TW (g)			K
	max	**min**	**mean ± s.d.**	**max**	**min**	**mean ± s.d.**	**mean ± s.d.**
Western	46.7	20.2	30.5 ± 3.9	1522.79	102.00	456.34 ± 199.19	1.52 ± 0.17
Eastern	48.1	29.8	38.4 ± 4.7	1971.34	425.10	848.51 ± 352.89	1.43 ± 0.15

Independent sample t – test was carried out in order to determine whether there was a statistical difference between the mean condition factors (K) of the two populations. The resulted 't' value was 2.846 and the two tailed '*P*' value was 0.005 at 95% confidential level.

<u>Length frequency distribution in the catch of *Epinepheluslongispinis*.</u>

According to the results, the length modes were not consistent across the two coastal regions (Figure 9). Considering the West coastal waters, the most frequent size class was 30.0 cm – 31.9 cm. There were two dominant size classes in the catch from the East coast as 32.0cm –

33.9cm and 42.0cm – 43.9cm. The mean TL for West coastal population was 30.5 cm ± 3.9 cm and for East coastal population was 38.4 cm ± 4.7 cm.



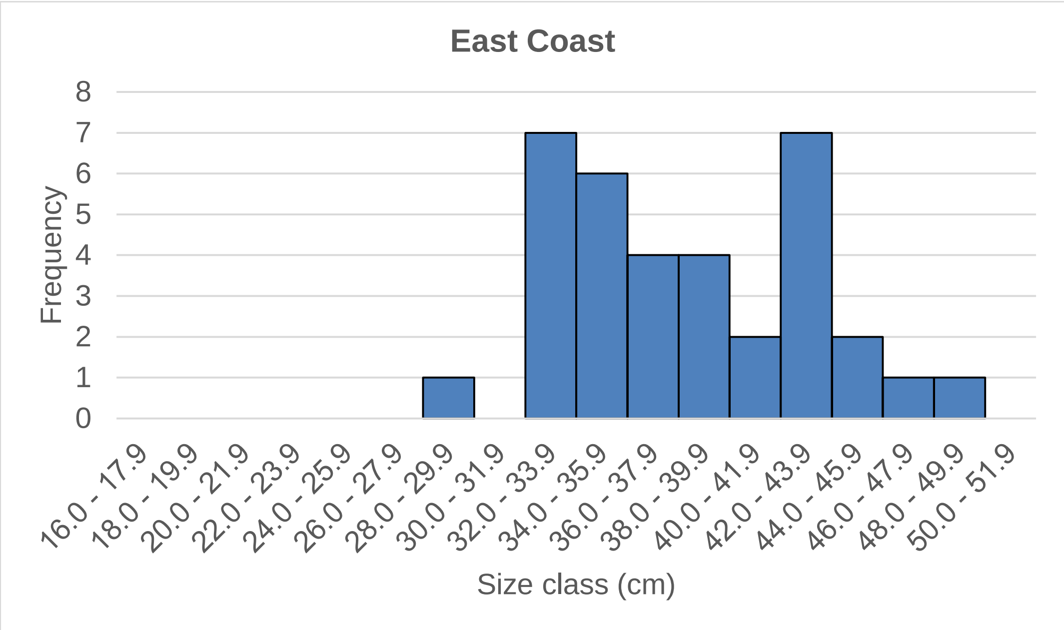


Figure 9. Length frequency distribution of *E.longispinis*in the commercial catch.

<u>Length at 50% maturity (L50) of *Epinepheluslongispinis*.</u>

In order to develop the logistic curve for the Length at 50% maturity (L50), there were not enough mature individuals of the samples obtained from both coastal areas.

Discussion

Status of the reef fishery in the West and East coasts

When comparing the reef fishery in the East coast and the West coast, fishing activities are carried out on more or less continuous basis in the West coast despite the seasonal rough sea conditions. Considering the fishing activities in the East coast, fishermen avoid fishing on reef areas during the north-east monsoon period. Thus reef fishery in the East coast prevails from April to October. Bottom set long line (‘*Bata loan’*) is the dominant gear type used in reef fishery. By today as a considerable quantity of reef fish landings are being exported, there is a good price for reef fish at the landing site. Fish byers prefer to buy reef fish in good condition without damage. When the fish are caught by gillnets fish are normally not landed in good condition. However, when they are caught by hooks, fish get a quick death and it will not get damaged. Most probably due to this reason, fishermen prefer to use bottom set long line rather than other gear types like gillnets. On the other hand,as per a regulation, setting of bottom set gillnets on sensitive areas like coral reef habitats has been prohibited andthis may further hinder the use of that gear in the reef fishery. During the interviews with the fishermen it was identified that the hand line is mainly used in the artisanal fishery for daily consumption especially for the fishing families. Through the interviews with the fishermen who operate bottom set long line revealed that about 10 years ago there were plenty of reef fishes in the respective areas thus they used hook sizes of no: 8 and no: 9 (which are larger than no: 10 and no: 11 that are currently being used) and a fewer number of hooks were also used per fishing operation. As a result, they mostly caught larger individuals. But by today the size of the hooks has been decreased whereas the number of hooks use per operation has been increased. It indicates the depletion of the reef fishery resources as well as elevated fishing pressure on the remaining reef fish recourses which may gradually lead for the ‘over exploitation’ of the resources. If this situation wasfurther continued, local extinction of some reef fish species would be inevitable.

According to the CPUE results, it was found that the species of family Lethrinidae were the major targeted group of reef fish in the West coast of Sri Lanka. Among the species of the family, *Lethrinusnebulosus* (‘*Meewati*’) and *Lethrinusolivaceus* (‘*Uruhota’*) were the most abundant species. For exportation, specimens of the weight of 400g or above with no physical damagefishes are sorted and selected. Based on the observations in the West coastal region, most of the specimens of above species had caught were around 500g. according to the published literature, the maximum size of the *L.nebulosus* (‘*Meewati*’) is 8.4 kg and

L.olivaceus('*Uruhota'*) is 14.0 kg. Thus based on the findings there is an apparent threat for these two species by catching immature ones which may lead for depletion of the resources.

Fulton's condition factor (K) of *Cephalopholissonnerati, Lutjanusfulviflamma*and *Epinepheluslongispinis.*

According to the results of the One way ANOVA test for three population of *C. sonnerati*, the resulted 'P' value at 95% confidential level was 0.132 which is greater than the 0.05. Thus there is no statistically significant difference in the 'K' value among the three populations'. The Fulton's condition factor (K) is a quantitative parameter of the Well-being State of the fish and reflects recent feeding conditions. Therefore, it was evident that three populations of *C. sonnerati*in the studied coastal regions were at same state of well-being at least during the study period. Considering the results of the 'K' for *L. fulviflamma* populations and *E. longispinis*populations the null hypothesis was rejected. Thus *L. fulviflamma* populations and *E. longispinis*populations in the west coastal region are in abetter state of well-being at least during the study period.The reason behind having high K values in the west coastal region may be due to higher productivity and food availability in the region and sometimes due to gonadal development in the populations.

Length frequency distribution in the catch and the Length at 50% maturity (L50) of *Cephalopholissonnerati, Lutjanusfulviflamma*and *Epinepheluslongispinis.*

Even though the sex composition of the catch of *C. sonnerati*, Male: Female was 1:5, it was unable to find a single male specimen with the gonad development stage of 4 or 5. Further there were few male specimens at the gonad development stage 3. The number of mature individuals (gonad development stage 3 and above) are essential for estimating the L50 thus it was unable to estimate the L50 for males in the *C. sonnerati*for the three studied regions. Research revealed that demersal fishing in Sri Lanka is rarely conduct beyond the depth of 50 meters. Unavailability of mature males of *C. sonnerati* in the fisheries catch possibly due to its deeper depth preference which is outside the depth that the bottom set long lines are operated. Considering the results, it was obvious that all the dominant size classes are less than the length at first sexual maturity of *C. sonnerati*for the three studied regions. According to the statistical results it is further statistically proved that the average size of the female *C. sonnerati*in the fisheries catch was significantly less than the corresponding L50 size in east coast and the west coast. But the mean size (TL) of the female*C. sonnerati*in the southern coastal waters was significantly higher than the corresponding L50 size. Considering the size (TL) of the females in the catch, 66.22% in the west; 54.84% in the south and 71.64% in the east were immature individuals. Thus it is evident that there is an apparent threat by capturing immature individuals of *C. sonnerati*in specially east and west coastal waters of Sri Lanka.

According to the results for *L. fulviflamma*, the size at 50% maturity for both males and females was 23 cm (TL) in the west coastal region and 22.1 cm (TL) in the east coastal waters. These sizes are tally with the other studies of Kamukuru&Mgaya, (2004) and Grandcourt, *et al*., (2006). According to the results of Fulton's condition factor, it was proven that there was a better environment for the *L. fulviflamma* population in the west coastal region. According to the studies conducted byDuponchelle&Panfili, 1998; Saborido-Rey &Kjesbu, 2005 and Jonsson, *et al*., 2013, it has been proven that better environmental factors can increase the L50 value. Thus, having a higher L50 in the west coastal population could be an effect of the more favorable environmental factors in the region. According to the results of L50 vs mean TL in the catch, it was statisticallyproven that the mean size of the catch for both males and females in both regions is higher than the L50. Considering the size distribution in the catch, 34.61% of the females and 38.60% of the males were immature in the East coastal region. The immature percentages in the catch from the West coastal region were 32.14% of females and 42.62% of males. Those values were below the level of 50% of the total catch. Thus there is no any apparent threat of capturing immature individuals for *L. fulviflamma*in both regions.

According to the results of *E. longispinis*, there were not enough mature individuals in the catch in order to estimate the L50 for both regions. That could be due to insufficiency of the number of individuals for the analysis and/or due to its habitat preferences. As it had mentioned earlier, bottom set long line which was the major fishing gear for capturing the species, had been operated around the depth ofbelow50m. But *E. longispinis* especially adults live up to 70m depth. Therefore, larger adults may not get caught to the fishing gears in the fishery. The most frequent length class of the catch in both areas are in accordance with the results of other scientific studies of the region such as Kandula, *et al*., 2015. When considering the mean TL of the catch vs L50 (from the literature) 56.0% of the females and 70.0% of the males in the East coastal catch were immature. 96.4% of the females and 100% of the males from the West coastal catch were immature. According to these findings the *E. longispinis*populations in both West and East coastal regions are in severe threat due to capturing immature fish. Further these findings are signaling the need for conducting urgent extensive studies on *E. longispinis*to provide betterinformationfor conservation andmanagement.

In fisheries management, the size limit of fish that should be cropped is normally set at size at first maturity, that is, the size at which 50% of the members of that species are matured. This allows 50% of the fish to breed before they are harvested. When the immature fish move into the areas where fishing is actually carried out, they can be captured when an inappropriate fishing gear is used, resulting in a reduction of sexually mature fish biomass present in the region. If there is an intensive immature fishing, the natural replenishment in the fishing grounds through their maturation and spawning processes get disturbed which is called growth over fishing. It may in turn results in lower yield and biomass. Further it may lead to the collapse of certain vulnerable fishery resources such as edible reef fish that having biological traits such as slow growth, low fecundity, restricted distribution etc. On the other hand when juveniles are caught in large numbers there is an economic loss as fishermen get very low prices for the small sized young fish as compared to the larger adults. Thus, there is an apparent threat for the survival of *C. sonnerati*and *E. longispinis*in the east coastal waters and the west coastal waters which require application of appropriate mesh size and hook size limitations which is very important to avoid capturing individuals of target species in their immature stages (FAO, 1997).

Spawning season of*Cephalopholissonnerati*and *Lutjanusfulviflamma.*

Considering the spawning period of *Cephalopholissonnerati* similar pattern in the average monthly GSI variation was observed in both east coast and the west coast regions. The highest GSI values were observed in the month of November, December and January. Thus it can be concluded that the spawning season for *C.sonnerati*prevails from November to January.

According to the results, it was obvious that the spawning period of *Lutjanusfulviflamma* in two studied regions were not similar. Considering the West coastal region, higher GSI values were present in most months of the year. When considering the *Lutjanusfulviflamma* in the East coastal region, highest GSI values were observed only in the first half of the year; from January to June. Different environmental conditions in its breeding grounds in two studied regions might be the reason for the difference in breeding seasons. Inconsistency of the availability of monthly samples of *Lutjanusfulviflamma* might have obstructed the definition of clear spawning period for *Lutjanusfulviflamma* in two studied regions. Therefore, based on the findings of this study, it was not wise to declare a spawning season for *Lutjanusfulviflamma* in two studied regions.

Recommendation

- It is recommended to discourage the use of No: 10 and No: 11 size hooks in the bottom set long line operations conduct targeting reef fishes.
- If the prevailing ban is meant to be lifted, implementation of the highest L50 value of 36.3cm (TL) as the minimum allowable size for capturing the *C. sonnerati* is recommended.
- If the prevailing ban is meant to be lifted,necessary actions should be taken to discourage the capture of *C. sonnerati* during the months of November, December and January in order to ascertain the survival of the brood stock.
- It is recommended to carry out an Exploratory Demersal Fishery Survey using different sizes of hooks by deploying them at different depths in order to determine an appropriate hook size and also to gather more biological data especially on male *Cephalopholissonnerati* and matured *Epinepheluslongispini*s

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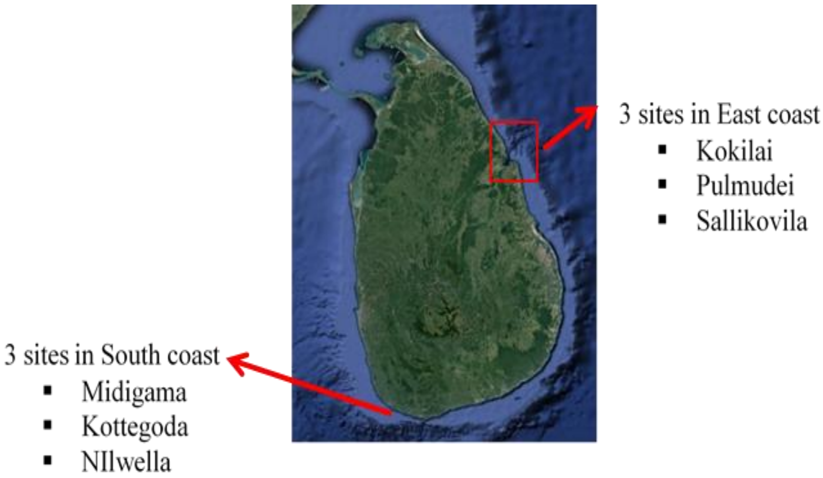
Assessment and monitoring of export oriented marine non-finfish fishery resources in Sri Lanka

Project No	:	2.1.2.2
Officers Responsible	:	Dr.Sisira Haputhantri, Udeshika Wimalasiri

2.2 Sea urchin fishery development in Sri Lanka

Sea urchins are spiny globular shape marine benthic invertebrates which belongs to phylum Echinodermata and family Echinoidea. The gonads of the male and female urchins usually callas sea urchin roe which are culinary delicacy in the world. 1Kg of sea urchin roe costs about 50 USD (Approximately Rs. 9000/=).



In Sri Lanka, a fishery for sea urchin has not yet been established. But Clusters of sea urchins are more common in shallow coastal waters in Sri Lanka (Depth range: 1-10 m) especially in coastal rocky habitats. Therefore, there is a possibility to extract or culture them for export purposes. In order to identify information on biological and spatial distribution patterns of edible sea urchin in Sri Lanka, a survey with regard tofind out their abundance and reproductive season(s) was conducted in 2018.

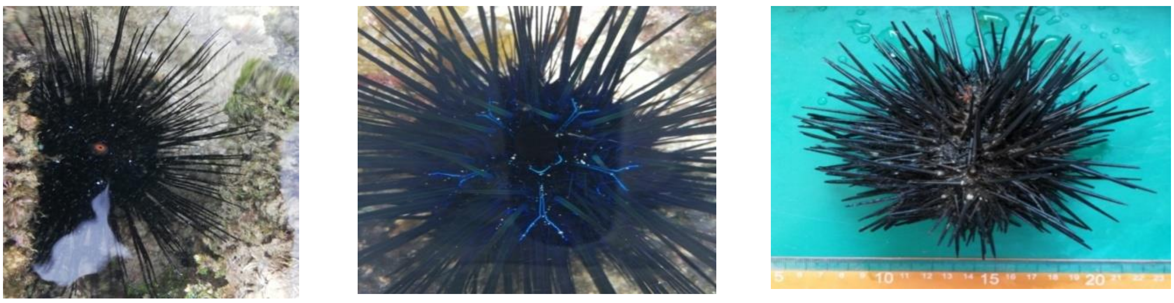
The study was conducted from January to December 2018 in Eastern and Southern coasts. For the determination of sea urchin abundance, random transect method was used in each stations. Transects were deployed vertical (seaward) to the shoreline and transect length varied from 15m to 20m. A quadrate of 0.5x0.5m was swept along transect to estimate sea urchin abundance. Sea urchin species within the plots were counted in order to determine abundance and diversity.

A total of 634 sea urchins from south coast and East coast were harvested. Samples were stored in ice box until transported to the laboratory for further analysis. Before store them,a 10 mL of 10% KCl was injected to every individuals for sex determination. At the laboratory, specimens were identified up to species level using standard guides. Sex determination was done based on the color of milt secreted by the gonads. Total body weight, test length, Gut weight and gonad weights of individuals were obtained using standard electric balance upto nearest 0.01 g. In order to identify the reproductive cycle, average Gonado Somatic Index (GSI) was calculated for different months of the year.

Total 634 sea urchins belonged to 6 families and thirteen species were found (Table 1, Figure 1).

Table 1 : Sea Urchin Species identified during study period and their respective families

	Family	Species name	South coast	East coast
1	Diadematidae	*Astropyga 45adiate*	Not observed	Present
2	Diadematidae	*Diadema savignyi*	Present	Present
3	Diadematidae	*Diadema setosum*	Not observed	Present
4	Diadematidae	*Echinothrix diadema*	Present	Not observed
5	Diadematidae	*Echinothrix calamaris*	Present	Not observed
6	Cidaridae	*Eucidaris thouarsii*	Present	Not observed
7	Cidaridae	*Phyllacanthus imperialis*	Present	Not observed
8	Toxopneustidae	*Tripneustes gratilla*	Not observed	Present
9	Toxopneustidae	*Toxopneustes* sp	Present	Not observed
10	Toxopneustidae	*lytechinus variegatus*	Not observed	Present
11	Stomopneustidae	*Stomopneustes voriolaris*	Present	Present
12	Echinometridae	*Echinometra mathaei*	Present	Not observed
13	Temnopleuridae	*Salmacis bicolor*	Not observed	Present



Diadema setosum *Diadema savignyi* *Stomopneustes voriolaris*

Figure 1: Edible Sea Urchin species identified during study period

Among different sea urchin species, black sea urchin (*Stomopneustes voriolaris)* is identified as the most abundant species (Figure 2). Black sea urchins found in both south coast as well as in East coast.

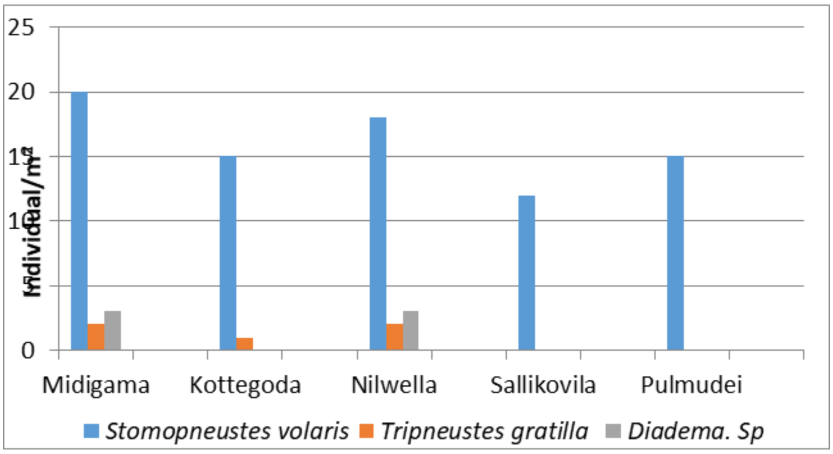
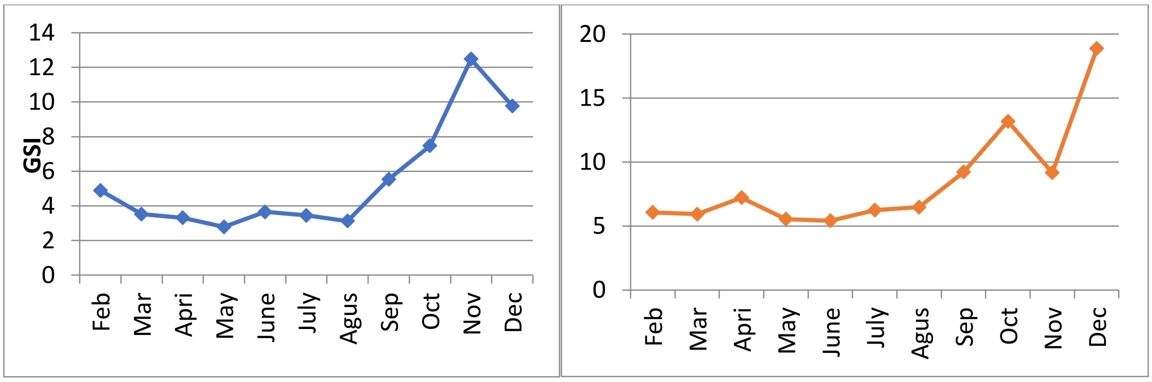


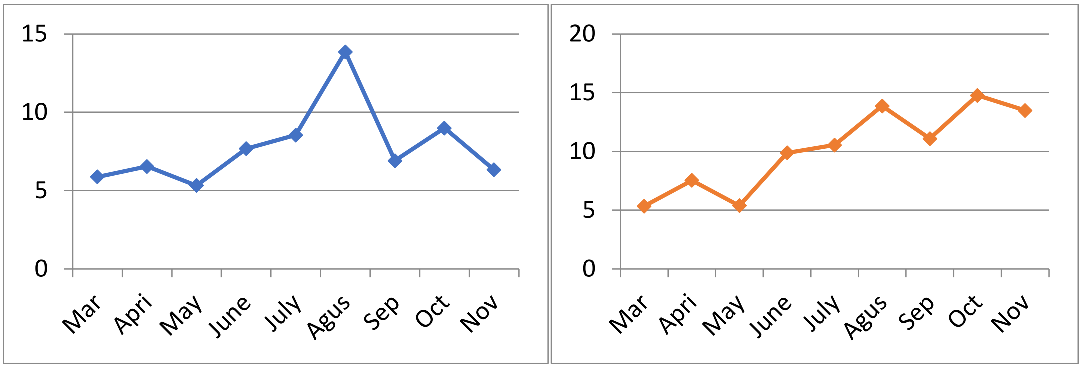
Figure 2:-Sea urchin abundance in different study sites

Gonado somatic Index(GSI) of black sea urchin was analyzed to identify the spawning seasonality. In Midigama the highest GSI was recorded in November for male and October and December for female (Figure 3). In Nilwella site for both male and female there is two clear GSI peaks around April and September. The GSI peaks in April and December in Kottegoda site for both male and female black sea urchin. GSI value is higherin August in Pulmudei (Figure 4). Fire sea urchins shows the highest GSI value around December in Kokilai area. The gonad index of population samples of sea urchins was found to vary periodically suggesting an annual cycle of reproduction. However, at any given timeof the year, some gravid individuals with ripe eggs or sperms could be observed, even though the average gonad size was small.



Male Female

Figure 3: GSI of *Stomopneustes voriolaris* in Midigama during study period



Male Female

Figure 4: GSI of *Stomopneustes voriolaris* in Pulmudei during study period

Discussion

Within the sampling sites Black sea urchin (*Stomopneustes voriolaris*) was the most abundant species followed by sand urchin (*Tripneustes gratilla*). Favorable benthic habitats and environmental conditions may be the reasons for their wide distribution throughout the shallow coastal rocky habitats.

Habitat of Black sea urchins are coralline algae. Sand urchin found mainly on sandy bottoms. According to the results, southern coastal region is rich in sea urchin population.

Since Black sea urchins are abundant, they were analyzed for the determination of the spawning season(s). GSI values in sea urchins collected from southern coast showed higher values in November and December. Therefore, this could be considered as their breeding season since breeding of sea urchins could stimulate by the change in environmental conditions like water temperature.

Results further indicate that East coast GIS values differ from location to location. This type of variation could be due to the different populations of same species and environmental conditions. A nutritional analysis and an analysis to find out the concentration of heavy metals accumulated within the gonads are needed to carry out for determining the possibility of Black sea urchin as an export commodity.

Recommendations

- 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.

- A nutritional analysis and an analysis to find out the concentration of heavy metals accumulated within the gonads are recommended to carry out as further studies.

- Further studies are also recommended to identify rest of the sea urchin resources around the country.

Inland Aquatic Resources and Aquaculture Division

IARAD

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

Project No : 3.1.1

Officers responsible : M. G. I. S. Parakrama

Introduction

As Tilapia culture in Sri Lanka is an arising and/or established farm practice, farmers engaging in the culture of the fish species are rapidly increasing. Tilapia has been identified as a highly demanding fish species especially in the rural areas, where sea food is rarely available. In addition, research on nutrition and culture systems, along with market development and processing advances, led to rapid expansion of the industry. Moreover, farmers are complaining that, as the unavailability of Tilapia feed in Sri Lanka is a great issue for the expansion of their production to cater the increasing demand. As such, the research is designed to develop a good quality fish feed for Tilapia culture.

Objective/s

To develop an economically feasible nutritious feed for Tilapia farming.

Methodology

- Work done as two activities. Outdoor trial done in cages installed at Moronthuduwa private fish farmer's pond. Three feeds with different protein percentages were formulated and prepared and tested with another commercial feed developed at Panapitiya RRC. Trial carried out for five months duration.
- Indoor trial was done with another three feed formulas using *Pistia* and *Eichornia* as plant substances as Tilapia is prefer feeding on plant matter.

  Trial conducted in cement tanks in the NARA premises as an indoor experiment. Duration was 60 days.

Experimental feed formulae used

(Feeding rate – initially thrice per day

5% body wt and later twice)

Ingredients	Feed 1	Feed2	Feed3
Fish meal	330	330	175
Soya meal	330	330	330
Pistia	300	-	-
[illegible]	-	300	-
MBM	-	-	140
Vitamin	5	5	5
Flour	175	175	330
Fish oil	[illegible]	[illegible]	[illegible]
	1000	1000	1000
Protein%	37.1	33.3	33.3
Price per kg (Rs)	113/=	113/=	113/=

Ingredients	Feed A	Feed B	Feed C
Fish meal	130	330	330
Soya meal	330	330	130
Poonac	300	300	300
Rice bran	100	100	100
MBM	100	100	100
Vitamin	5	5	5
Flour	15	15	15
Fish oil	[illegible]	[illegible]	[illegible]
	1000	1000	1000
Protein%	30.5	33.4	33.3
Price per kg (Rs)	102/=	130/=	13[illegible]/=

Results

Pond culture trial

Treatment	T1 (Feed A fed Fishes)	T2 (Feed B fed Fishes)	T3 (Feed C fed Fishes)	T4 (Feed D/ comm .feed)
Total. ini. wt (g)	254.8^{a}	274.7^{b}	252.8^{a}	272.9^{ab}
Avg.wt gain/fish(g)	163.1^{a}	160.3^{a}	165.5^{a}	124.6^{a}
Exp. Duration and stocking density	5 months , 20 fishes per m3			
Protein% of feed	30	33	35	38
% weight gain	160.63^{a}	157.65^{a}	163.04^{a}	121.95^{a}
Survival rate	87.0^{a}	85.3^{a}	85.0^{a}	85.6^{a}
SGR calculated	3.46^{a}	3.37^{a}	3.45^{a}	3.20^{a}
FCR calculated	1.93^{a}	1.93^{a}	2.13^{a}	2.39^{a}
FER calculated	0.51^{a}	0.53^{a}	0.53^{a}	0.41^{a}
Cost/kg feed	102/=	120/=	128/=	175/=

Indoor culture trial

Treatment	T1 (Feed 1 fed Fishes)	T2 (Feed 2 fed Fishes)	T3 (Feed 3 fed Fishes)	T4 (Feed 4/ comm .feed)
Total. ini. wt (g)	89.96^{a}	98.06^{a}	91.7^{a}	94^{ab}
Total final wt(g)	181.1^{a}	193.7^{b}	183.8^{a}	183.5^{a}
Duration and stoking density	60 days 35 fishes per tank			
Protein% of feed	27.1	25.3	35.2	38
% weight gain	102.89^{a}	98.27^{a}	102.05^{a}	95.51^{a}
Survival rate	100	100	100	100
SGR calculated	1.17^{a}	1.13^{a}	1.16^{a}	1.11^{a}
FCR calculated	3.70^{a}	3.70^{a}	3.69^{a}	3.88^{a}
FER calculated	0.27^{a}	0.27^{a}	0.27^{a}	0.25^{a}
Cost/kg feed	115/=	115/=	115/=	175/=

Outcomes

According to pond culture trial

- No significant difference in FCR, SGR, FER, % wt gain

  or survival in experimental fish.
- 30% protein is enough for tilapia grow out culture.
- No use of increasing the protein level of the feed and it leads to the loss in fish culture cycle.
- Best experimental feed should be- Feed A (lowest price),

  however should further improve for lower the FCR value.
- Further studies for finding a better FCR value.

According to indoor trial

- No significant difference in FCR, SGR, FER, % wt gain or survival in experimental fish..

- Though the feed cost was comparatively low, FCR value is too high and further studies are needed for decreasing the value.

Recommendations

- 30% protein is enough for tilapia grow out culture and no use of increasing the protein level
- Feed cost should be low as the price per kg fish is vary from 250 -300 LKR in some areas.

Outputs & outcomes

- Low cost feed for Tilapia culture.
- Enhancing of Tilapia farming in smale scale farmers
- Strenthning of fish feed industry in Sri Lanka

Progress: **Financial** 100% **Physical** 100%

Constraints

Seasonal heavy rain and flood in the district covered the research site area and could not reach to the site for few days.

Plant beds installed in the fish cages were destroyed due to flood.

Evaluation of formulated feeds developed for Asian Sea bassthrough community-based Sea bass farming in lagoon floating net cages

Project No : 3.1.2

Officers responsible : D.A. Athukorala, R. Weerasinghe

Introduction

Asian Seabass 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 such as Thailand, Malaysia, Indonesia, Singapore, Taiwan and Hong Kong. As sufficient brackish water resources, there is a good potential to develop Seabass culture also in Sri Lanka. At present some hatcheries have developed Seabass breeding technology and some farmers are engaged in Seabass farming in Sri Lanka. However, main obstacle for developing this aquaculture practice is lack of low-cost nutritious feeds in the market for Seabass fish. As no appropriate feeds locally available in the market for an affordable price, most of the farmers mainly use trash fish for Seabass culture. Due to the unavailability throughout the year and fail to give good growth rate, trash fish cannot be considered as an ideal feed for profitable Seabass farming. Therefore, development of low-cost, nutritionally balance feeds through experimental trials is very important for Seabass farming in Sri Lanka.However developed feed formulae at experimental farming level must test at commercial farming level before release to the industry. This project is aim to test the developed feeds for Seabass culture through community-based Sea bass farming in lagoon floating net cages at commercial level.

Objectives

1. To test the developed feeds for Seabass culture in lagoon net cages at commercial level
2. To compare different formulated feeds developed for Asian Seabass on growth performance and survival rates of Seabass
3. To assess the economic viability of developed feed for Seabass culture in lagoon floating net cages at commercial level
4. To promote community-based Seabass cage culture in lagoons

Activities carried out

1. Awareness meetings for selected farmers for the study
2. Net cage construction training for the selected farmers
3. Preparation of sea bass experimental feeds
4. Construction of experimental net cages with the participation of selected fish farmers
5. Installation of constructed net cages in the lagoon.
6. Acclimatization of sea bass fingerlings to the study location
7. Sea bass experimental feeding trials
8. Monitoring of water quality of study location
9. Periodic cleaning of experimental net cages
10. Collection of fish growth data
11. Data analysis

Results

According to the results of data analysis up to 06 months trial period, tested 03 feed formulas showed satisfactory results on growth performance, feed conversion ratio (FCR) and Survival Rates of fish. Feeding trials will be continued to complete the 09-month culture period as planned to get final results. The results of data analysis up to December 2018 on growth performance, survival, water quality of study location and proximate composition of tested feeds are shown in Table1 to Table 3 respectively.

Table 1. Feed Tested and Results

Feed Tested	F1	F2	F3
Survival (%)	85.4	82.8	79.1
Final weight (g)	225.2	197.2	183.6
FCR	2.8	3.1	3.5
Price (Rs./kg)	165.00	207.00	148.00

Table 2. Water quality data of study locations

Study Location	Salinity ppt	pH	DO	Water Temp. ^{0}C
Gangewadiya (Location 1)	24.6 ± 6.2	7.0 ± 0.3	6.2 ± 0.4	27.8 ± 0.8
Gangewadiya (Location 1)	28.4 ± 5.9	7.0 ± 0.3	5.9 ± 0.7	28.4 ± 0.5
Serakkuliya	32.2 ± 3.5	7.1 ± 0.2	5.3 ± 0.4	29.0 ± 0.7

Table 3. Proximate composition of tested feeds

	F1- (Peliyagoda fish meal-based)	F2 -(Mannar fish meal-based)	F3 -(Peliyagoda fish meal-based)
Moisture %	5.2	5.3	4.6
Protein %	40.8	41.1	42.1
Fat %	7.8	12.2	11.7
Ash %	20.0	20.0	21.0
Fiber %	2.2	2.9	2.4

Recommendations

Most economically viable feed is F3 42% protein at the cost of Rs.148.00/Kg .

In general both the F1& F3 formulas could be introduced for commercial level feed manufacturing for sea bass farming in Sri Lanka.

Outcomes

1. Economical feeds for Asian Seabass culture in floating net cages at commercial level.
2. Increased number of seabass farmers
3. Increased Seabass production

Progress: Physical 68% Financial:

Constraints

Unable to start feeding trials in 2018 May as planned due to the delays in purchasing sea bass fingerlings and feed ingridients on time.

Fish feed development and ornamental fish production program at Panapitiya Regional Research Center

Project No : 3.1.3

Officers responsible : G.S.C.Perera, M. Epasinghe

Introduction

Sri Lankan ornamental fish industry depends on the imported feeds and the lower quantity is produced locally. Therefore considerable amount of foreign money is wasted and some health problems such as fatty liver development of fish has occurred due to unspecific feeds like shrimp feeds because of the imported feeds.

As an effort to overcome the above issues, NARA initiated its ornamental fish feed production 03 years before and the production was used to its internal ponds at the initial stage. Being minimized the issues of the produced feeds using trial and error method, and also purchased a smaller extruder, feed selling program was began in 2017 and we could be able to sell about 1.5 tones and total production is over 2 tones. It is expected to empower the provincial level fish feed producers and to form private public partnerships in the year of 2018.

As research activities, we could be able to produce a nursery feed and two pellet feeds and hope to upgrade the quality of the feed.

Objectives

1. Commercial fish feed production as models for the farmers.
2. Production of rearing stages and brooders of ornamental fish.
3. Application of enzymes in fish feeds for enhancing feed efficiency and maximize the fish meal replacements towards more economical returns.
4. Improving the quality of the present feeds towards healthy fish.
5. Development of brooder feed.
6. Empowering the provincial level fish feed producers and to initiate private public partnerships (ppp) through experience and knowledge sharing.

Activities

- Purchasing of Chemicals.
- Purchasing of equipments.
- Procurement of fish feed ingredients
- Production of feed.
- Testing proximate analysis.
- Feeding trials
- Revising the feeds formulas observing the results and Feedbacks.
- Preparing formulas and educating the farmers.
- Selling the feed.
- Pond preparation
- Fish breeding
- Fish stocking
- Fish harvesting
- Selling the fish and keeping the suitable fish for backup.

Methodology

- Three feed types (nursery, grower(02mm) and grower(5mm) for the ornamental fish were produced at Panapitiya Regional Research Center and after being used for the internal ponds the excess production was sold to the farmers. Considering the feed backs the applicable formulas were further developed. The identified formulas were issued to the farmers those who interested in fish feed producing. Income was handed over to the head office.

- Koi Carp ,Tin Foil Barb(Golden), Angel and Gold Fish were reared using mud ponds and cement tank system and the selected brooders were issued to the farmers and the rest production were issued for the buyers and the income was handed over to the head office.
- Phytase included Commercial enzyme was used while replacing the fish meal by soya in order to determine the growth performance. Fish meal was replaced by 03 percentages (35%, 70% and 100%) by soya and in addition to the control, 06 treatments were used for the above percentages with the optimum inclusion level of the enzyme and with doubling the enzyme level. Using Koi Carp fry stage, SGR, PWG and PLG were analyzed as the growth performance indicators.

- Basic trial was conducted to determine the fatty liver development in Guppy fish fry. Fat deposition of the liver was checked introducing different feed types. Suspicious feed related factors for fatty liver development in fish such as shrimp feed (2 feeds), extruded feed, lipid level, growth promoters and commercial enzyme were tested in different feed types
- Brooder fish feed was developed based on the special nutritional requirements of the brooder stage and it was tested under practical conditions at Sunrise Aquaphonics Agri Business at Pannala.
- Identified small scale farmers who engage in fish feed productions were empowered to mitigate their problems and the identified formulas and the technical knowhow.

Results

- Fish feed production progress

Month	Grower Feed (Kg)	Nursery Feed (Kg)	Total Production (Kg)	Income (Rs)
January	51.50	247.00	298.50	48512.00
February	49.75	275.25	325.00	58612.00
March	59.25	345.00	404.25	79400.00
April	28.75	182.75	211.50	41612.50
May	50.00	197.50	247.50	48075.00
June	69.25	232.75	302.00	58875.00
July	98.50	200.75	299.25	57450.00

August	43.25	134.25	177.50	34625.00
September	----	18.20	18.20	3640.00
October	14.00	19.00	33.00	6250.00
November	50.75	26.00	76.75	13556.25
December	82.00	9.5	91.5	16806.25

Total feed sale - 2484.95 Kg (2.49 tones)

Total income - Rs 467414.50

Ornamental Fish production progress

Month	Rearing stages	Brooder fish	Total Production	Income (Rs)
January	220		220	2832.00
February	446	14	460	10750.00
March	395	54	449	30040.00
April	216	20	236	9054.00
May	84	279	363	4880.00
June	134		134	9320.00
July	08		08	500.00
August				
September	134			
October	196		134	8360.00
November			196	11220.00
December			1027	33934.00

- **Total ornamental fish production – 3227**
- **Rearing stages - 1833**
- **Brooders - 367**
- **Total income Rs: 120890.00**

- Best growth performance was recorded from the control and the best replaced treatment was 35% fish meal by soya and when the replaced fish meal percentage were increased growth performance were decreased. When the enzyme level was doubled, SGR, PWG and PLG were increased in 70 % and 100% fish meal replacements. But both treatments were not significantly different. Simultaneously, when the plant based protein amount was increased, the positive effect of the enzyme has been increased.

- Out of the 2 shrimp feeds, Guppy fed with one shrimp feed showed severe level fatty liver while the rest showed the moderate level. There was no relationship between extruded feed and fatty liver development because Guppy fed by both normal pressed and extruded feed showed the same results. When the growth promoter was included quite improvement of fatty liver was seen. When the feed fat level was increased from 7% to 10% no improvement in fatty liver was seen in fish. Moreover there was a negative impact on enzyme inclusion and fatty liver development. So it is impossible to find the correct relationship between fatty liver development and feed type given. But it is worth to further analyze the differences between two shrimp feed types. Furthermore, revising the research using different level of growth promoters is also beneficial.
- 10% breeding performance was recorded according to the hatchery at Sunrise Aquaphonics Agri Business at Pannala based on Molly and Platy. It is worth to test the same formula for the different fish species.
- Issues of the small scale fish feed producers have been resolved at their request.

Outputs

- Producing sustainable fish feed formulas in economical and health point of view.
- Motivation and empowering the local fish feed producers.
- Supplying the brooders and other ornamental fish stages for the farmers.
- Soya can be replced by 35 % with doubling the phytase enzyme without adverse effect to the growth of Koi

Outcome

Maximizing the local ornamental fish and feed production through empowering towards being minimized the imported feeds.

Progress: Physical: **1**00 % Financial :

Constrains

- Insufficient allocation of helpers.

- Dry weather in the first quarter and insufficient water supply led to low ornamental fish production.

Effects of brewers'yeast (Saccaromyces cerevisae) and Sargassum sp. on growth of sea cucumber (Holothuria scabra) juveniles

Project No : 3.1.4

Officer Responsible : R. Weerasinghe , P.A.D. Ajith Kumara, C.B. Medagedara

Introduction

Holothuria scabra is abundant and widely distributed in shallow soft-bottom habitats throughout the Indo-Pacific region. It has a high value on the Asian markets, where it is mainly sold as beche-de-mer. *H. scabra* is only tropical holothurians species that can currently be mass produced in hatcheries. People involves in this production mainly because of the demand. This demand of sea cucumber has been increased because of commercial exploitation. Due to over exploitation wild stocks are being declined. Lack of good quality formulated feeds for sea cucumber is identified as a major problem for sea cucumber seed production and farming.

Fishmeal is still the main or even the only protein source in fish feeds. Because of the most adequate amino acid profile is supplied by fish meal. Many of alternative protein sources to replace fish meal have been studied. But negative impacts have been occurred with the use of plant protein sources as alternative sources such as, amino acid unbalances, presence of anti-nutritional factors, low palatability, a high level of replacement of fish meal with plant feedstuffs is also generally not well accepted. The key ingredient which is used in this experiment is brewers' yeast and it is a single cell protein. Single cell proteins (SCP) include micro algae, bacteria and yeast, and are alternative non-conventional protein sources that are frequently used as feed ingredients for fish, due to the nutritional value of their nutrients such as proteins, B-vitamins, pigments and complex carbohydrates, such as glucans (Sanderson and Jolly, 1994; Tacon, 1994). Decaying sea grass is one of interested feeds of sea cucumber and more studies have been focused on that. In the study we used *sargassum* to combine with brewers' yeast for optimization of growth. We found the optimum level of brewers' yeast to growth of juvenile sea cucumber by the previous study.

Objectives

To find the effects of brewers' yeast (*Saccaromyces cerevisae*) and *Sargassum* sp. on growth of Sea cucumber (*Holothuria scabra*) juveniles

Materials and methods

Hatchery of Regional Research Center, Nara, Kalpitiya was selected for the feeding trial. Semi re-circulatory tank system was arranged with 12 round fibreglass tanks. Four diets (T_1: 0% of brewers' yeast and Sargassum powder (Basal diet; Control); T_2: 10% of brewers' yeast; T_3: 5%

of Sargassum powder + 10% of brewers’ yeast; T_4: 10% of brewers’ yeast + 10% **Sargassum** powder) were formulated. The feeds were crushed and passed through a 1mm sieve and stored for the feeding trial. Twelve round and conical fibreglass tanks were used and each feed randomly assigned to three replicates. Five sea cucumber juveniles averaging 1.42±0.12g were allocated in each tank. The second batch which used for the trial was transported from Gui lan (Pvt) Ltd, Jetty road, Ariyalai east Jaffna. Sea cucumber juveniles were procured firstly by a private sea cucumber hatchery at Silawathurei Mannar. But all were stressed and died due to healthiness of fish and long distance uncomfortable travelling.

Figure 1 -5: The first batch which procued from Mannar were discarded.

Figure 6-9: Second batch which transported from Jaffna was healthy and used for the feeding trial

Fig 10: *Sargassum* powder

Fig.11: Experimental diets

Sea cucumber juveniles were acclimated to the tank system and experimental feeds for a week. Feeding trial was conducted for 42 days. Water quality parameters (Salinity, DO and NH_4^+)were checked daily.

Water exchange was done thrice per week and re circulatory system was run 2 hrs in a day. Feeding was preceded once per day. Growth data was collected biweekly.

Results

Table 01: Growth performances of juvenile tiger sea cucumbers fed four different diets

	T_1	T_2	T_3	T_4
Initial weight	1.35	1.42	1.50	1.42
Final weight	0.73[a]	0.98[a]	1.05[a]	0.74[a]
Difference	-0.62	-0.44	-0.44	-0.68

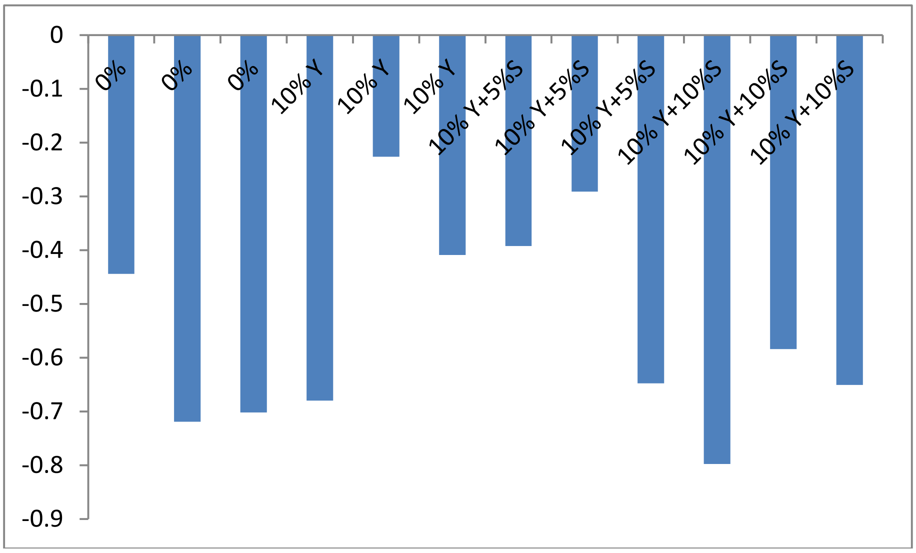


Figure 12: Growth changes of sea cucumber juveniles fed four different diets at the end

Probably, diet 2 and 3 showed better performances than others. But it is difficult to prove in this situation.

Progress: **Financial** 100 **Physical** 95%

Out puts

- Preparation of feed formulae
- Proximate composition analysis report of each formula

- Identify the replacement level of high value fish meals by brewers' yeast and *Sargassum sp*. to reduce the cost of formulated feeds
- Maximize utilization of by-products of distilleries industry
- Establishment of semi-recirculated system for the tank with bottom fine substrate

Outcome

Development of sea cucumber juvenile feed

Increase the returns of sea cucumber farming with formulated feeds

Conclusion /Recommendations

Better growth performance was shown when sea cucumber juveniles feed with 10% brewers' yeast (T2) and 5% *Sargassum* and 10% brewers' yeast (T3) diet. Semi-recirculation system was workable to conduct sea cucumber feeding trial when juvenile put under soil substrate. The observed water quality parameters were within acceptable level under controlled conditions. Further research need to investigate optimum level of replacement of brewers' yeast and *Sargassum* before commercialize of feed. Therefore, feeding trial need to be repeated.

Use of Chitosan and its nano particles as an immune-stimulant in tiger shrimp (Penaeus monodon) feeds to enhance growth and disease resistance

Project No : 3.1.5

Officer Responsible : R. Weerasinghe , Thiruchenduran, T. , P.A.D. Ajith Kumara

Introduction

Sri Lanka is a country involving in large scale intensive shrimp farming. Most of shrimp products are export oriented. WSSV cause severe damage to shrimps and prawns while leading to economic lost. White spot syndrome is a viral infection of Penaeid shrimp. The disease is highly lethal, contagious and killing shrimps quickly. Since this disease is caused by a virus, there is no anti-viral treatment for the disease.

Chitosan is an amino polysacharide prepared by processing shrimp waste (shell) which involve partial deacetylation of chitin and second most abundant natural polymer (Puvvada et al 2012). Both chitin and chitosan exerted immune-stimulatory effect on common carp (Gopalakannan and Arul, 2006). Immuno-stimulants can reduce the losses caused by disease in aquaculture; however, they may not be effective against all diseases.

Objectives

- To compare the effects of Chitosan and its nano particles on growth performances.
- To enhance immunity to resist diseases specially WSSV.

Materials and methods

Experimental site:

A hatchery which accomplished with clean, filtered and treated sea water as well as sound environment for the experiment was selected around Ambakandawila, Chilaw area.

Figure 1: Experimental design arrangement

Extraction of Chitosan

Shrimp shells were hired from Alpex® marine shrimp processing factory, Alakanda, Wattala. Cleaned shrimp shell was washed with running water to remove any remaining muscles and membranes and dried at 60° C for 2 days continuously. Fragile chitin shells were crushed into powder using a motor and pestle. The chitin powder was deproteinized and washed with distilled water until the pH of wash offs become neutral. Deproteinization and washing steps were continued until the wash offs become colorless. Demineralization of the deproteinized chitin was done and the boiling was stopped when there was no bubbles detected in excess HCl. Chitosan was washed thoroughly in distilled water and dried at 70° C for 5 hrs. The chitosan powder was boiled for 12 hours and washed with distilled water and dried. Chitosan nano particles were produced by few more chemical reactions and liquid nano particles were produced.

Experimental feeds:

Four diets (T_1: Basal diet; T_2: Include extracted Chitosan 1%; T_3: Include extracted Chitosan 2% and T_4: Include extracted Chitosan 1% and 0.5% Chitosan nano particles) were formulated.

Figure 02: Experimental diets before crumbling

Experimental design and feeding trial:

Re-circulatory tank system was used in the trial with 12 glass tanks. Each feed randomly assigned to three replicates. Sixty late stage post larvae (Juveniles around 0.01g) were allocated in each tank. Shrimp were acclimated to the tank system and experimental feeds for one week. Feeding trial was conducted for 60 days. Water quality parameters (Salinity, DO and NH_4^+)were checked once a month. Feeding was preceded thrice per day. Growth data were collected biweekly.

Results

Table 1. Growth performances of juvenile tiger shrimps fed four different diets (Mean ± SD)

	T_1	T_2	T_3	T_4
Initial weight	0.017	0.017	0.016	0.015
Final weight	0.128	0.097	0.085	0.106
Percent weight gain	659.16±425.30^a	458.80±149.26^a	419.32±133.19^a	618.52±244.78^a
Survival rate (%)	12	12	24	21

*mean values with same letters are not significantly difference at P<0.05 using lsd.

Progress: Physical 95 % Financial: 100 %

Out puts

- Enhance the immunity of tiger shrimp to resist viral diseases
- Utilization of shrimps processing industry by products in ecological sound manner
- Development of chitosan extraction methods and its nano particle incorporated methods in to feed

Outcome

Development of a healthy shrimp stocks in shrimp farming industry

Recommendations

Highest survival rate recorded in shrimps fed with chitosan 1 % (T3) while nano particles fed (T4) juveniles shown higher percent weight gain than T3 fed ones. However, highest percent weight gain shown post larvae fed with basal diet (T1). By the study in 2017, we identified that adding 2% chitosan into the diet increased the growth of tiger shrimp (*Penaeus monodon*). But during this study significance difference was not observed as low survival of the shrimp and it seems to be < 30%. Therefore it is recommended that feeding trial need to be repeated with optimum combinations of chitosan percentage.

Development of marine fish breeding technology – Culture of seahorse in lagoon cages & Alteration of life span of fire shrimps

Project No :3.2.1

Officer Responsible : M.A.J.C.Mallawaarachchi, W.Rajapakshe

Introduction

a) **Microalgae**

Microalgae play indeed a crucial nutritional role with regard to marine animals in the open sea, and consequently in aquaculture. Most marine invertebrates depend on microalgae for their whole life cycle and commercial and experimental mollusc or fish hatcheries have included a microalgae production system in parallel to their animal production itself. Microalgae are utilized as live feed for all growth stages of bivalve molluscs (e.g. oysters, scallops, clams and mussels), for larval/early juvenile stages of abalone, crustaceans and some fish species, and for zooplankton used in aquaculture because they serve as a natural resource for polyunsaturated fatty acids

Variety of microalgae species are used in hatcheries in Sri Lanka. In addition to food source microalgae are important bio-fuel production. It is vital to analyze algal nutritional properties and growth performances indoor and mass culture practices within Sri Lankan environmental conditions.

This project aims to develop technologies for marine ornamental aquaculture using developed technologies in micro algae culture.

b) **Marine ornamentals**

The interest in the trade of tropical fish has increased significantly, by creating direct negative effect on coral reefs and marine ecosystems. People use unmanaged and destructive methods to collect marine ornamentals from coral reefs.To ensure a sustainable marine ornamental industry it is obvious and vital to develop captive breeding techniques for marine ornamental species, in particular, coral reef fish. The marine ornamental aquaculture sector is still receiving limited research attention and very slow development compared to the technical and industrial advances made in food fish and fresh water ornamental fish aquaculture.

c) Polycheate culture

Polycheates play major role in marine ecology as a food source for benthic feeding animals. They contain nutritionally balanced source of polyunsaturated fatty acids which are important for egg maturation of cultured shrimps. Polycheate show increasing demand in aquaculture sector. It is vital to develop pathogen free polycheate stocks as feed for aquaculture species.

Development of polycheate culture procedures were highlighted by shrimp hatchery owners in NARA stake holder meeting held in 2016.

Objectives

a) To study culture environmental requirements of commercially important algae species (*Chaetoceros sp., Nannochloropsis sp., Isoschrysis galabana, Spirulina sp.).*
b) To establish laboratory and outdoor culture procedure for Spirulina sp.
c) To study growth and reproductive performance of seahorse in cage culture
d) To study culture practices of cleaner shrimp fry
e) To investigate the different substrate on the culture and growth of polycheate

Methodology, Results and conclusions

a. Micro algae

Experiment 1: <u>Laboratory culture of micro algae</u>

Methodology

Micro algae (*Nannochloropsis* sp.) were culture in three different media for 10 days. Initial, 4 days, 6 days and final cell counts were taken. (Done by Janaka Pushpakumara). The initial absorption (oceanography division) and final absorption (ESD division) were taken for chlorophyll analysis.

A. F2 media
B. Walne media
C. Chu- 10 media

Results

Walne media showed significantly higher growth than other two media within 10 days culture period.

Experiment 2

Methodology

Nannochloropsis outdoor culture study with two different pro-biotic concentrations.

- $5g/m^3$
- $10g/m^3$

- Control – without pro-biotic

Laboratory cultured algae transferred to 200-liter tanks prepared outdoor. Initial cell counts and chlorophyll content were taken.

Figure 1: (a) Scaling up of outdoor *Nannochloropsis* culture. (b) Initiated culture experiment

Results

Due to unfavorable weather condition this first outdoor culture was collapsed and the experiment is continuing.

b. Marine ornamentals

i. Cleaner shrimp

Methodology

To initiate cleaner shrimp culture, it was needed to culture Rotifer as fry feed. Rotifers were collected two times from a private hatchery and cultures were collapsed. Next, Rotifer were collected from the natural habitat and grown in hatchery conditions.

ii. Seahorse

Methodology

Seahorse cages were constructed at Munnakkaraya, Negombo. Seahorse Brooders (59) were collected from Kalpitiya area was transported to Negombo. All together 60 brooders were placed in 6 cages.

Brooder performance in different cage environment were tested

- Brooders with mussel and fed with glass shrimps (treatment 1)
- Brooders fed with glass shrimps only (treatment 2/ control)

salinity was measured in lagoon within the culture period. Ammonia and nitrite were measured in weekly intervals. Total four months culture period two months brooders were in cages. The other two months brooders were in the hatchery due to low salinity created in the lagoon.

Figure 2: Sampling of seahorses rearing in lagoon cages

Results

Two months culture period in lagoon total 5 gravid males were collected from treatment 1 and one gravid male collected from control cages.

Conclusion

Even though it is not significant environmental manipulation could increase brooders performances.

b) Polycheate (*Nereis* sp.) culture

Methodology

Field survey was conducted to collect data on polycheate (*Nereis* sp.) collectors and collecting places in Negombo area. Next polycheate (*Nereis* sp.) were collected from Negombo lagoon were transported to NARA premises. Then polycheate(*Nereis* sp.) were cultured in different substrates and data were collected.

1. Only lagoon soil (control)
2. Lagoon soil + sand (treatment 2)
3. Lagoon soil + cow dung + chicken manure (treatment 3)
4. Lagoon soil + kitchen waste (treatment 4)

a

b

Figure 3: (a) Harvesting polychete cultured in controlled condition. (b) Polycheates harvested from a experimental tank.

Results

After 4 months culture period the treatment 4 shown significant growth than other substrates. New polycheate (*Nereis* sp.) juveniles were in all the substrate.

Cultured polycheate (*Nereis* sp.) samples will be subjected to white spot disease.

Conclusion

Polycheates could be cultured successfully in lagoon soil and kitchen waste mixed substrate.

Recommendations

1. Walne media could be used to obtain higher growth in *Nannochloropsis* laboratory culture. In future experiments it is need to analyzed nutritional properties of *Nannochloropsis* grow in Walne media.
2. With the environmental manipulation it could be increased seahorse brooder performances.
3. Polycheates (*Nereis* sp.) could be cultured successfully in lagoon soil and kitchen waste mixed substrate. It is need to analyzed growth performances of polycheates (*Nereis* sp.) in large scale culture areas.

Outputs & outcomes

1. Development of indoor and outdoor culture facilities for algae.
2. Identification of suitable media for *Nannochloropsis* laboratory culture.
3. Development of protocol to culture polycheates (*Nereis* sp.) in controlled environmental conditions.
4.

Progress: **Financial** **Physical** 90%

Constraints

1. For the outdoor algae culture it was requested construct outdoor culture unit in 2017 project period. But it was not constructed due to unavailability of funds.
2. It is difficult to predict experimental output within current Ngombo lagoon condition. Day by day the community establishing dry fish factories surrounding lagoon area and releasing effluents directly to the lagoon.\
3. Lack of training experience in live feed (zooplankton) culture for the NARA scientific staff

Development of better bredding technology and introduction of Pethia melanomaculata for export market.

Project No : 3.2.2

Responsible Officer : R. R. A. Ramani Shirantha

Introduction

Of 52 endemic fish species nearly 24 spp. are colourful attractive spp. but only about 15 spp. are popular as tropical ornamental fishes. Several attractive endemic fish species are underutilized and they have potential to become candidate in tropical ornamental fish industry. But this is hindered mainly due to lack of proper knowledge on their breeding/culture technologies, biology and ecology. Therefore, there is need to develop such technologies while explore their biology and ecology for sustainable utilization.

Wild population of some endemic fishes continue to decline, in particular more attractive spp. and almost all are threatened (Redlist, 2012). *Systomus asoka* is such critical endangered fish species. In 2017, NARA could bring it to a spawning stage under captive condition through environment manipulation but all suddenly died due to unexpected disease condition coupled with rapid changes in weather conditions. The study on wild stocks carried out in 2017 revealed that this fish species is now at high risk of extinction and needs adopt conservation measures. NARA needs to collect and maintains collection of endemic fishes for education and awareness purposes and also need to study wild population of endangered fish species to gather updated information in order to make suitable recommendation for the relevant authorities wherever necessary. Considering all above facts the present study was conducted with following objectives.

Objectives

- To develop better technologies for culture, breeding and rearing of Tic Tac barb (*Pethia melanomaculata*).
- To introduce new endemic ornamental fish species to the ornamental industry.
- To conserve rare threatened fish species e.g. *Systomous asoka.*
- Collection and maintenance of endemic fish for education purpose.

Methodology

In March 2018, *Pethia melanomaculata* brooders (2.5-3.7cm total length) were collected from the Manampitiya flood pains in Polonnaruwa, and transported to NARA. They were reared at one-side-glassed cements tanks of 2.5’×1.5’×2.0’. Once fish matured sexing was done and transferred into two separate tanks and fed with chopped ox-heart twice a day. Multi-vitamin mixed with feed was provided as a supplementary feed. The fish rearing tanks were continuously aerated.

In September 2018, the environment manipulation *viz.* introduction to low water leveled tank was applied as breeding technology (water stress) under 1:2 male to female sex ration. The submerged aquatic plant *Hydrilla verticellata* spread over 1/3 of the tank was used as breeding substrate. After 48 hour period all fishes were taken out, and the breeding tanks of newly dropped eggs were aerated thoroughly. During the experimental period (over 4 months) some water quality parameters i.e. dissolved oxygen (mg/l), nitrite level (mg/l), ammonia level (mg/l), phosphate level (mg/l), alkalinity ($Cacao_3$ mg/l), pH and water temperature (°C) were measured weekly following the standard methods. The records on number of eggs laid, number of larvae hatched out and number of death were recorded. The fecundity and survival rate were then calculated. During the four months period three breeding trails were completed.

Experiment of effect of three different feed types

In October 2018, another experiment was started to study effect of three different types of feeds *viz*. *Monia*, bread worm and commercially available fish feed on the growth performance of *Pethia melanomaculata* under captive condition. The objective was to identify most suitable feed for larval rearing. Initially total body weight and total length were measured and 10 individuals were introduced into each treatment tank (2’×1.5’×1’size). All fish are given vitamin as a supplementary feed. At every two week intervals the measurements on total length and body weight of each fish and some water quality parameter are recorded. This experiment is still going on.

Study on the rare threatened fish species *Systomous asoka.*

Three field visits were made to study wild populations of *S. asoka*. Based on past two years experience and information, species recovery plan was designed and full report preparation is in progress to submit Department of Wildlife Conservation.

Results

P. melanomaculata was bred successfully in captivity condition following environment manipulation procedure under slightly alkaline condition (pH is 7.56). It was found as an easy breeding fish species ideal for ornamental fish trade as it has short breeding cycle ≤ 3 months i.e. a breeding cycle from brooder sexing to larval rearing up to 2 cm total length with 89% larval survival. The experiment also confirmed its high turnover rate. However, it has very low fecundity average for 43, which is relatively lower compare to those of other *Pethia* species in Sri Lanka. The egg hatching period was found as 1 to 3 days.

Plate1 adult male and females of

Pethia melanomaculata

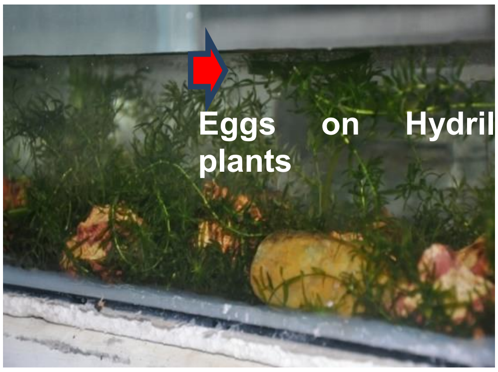


Plate 2 A breeding tank

.

It can be reared and bred under very simple aquarium condition (see table 1, Figure 1 and plate 2), and can easily be fed with natural feed as well as simple furmulated feed. Therefore, production cost would be very low compare to other endemic fishes of Sri lanka. As such it is a good candidate for tropical ornamental fish industry but presently unutilized fish species. However, further studies are needed to develop body colur and to increase fucundity if this species is going to promote as a tropical ornamntantal fish species.

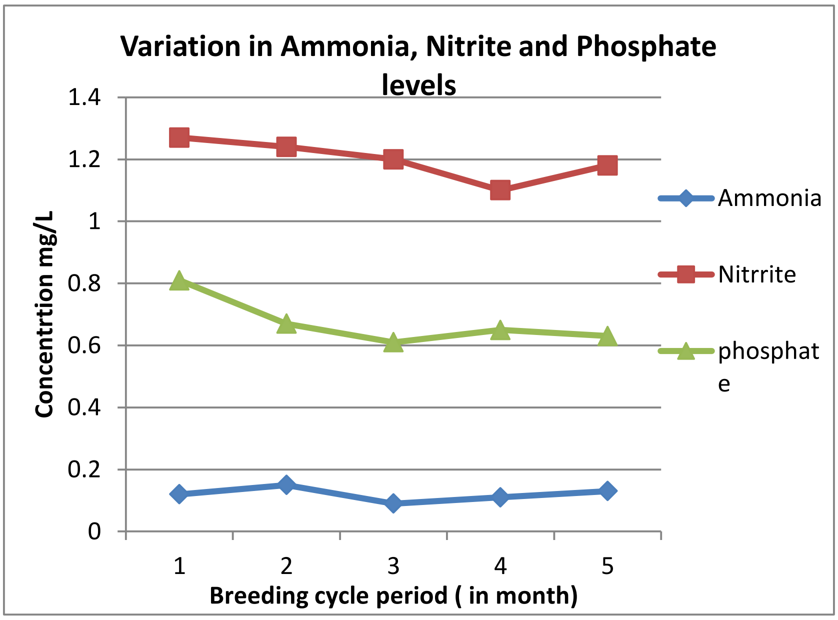


Figure 1: variation in main nutrient contents (mg/l) in water at breeding tanks (average for three breeding cycles).

Table 1 Average values for some physio-chemical parameters of the water at *Pethia melanomaculata* breeding tanks.

Parameter	Time in weeks					**Average for a breeding cycle**
	1	**2**	**3**	**4**	**5**	
DO (mg/l)	5.68	5.96	5.78	6.9	5.58	5.98
pH	7.71	7.7	7.8	6.9	7.72	7.56
Alkalinity ($Caco_3$./L)	76	75	65	72	79	73.4
Hardness	35	35	38	36	39	36.6
Water Tem. (^{0}C)	26	26	26.4	27.5	28.9	26.96

Conclusions

P.menalomaculata to can easily be bred under captive condition following environment manipulation method while dropping water level at their breeding tank. But low fecundity compare to other endemic *Pethia* fish species and poor colour development in F1 offspring were identified as the issues.

Recommendations

Tic-tac barb can be a candidate in tropical ornamental fish industry. Further research need to increase the fecundity and intensify the body colour.

Outputs & outcomes

- Easy breeding technology for *Pethia melanomaculata.*
- Baseline data and a species recovery plan on critically endangered fish species *Systoums asoka*.

Progress: Financial ....% Physical : 93%

Constraints:

Lack of enough labour.

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

Project No : 3.2.3

Officer Responsible : E.D.M. Epasinghe

Introduction

Ornamental fish industry in Sri Lanka has a long history and was started in 1952 as a commercial industry. The industry was commercialized by a few entrepreneurs about 50 years ago and has now developed into a thriving industry with an export market, affording profit and employment to many People (kuruppu, 1998). Sri Lanka exports marine, freshwater, brackish water fish species and marine invertebrates. Freshwater aquarium fish comprise the more colourful and more striking species of guppies, swordtails, platys, barbs, tetras, angels, gouramis, catfishes etc. Out of these freshwater species being exported from Sri Lanka about 60-70% consists of famous fancy guppies of which the high recognition is there in the international market due to the strength and high diversity of the

particular fish species when compared to the other countries (MFARD, 2015). This potential has encouraged and boosted the sector due to increasing world demand. Ornamental fish industry being a low cost operation and high profitability for farmers provided an appropriate form of income and improvement in the living conditions. This is emphasized that in year 2015, total ornamental fish income of Sri Lanka was Rs 1.9 billion (MFARD, 2015).

However, the development of activities related to aquaculture is conducted in an indiscriminate way may cause damage to the natural environment, causing eutrophication in water bodies, introduction of exotic species and dissemination of new diseases in the environment. In this way, it becomes of utmost importance the development of techniques to reduce the environmental impacts caused by effluent rich in nutrients produced by current systems of production and discarded in nature, so that there is a reduction of biodiversity, depletion or compromise of any natural resource or significant changes in the structure and functioning of ecosystems (Valenti, 2002). Furthermore, the main challenges for further expansion are related to environmental issues and the impacts of aquaculture on biodiversity and ecosystem services (OECD-FAO, 2015). The prime goal of aquaculture extension must be to produce more aquaculture products without significantly increasing the usage of the basic natural resources of water and land (Avnimelech, 2009). The second goal is to develop sustainable aquaculture systems that will not damage the environment (Naylor et al., 2000). The third goal is to build up systems providing an equitable cost-benefit ratio to support economic and social sustainability (Avnimelech, 2009). All these three prerequisites for sustainable aquaculture development can be met by biofloc technology. Biofloc technology is a technique of enhancing water quality in aquaculture through balancing carbon and nitrogen in the system. This technology has recently gained attention as a sustainable method to control water quality, with the added value of producing proteinaceous feed *in situ*(Crab et al., 2012).

Objective

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

Methodology

A lot of 1000 sorted out juveniles *Poecilia reticalata* (guppy) were obtained from guppy farmer. After acclimation period, guppies were divided in to the 24 fibreglass tanks of 120 L capacity (45 juveniles each one), with air diffuser in the middle line of the tank to assure continuous water movement and suspended particles. Everyday juveniles will be fed 3 % of their body weight (BW) with commercial diet (Prime ornamental fish feed or NARA ornamental fish feed) with 40 % CP and particle size 1.5 mm – 2.0 mm. Every 15 days, food quantity will be adjusted according to their BW for 90 days culture cycle.

To assure the biofloc development in the culture system, a C/N ratio of 20:1 (Avnimelech, 2012) will be maintained using three carbon sources: molasses (MOL), wheat flour (WF). Rice polish powder (RB) and equal mix of rice bran and molasses (MIX). A control diet will be considered without carbon source. Four replicates will be maintained for each treatment. To adjust C/N ratio, requirements calculations will be made according to Emerenciano *et al.* (2011).

Five random samples of guppies will be sacrificed in order to separate their liver and fixed samples in 10 % formal saline will be submitted to faculty of veterinary medicine and animal sciences of University of Peradeniya to prepare histological slides.

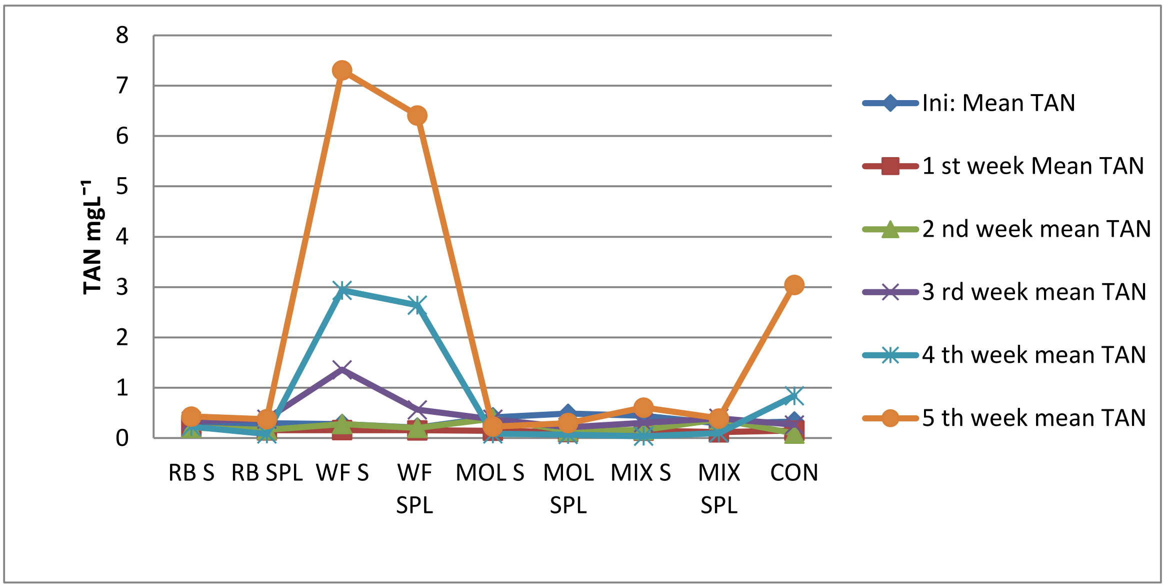
Water quality parameters and biometric parameters will be measured weekly and every fortnight respectively.

Results

Water quality dynamics

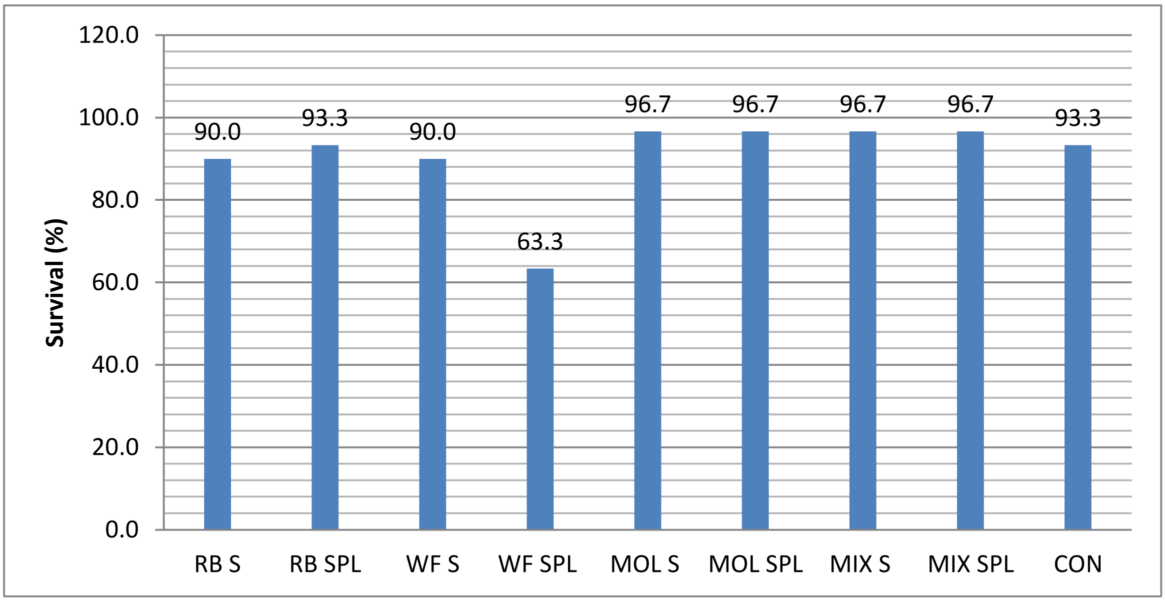
The temperatures (chart I), pH and Dissolved oxygen concentrations among the treatments were ranged between 25.2 -26.2˚C, 6.9-7.4 and 9.93-8.6 mg L^{-1} respectively. The total ammonia nitrogen (TAN) levels maintained less than 1.0 mg L^{-1} throughout the period except for WF- S for 3rd, 4th and 5th weeks and Control for 5th week. There was no necessity to change and/or siphon out water throughout the culture cycle (60 days) except top up the evaporated amount of water.

Chart I



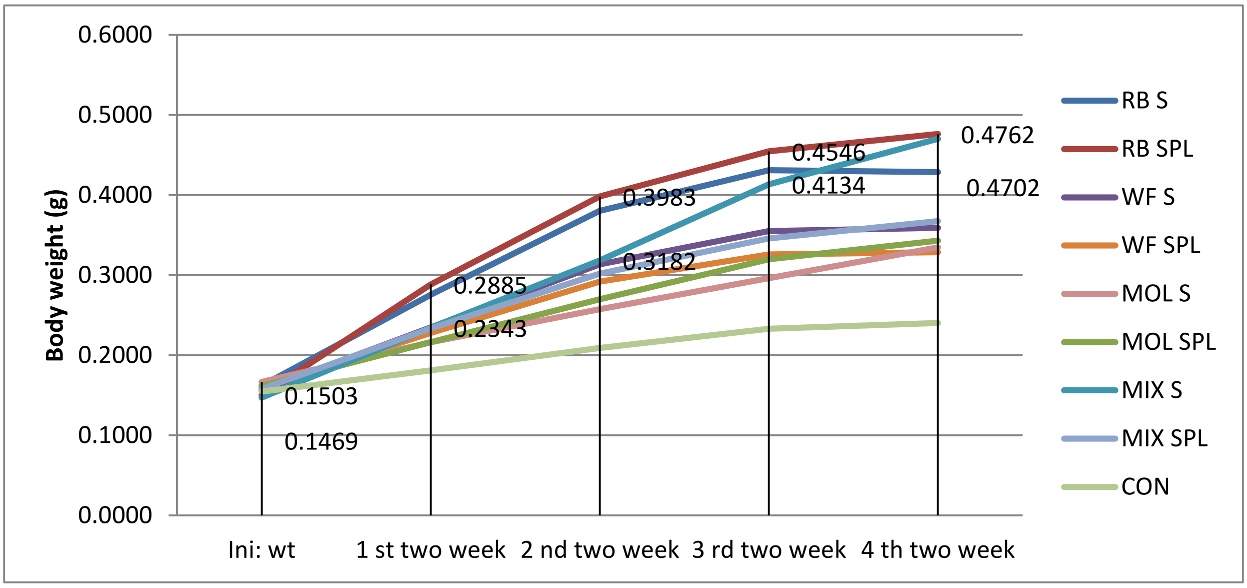
Weekly mean of TAN (mg L $^{-1}$)

Survival and growth parameters



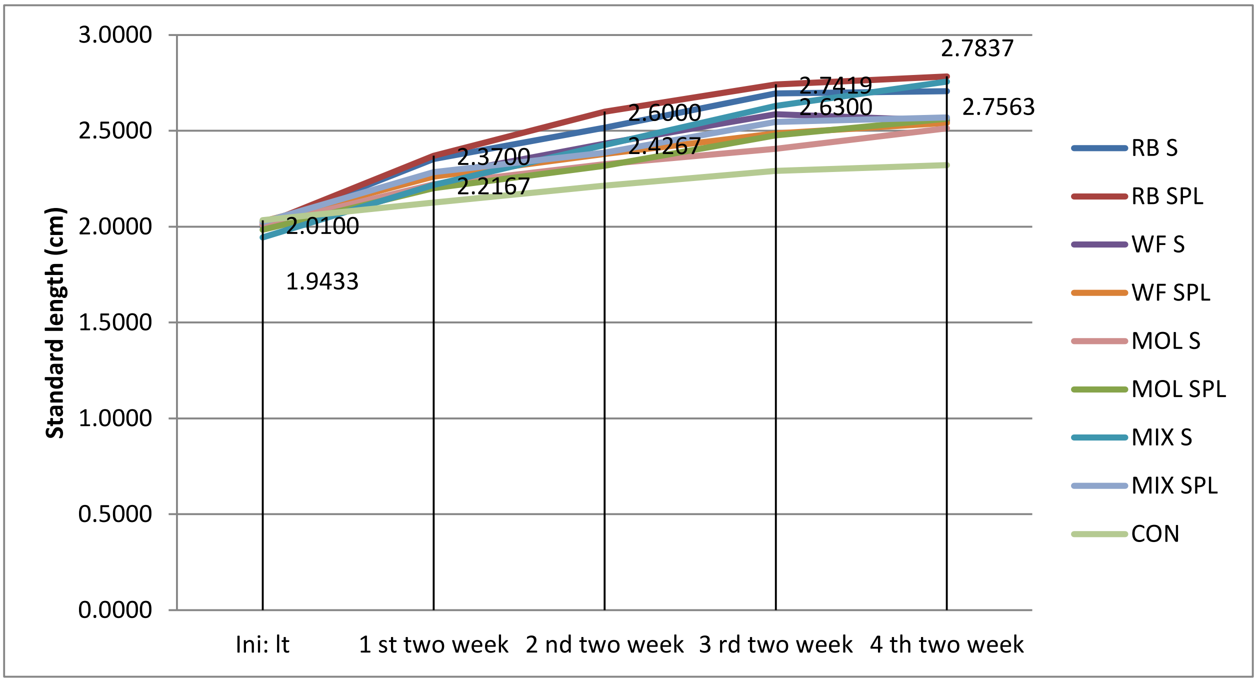
Survival rate (%)

Rate of survival was over 90 % and lowest 63.3 % for the WF.



Body weight (BW) (g)

After sixty days of the experiment highest BW observed for RB and MIX treatments and it was 0.4762 g and 0.4702 g respectively.



Standard length (cm)

This is same as BW, highest standard length of the fish observed for RB and MIX treatments and it was 2.7 cm.

Liver histopathology

Liver histopathology showed fat depositions in all treatments except control.

Conclusions

Based on the results of this project, locally available carbon sources can be used to control TAN in the BFT system successively.

Highest body weight and length can be achieved by using RB as a single source and RB-MOL as a mix treatment.

Recommendations

BFT can successively be adopted to grow guppies without changing water for 60 days. Rice bran 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.

Output

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

Outcome

Sustainability of ornamental aquaculture industry in Sri Lanka has enhanced with novel aquaculture technology (BFT) using in world aquaculture field.

Progress : Financial 100% Physical 100%

Constraints

Some of the ordered equipment that is planned use for quaitifying floc was not received so far.

Development of breeding techniques for selected fresh water ornamental fish using existing facilities at RRC Rekawa.

Project No : 3:2:4

Officers Responsible: J.S.Jayanatha, W.K. Suwandahannadhi

Introduction

Fresh water ornamental fish species are economical very important to increased livelihood opportunity in rural community. It has influenced increased economic beneficiary in rural area. In southern region several ornamental fish species are used for regular culturing activities. However, there is no sufficient seed supply chain for southern region to consistent supply of the industry requirements. Moreover, existing facilities at RRC Rekawa can be used for development of selected fish breeding techniques in this area. Such as, induced breeding for koi carp in cement pond reared brooders, and study also breeding performance in different rearing conditions.

Objectives

Optimization of induced breeding for different condition reared koi carp fish. Development of strategies to used existing facilities at Rekawa RRC to consistent supply of seed for community.

Methodology

Brooders conditioning-the broodes were reared under the 15*10 feet cement tamks were used brooders were kept untill reached thier breeding condition with supply prima articifcal feed with meat trice a week.

10 female: 20 male breeding was conducted using 1:2 female and male ratio were used to induced breeding. ovalin for female 0.25ml/kg and female induced with 0.5ml/kg eggs were collected with net materilas in a cemnet tanks (8*4). larval feed-after hatching egg yolk biled used to feed them until 2 days trice a day. 15 days feed-newly hatch artimea-15 days prima fish feed powder, water quality parameters also montirred. Induced breeding-selected brooders were used to induce by the Ovalin, different season to check the production in different time and environmental factors.

Larval rearing-stocking density were checked with the different density 864L cement tanks with following densities 1000,1500,2000 larvae. Growth parameters and water quality parameters were recorded.

Date	Male	Female
26/03/2018	350g	490g
	350g	350g
	350g	400g
14/05/2018	220g	510g
	370g	450g
	380g	465g
	425g	410g
	395g	270g
	345g	
26/06/2018	735g	540g

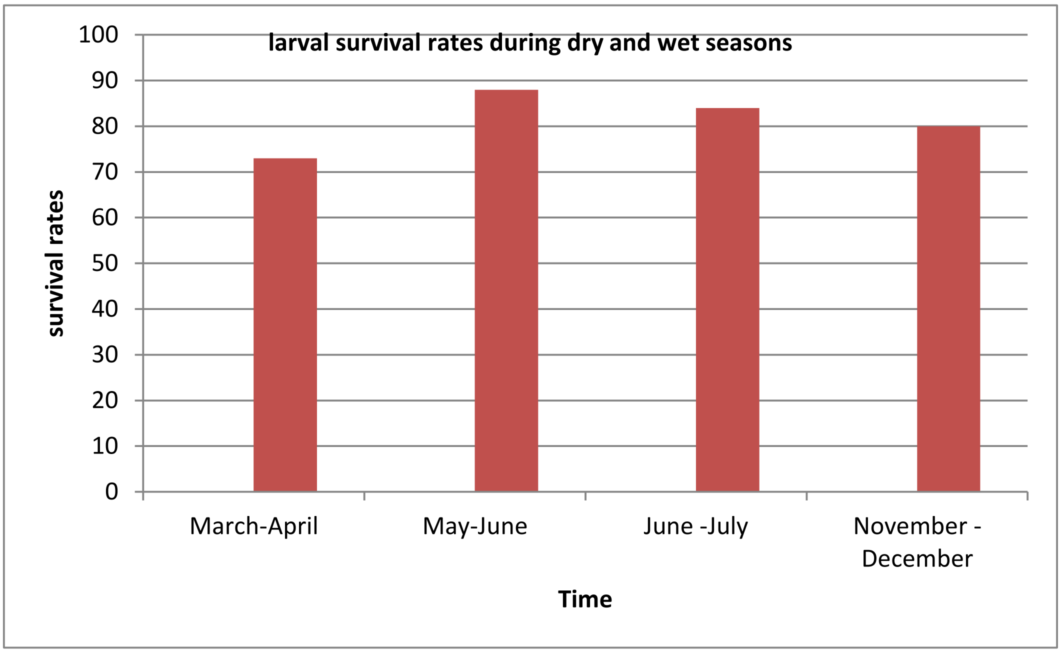
	425g	360g
	515g	
	500g	
	450g	
26/11/2018	1010 g	290 g
	375 g	555 g
	375 g	650 g
	450 g	

Selected weight male/female

Results

The high production s coming from the different seasons, however, more suitable season lay during the dry period. Rearing density up to one month juvenile can be used as 1170 fry per square meter.

induce breeding	larval received	Egg yolk	Artimea	Initial fry	fry after a month	survival rates
26/03/2018	29/03/2018	05days	14dasy	21000	15300	0.73
14/05/2018	16/05/2018	5days	14days	16000	14000	0.88
26/06/2018	29/06/2018	05days	14dasy	16000	13425	0.84
26/11/2018		05days	14 days	23000	18500	0.80



Conclusions

production of fry is depending on healthy brooders, time of breeding and performance of the brooders**.**

Recommendations

suitable breeding season is recomneded during the dry period thatn the rainy seasions in this area.

Outputs & outcomes

Increased the production as a major counterpart in Rekawa station (koi carp), by increasing the fry availability and achieved target production. Farmers demand increased by making availability health fry. Income generation also increased among community those who are engaged in an ornamental industry. For future expansion of the industry will depend on availability of healthy brooders, therefore, stock has increased y growing healthy fish.

Progress: **Financial** 100% **Physical** 95%

Constraints:

Extreme whether condition may have effected on brooders condition in cement ponds.




Efficiency of hormones on spawning characteristics of selected exotic fish species in family Cyprinidae and maintenance of existing ornamental fish breeding facility.

Activity 1 : Maintenance of existing ornamental fish breeding facility.
Activity 2 : Efficiency of hormones on spawning characteristics of selected exotic fish species.

Project No : 3.2.5

Officer/s Responsible : Amitha Adikari, E.D.M. Epasinghe

Introduction

Many fish populations worldwide have experienced a drastic decline over the years largely due to the effects of the industrialization, pollution and habitat loss. Though there are many strategies been adopted to stabilize the population decline and sustainable availability of fish for food and recreational activities, still more to be done. One of the useful ways to replace the declining natural stocks and also for the commercial culture practices is through captive breeding in hatchery programs. Therefore environmental and hormonal manipulation of fish ovulation is important in fish culture for assuring frequent brood stock management, controlling gametogenesis in captive brood stock to yield fry when ever needed. The use of exogenous hormones is an effective way to induce spawning and producing fertilized ova and finally hatchlings. Presently more commercialized potent fish inducing agents such as Human Chorionic Gonadotropin (HCG), Salmon Gonadotropin Releasing Hormone (sGnRH) and

Luteinizing   Hormone Releasing Hormone analogues (LHRHa) has been successfully used to induce maturation and synchronize ovulation of many commercially important fish. Each fish species respond differently for different type of inducing agents. The successful fertilization of viable eggs solely depends on the determination latency period of each species for desired hormone dose of inducing agent. This will determine the success of commercialized fish induced breeding practices .Latency period and Ova viability after ovulation are most vital information in hatchery operations of commercially important fish species. For many commercially important aquaculture fish species, induce breeding methods been adopted to ensure continuous supply of seeds for the production units. Especially exotic ornamental fish species and food fish species are been produced in captivity use induced spawning methods to reduce the pressure on wild caught fish to a considerable level. In 2016 &2017 research work were conducted on induced breeding of *Puntius denisonii* and *Balantiocheilos melanopterus* found different latency responses for same dose, hence further studies required to find correct latency period for hormonal doses.

Objectives

- To find out the spawning latency period in the hormonal induced reproduction in selected exotic fish species
- To find out the effect of different hormones and it combination on egg quality

Methodology

Activity 1:

Brood-stock management-

Existing brood-stock of different exotic species (*Cyprinus carpia, Carassius auratus, Poecillia reticulate, Danio rerio, Puntius spp, Betta spp, Astronotus ocellatus, Osphronemidae* ect.) were reared in outdoor tanks and continuous aeration was provided by using an aquarium air blower. New varieties which have high market demand of barb spp., tetra spp., Betta spp, Gold fish spp. and Koi carp spp were purchased from outside aquarium and reared under the same condition. Fish were fed with both artificial (42% protein containing floating feed) ox-heart mixed with vitamin E and live feed (*Artemia naupli* and moina) three times per day *ad libitum*.

Breeding-

Maturity of fish were identified by visual examination and separated according to the maturity. Natural breeding was carried out all other species except *Cyprinus carpia*. *Cyprinus carpia* breeding was done by hormonal induced breeding method using Ovaprim.

Rearing of larval and juvenile stages-

In most of the varieties post larvae (PL) were reared in breeding tank according to the survival percentage. Newly born free swimming larvae were fed using *Artemia nauplii* with *adlibitum.* Four week old larvae were stored in separated growing tank and fed with (*Artemia naupli* and moina) and artificial (42% protein containing floating feed) three times per day *ad libitum*. Up to the marketable stage fish were reared in outdoor tanks suitable fish as a brooder were separated and grower in separate tank.

Sales-

Sales were done according to the request. Most of the time *Cyprinus carpia* were sold at PL stage for pond fish farmers in bulk amount and also stocked in ponds at Pannapitiya RRC.

Activity 2-

Brood-stock management

High value and highly demanded exotic ornamental fish species in family Cyprinidae such as *Balantiocheilos melanopterus*, *Barbonymus schwanenfeldii*, *Epalzeorhynchos frenatum* and *Puntius denisonii*used to study efficiency of hormones on spawning characteristics. Brood-stock of above species except *Balantiocheilos melanopterus* and *Puntius denisonii*were reared in outdoor tanks and continuous aeration was provided by using an aquarium air blower. *Balantiocheilos melanopterus* and *Puntius denisonii*were reared in indoor condition due to it high susceptibility to *Ichthyophthirius* disease condition. Temperature of indoor brood-stock tank was maintained 27-28^{0}C using aquarium heaters. Fish were fed with both artificial formulated (42% protein containing floating feed), ox-heart mixed with vitamin E and live feed (*Artemia naupli* and moina) three times per day *ad libitum*.

Management of water quality

Water quality parameters such as Temperature, Dissolved oxygen, pH, Hardness, Ammonia concentration and alkalinity were measured. In Brooders tank water quality parameters such as pH, DO, Temperature, Hardness were measured Weekly In Spawning tank pH, DO, Temperature , Hardness were measured three times per day. In Egg incubation jar pH, DO, Temperature, Hardness was measured three times per day.

Selection of brooders

As there is no distinct sexual dimoephism in these species; the only dimorphic character observed was that female has a slightly wider body than the male when sexually mature. Therefore, suitable males were selected as brood fish by checking the release of milt, when the belly was pressed or squeezed slightly. Selection of females was by observing the round, bulged belly and reddish papilla and the softness of abdomen. The same female brood-fish were subjected to the ovarian biopsy during the breeding experiment. Ovarian biopsies were carried out to determine the maturity of the ripe eggs by observing the position of the migratory nucleus of the eggs under the microscope. A fine polyethylene tube of 0.8mm inner diameter and 1.0mm outer diameter was used to get the egg samples. Serra's solution (60%Alchol:30Formalin:10 Gleceric acid) was used to clean the eggs and examined under the photomicroscope (3012 model).Since the brood fishes are very sensitive and handling stress can be lead to their mortality, the fish were anaesthetised before handling using Tricaine methane sulfonate (MS 222 tricaine, TMS) at 50-100 ppm concentration. Anesthetic bath was prepared by dissolving 150 mg /l of Tricaine methane sulfonate (MS 222 tricaine, TMS) in 3ml of water .Before the ovarian biopsy and administration of hormones, sedation was carried out.

Acclimatization of brooders

Selected male and female fishes were stocked separately in 300 cm X 300 cm X 300 cm cement tanks four weeks before the experiment at a stocking density of two individuals per m^2. Fishes were fed with *artemia* nauplii, *micro worm*, moina and vitamin E enriched minced ox-heart three times per day *ad libitum*. Each tank was provided with conditioned water and a constant aerator.

Breeding

Hormonal induced breeding method was used to breed the *Barbonymus schwanenfeldii and Cyprinus carpia*. Different gonadotrophin hormones such as SGnRHa, LHRHa and HCG were tested according to the following concentrations. IM method was used and three replicates from each treatment were carried out. Five different concentrations (0.2, 0.3, 0.4, 0.5 and 0.6 ml/kg).of SGnRHa were tested.

Determination of latency period

Time interval between injection of the female fish and stripping of eggs were measured with respect to the Species, hormone, doses and the maturity of fish.

Determination of egg quality

Egg size, Egg buoyancy, Weight increases during the water hardening process, Fertility rate, hatching rate and egg development stages were taken to determine the egg quality.

Results

Activity 1-

In 2018 total post larvae and juvenile, adult production as follows

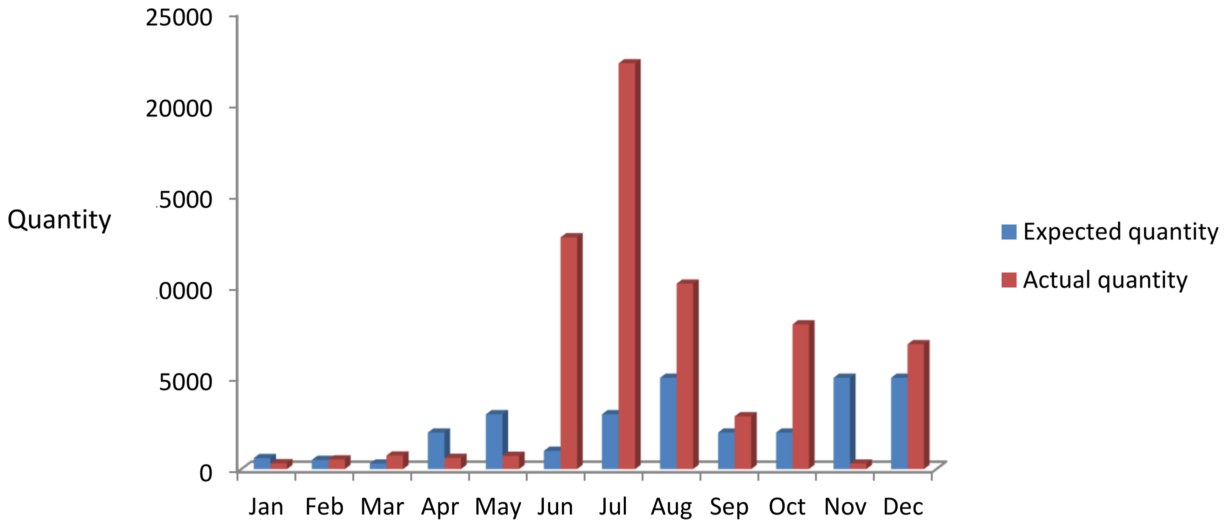


Fig1: Total production of exotic ornamental fish unit- 2018

Total sale of exotic ornamental fish species in 2018 was recorded as 65,925. Current available stock of post larvae in exotic ornamental fish unit of IARAD around 35,000 mainly Koi carp and other species. Therefore, total production of the unit in year 2018 was 100,925.

Activity 2-

During the study period in indoor broodstock tanks of *Balantiocheilos melanopterus* and *Puntius denisonii* water pH were suddenly decreased. In *Puntius denisonii* indoor brood stock tanks pH was decreased up to 3.4 at 26.9 ^{0}C but any mortality were not recorded. And also in *Balantiocheilos melanopterus* indoor tanks pH decreased up to 3.6 at 28.59 ^{0}C.

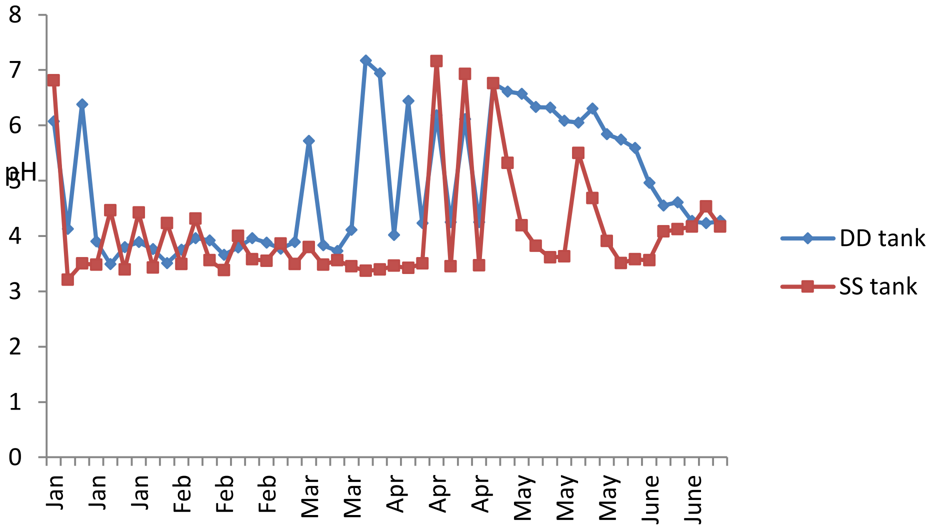


Fig 2: pH variation in *Balantiocheilos melanopterus*and*Puntius denisonii* indoor broodstock rearing tanks

According to Mercy *et al.*, (2013) reliable pH range for *Puntius denisonii* growth, sexual maturity and breeding is 6.8-7.8. and also *Balantiocheilos melanopterus* required **6.0-8.0 pH level in water for the sexual maturity (Rainboth, 1996).**But under the experiment condition it was maintained below that level.

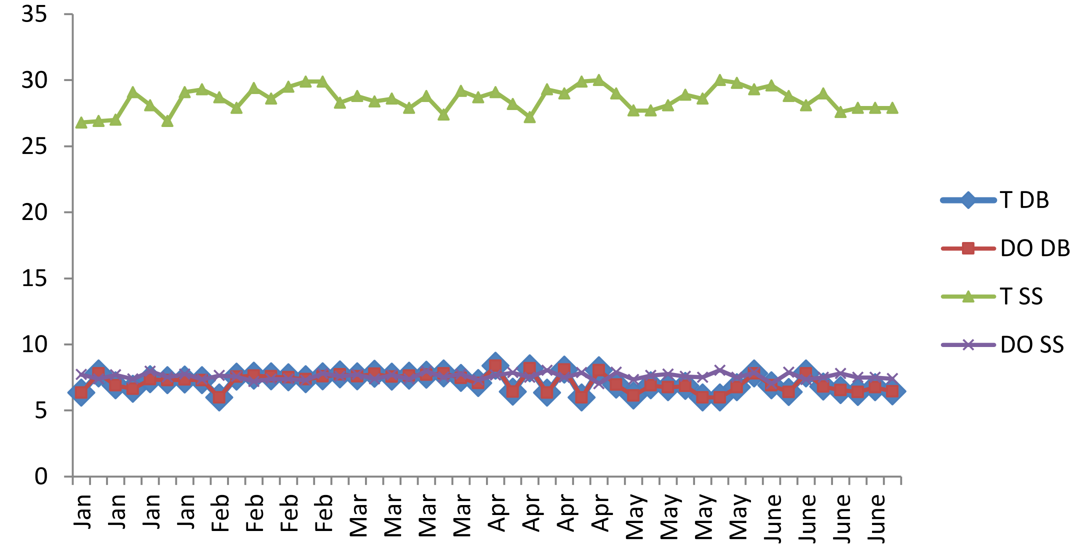


Fig 3: Temperature and DO variation with different pH levels in *Puntius denisonii* and *Balantiocheilos melanopterus* indoor broodstock rearing tanks

Temperature and DO were varied with acceptable level for *Puntius denisonii* and *Balantiocheilos melanopterus* growth, maturity and spawning (Mercy 2013). During the study period any fish of *Puntius denisonii* and *Balantiocheilos melanopterus* broodstock were not attained to the sexual maturity. It may be due the lower pH level in broodstock rearing tanks.

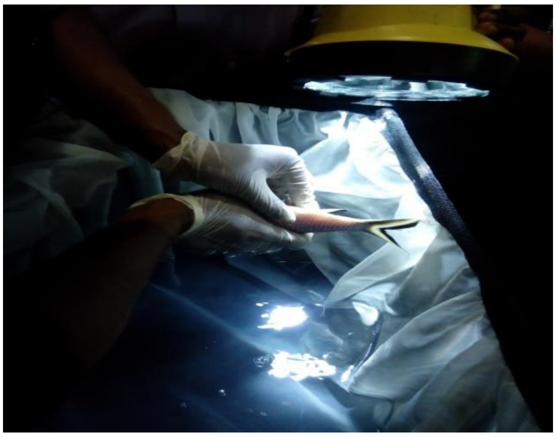


Fig 4: Immature male of *Balantiocheilos melanopterus*

According to the Mercy *et al.*, 2013 and **Rainboth, 1996** suitable pH level for maturity of *Puntius denisonii* and *Balantiocheilos melanopterus* are 6.8-7.8 and 6.0-8.0 respectively. But in study period it was decreased that level.

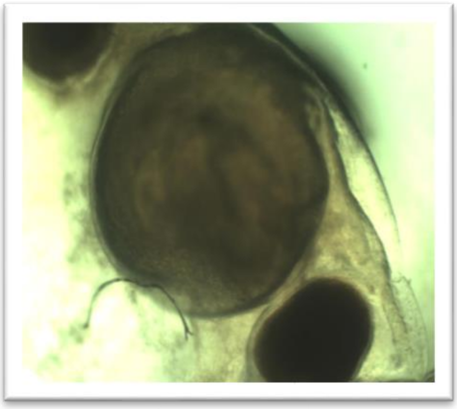


Fig 5: Immature eggs of *Balantiocheilos melanopterus*

Hence experiments were carried out to find reason for sudden decrease of pH of brood-stock tank. Two experiments were carried out to find effect of different feed and fish species to decrease the water pH level. Ox heart and formulated feed were fed twice per day 5% of the body weight to *Pterophyllum spp, Balantiocheilos melanopterus* and *Barbonymus schwanenfeldii* to find the effect to pH level of water.

	T1	T2	T3	T4	T5	T6	T7	T8
R1								
R2								
R3								

T1- Water only

T2- Water and fish only (not feeding)

T3- *Pterophyllum spp* fed minced ox-heart

T4- *Pterophyllum spp* fed formulated feed

T5- *Balantiocheilos melanopterus* fed minced ox-heart

T6- *Balantiocheilos melanopterus* fed formulated feed

T7- *Barbonymus schwanenfeldii* fed minced ox- heart

T8- *Barbonymus schwanenfeldii* fed formulated feed

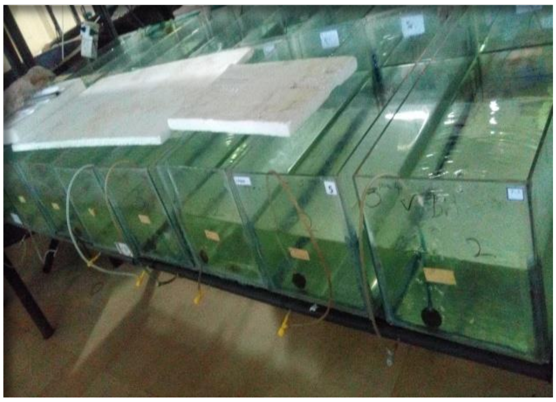


Fig 6: Experiment set up for sudden of pH changes in brood stock tanks

Water quality parameters such as water pH, temperature, DO, hardness, NH_3 and alkalinity was measured twice per day.

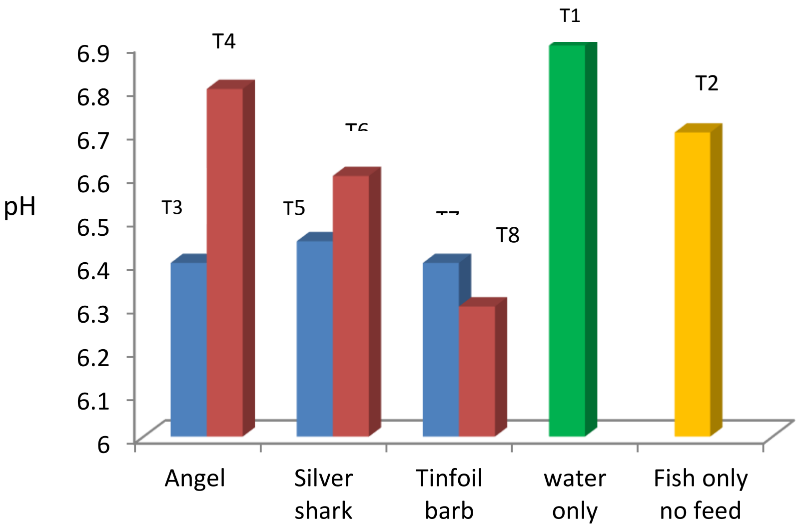


Fig 7: Water pH level variation in experimental tanks

Water temperature and DO were varied 27.26±0.45 ^{0}C and 7.5 ±05 mg/l respectively. Therefore, theses parameters are in the acceptable level for fish growth, maturity and reproduction and also no any significant difference in temperature and DO levels among the different treatments. Water hardness and the alkalinity were recorded as the 32±2 mg/l and 17.9±0.2 mg/l and also theses parameters were at low level compared with recommended level for fish maturity and reproduction. Water source that use in ornamental fish hatchery of also has low alkalinity level.

According to the above experiments feed type and fish species are not effect to the reduction of water pH level in indoor brood stock tank. Therefore, further experiments are needed to carry out to find out the relationship between alkalinity levels and water pH, suitable alkalinity levels for *Puntius denisonii* and *Balantiocheilos melanopterus* captive breeding condition under Sri Lankan condition and methods of management of alkalinity in indoor hatchery condition.

Spawning characteristics of new high value exotic fish species *Epalzeorhynchos frenatum* were studied. *Epalzeorhynchos frenatum* with initial length of 1.86±0.6cm and initial weight of 6±0.55g were purchased and reared in outdoor brood stock tanks.

Fig 8: Initial stock of *Epalzeorhynchos frenatum*

Experiment was carried out to find the sexual maturity time of *Epalzeorhynchos frenatum* under captive condition in Sri Lanka. Therefore, weight gain and length gain were measured and also ovarian biopsy and milt production were checked subsequently in every sampling time.

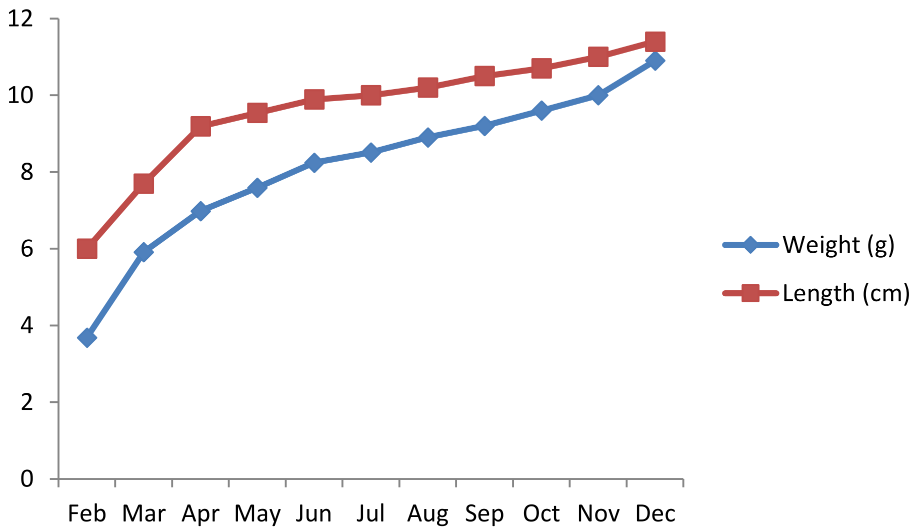


Fig 9: Total length and weight changes of *Epalzeorhynchos frenatum* under captive condition

Up to the nine month growth period *Epalzeorhynchos frenatum* were not attained to the sexual maturity under the captive condition in Sri Lanka. Although it may be attain to the early sexual maturity under pond rearing condition.

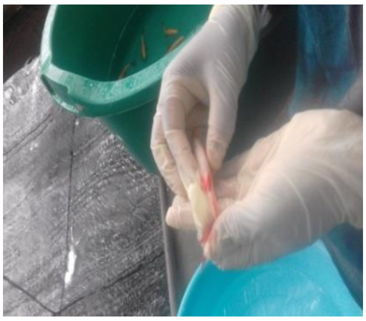


Fig10: Immature male of *Epalzeorhynchos frenatum*

Fig 11: Immature female of *Epalzeorhynchos frenatum*

Effects of different hormone concentrations and hormone on latency period of *Barbonymus schwanenfeldii* were studied.

Fig 12: Latency period and egg quality determination experiment

Ovaprime hormone was used to study the latency period of *Barbonymus schwanenfeldii* at five different concentrations such as 0.2, 0.3, 0.4, 0.5 and 0.6 ml/kg. According to the results the least latency period was recorded at a dosage of 0.6 ml/kg of body weight at a time lapse of 3.20±0.17 hrs. The maximum latency period was observed at 0.2 ml/kg of body weight at a lapse of 11±0.51 hrs.

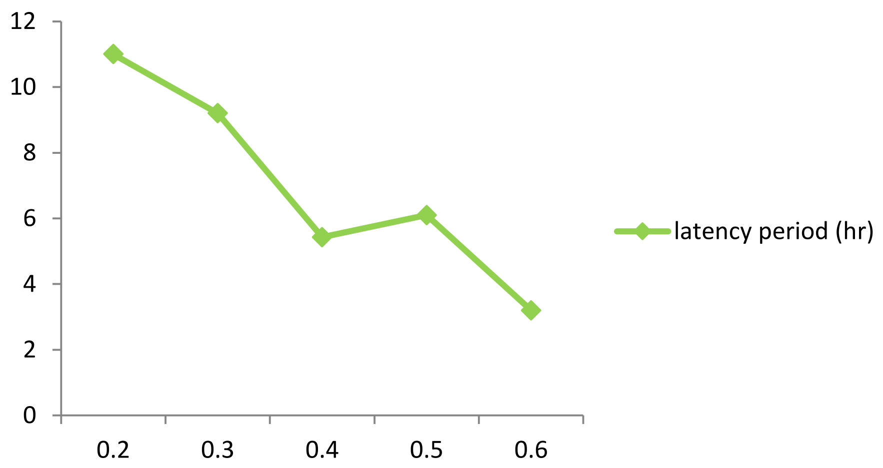


Fig 13: Latency period variation with different hormone concentration of *Barbonymus schwanenfeldii*

The maximum fertility rate was observed in the fish group receiving 0.5 ml/kg of BW of the Ovaprime and lowest was recorded as 33.33±9.07 for 0.6 ml/kg of BW.

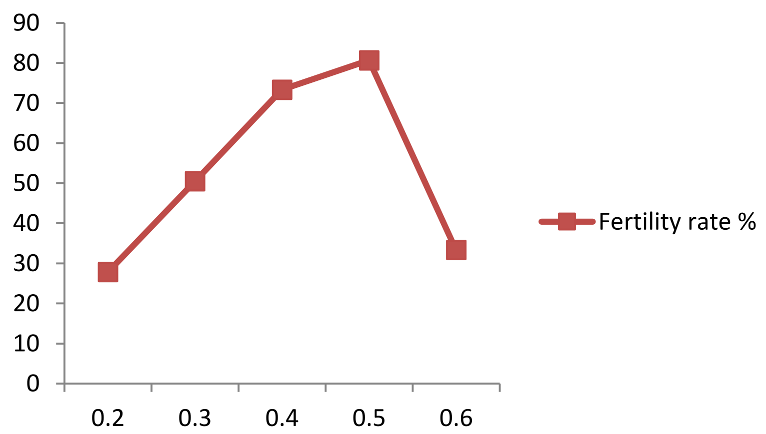


Fig 14: Fertility rate variation with different hormone concentration of *Barbonymus schwanenfeldii*

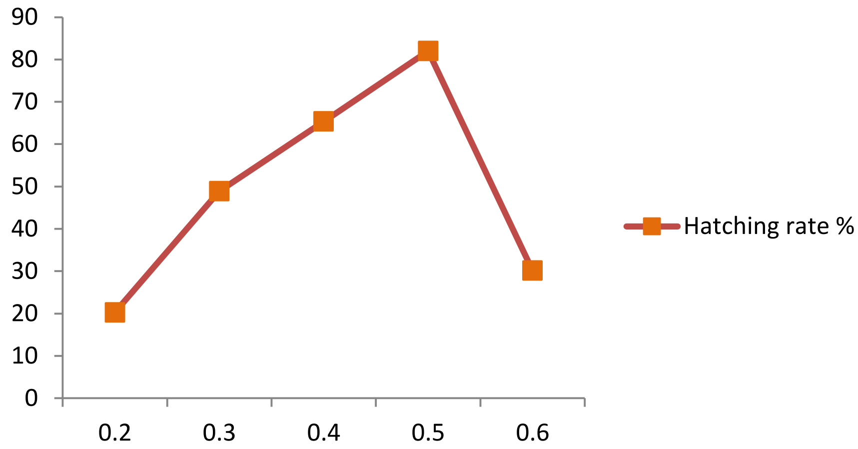


Fig 15: Hatching rate variation with different hormone concentration of *Barbonymus schwanenfeldii*

The maximum hatching rate was observed in the fish group receiving 0.5 ml/kg of BW of the Ovaprime and lowest was recorded as 20.3±9.07 for 0.2 ml/kg of BW. Therefore, with increased of hormone concentration latency period of *Barbonymus schwanenfeldii* is decrease. But egg quality is increase with increase of hormone concentration, but at some maximum level it again decreased. Hence, maximum spawning characteristics of *Barbonymus schwanenfeldii* can be obtained 0.5ml/kg of BW concentration of Ovaprim in induced breeding method under Sri Lanka captive breeding condition. *Barbonymus schwanenfeldii* breeding was not successful using LHRha and HCG hormones.

Conclusions

Egg and sperm maturity highly depend on water quality condition in rearing tanks in captive breeding of high value exotic fish species. Latency period is decrease with increase of hormone concentration and egg quality increase with hormone concentration up to some concentration limit.

Recommendations

- *Puntius denisonii* and *Balantiocheilos melanopterus* brood- stock should be reared in 6.0-8.0 water pH level otherwise fish will not attain to the sexual maturity.
- In hormonal induced breeding of *Barbonymus schwanenfeldii* latency period varied 6-8hrs.
- Latency period depends on maturity of fish, hormone concentration and temperature.
- Egg quality of the exotic species increase with hormone concentration up to certain level and then it will reduce.

Outputs:

- Obtain required reproductive information of exotic fishes for hatchery operation
- Development of induced breeding protocol for exotic species

Outcomes:

- Enhancing of large scale production of seedlings of exotic species
- Enhancing income of fish breeders and fish exporters

Progress: Financial : 100 % Physical : 90%

Constraints:

Brood stock management was difficult under existing tank facility.

Biotechnological applications on aquatic plants and seaweed industries.

Project No : 3.2.6

Officer Responsible : D.M.S.Sugeeshwari, Dr. V. Pahalavattaarachchi

Aquatic ornamental plants are used for the decoration of ponds or aquaria. Most popular and high valued aquatic plants are *Microsorium, Anubias, Echinodorous*. Among these species *Cryptocoryne* , *Lagenandra*, *Aponogrton* and *Microsorium* are the most important aquarium plants in Sri Lanka.

Microsorium pterous specie is a hardy plant which grows in a vast range conditions. The java fern reproduces by spores which are contained in sporangia on the underside of the fronds. According to the information provide by major aquatic plant growers in Sri Lanka, Java fern is high value ornamental aquatic plant. Hence development of a technique for micro-propagation of this plant is important.Traditionally, *Anubias baarteri* var .*Nana* is propagated vegetative by rhizome division. The genetic informality is important for the quality of a plant. Therefore, plant tissue culture help to maintain the genetic uniform of a selected strain.

This *Kappaphycus alvarezii* (Cottonii seaweed) specie is one of the most important carrageenan producing red algae. Carrageenan is used in a variety of commercial applications as gelling, thickening and stabilizing agents especially in food industry. The cultivation of seaweed contributes significantly to the national economy and provides employments to the economically backward communities. Cultivation of seaweeds on a commercial scale requires a large number of propagules with desirable phenotypic traits which includes high growth rates and resistance to diseases. One of the biggest issues in the seaweed farming industry is lack of seeds.

Seaweed tissue culture can be considered one of the best methods to provide a large amount of seedling for cultivation. Hence, improvement of micro- propagation technique for seaweed is important.

Objectives

- To develop protocols for the *Microsorium pterous Anubias baarteri* var.*Nana, Kappaphycus alvarezii* to produce highest numbers of shoots or callus from explants.

- To do the genetic improvement of *Cryptocoryne wendtii*.
- Aquatic plants collection and plant house maintenance

Methodology

Aquatic plants

After the surface sterilization, explants are Culturing on Murashige and Skoog medium with different hormone concentrations for the callus and shoot initiation. Continue with sub culturing for multiplication. Then media transfer for the rooting and then hardening.

Seaweeds

After surface sterilization of thallus explants of seaweed, acclimatize the explants by using PES medium providing good aeration. Culture the explants on well dishes with PES and growth regulators. Observe for callus development and after callus development, sub culture for multiplication and Culture on medium to develop thallus from a callus

Genetic manipulation of *C.wendtii*

One gram of in vitro four weeks old laves is cut into 1-2 mm wide stripes in a washing area. The sliced tissues are plasmolyse by immersion in washing solutions and plamolyse solution pipette off and replace with enzyme mixture. Prtoplasts are filter through nylon mesh and then Protoplast culture in liquid layer method.

Results

1. **Development of protocol for** *Microsorium pterous*
   - The phenolic content of the ex plant (leaf) was much barrier to initiate the callus from explants.
   - Murashige and Skoog (MS) media added with activated charcoal was effective to minimized the activity of phenol in the ex plant and reduce the browning of the ex plant.
   - The activated charcoal concentration 1 g/L was best for this experiment.
   - Then different concentrations of growing hormones were tested for the callus initiation.
   - After several trials callus initiation was succeeded with a MS medium addition of 4 mg/L 2,4- Dichlorophenoxyacetic acid .
   - Callus was initiated after 60 days of culture period.

Callus from ex plant

2. **Development of protocol for***Anubias baarteri* var.*Nana*

- Rhizome segment of *Anubias baarteri* var.*Nana* plantwas selected as ex plant.
- Sterilization protocol was developed.
- 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.after culture on MS medium with 14 days.
- The shoot initiation was succeeded and maximum number of shoot was initiated at 2mg/LBenzyle adenine purine (BAP) with0.5 mg/L Indole Butric Acid (IBA).

Shoot initiation

- The maximum number of 5 Shoot was initiated per ex pant with the above hormone concentration.
- Shoot multiplication was suceeded and maximum shoot multiplication was able to get by providing 2mg/L BAP the maximum number of shoot was 6 per cycle after 6 weeks of culture period.

Sh oot multiplication

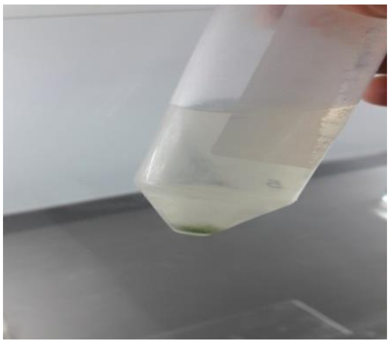
3. **Development of protocol for** *Kappaphycus alvarezii*

- Round shaped glass bowls used to culture the ex plant of seaweed.
- Areation was provided from bottom and up side to provide the better rotation for the explant.

- ½ PES medium and UV sterilized sea water used as culture medium with 1mg/L BAP growth hormones.
- The thallus initiation was suceeded in this method.

Thallus formation from ex plant

4. **Genetic manipulation of *C.wendtii***
    - The purified protoplast isolation was the main barrier for this study.
    - The tissue cultuted 30 days old leaves of *C.wendtii* was used for this experiments.
    - Purification of protoplast was succeeding with using 0.2 (w/v) pectinase and 2 % (w/v) cellulase digestion.
    - But further research is caring out to get 100% purity of protoplasts with the age of tissue cultured leaves and the concentration of the digestion enzymes.



Isolation of protoplast after centrifugation

5. **Aquatic plants collection and plant house maintenance**
    - All the mother plants of Tissue culture target varieties are maintaining in the plant house.
    - Java fern sporophyte generations from plant leave also done in the plan t house.
    - Collecting of economically imprtant high valued ferns and some aquatic plant varieties in the plant house.
    - Hardening of tissue cultured plants in the plant house.

Recommendations

1. Callus initiation of *Microsorium pterous* (Java Fern) could achieve with MS medium supplemented with 4 mg/L 2,4- Dichlorophenoxyacetic acid.
2. 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.
3. Shoot initiation was with2mg/L BAP and 0.5 IBA.of Anubias
4. Shoot multiplication was 2 mg/L with BAP of Anubias.
5. Thallus initiation could achieve by using Sterilized Sea water as a media in globular shaped glass ware with better aeration.

Outputs:

1. Java fern callus initiation was able to get by using 4 mg/L 2,4- Dichlorophenoxyacetic acid with MS medium with 1g/LActivated charcol .
2. Protocol developed for Anubias (Best Sterilization method-70% ethanol 30second and 6% clorox for 15 minutes and 4% clorox 10minute and five times washed with strilized distilled water). Maximum shoot initiation - suplementing2 mg/LBAP and 0.5 IBA.
3. Seaweed new thallus initiaton was successful using ex plant with UV sterilied seawater as a medium.
4. Best method for Protoplast isolation of *C.wendtii* was the enzyme digestion method using 0.2% (w/v)pectinase and 2% (w/v) cellulase of 1 month old tissue cultured leaves,

Outcome

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

Progress: **Financial** 85% **Physical** 90%

Constraints

1. The callus initiation was succeeded with long term of culture period. But the sample contamination was a big barrier to continue the research to shoot initiation.
2. Bioreactor is a best one to conduct the experiment for sea weed. As the ex plant of the seaweed is having a considerable weight, big barrier for the continuing rotation of explants to get thallus initiation without a bioreactor

Study of the Sea Cucumber, (*Holothuria scabra)* Grow-out Farming in North-western and Northern Provinces in Sri Lanka

Project No : 3.3.1

Officer Responsible : P. A. D. Ajith Kumara & C. B. Medagedara

Introduction

In order to address the problem of rapid depletion of sea cucumber natural resources artificial breeding programmes of economically important sea cucumber species (i.e. sandfish; *H. scabra*) has been introduced presently. These seeds are being used for not only commercial aquaculture but also stock enhancement programmes. Early larval rearing is fundamentally important to commercial hatcheries that rear sea cucumbers, because larvae are more susceptible than juvenile and adults. Therefore, present study is important to further development of breeding performances, fecundity, hatchability, larval survival rate and other desirable factors (soil texture, organic matters content etc.) relate to sea cucumber open water farming.

Objectives

- Further development of breeding, rearing and grow-out culture techniques of economically important sea cucumber; *H. scabra*
- Monitoring of community-based sea cucumber farming programmes through transferring technical ***know-how*** to fishing communities
- Address and cater to the issues in sea cucumber farming in Northern coastal waters

Activities Carried Out:

- Establishment of hatchery facilities for *H. scabra*, collection and conditioning of broodstock, induce breeding and larval rearing
- Community-based sea cucumber farming
- Investigate potential for integrated multi-trophic aquaculture of *H. scabra*,mangrove oyster (*Crassostrea spp*.) and seaweed (*Gracilaria edulis*) in Puttalam lagoon
- Monitoring of sea cucumber farming in Northern coastal waters
- Awareness programmes

Results

❖ **Establishment of hatchery facilities, collection, conditioning of broodstock, perform breeding trials and larval rearing with formulated feeds for enhance the survival rate in order to develop consistent and quality seed production of *H. scabra.***

Fourty numbers of wild caught brooders (550.0±87.2) were collected from Mannar and have been conditioning as a broodstock.

One breeding programme of *H. scabra* performed in early January and produced 500,000 no's fertile eggs. At the end of early larval rearing period remained only 500 no's one month old juveniles (survival rate 0.01 %). They were reared further 45 days until weight gain about 10-15 g in size and observed survival rate was 54%. Out of reared 270 juveniles, 180 no's of juveniles were used to test a feed trial which was being conducted by using brewers' yeast and seaweed-based (*Sargassum* spp.) formulated feeds. The results of this component will be presented under Project No. 3.1.5. The rest were introduced in to lagoon pensin where they were used to investigate potential for integrated multi-trophic aquaculture withmangrove oyster; *Crassostrea spp*. and sea moss; *Gracilaria edulis* in Puttalam lagoon.

- **Community-based Sea Cucumber Farming**

Three community-based sea cucumber farming projects were started at Serakkuliya in Wanathavilluwa Divisional Secretariat and two Isles called Illipantivu and Rodhapadu in Kalpitiya Divisional Secretariat. Hundred fifteenno's beneficiary families were selected from the respective societies last year and three pen enclosures (225.0 m^2 in size) were prepared with community participation.

450 no's of nursery-reared juveniles (size 5.0-10.0 ± 3.48g; stocking density 1.5 juvenile per m^2) obtained from private hatchery and stocked 150 no's in each pen in April 2018. NARA had given technical *know-how* to conduct the farming activities throughout the culture cycle by routine monitoring of growth and water quality parameters as well as analyzing sediment characteristics.

After 2 month culture period pen enclosure in Rodhapadu completely washed off from rough waves therefore the remaining juveniles (40 no's) were put in to Uchchamunei pen in where one of pilot project conducted in 2016, after renovation the pen.

Average weight gained for the seven-month culture period from April to November in Serakkuliya and Illipantivu were 330.45±6.35g and 270.12±7.01grespectively. The maximum and minimum size ranges in two sites; Serakkuliya and Illipantivu were 230.31-355.12g and 184.35-295.32g respectively. Maximum and lowest daily growth rate were observed as 0.97 and 0.32 g for the months of May and November for Serakkuliya whereas 0.91 and 0.21g for the months of May and November respectively at Illipantivu site. The survival rate in two sites was observed as 40 % Illipantivu and 75 % Serakkuliya. The expected income to the fishery society will be about Rs 200,000.00 for 10-12 month culture period.

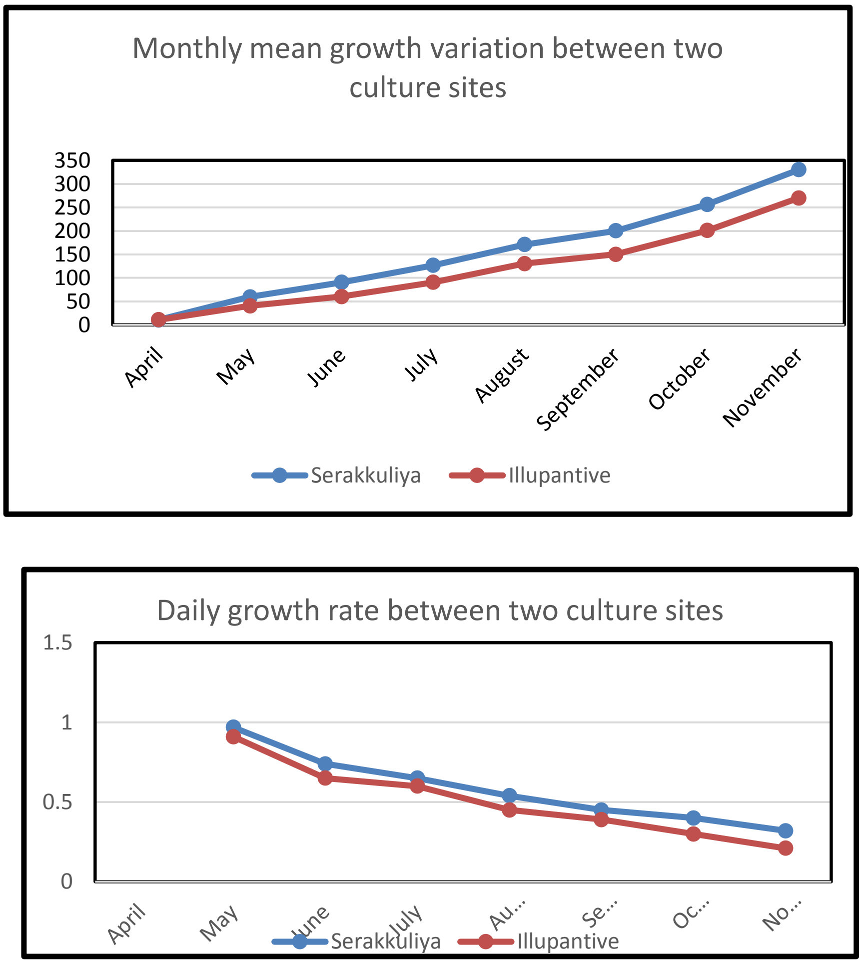


Fig.1 Monthly variations of mean growth (g), daily growth rate (g day^{-1}) and maximum growth (g) obtained in two farming sites

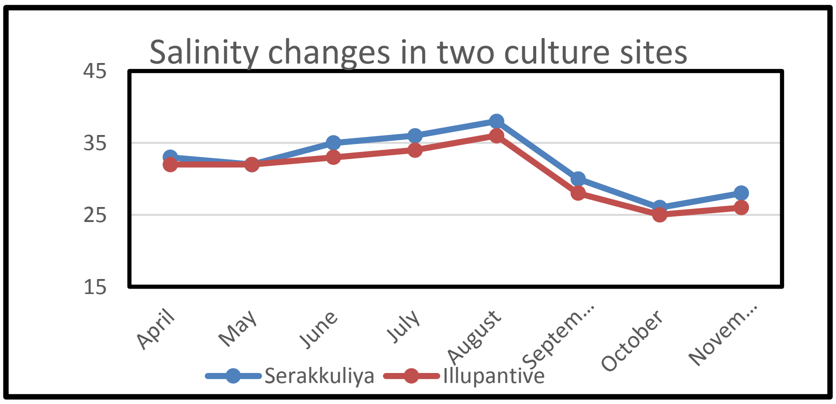


Fig. 2. Monthly variations of salinity in two farming sites.

❖ **Investigate potential for integrated multi-trophic aquaculture of *H. scabra,* mangrove oyster *Crassostrea spp*. and seaweed (*Gracilaria edulis*) in Puttalam lagoon**

This component was carried out by a under graduate student from University College of Anuradhapura as a partial full filament of her degree programme. In this experiment we have investigated that the possibility of substances release from one system could be utilized to other system in a productive and environmental friendly manner.

Here, sea cucumbers (SC, 30 no's each) were co-cultured with seaweed (SC+Sw) and oysters (SC+Oy) in lagoon pens with a control for 5 month period starting from July 2018. Growth of SC, Oy, Sw and percentage organic matters were calculated in 3 pen enclosures once a month interval while water quality parameters were measured fortnightly. The results are graphically shown under this chapter.

The results revealed that the pens with SC+Sw and SC+Oy shows remarkable high amount of organic matters accumulation than the control and outside the pen. These autochthonous organic matters accumulates inside the pens due to decayed seaweeds and excretion substances of oysters and could act as feed for sea cucumbers. Therefore, sea cucumber culture with seaweed and oyster can be feasible than the control in which sea cucumber culture alone.

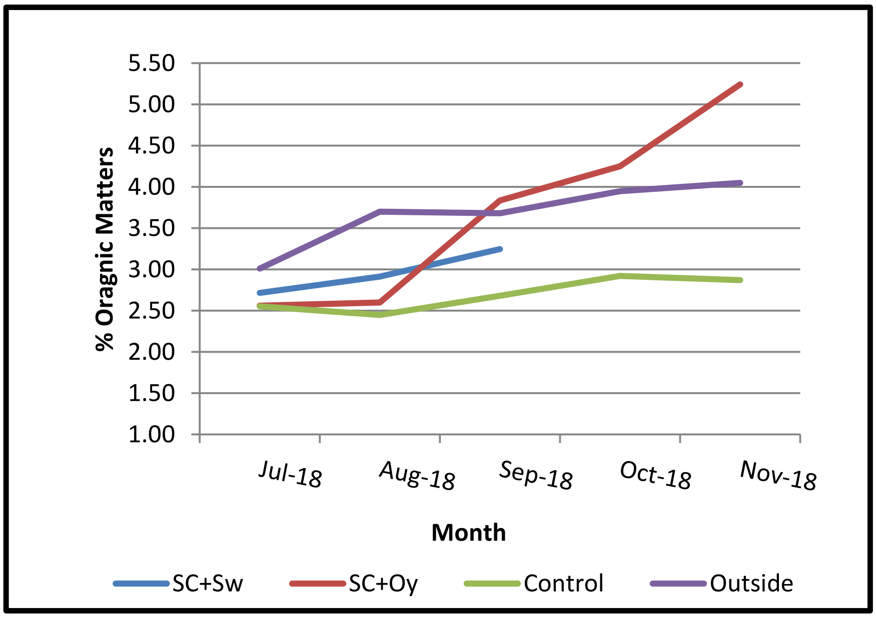


Fig.3. Monthly variations of organic matters in pen structures (SC- Sea cucumber; Sw-Seaweed; Oy- Oyster)

❖ **Monitoring of sea cucumber farming in Northern coastal waters**

38 operating and 15 abandoned grow-out farms were observed in Northern coastal waters. GPS locations of each farm and stocking data were recorded as possible as we can. 15 farms were monitored at regular 2 month interval in three districts Jaffna (5), Killinochchi (9) and Mannar (1) (Fig.4). Out of the 15 abandoned farms, 11 were in Killinochchi district while the remained in Jaffna district. Only one farm is being operated in Mannar district presently. Several maps were produced so as denote existing farms, abandoned farms, juvenile collection grounds and suitable areas for further expansion of the industry (Fig.5).

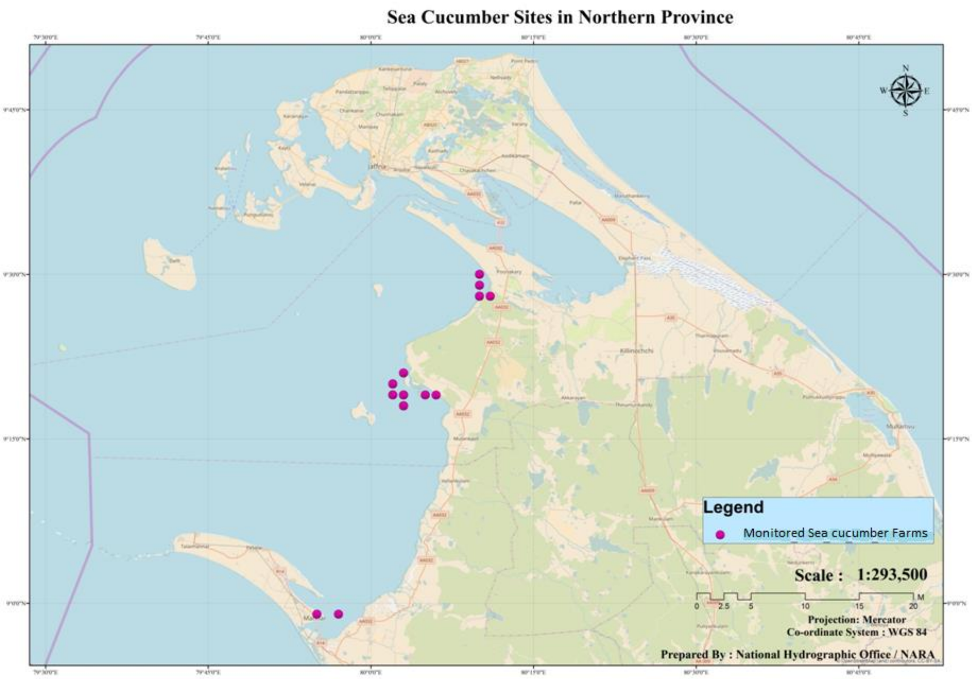


Fig.4. Sampling locations

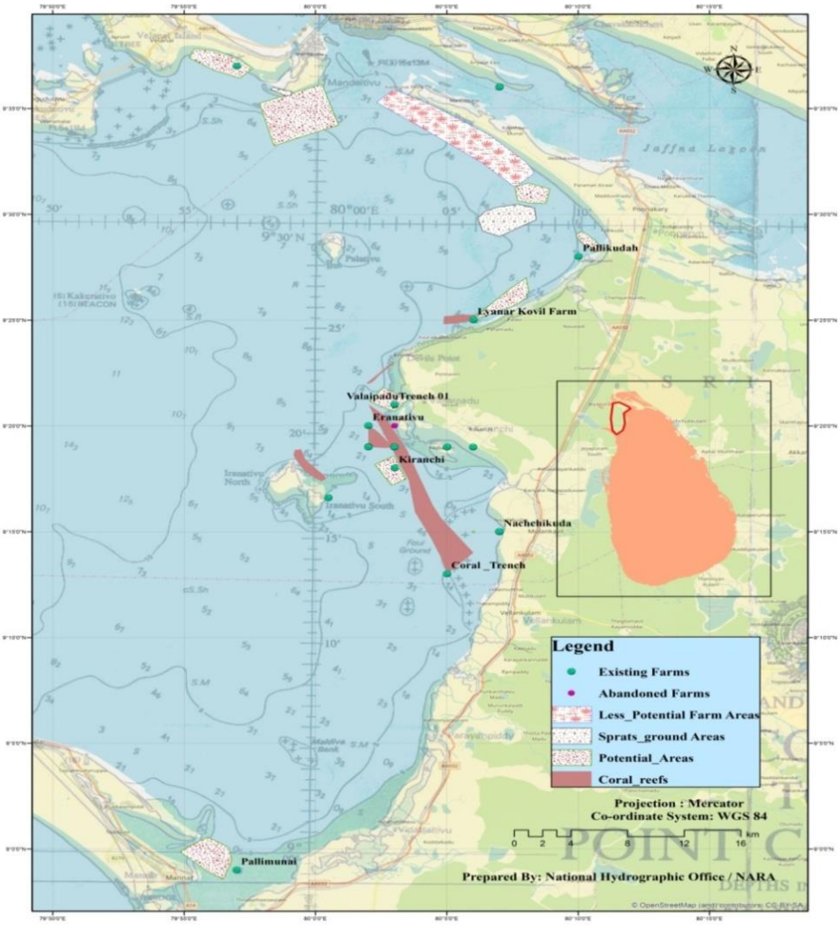


Fig 5. Distribution of sea cucumber farms in Northern Province

Output:

1. Built up awareness among fishing communities, university students on sea cucumber Farming
2. Hand-on experience for fisher-folks on community-based sea cucumber farming
3. Dissemination of the technical *know-how* by preparing scientific publications and guiding under graduate students
4. Possibility of multi-trophic aquaculture practices for aquaculture development
5. Develop methods for soil organic matter analysis
6. Detailed maps for overview exiting sea cucumber farming areas in northern coastal waters
7. Identification of natural sea cucumber breeding grounds
8. Preparation of site selection maps, site selection report
9. Size suitability of juveniles for stocking in open sea water enclosures

Outcome:

1. Capacity building of fisher communities on alternative livelihoods

2. Identification of suitable sites for expand sea cucumber industry in Northern Province

3. Diversification of aquaculture industry

Constraints

Heavy precipitation had been received to north western and north central provinces throughout the year 2018. As a result of that spilling of perennial and seasonal tanks in two provinces discharges lot of rain water through Mi Oya and Kala Oya which are the major two rivers connected with the Puttalam lagoon. That had been caused to drastic salinity changes in the lagoon not only during monsoonal period as usual other period in the year. We were facing great problem in water exchange process both indoor and outdoor tanks at that time and had to transport sea water. As a result of that low growth rate and high mortality rate were recorded during larval rearing period in this year when compare with other years. Therefore, only one breeding programme was able to perform. Irregular stocking and partial harvesting methods also disturbs to develop systematic data collection system when conducting commercial pen monitoring work

Progress: **Financial** 100% **Physical** 95%

Conclusions/ Recommendations

- According to eight months of culture period between two selected culture sites, there is a significant high growth observed in Serakkuliya community-based farm site than Illupantivu CBF. 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 are suitable for sea cucumber farming in future whereas culture site in Rodhapaduwa was difficult to continue due to rough wave and high windy condition during southwest monsoonal period.
- However, Northeast monsoonal period is suitable to perform grow out fattening in Rodhapaduwa because less windy condition could minimal damage to pen structures.

- 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 in to grow out farming.
- When site selection for grow out farming of sea cucumbers in open waters in addition to conventional site selection parameters, micro habitat conditions of the bottom also take into consideration.
- Changes of natural food availability in pen enclosures should be monitored continuously till recognize it is cut off level in which growth becomes retardate.

Establishment of gene bank for Kapphaphycus & Euchema varieties suitable for culture in Sri Lanka and culture of other potential seaweeds.

Project No : 3:3:2

Officer/s responsible : J.S.Jayanatha, U.S.P.K.Liayanage, V.Pahalawattaarachchi

Introduction

The culture seaweed has been successfully adapted in to Sri Lanka climate and cultivation method. Those are the major carragenophytes in the world market. Farming techniques have undergone several innovations since it was first introduced. This seaweed species farming is a viable alternative source of income for small scale fishermen. The *k. alvarezii* is one of the best sources for kappa carrageenan as compared to other seaweeds. However, still we are using imported varieties; therefore, we need to identify correct varieties those who has highest carrageenan percentages. However, there was no suitable method for identifying commercial high value varieties in Sri Lanka. Although, developing bio marker for identifying good quality seed materials, varieties, for future culture expansion in Sri Lanka.

Objectives

Development of culture techniques for potential species of seaweeds and **maintain further** improved parent seed stock of *K. alvarezii*

To have vigour improved national seed stock of *K. alvarezii* to cater the need of the industry,

Establishment of seed banks for other seaweed species and varieties in Sri Lanka which area imported from Indonesia, named *Eucheuma cottoni*, *Kappaphycus striatum, Eucheuma spinosum*. Those species were inserted to same methods at Dondra November 2018.

Methodology

Seed inserted and preparations: well branched with good quality seed materials selected in the mass selection procedure in previous years. The propagules were weighted approximately 100g, 150g, 200g was inserted in single braid knot (8 knots/single rope) inserted. The distance between each tried knot between 20cm.

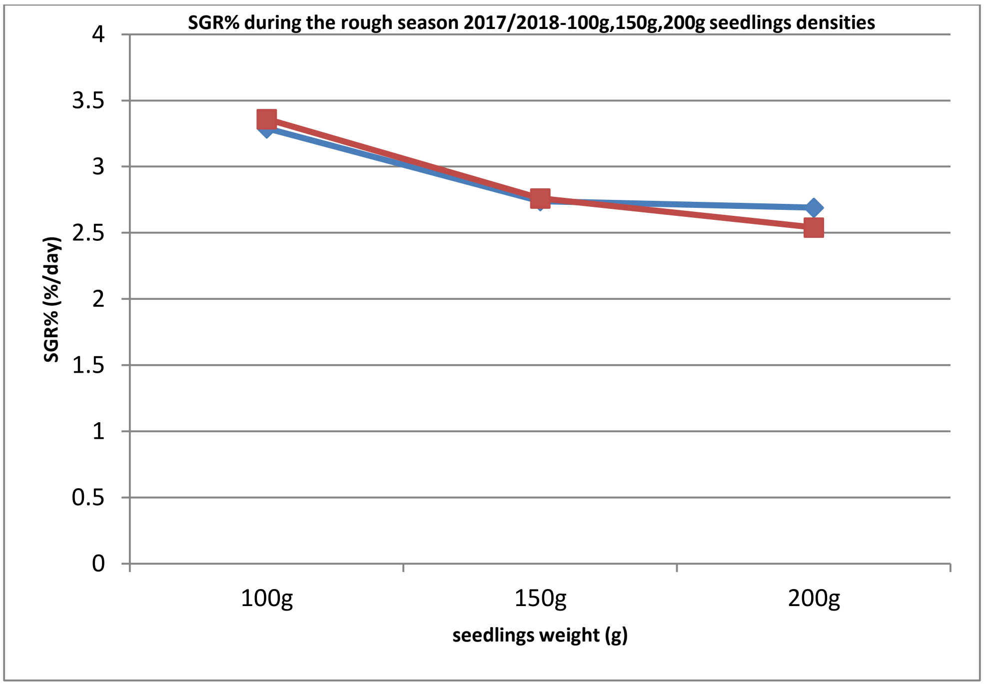
Seasonality:

The experiment was conducted for covering monsoon and imtermonsoon periods in 2018. SGR% was calculated every 30 days trials.

Experimental design: Three different initial seedling densities 100g, 150g, 200g were tried in the intervals of 20cm distance between two propagules for the present study. In order to find out best culture protocol , 30 days culture period was used to evaluate the SGR%.

Results

The mass selected good quality seed propagules of *K. alvarezii* has remarkable growth rate in net cages; increase of average weight in particular net cages with time shows exponential growth rates according to seedling SGR% in 2017 and 2018 there were highest SGR% from 100g initial seedlings, which was reported as 3.36 in 2018 and 3.29 in 2017 % per day. Therefore culture protocoal for seed rearing at rectangular net cages with 100g propagate at 20cm distance is validated seedling density for commercial culture.



Period	Unakuruwa	Polhena	Dondra	Kiranchi
October	100kg	-	60kg	100kg
November	60kg		60kg	60kg
December	25kg	40kg		
Total	505kg			

Among those three varieties imported, *Kappaphycus striatum* species recovered in this culture site and the growth is progressing. This species can be used as pilot culture projects in new area for increase the quantity.

Capacity of the seed bank- 1800kg / Best season

Seed delivery schedule in 2018

According to farmer and private company reported southern coastal is suitable area for making good quality seedlings with good branching; those seedlings has high number of shoots and high rate of growth.

Conclusions & recommendation

Dondra seedbank could be used as national seed bank to provide seeds for community based seaweed farming. Therefore best **culture protocoal for seed rearing at rectangular net cages with** 100g **propagate at 20cm distance between each propagule.**

Outputs

Established seed bank with good qulity seeds

Initiation of community baed projects through 0.5mt seeds which will yeild 4MT by February 2019.

Outcome

Incrase foreign exchange ernings through seaweed production

Progress: **Financial** 100% **Physical** 100%

Constraints:

Extreme conditions were reported several growth trials, handilng and maintained the cages are difficult. Propagule grazing small reef fishers could be observed.

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

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Project No : 3.3.3

Officers Responsible : A.S.L.E. Corea , C.B Medagedara and V. Pahalawattearachchi

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 is being tried out. However, collectors to collect large number of spat at once has not been possible. Therefore, the project would try to introduce methods to collect sufficient spat for culture t commercial level

Another problem through wild collection of spat has been the damage to the existing reefs The availability during all seasons is also a problem as spat are available only when suitable climatic conditions prevail. Therefore, to enhance the wild populations reef restoration methods would be tried out using suitable material. The newly built reefs will be transferred to sites close to culture activity so that spat collection from the area will be possible for farmers.

Goals and objectives

Increase the commercial bivalve culture among fisher communities

- To collect sufficient spat for commercial oyster culture
- To build more oyster reefs so that a steady breeding population is established in areas suitable for culture
- To provide economic benefits to the farming societies by aiding community based culture programs

- To Improve oyster spat collection and culture techniques
- Disseminate technical knowhow among oyster farmers

Methodology

1. Spat collectors of different type will be deployed to collect spat during spat falling seasons
2. Artificial reefs will be prepared for spat to collect and grow, so that new oyster reefs are in function after 3 years and could have a new breeding population It will support spat collection in areas close to culture sites.
3. For monitoring conditions near artificial reef and spat collectors water quality will be monitored monthly
4. Check the availability of spats and their growth bi weekly
5. Awareness programs for the community will be conducted for dissemination of knowledge

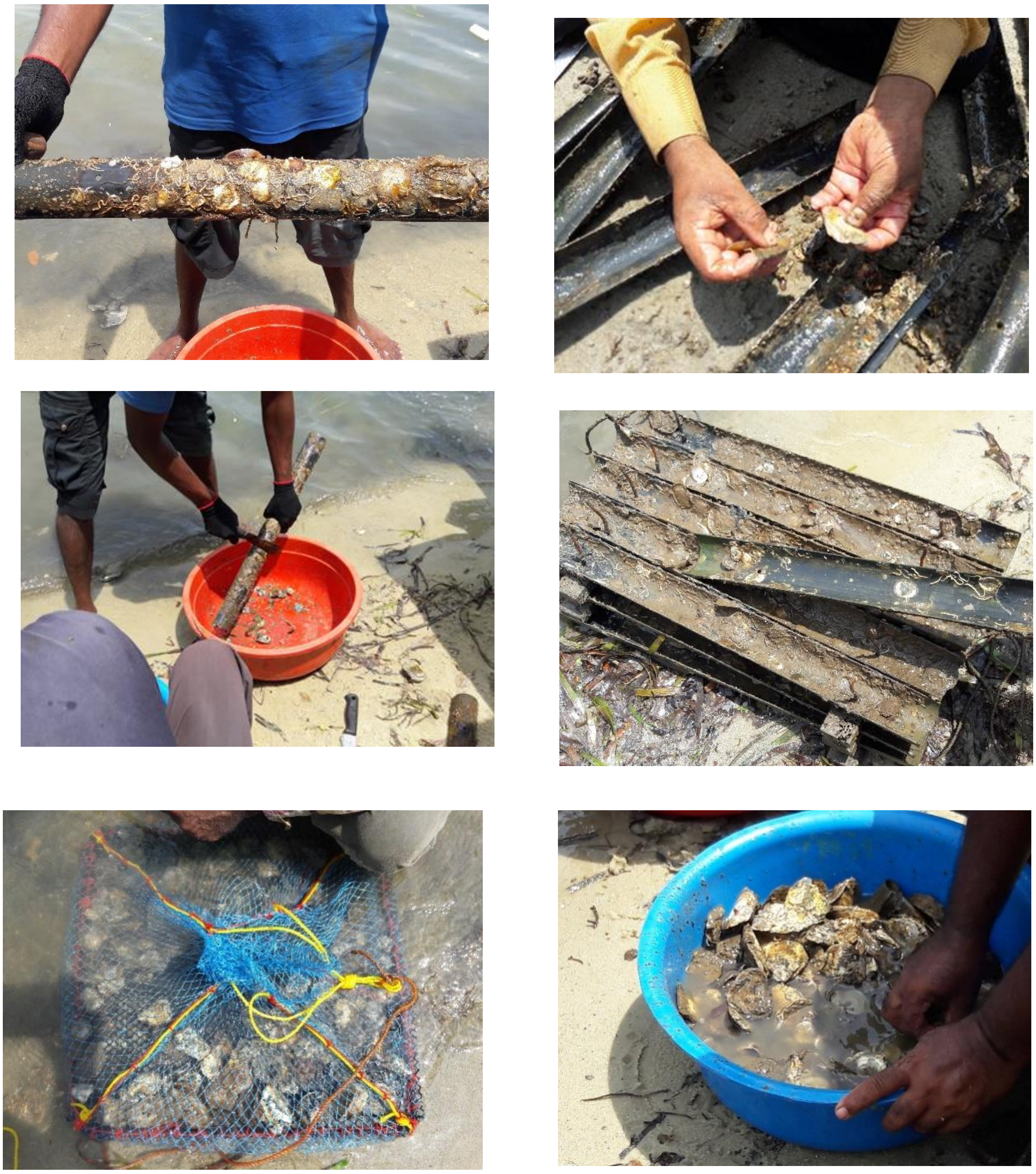
(1^{st} year – reef building and monitoring of spat growth with water quality
2^{nd} year – reef monitoring to see the growth of the new oyster population
3^{rd} year - monitoring the growth and breeding of new population.)

Results

- To collect sufficient spat for commercial oyster culture

Community based commercial oyster farming practice in Kandakuliya, Anawasala ,Janasavipura and Thoradiya by selected members of women societies. Kandakuliya lagoon area is rich with oyster spats during the spat falling period from August to December, because there were natural oyster reef presents and thousands of oysters cultured by community. Therefore, no need to supply oyster spats for Kandakuliya community they are still self-sufficient with spats. Thoradiya was the new place identified for commercial oyster farming and ten number of women formed a society and started oyster farming since April 2018. They stocked nearly 2000 oyster spats in batch wise method. Larger juveniles requested by the oyster buyer and they sold 800 oysters in November. According to the monthly observation Thoradiya is s suitable site for commercial farming due to the unique water quality and less disturbance due to the wave action. Anawasala farming location is important community based station which was firstly identified d as a best place for oyster culture. Currently they faced a problem of finding and enough spats for their culture activities. Because Anawasala lagoon cove does not possess any mature oyster stocks and NARA supplied oyster spats for them during the spat falling season. Janasavipura is the next community based farming site with stocked 1500 oysters as batch wise culture. They also do not have sufficient spat close to the ulture site and NARA had to provide necessary spat.

As a remedy for this culture issue NARA deployed number of newly developed PVC, plastic spat attachment structures in Gangawadiya area during the identified spat falling season in this year to collect spats for commercial level oyster farming communities. According to the records about 5000 spat were collected and distributed among farmers. Every month NARA research crew checked attachment materials for spat fall. With the expand of farming density on above sites it will require more number of spat for upcoming year.



Novel spat attachment materials and traditional spat attachment materials hanged in Kumburawa / Gangewadiya natural oyster beds.

After received annual monsoonal rain to kalpitiya, we deployed prepared materials with the intention of collect spats from natural oyster beds. According to the monthly water sampling results, it has been observed that some D shape free swimming juvenile stages present in water samples.

Type of attachment	Amount of attachments used
PVC attachments	50
Electrical casing box structures	40
PVC conduit reinforced flexible net spat collector	40
Coconut shells	200 strings
Asbastose	100 strings
Oyster shells	200 strings
Fiber sheets	100 strings
Tile	200 bed type

Novel attachments successfully hanged on newly made oyster racks, beside naturally grown heap of oyster beds. Other traditional materials may have hanged on mangrove twigs and roots. Due to the low water flow with comparing of the left bank of river right bank was selected for experimental work. Undergraduate research student attached to University college, Anuradhapura conduct an experiment of density spat falling from an artificial reef built with 2000 mature oysters, on novel oyster spat attachment structures in Thoradiya community based farming site.

Naturally available oyster shells, Coconut shells, roof tiles, asbestos sheets and fiber sheets used to prepare traditional oyster spat attachment clusters. The identified problems regarding this type of materials are the low surface area and roughness of the surface. Actually low surface areas reduce the chance of attaching free flowing spats. Roughness of the surface affect when spat mechanically detach from the adhered surface. Asbestos sheets are not environment friendly and fiber sheets are not cost effective. Therefore, PVC attachment material is more suitable as oyster attachment material. It is easy to prepare and easy to hang on wooden poles. Spat detachment can be done without damage to the oysters.

- **To build more oyster reefs so that a steady breeding population is established in areas suitable for culture**

Oyster reef restoration was established as first time in Sri Lanka in Kumburawa selected Kala oya river mouth area Lat:$8^0$1832.91N Lng:$79^0$5009.54E. There were three sites developed using reef restoration structures including cylindrical and box type structuresalong the river mouth. 3mx3m structures were prepared using wooden poles to hold spat collection structures.

Type of restoration structure	**Amount of structures used**
Cement structures	50
Plastic mesh box structures	50
Plastic mesh cylindrical structures	40
Plastic mesh mat structures	200 strings

1m^2 areas of each structure type was already covered with different structures according to the benthic topography. Box type and cylindrical type structures used to make reef restoration clusters. Those clusters already located 8m gap between each other.

Cement structures were paved nicely around mangrove bushes along the river bank and covered 20m^2 area. Those structures paved minimally disturbed to general indigenous fishing methods.

Oyster mat structures paved same as cement structures and covered mainly 30m^2 area. Nearly 50m^2 area was covered by artificial reef restoration mat structures.

- **To provide economic benefits to the farming societies by aiding community based culture programs**

Community based oyster farming was helped to overcome financial problems of community members in four culture sites. Oyster marketing procedure conducted to have benefits for all farmers during the year. Oyster orders rotate among farming sites to receive equal benefits. The main problem encountered was the low market value paid by the buyer.

• Participatory Rural Appraisal

[PRA] was carried out with the participation of the members of women societies in selected villages. Thirty members participated in this appraisal. All the participants actively participated and developed village resources map and social map. The group identified one of the main resources of their village is the lagoon. Some women were already engaged in collecting shellfish from the lagoon. It was revealed that women of the society were willing to start oyster culture as a livelihood activity with necessary training. The community based oyster farming empowering the marginalized low income fisher women by aquaculture self-employment.

Total revenue earned by three community based oyster farming societies 2018

Name of the society	Location of the farm	Total sold oysters	Total revenue earned by the society (Rs)
Diriya Dheewara kantha samithiya	Janasavipura	1450	29,000.00
DiriyaKantha Karyasamithiya	Anawasala	850	17,000.00
Praja Sanwardana Samitiya	Kandakuliya	2000	40,000.00
Thoradiya kanthasamithiya	Thoradiya	800	16,000.00

- **To Improve oyster spat collection and culture techniques**

Oyster spat attachment materials were deployed during the spat falling season to collect as much as juvenile stages for farming process in four locations. Spat collectors should clean as usually three months' period to detach spats then spats will grow in separate culture structures for further batch culture. Spat collectors can be use long time to collect spats because after collect spats that collectors can be clean and reuse for another period of time. Wooden structures (Racks) should be replace annually or when repairs needed.

Oyster reef restoration is completely a separate concept, different type novel developed structures paved along the river bank and around mangrove bushes. It caused minimal disturbance to the traditional lagoon fishery. Reef restoration site was selected by researching the best growth of oyster clusters along the river and shallow benthic characters. During the annual spat falling period, in mid-October found out that spats were in everywhere at these structures. Spats will not detach as in spat collectors and allow them to grow. After some period these structures can be move to any other place Ex- community based farming site or keep it is to make huge oyster cluster. Project was designed to move those structures to community based farming sites to make artificial reef there to collect oyster spats from attached mature oysters after due time. Then farmers can collect their own spats on site and continue culture without help of NARA.

Community based oyster culture programe conducted for the newly identified oyster farmers in Thoradiya culture site. Hand on training given to farmers about rack preparation, culture basket preparation, cleaning and bagging of oyster spats, depuration process and marketing. 2000 spats to medium juveniles has been stocked prepared culture baskets.

Most effective culture basket was introduced to Thoradiya community based farmers; round structure with 2/3 black mesh to bottom and flexible net for wall to easy water flow and light weight. Stocking density of this basket was 30-40 mature oysters at a time. Due to light weight nearly 20 baskets can accommodate in one rack. Easy to handle, cleaning and durability with long shelf life are other remarkable factors to popular among farmers. This basket can be used to hanging type mussels culture in Puttalama estuary. Production cost per one basket Rs 150.00. Rack culture system changed in to more precise way to accommodate more baskets with minimal usage of wooden poles. Two-way double center beam structure can hold 20-30 baskets and strength of rack is much higher than previous tripod one beam structure. For made new structure it needs 10-12 mature wooden poles.

- **Disseminate technical knowhow among oyster farmers**

We conducted awareness programs for community based farming groups in Janasavipura and Anawasala and Thoradiya. In that sessions disseminated knowledge on oyster farming technology, culture structures production, oyster attachment materials preparation, Hygiene and depuration process and marketing aspects. All the farmers actively participated that sessions held on their farming places

Progress: **Financial** **Physical : 85%**

Constraints

Climatic changes acted as the major killing factor of this year because due to prolong dry period during most productive months from May to November spat falling was reduced. After the North East monsoon, Kala oya received rainy water which act as natural stimulation for oyster breeding and spat falling. Spilling of perennial and seasonal tanks in the two province heavy water load drained through MeeOya and Kala Oya that are the major two rivers connected with Puttalam lagoon. Due to the sloppy benthic features and deepness of the kala Oya River it was difficult to established oyster reef restoration structures along the river bed. Therefore, we selected Sub River of kalaoya which was not such deep and sloppy. However, silt and debris accumulation was observed in the area, which affected survival of oysters.

Output

- We produced five different types of reef restoration structures named as Oyster mat, cement structures, box type filled with oyster shells, box type filled with coconut shells and cylinder type filled with oyster shells and coconut shells.
- Found a most suitable place to lay reef restoration structures by extensively search of along the river and sub rivers.
- Different types of restoration structures were increased the spat attach ability than single mode of structures.
- Reef restoration and spat collection will be continued with monitoring the new reefs and with changes to structures if necessary

Outcome:

Successful oyster culture for the provision of livelihood alternative and also natural spat collection that reduce the pressure on the lagoon environment. This project was designed to increase the natural oyster spat collection for making of oyster reefs in community based culture sites. Then with the years community farmers do not in search of spats in Gangewadiya area, because of mature oyster reef in commercial farming site. In this project it was identified that community based oyster farming is increasingly advocated as such an alternative that are readily accepted by coastal communities

Recommendation

Community based oyster farming was popular among fisher folks during past two years and more people wants to culture oysters as their livelihood. Spat availability and collection is the main issue for expansion and natural spat collection should develop more during next years and oyster hatchery should established to supply quality seeds for commercial level farming. Because now there is a growing demand for Sri Lankan oysters among consumers. Oyster reef restoration is novel initiative in local oyster farming in Puttalam estuary and first introduced by NARA. The prime intention of this project is to making of oyster reefs in commercial culture sites to collect spats. This project to is be continue during next two years.

Study on the potential for commercial use of naturally abundant oyster (*Crassostrea* sp.) in Negombo estuary

Project No : 3.3.4

Responsible Officer : M. Gammanpila and B.R.C Mendis

Introduction

The Oyster (*Crassostrea*sp.), is an important estuarine resident that spread rapidly through the Negomboestuary over the last decades. Formation and growth of oyster beds is greatly influenced by the prevailing environmental factors in the habitat. Feeding, growth, maturation, spawning and development are greatly influenced by the varying environmental factors such as water temperature, salinity, pH, dissolved oxygen, current velocity and phytoplankton.

The oyster distribution, which had shifted throughout the estuary, means impacts on salinity in oyster producing regions of the estuary has limited effects, with suggestions that other factors are more important in controlling oyster population dynamics. However dramatic increase of the oyster population in the Negombo estuary during the last decades due to lack of commercial used has impacted the ecosystem. The native oyster of the Negombo estuary has been the subject of relatively few ecological investigations and no studies to understand various biotic andabiotic characteristics pertaining to the oyster areas. In thepresent study, attempts was made to study the environmental parameters(temperature, salinity, pH, turbidity, dissolved oxygen and nutrients) on growth and distribution of oyster population and whether any contamination of heavy metals and micro-organism in oyster body which prevent of better managing and commercial use of oyster resources for long-term sustainability oyster beds in Negombo estuary.

Objectives

- To quantify the oyster population in the Negombo estuary for developing management options to the health of oyster resources.
- Seasonal variation of water quality in Negombo estuary, including the identification of most likely factors effect on growth and distribution of oyster (*Crassostrea* sp.) population in Negombo estuary.
- Laboratory analysis for contaminants and development of depuration system for ensuring public health and commercial use of oyster population in the Negombo estuary.

Methodology

Sampling frequency

Monthly field trials were conducted to five sampling sites from February to November 2018 to evaluate the seasonal changes of environmental parameters and growth of oysters.

Growth Studies of oysters

Growth study was conducted in five locations, Thaladuwa, Munnakkaraya, Pitipana, Wedikanda and Dungalpitiya in Negombo lagoon, based on environmental parameters. Three plastic cages size of 30x … cm were installed in each location and 15 oysters at a size range of 45-60 mm were stocked in each cage. Growth of each oyster including length, width, height and weight were measured to the nearest millimeter and gram by using Vernier caliper and digital balance (±0.01g). Water quality of adjacent cages and growth were measured monthly.

Analysis of water samples

Water samples were analyzed in accordance with APHA (20^{th} Edition) standard method as followed.

Thermometer is used for measure water temperature (^{0}C), pH is measured by HACH sension 1 portable pH meter, EC - Hanna portable multi range Conductivity meter HI 8733, Salinity is measured by Refractometer, Dissolved Oxygen is measured by Winkler method, Biochemical Oxygen Demand (BOD) - Aqua Lytic BOD sensors, using a method of (APHA, 1998). The chlorophyll a concentration is determined spectrophotometrically after filtering samples through Whatman GF/C filters described by Parsons *et al*. (1984). Turbidity is measured by using portable turbidity meter (Model: Eutech-TN 100) and secchi depth is measured by using secchi disc. Ex-situ analysis will be conducted for the determination of Nitrate -4500 E Cu/Cd Reduction Method (APHA,1998), Nitrite -4500 B Colorimetric method NED/Sulphanilamide (APHA, 1998), Phosphate - 4500 P E Ascorbic acid method (APHA 1998), Ammonia- 4500 NH_3 F Phenate method(APHA, 1998) COD 5220 Open reflux method (APHA,1998).

Study of population and distribution pattern

Quadrat sampling (1x1m) was carried out nearly 255 locations to study distribution and density of oyster population in Negomboestuary (length, width, height and weight of 25% of population in each quadrat were measured).

Transects were established across the estuary and GPS coordinates were used to place markers at all sampling stations. Square-meter (1x1m) sampling was conducted in each locations to assess the stock size of the resources by placed one square-meter iron frame directly on the bottom. In each quadrate, live oysters were counted and 10% of each samples were measured for individual length and weight.Spat, seed and sack size oysters were counted separately. Seed oysters, which are measured less than 75 mm and sack oysters, which measured 75 mm or greater. Estimate standing stocks and yield were expresses as oyster per square meter.

The values of daily weight gain of eachsampling locations were tested for using one-way ANOVA ($p<0.05$ was considered significant). All statistical data analyses were performed using MINITAB software (release 16).Statisticalcorrelation of oysterdensity with the variation in water quality parameters was tested by regression analysis.

Development of depuration systems

Demonstration unit of depuration system will be setup in Kadolkele/RRC with Sand and UV filters.

Results

The highest population density and distribution of oysters in Negombo estuary were observed in shallow areas where associated in islands located in northern part of the estuary. The mean densities (number/ m^2) ranged from 1 - 240/$m^2$from the midpoint of the estuary to the northern shallow area. In addition considerable density of oysters was recorded along the major canals in the estuary. Nearly 57.05% of oysters are seed oysters, which less than 75 mm in length.

In the results of growth study significant ($p<0.05$) higher daily weight gain (0.22±0.01 and 0.16±0.02 g/day) were recorded in Pitipana and Munnakaraya. Survival rate of oysters was not significantly different in sampling location.

Among the physico-chemical parameters, mean salinity was highest (20.43±0.87 ppt) at the Pitipanawhile the lowest salinity of 12.57±1.13ppt was recorded at the Thaladuwa where inflow ofurban waste water canal in to the estuary. Turbidity at each sampling site was significantly different($p<0.05$) ranged from 8.41±0.38 to 18.94±3.82 NTU between the five sampling locations.The estuarine water pH varying between 7.22±0.09 to 8.37±0.38 andConductivity was highest (49.37±7.98 ms/cm) at the Munnakkaraya followed by 48.67±6.02 ms/cm in Thaladuwa.The mean concentration of ammonia ionswashighly variable ranging from 0.09±0.04 to 0.55±0.06 mg/l and significantly different among thesites.

Water salinity, chlorophyll-a and nutrient are positively correlated with oyster growth and turbidity and conductivity showed negative effect.However correlation between oyster growth and salinity was not highly significant ($p > 0.05$) in present study ($R^2 = 0.2557$).

Conclusion

Oyster population's generallyrecovered as salinity levels increased back within theoyster's preferred tolerance range. Due to lower effect of salinity on oyster growth, there might be possibility to spread oyster population in southern part of the estuary where lower salinity has been occurred.At the same time sea water influence by strong wave action in the estuary allowed brackish water as far as 7-8 km from the estuary mouth probably cause the colonization success of the oyster population within the Negombo estuary.

	
1x 1 m Quadrat sampling in the estuary	Installing of oyster cages in natural environment
	
Plastic cages used for growth studies	Measuring of oyster growth

Recommendations

Note: Since results of heavy metal and microorganism contaminant in oyster mussels have not been received by IPHT laboratory, further recommendations are impossible.

Outputs & outcomes

- Recommendations for management of oyster population with proper scientific backgrounds.

- Identification of factors that effect on oyster growth and distribution allowed to make management decision and biodiversity concerns.
- Possibility of commercially use of oyster beds in Negombo estuarythat provides alternative income for fisher families living around the estuary.

Progress: **Financial** 107% **Physical** 85%

Constraints

Delay of purchasing of filters to install depuration system and chemical analysis of IPHT-NARA

Exploration on frequently recorded white spot disease outbreaks and survey on Tilapia Lake Virus in Tilapia fish populations in Anuradhapura District in Sri Lanka

Project No : 3.4.2

Responsible Officer : A.D.W.R.Rajapakshe

Introduction

The current trend towards intensification and commercialization of ornamental fish culture increases the risk of fish diseases. Parasitic infections are very common among the ornamental fish industry. White spot disease is one of the most dangerous parasitic infection among ornamental fish recorded within past few years. Tilapia Lake Virus (TILV) has been disease of emerging as a significant disease of wild Tilapia and farmed tilapia in many countries through several reports.(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 to enter these pathogen. Tilapia pond culture is been practiced mainly western province and different varieties of tilapias have been cultured. Therefore this project was initiated to surveillance, control and management and emergency preparedness on TiLV.

Objectives

To find out better control measures for white spot disease.

Improve the remedial measures for TiLV

Methodologies

Part1

Glass tank setup arranged for the experiments.

Maintain the different fish in tanks for infecting by the parasite.

Part11.TiLv Infections

Selected 06 manmade tanks in Anuradhapura District.(Kalawewa, Balalu wewa, Mahakanadarawa wewa, Nuwara wewa, Nachchaduwa wewa and Rajanganaya wewa)

Monthly visited the tanks and collected 5- 10 fish from each tank. Liver and brains were separated from each fish and preserved in 70% alcohol.

PCR samples were preserved in -80 freezer.

Preserved samples send to Veterinary faculty of Peradeniya for histopathology and VRI, Gannoruwa for PCR analysis.

Results

Couldn't make the infection and isolate the parasite due to lack of infected fish in NARA Hatchery and outside samples.

Part 11.

Clinical observations- Not observed any clinical symptoms and mortality through out the sampling period

According to the histopathological observations samples are negative for the TILV.PCR results pending.

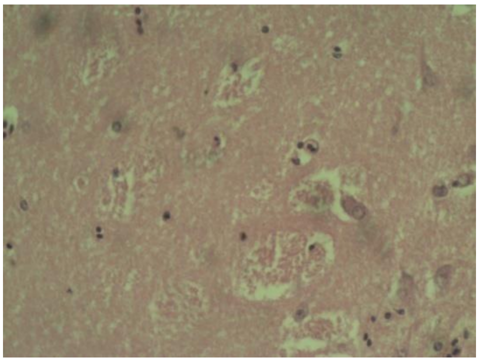


Figure 1 Brain of the tilapia in Kalawewa

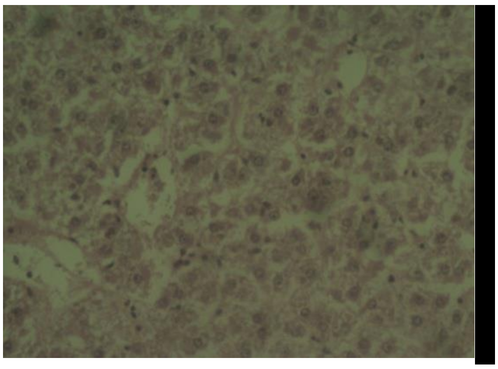
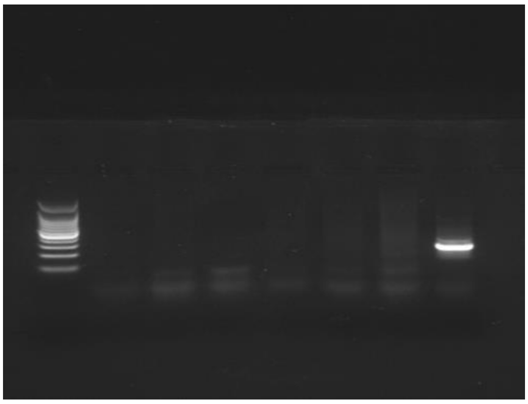


Figure 2 Liver section of the tilapia in



Kalawewa

Fig.3 PCR investigation for 6 tanks

Conclusions

part 1 Experiments still going on to achieve the target.

Recommendations

Part one experiment should continue for having expected results.

For part two surveillance programme should continue for the better results.

Out puts

Histopathological and PCR findings reveal that selected 6 tanks are negative for the TiLV.

Outcomes:

Tilapia Lake Virus free of selected 6 tanks

Progress: Financial: 70% Physical: 80%

Constrains

- Pathogen of white spot disease was not grown in trial experiments. Therefore couldn't continue the experiments.
- Due to the objection of ornamental industry people project has to change in the middle of the year.

Enhancing the effectiveness of the stockings in perennial reservoirs

Project No : 3.5.1

Responsible Officer : G.S.C.Perera , M. Epasinghe

Introduction

Despite the main purpose of the perennial reservoirs in Sri Lanka is agriculture, culture based fisheries under extensive culture has been practicing since more than four decades. As a recent trend fry stage is reared in the cages and fingerlings are released to the reservoirs instead of direct fingerlings stocking to the reservoir because it is economical from the fishers organizations point of view. But several densities are being practiced and also several feed types are being used. The aim of the research was to find out the better stocking density and feed types for Indian Carps.

Katupatha and Siyabalangamuwa reservoirs in Puttlam District were selected for the above program and the respective fisheries societies were also educated in 2017. Moreover purchasing of raw materials and cage preparing were conducted. But it was impossible to stock the fry in the net cages because of the unexpected long run drought which effected for the selected perennial reservoirs.

Therefore , Karawita and Mahauswewa reservoirs in the same District were re selected for the above program in in 2018.

Moreover freshwater prawn stocking in perennial reservoirs have been identified as a higher income generation source. But no sound knowledge of the optimum and economical stocking density. So it is expected to identify the optimum stocking density , analyzing the present and former harvesting data.

Objective

01. Identifying the optimum and economical stocking densities for rearing from fry stage to fingerling stage of *Catla catla* for the net cages under the different water quality parameters.

02**.** Identifying the economical fish feed formulas for the fry stage of *Catla catla*.

03.Identifying the better stoking densities for freshwater prawn..

Methodology

1. 21 net cages of 4.5 m ½ 4.5 m ½ 1.2 m were prepared and 9 net cages will be established in Karawita reservoir and 12 net cages were established in Mahauswewa reservoir.
2. *Catla and Rohu* fry were stocked under 3 stocking densities. (350/m^2,450/m^{2}and 550/m^2.) in the 09 cages established at Karawita reservoir.

(3 treatments and 3 replicates)

Date	Reservoir	No: of total fry	No: of cages	Stocking density (fry/m^2)	Purpose

15.02.2018	Karawita	81000	09	350,450 and 550	Identifying the better stocking densities
05.06.2018	Mahauswewa	84000	12	350	Identifying the better feed formulas
26.06.2018	Karawita	81000	09	350,450 and 550	Identifying the better stocking densities

3. Formulated feed of 40 % crude protein at 10 % of the body weight were given the fry of the above cages.
4. Body weight and total length of the samples were measured.
5. Final data were recorded after 50 days of stocking.
6. Catla fry were stocked in 12 cages in Mahauswewa reservoir at $350/m^2$ stocking density
7. 04 fish feed types were tested .
8. Best economical feed type was identified using the above growth parameters.
9. Water quality parameters were monitored in both reservoirs. (pH, Water Temperature, Alkalinity, Hardness, Conductivity)
10. Stocking densities and production for freshwater prawns were identified referring the log books of the selected reservoirs in Puttlam , Rathnapura and Kurunegala.

No	Reservoir	District	Area (Ha)	No: of PL Stocked in 2017	No: of PL Stocked in 2018	Average stocked PL (PL $ha^{-1}year^{-1}$)	Average production (Kg $ha^{-1}year^{-1}$)
01	Mahauswewa	Puttlam	212	254000	50000	716.98	5.21
02	Udawalawa	Rathnapura	3339	500000	900000	284.50	2.53
03	Chandrikawewea	Rathnapura	269	272000	350000	1156.10	8.32
04	Kibulwanaoya	Kurunegala	238	500000	500000	2100.80	8.72
05	Galgamuwa	Kurunegala	259	400000	100000	965.25	5.58
06	Inginimitiya	Kurunegala	1890	800000	200000	264.55	3.15

07	Deduruoya	Kurunegala	1945	600000	200000	205.65	2.32
08	Hakwatunaoya	Kurunegala	389	800000	200000	1285.30	6.62
09	Akaragalla	Kurunegala	122	300000	DNS	1229.50	3.70
10	Uththala Siyabalangamuwa	Kurunegala	769	900000	400000	845.250	5.52

Results

Cage culture trials

350/m^2 and 450/m^2 were showed the better growth performances respectively for both the species and but the economical point of view , 450/m^2 is the most suitable stocking density for cage culture. But the trial should be repeated under different water qualities to gain unbiased results.

In the second trial, three feed formulas were tested with a controlled formula which is higher in fish meal . In the rest of the treatments fish meal was replaced 50 % of soya protein and 50 % and 100 % meat protein respectively. Control showed the highest growth performance while 100% fish meal replacement by meat meal showed the lowest growth performance. Growth performance decreased dramatically while fish meal was replaced.

Meat meal inclusion is not a suitable option for the formulas for the fry stage of *Catla.* Control and the 50 % soya meal replacement are the better formulas which should be further developed.

Effect of the zooplankton for the growth is an error and better results could be obtained conducting the trial in different reservoirs under different zooplankton levels.

Freshwater prawn stocking

Freshwater prawn stocking densities were obtained 200 Kg/ ha/year to 2000 Kg/ha/year and when the stocking densities were increased production has also increased. 200 Kg/ ha/year to 1000 Kg/ha/year there was a dramatic increase in production. But stocking densities from 1000 Kg/ha/year to 2000 Kg/ha/year production increase is unclear , though there was some production increase obtained. According to the available data , 1000 Kg/ha/year to 2000 Kg/ha/year is suitable for stocking. But island wide data is needed to gain a unbiased decision.

Progress: Financial: Physical: 88%

Aquaculture possibilities in selected floodplain ecosystems of Nilwala river in Matara district

Project No : 3.5.2

Responsible Officer : K.W.R.R.Amaraweera

Introduction

Flood plains are the relatively flat lands adjacent to a body of water, such as a river or stream, that become flooded (inundated with water) when channel capacity is exceeded and overtopping occurs.

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 was inundated by floods. 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.

Thihagoda, Malimbada, Athuraliya, Matara and kamburupitiya are the most 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 (Inundation area map, Nilwala gaga basin in May 2017, Department of irrigation). These divisions consist of considerable resources such as abandoned paddy fields, swamps, Marshes, and minor reservoirs which can be used for aquaculture and fisheries productivity. There is no special project or plan to develop aquaculture and fisheries in Nilwala river basin at the moment but small scale (daily consumption levels) fisheries activities are taken place. Proposed study will result a comprehensive analysis of the full aquaculture and fisheries potential in the area.

Objectives

- To assess aquaculture potential in Nilwala river basin
- To get the maximum utilization from flood plain for aquaculture production
- To assess land use patterns, ecosystem services, aquatic biodiversity in Nilwala river basin
- To engage the community people towards a sustainable production system from which they can improve their socio-economic condition.

Methodology

Study Area

Matara, Thihagoda, Malimbada, Kamburupitiya, and Athiraliya where the most flood inundated DS divisions of Matara District in Nilwala river basin, as a potential economic compensation for the flood affected local community. (First year Matara & Thihagoda Ds Disions)

1) A preminary survey will be carried out to demarcate flood plain areas of Nilwala river basin.
2) Suitable sampling locations will be selected for collecting environment data

According to the flood, water availability and rainfall data (Department of Irrigation)

Data collection in suitable sampling location

(a) Water quality parameters - T, pH, DO, salinity, Turbidity, Nitrate, Phosphate, chlorophyll a, Heavy metals- Cd, Pb, As, Hg
(b) soil quality- soil type, pH
(c) Survey of land use pattern
(d) Socio economic status of vulnerable families

3) Carryout experimental aquaculture practices in selected sites

- Site survey was carried out for selecting suitable mud ponds for fish culture help of Govi Jana Seva department and NAQDA extension office – Matara
- According to the water quality data two sites were selected

Site-A mud ponds in abandoned paddy field (Nadugala Thihagoda DS division)

Site –B mud pond in marsh area/ *Alkuburu* (Diyagaha-west Matara DS Division)

- Tilapia was selected as suitable fish species for mud ponds. (abundance of species composition, demand of local market easy to handling).
- Purchased GIFT tilapia advanced fingerlings from NAQDA – Udawalawa and stocked in mud ponds. (Stocking rate 3 individuals / m^2 , initial weight 32.1 g)
- Feeding formulated fish feed 1 to 2 % of the total body weight daily.
- Recorded water quality parameters and growth performance once a month.
- Conducted socio-economic survey vulnerable families in Nadugala (Thihagoda DS division) & Diyagaha-west (Matara DS Division).

Results

Feed ingredients and compositions used for the formulated feed

Ingredients	Weight / kg

Fish meal	**2.5**
Meat & Meat bone meal	**2.0**
Soybean meal	**1.0**
Maize meal	**1.0**
Rice brand	**1.0**
Oil cake *(punnakku)*	**1.0**
Wheat flour	**1.0**
Vitamin mixture	**0.5**
Total	**10**

Feed cost Rs 115/= per kg & Crude protein content 35.2

quality parameters ranges in Mud ponds site A & B

Parameter	**A 1**	**A 2**	**A 3**	**B 1**	**B 2**	**B 3**
Water tempera (^{0} C)	28 – 29.5	28 – 29.5	28 - 29	28 – 29.5	28 - 30	28 - 30
Water pH	6.36 – 7.46	6.65 – 7.42	6.71 – 7.14	6.80 – 7.06	6.91 – 7.61	6.95 – 7.88
Dissolved Oxygen(mg/L)	4.80 – 6.52	4.80 – 6.48	4.95 – 5.48	4.86 – 5.80	4.91 – 5.95	4.86 – 5.90
Toxic ammonia (mg/L)	0.02-0.03	0.02-0.33	0.01-0.03	0.02-0.03	0.02-0.3	0.02-0.03
Nitrate(mg/L)	0.01 – 0.04	0.01 – 0.04.	0.01 – 0.04	0.01-0.03	0.01-0.04	0 – 0.03

Nitrite (mg/L)	0.001–0.005	0.001-0.005	0.001-0.005	0.004-0.029	0.004-0.29	0.004-0.29
Phosphate (mg/L)	0.5 – 0.6	0.04 – 0.84	0.04-0.79	0.42- 0.79	0.04-0.62	0.05- 1.20
Alkalinity (mg/L)	30-127	57-140	83-134	22-150	13-118	20-168
Hardness (mg/L)	184-240	198-268	171-256	196-260	182-247	198-260
Turbidity (NTU)	8.3-22.5	8.0-36.2	8.0-13.7	17.9-36.2	23.1-52.0	23.7-38.0

Soil samples in Mud pond site A & B

	A 1	**A 2**	**A 3**	**B 1**	**B 2**	**B 3**
Soil pH	6.47	6.56	6.74	6.63	6.80	6.72
Soil type	Clay loam	Clay loam	Clay loam	silty clay loam	Silty clay loam	Silty clay loam

Growth performance after 150 days culture period

	A 1	**A 2**	**A 3**	**B 1**	**B 2**	**B 3**
Initial weight (g)	32.1	32.1	32.1	32.1	32.1	32.1
Final weight (g)	282.5	283.3	283.8	282.8	283.9	283.1
Growth rate (g/day)	1.66	1.67	1.68	1.68	1.68	1.67

Socio-economic survey

According to the socio-economic survey vulnerable families in Nadugala (Thihagoda DS division) & Diyagaha-west (Matara DS Division) more than 60% paddy lands were banded due to the floods and failures of Nilwala scheme. It was recorded that vulnerable families have less than 5% knowledge or experience in fish keeping. Vulnerable families in Diyagaha-west in Matara DS Division use abandoned paddy field for farming *Gotu kola* (Centella asiatica).

Conclusion

Thihagoda, Malimbada, Athuraliya, Matara and Kamburupitiya are the most 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 in **s**elected sites in Nilwala river basinSite-A mud ponds in abandoned paddy field (Nadugala Thihagoda DS division) and Site –B mud pond in marsh area/ *Alkuburu* (Diyagaha-west Matara DS Division) are suitable for fish culture development.

GIFT Tilapia cultured in **s**elected sites in Nilwala river basinSite-A mud ponds in abandoned paddy field (Nadugala Thihagoda DS division) and Site –B mud pond in marsh area/ *Alkuburu* (Diyagaha-west Matara DS Division) showed satisfactory growth performance.

Recommendations

The formulated feed used for the fish culture in mud ponds showed satisfactory fish growth performance and cheap than the commercial feeds can be recommended for Tilapia fish culture

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

Out put

- ✓ Identifying flood affected areas in Nilwala river basin
- ✓ Identifying suitable sites for aqua culture in flood plain
- ✓ Development of flood plain aqua culture

Out comes:

- ✓ Alternative livelihood development
- ✓ Utilization of abundant flood lands
- ✓ Maximizing fish production through aqua culture

Progress: financial 60% Physical 65%

Constraints

Lack of vehicle for field works

Permission was issued in May 2018 for the project and so the time was not enough to complete the project activities.

Publications

Abstracts presented /Conference Proceedings:

- **Amaraweera K.W.R.R**. Jayasiri H.B. and **Pahalawattaarachchi V**. 2018. An attempt on selection of prospective aquaculture sites based on selected biophysical attributes in Rekawa lagoon, Southern Sri Lanka. International Scientific Sessions- 2018, National Aquatic Resources Research and Development Agency Colombo15, Sri Lanka
- Athukorala D. A * and R. Weerasingha **(2018) Development of formulated diets for culture of Sea bass (*Lates calcarifer*, Bloch) juveniles in floating net cages. *Proceedings of the International Scientific sessions of National Aquatic Resources Research and Development Agency (NARA) 2018*, 25th-26th July 2018; Auditorium of National Aquatic Resource Research and Development Agency, Colombo 15, Sri Lanka. pp.8.**
- Dissanayake,D.T.A.S.P,S.C.Jayamanne**, G.H.Galahitigama and V.Pahalawattaarachchi** (2018) Optimization of conditions for release of swamers in Ulva lactuca under Sri Lankan conditions**.**Sri Lanka. *SLCARP International Agricultural Research Symposium 2018,* 13th-14th August 2018; Taj Samudra Hotel, Colombo, Sri Lanka.**Pp 115.**
- Harshani,W.M.S., V. **Pahalawattaarachchi,** K.Radampola, S.S. Herath (2018) Effect of fertilization level on the growth performance of micro-propagated *Cryptocoryne wendtii* (Water Trumpet) *SLCARP International Agricultural Research Symposium 2018,* 13th-14th August 2018; Taj Samudra Hotel, Colombo, Sri Lanka, **Pp120.**
- **Jayanatha,J.S.,** W.K. Suwandahannadi**, V.Pahalawattaarachchi** and H.M.P.Kithsiri 2018 Plant diversity and structural dynamics of mangroves in Rekawa lagoon, Sri Lanka. *SLCARP International Agricultural Research Symposium 2018,* 13th-14th August 2018; Taj Samudra Hotel, Colombo, Sri Lanka.**Pp 111.**
- Makavita, W.A.K.D. Madurangika, **D.M.S.Sugeeshwari, V.Pahalawattaarachchi** (2018) Sterilization procedure for Java Fern *(Microsorium pterous).* V.*International Scientific Session .2018*, National Aquatic Resources Research and Development Agency, P 22.
- **Mallawaarachchi J., R.R.A.R. Shirantha** and **V. Pahalawattaarachchi** (2018). Recent study on *Hippocampus* (Syngnathidae) diversity in the western and north-western coasts of Sri Lanka: remarks on extraordinary species diversity. In: *The proceeding of the International Scientific Sessions of NARA 2018, Colombo.* Abs. 41p.
- **Medagedara C.B, H. Galahitigama, S. Corea**& M.S.M Fahim (2018). Performance of newly developed culture basket types for suspended rack culture of edible *Pernaperna* (brown mussels) in the Puttalam estuary, Sri Lanka. Proceeding of International Scientific Session of National Aquatic Resources Research and Development Agency (NARA) July, 25th& 26th 2018. Sri Lanka.
- Nanayakkara, R. P., **Shirantha, R. R.** A. R. and D. K.K. Gunarathna (2018). Cascade agro bio-diversity for food security; case study in northwestern Sri Lanka. In: *The proceeding of the “WINC 2018” International Conference of Wayamba University of Sri Lanka, Kuliyaitiya.* Abs. 43p

- Nishanthan G, **P. A. D. A. Kumara**, M. D. S. T. de Croos, D. V. P. Prasada & D. C. T. Dissanayake (2018). Effects of processing on proximate and fatty acid compositions of six commercial sea cucumber species of Sri Lanka. *Journal of Food Science and Technology*, 55:1933-1941, DOI 10.1007/s13197-018-3111-4.

- **Pahalawattaarachchi V**. *, D. D. G. L. Dahanayaka, **P. A. D. Ajith Kumara and R. Weerasingha** (2018) Variation in growth rates and Carrageenan properties of *Kappaphycus alvarezii* at commercial culture sites in Killinochchi District. *SLCARP International Agricultural Research Symposium 2018,* 13th-14th August 2018; Taj samudra Hotel, Colombo, Sri Lanka.**Pp 116.**
- **Pahalawattaarachchi, V, D.D.G.L. Dahanayaka(2018)** Abundance distribution and diversity of seagrass species in Gulf of Mannar , Palk Bay and Palk strait of Sri Lanka, Proceedings of the Annual Session, Wild Lanka.
- Parakrama, M. G. I. S**.** , 2018 **"Field trial for evaluating the acceptance of formulated feed for fattening of mud crab *Scylla serrata"* abstract published in the NARA annual symposium**
- **Sugeeshwari D.M.S, V.Pahalavattaarachchi**, D.Madurangika, H. Rupika, R.Samaraweera ,2018 Development of *in vitro* Propagation method for *Cryptocoryne wendtii ,. International Agricultural Research Symposium*, 2018. Sri Lanka Counsil for Agricultural Research Policy. P 117.
- **Perera, G.S.C., D.M.S.Sugeeshwari**, N.W.J.P.Kumara, A.J.Jayathissa and M.Indika 2018 Suitability and safety of the protein based ingredients for economical feed production for Asian Sea Bass (*Lates calcarifer)* in Sri Lanka.**-** Proceedings of 5th International Conference on Fisheries and Aquaculture ,23rd to 24th August 2018, Colombo.
- **Weerasingha,R.** 2018. Variations on growth rate and carageenan properties of *Kappaphycus alverzii* at commercial culture site in Killinochchi district p.116. SLCARP International Agricultural Research Symposium 2018 Sri Lanka Council for Agricultural research Policy 13-14 August 2018, Colombo.
- Weerasingha R.**, N. Wicramarachchi, T. Somasundaramand R.M.P. Dhanushka (2018) Use of chitosan as an immunostimulant in juvenile tiger shrimp (*Peneous monodon*) feeds to resist viral diseases. *SLCARP International Agricultural Research Symposium 2018,* 13th-14th August 2018; Colombo, Sri Lanka.Pp 118.**
- **Weerasingha, R.,** M. S. M. Fahim, **P. A. D. Ajith Kumara**, D.R. Kumarasingha and C. Medagedara (2018) Partial replacement of local fish meal by brewers' yeast (*Saccharomyces cerevisiae*) in the diets of Sea cucumber (*Holothuria scabra*) juveniles. *Proceedings of the InternationalScientific sessions of National Aquatic Resources Research and Development Agency (NARA) 2018,* 25th-26th July 2018; Auditorium of National Aquatic Resource Research and Development Agency, Colombo 15, Sri Lanka. **pp.10.**

Monographs

Shirantha, R.R.A.R. (2018). Endangered freshwater of South Asian Region (Giri, S.S. Ed) South Asian Agriculture Regional Cooperation, (SARRC), Dhakah, Bangladesh.

Pahalawattaarachchi, V. (2018) Best Management Practices in Aquaculture in Sri Lanka, Chap 3, 35p (In Best Management Practices in Aquaculture, Capacity Building and Policy Management (Giri, S.S. Ed) ,SAARC Agriculture Center, Dhaka, Bangaladesh, 154p.

Athukorala D. A. (2018). Farm made feeds for aquaculture in Sri Lanka. In: Shiba Shankar Giri (ed.) Farm-made Aquafeeds: Opportunities, Challenges and Policy Intervention. Agriculture Centre (SAC), South Asian Association for Regional Cooperation, BARC Campus, Farmgate, New Airport Road, Dhaka-1215, Bangladesh.

Journal article

Ramani Shirantha (2018). Living water heritage in Heen Ganga in Knuckles Conservation Forest, *Vanajeevi*, A journal of Department of Wildlife Conservation, Sri Lanka.

Poster

Rajapakshe, A.D.W.R., Thanthrige, R, Adhikari,A.M.A.N. and Epasinghe,E.D.M.2018 Exploration on Prevailing Diseases of Cage Cultured Asian Sea bass (*Lates calcarifer*) Bloch in Western and North Western Provinces in Sri Lanka. in 5th International Conference on Fisheries and Aquaculture on 23rd -24th August 2018 in Taj Samudra hotel , Colombo, Sri Lanka.

Report/Letters prepared:

- On the request made by the Director General, Department of Fisheries and Aquatic Resources Development (DFARD) on “Collection of under size sea cucumber juveniles by fishermen to sell for fattening in Northern Province”, I have prepared and submitted NARA observations on 14.08.2018.
- On the request made by the Director (Industrial), Department of Fisheries and Aquatic Resources Development (DFARD) on 21.08.2018 under the theme of “Potential for re-stocking tilapia in to some selected lagoons to enhance fisheries production under theirs Lagoon Development Project”, I have submitted comprehensive report on 29.08.2018.
- NARA observations were submitted to Department of Wildlife Conservation on 10.08.2018 regarding their request on prepare a proposal to the list sea cucumber of the families Holothuridae and Stiochopodidae in Appendix ii of the CITIES Convention.
- On the request made by the Director General & Head/IARAD, visited fish farming site at Nilawala basin area, Matara and gave a comprehensive report on feasibility of tilapia farming there on 18.10.2018.

- Interim and final reports on Environment Assessment Study (EAS) of Vedithalahtive Nature Reserve, Mannar (September, 2018) submitted to Department of Wildlife Conservation.
- Report on fish fingerling cage culture in Randenigala reservoir with recommendation (June 2018) submitted to NAQDA.

- Report of preliminary survey on fish breeding sites in Senanayake Samudraya reservoir (December, 2108) submitted to NAQDA.
- Report of the population of *Systomus martenstyni* in Loggala Oya river at Meegahakiula, Badulla (July, 2018) submitted to CEA.
- Report of the population of *Systomus asoka* in Kitulgala mini Hydro power project area at Kitulgala (July, 2018) submitted to CEA.
- Two technical reports on water pollution in Kandy Lake and surrounding area submitted to Urban Development Authority of Central province.
- Additional information of *Labeo fisheri* in the Mahaweli river basin submitted to IUCN.

External Supervision:

1. Adikari A.M.S.S., 2018. Polyculture of sea cucumber, (*Holothuria scabra),*mangrove oyster (*Crassostrea spp*.) and seaweed (*Gracilaria edulis*) in Puttalam lagoon: potential for integrated multi-tropic aquaculture (Thesis in progress). Department of Aquaculture and Aquatic Resources Management University College of Anuradhapura, University of Vocational Technology.

2. P.S.Jayasinghe – Evaluation of quality characteristics and utilization of locally available seaweeds species of industrial potential, PhD thesis, University of Sri Jayawardanapura

Extension work

Awareness, Trainings & Workshops conducted

- Practical work shop on” Fish breeding, culture and fish feed processing” for the under graduate students of Open University Sri Lanka.
- Graduate training from Uwawellassa University has been trained for initiating biofloc in glass tank system. In year 2019, planned to initiate guppy grow out system with export oriented guppy farm.
- Annual ten day training of Ornamental fish Breeding, Culture and Management including induced breeding of ornamental fish species was done for 31 persons.
- Three day training of ornamental fish culture and management for 22 development officers of North Western provincial council.
- Five day training of ornamental fish culture and management for 20 ornamental fish farmers according to the request of North Western provincial council.
- Two day training of ornamental fish culture and management for 20 persons in Industrial Development Authority of Western provincial council.

- Two day training course on Livelihood development of ornamental fish farmers in Colombo, Kalutara and Gampaha districts through breeding high value ornamental fish species using induced breeding techniques (MFAR-02 funded project).
- Information and instructions were provided to the ornamental fish farmers who engaged with fish induced breeding on their request.
- People who came to NARA for gathering information and expecting consultancies regarding ornamental fish breeding, were consulted and showed the correct path to them for responsible aquaculture practices.
- Resource person for the field visit programme on Ornamental fish diseases 0n 09^{h} May 2018 at the NARA.
- Tested disease fish samples from outside and given the therapy and precautionary measures. Outside
- Trainings for the Ministry funded Aquatic Plant Culture project, beneficiaries for Aquatic Plant culture.
- Training of student of Ocean University on Plant Tissue Culture.
- Awareness of agriculture assistant on importance of using abundant lands for Aqua culture at Irrigation office Matara (*govi kamituwa*)
- Three community-based sea cucumber farming projects have been carried out providing technical *know–how* to fisher-folks in Puttalam district.
- Three residential breeding programmes were conducted for University Vocational and Technical College (UNIVOTEC**)** Anuradhapura (31 January), University students from Ruhuna (08 May),& Jayewardenepura (July 27). They were given first hand on experience on different aspects of sea cucumber mariculture *viz* broodstock handling, spawning tank preparation, induced breeding, egg collection, incubation, preparation of larval rearing facility, live feed culture, nursery tank preparation and feeding.
- A Field class was conducted for under graduate students from University Vocational and Technical College (UNIVOTEC) Rathmalana in October 2018
- Training workshops on seaweed culture in three different community groups in Polhena, Unakuruwa and Kiranchi on 2018 December 05th.
- Awareness and demonstration program for the shrimp farmers of Society, Chilaw on extruded feed preparation using the extruder at Panapitiya RRC
- One day workshop for the ornamental fish farmers on fish feed production at Aquaculture Development Center, Pitipana, Negombo conducted by Ministry of Agriculture, Western Province.
- A lecture series conducted on "Fisheries and Aquaculture in Sri Lanka' for Naval officers at Naval Base academy, Trincomalee.
- Lecture on Freshwater Biodiversity representing Aqua Club Education program of NARA for 55 schools.

Workshops and Training (local Attended:

- Participated to the "Ecosystem survey in Sri Lankan coastal waters using R/V Dr. Fridtjof Nansen Cruise" from 23 June to16 July 2018.
- Attended to the workshop on "Investor Forum 2018" conducted by National Aquaculture Development Authority (NAQDA)on 20.08.2018 at Water's Edge Baththaramulla.
- Attended to the workshop on "Carrying Capacity Assessment of Lagoons" from 01st to 05th October 2018, jointly organized by Institute of Marine Research (IMR) Norway and NARA in Negombo.
- Attended to the workshop on "Wilpattu National Park Management Plan 2019-2024" on 26.11.2018, jointly conducted by Department of Wildlife Conservation and German Cooperation at Water's Edge in Baththaramulla.
- Validation of Biodiversity Profile of Sixth National Report of Sri Lanka to the United Nation Convention on Biological Diversity organized by Bio Diversity Secretariat, 22-23 October 2018.
- Validation workshop of Biodiversity Finance Plan under Biodiversity Finance Initiative project of UNDP organized by Bio Diversity Secretariat.
- Finalizing and validation of prepared sustainable harvesting guidelines and improved management practices organized by Biodiversity Adaptation to Climate Change project of Department of Agriculture, 4-5 December, 2018.

International meetings/ workshops/training

*******Only one opportunity got the IARAD division for attending 04 days foreign workshop and no trainings were got in 2018.

- International workshops on FAO/China Intensive Training on Tilapia Lake Virus in Sun Yat _Sen University Guangzhou, China from 18th -24th June 2018**.**

External Projects conducted:

- On the request made by the National Aquaculture Development Authority (NAQDA), feasibility study on "Establishment of sea cucumber export village in Poonakary, Killinochchi district" had been carried out for 6 month period and a report with maps submitted on 08.10.2018.
- GEF funded project on Ensuring seagrass ecosystem values are incorporated with coastal area planning in Sri Lanka
- Desktop study on Living resources in coastal region around Sri Lanka, for Petroliam Resources Development Survey'
- Environment Assessment Study (EAS) of Vedithalahtive Nature Reserve, Mannar for Department of Wildlife Conservation.

Meetings Attended:

- Meeting with Foreign Investor's team at 02.03.2018 at Ministry of Fisheries and Aquatic Resources Development.
- Discussion on Northern Province Fisheries Projects on 21.03.2018 at Ministry of Fisheries and Aquatic Resources Development.
- District fisheries meeting held at District Secretariat Puttlam
- Regional Coordinating committee held at Divisional secretariat Kalpitiya
- District fisheries meeting held at District Secretariat Puttlam
- AMR meeting at NAQDA to reduce antibiotic use in aquaculture
- Attended pearl oyster culture meeting at BOI
- Attended entrepreneur facilitation meeting at MOFAR
- Attended the workshop on Aquatic Resources sector for 2030 organized by SLCARP on 18^{th} Sep.2018.
- Preliminary consultation meeting on monitoring Antimicrobial Resistance on 11^{th} Dec.2018 organized by NAQDA.

Others (event organized/held position, responsibilities etc):

- Arranged and facilitated the visit of International consultant Prof. Jiasong Zhang who provides technical assistance for designing Multi-functional marine hatchery for NARA during 20-25 July 2018.
- On the request made by the Director (Industrial), Department of Fisheries and Aquatic Resources Development (DFARD) on 25.07.2018 to seeking NARA technical guidance to implement aquaculture projects in selected lagoons, the necessary assistance and guidance were given.
- Handling the file to acquisition of land to NARA to establish a multi-species marine hatchery at Kudawa, Kalpitiya area.
- Served as a Technical Evaluation Committee (TEC) member of net, rope and fiber materials purchase to NARA.
- Conduct demonstrations about Sea Cucumber culture, Oyster culture and Sea weed culture for undergraduates of Ruhuna University of Sri Lanka at RRC premises
- Conduct demonstrations about Sea Cucumber culture, Oyster culture and Sea weed culture for undergraduates of University college Anuradhapura at RRC premises
- Conduct demonstrations about Sea Cucumber culture, Oyster culture and Sea weed culture and sea food processing for undergraduates of UNIVOTEC Rathmalana at RRC premises

- Act as a taskforce member of the Ornamental fish culture industry organized by MOFARD on 30.08.2018,13.09.2018
- The koi carp fingerlings were supplied continuously to the farmers in this area. Support to the requested farmers to initiate farming activities.

Presentations made;

- Presentation made to IUCN on the results of *Labeo fisheri* survey
- Presentation on *Labeo fisheri* in Mahaweli river system made for fish expert review panel appointed by DWC.
- Results of Environment Assessment Study of Wedithalathive Nature Reserve in Mannar, presented to the NARA Govern Board, December 2018.

Technical committee of different organizations as a NARA representative

- Monthly Aquaculture Technical Committee Meetings of NAQDA) every month as NARA representative.
- Environmental approval committee of CEA /Restoration of Mahaweli River left bank and protection of Thapowanaramaya temple at Getambe.
- Field infection visit to Puttalam lagoon under Lagoon Development Project of the Department of Fisheries and Aquatic Resources Development, June, 2018.
- National Biodiversity Strategic Action Plan of Bio Diversity Secretariat of Ministry of Environment and Mahaweli Development.
- Technical committee/Climate change adaptation project of Ministry of Environment and Mahaweli Development.

Worked as resource person:

Training workshop on Invasive Alien Species (IAS) Control and Management conducted for Forest Officers of the Central Province as per request of Forest Conservation Department, 18-20 September 2018.

Initial biodiversity survey in Adam’s Bridge National Park, as per request of Department of Wildlife Conservation, 29-30 November,

Industrial training / external undergraduate supervision

Institute/University	Number of students trained
University of vocational studies	20
Ocean University	2
University of Kelaniya	4
University of Jaffna	1
University of Peradeniya	6
Universiy of Moratuwa	6
University of Uvawellassa	4
University of Ruhuna	6

Fishing Technology Division

FTD

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

Project No : 1.4

Officers responsible : N.B.P.Punyadewa

Introduction

Fish are highly migratory species. Fishes are associate with floating objects in nearly all oceans. Fish also gather around fish aggregating devices (FADS), floating object deployed to aggregate fish species and thereby to enhance the fish production of especially artisanal fishery. Some other countries have deployed floating objects for the commercial fishery too. Deployment of Fish Aggregating Devices (FADs), Fish Enhancing Devices (Submerge FEDs) to enhance the fish production in coastal water. In the open ocean many species, including tunas, associate withobjects floating or submerged structures. FADs can be located quickly, minimizing search time and operating costs, and they can be can fished on at dawn.

A Fish Aggregating Device (FAD) is basically one of three types:

— placed on the bottom

— Anchored or drifting and with the attracting structure on or near the water surface

— Anchored and with the attracting structure in the submerged in water column

The three types function in different ways: Type (a) FADs (placed on the bottom) serve mainly as shelters and hiding places and also as an improved/expanded habitat for fish larvae and as feeding grounds for larger fish; Type (b) surface or near-surface FADs provide shade and shelter and have, in common with Type (c), the function of a complex feeding—"ground". The mechanism is understood to be such that when the FAD is first put in the water, bacteria and micro-algae as well as larger algae start growing on it.

These house a large numberof smaller animals and together attract smaller species of pelagic fishes that feed on them.The smaller fish will in turn attract individuals of larger species feeding on the smaller ones. Under this programme submerged FADS were deployed in Sinnapaduwa and Weligama area of Sri Lanka and trial fishing were conducted to evaluate the fish aggregation in Sinnapauwa area.

Objectives

- Enhance the capture fishery & Fish production
- Enhance the livelihood of coastal fishing community
- Providing research opportunities for testing ecological processes

Methodology

Study area

Project was conducted in two area as Sinnapaduwa and Weligama in calm sea condition. During 1st quarter of the year 2018 projects work conducted in Sinnapaduwa area. And After 2nd.3rd and 4th quarters project works were conducted in Weligama area .

Construction and deployment of submerged fish aggregating devices

Submerged Fish aggregating devices (FEDs) were constructed using iron bars (6mm) in a spherical shape. Those FEDs were covered by polyethylene net with ½" eye size. An object which used for the keep floating in the water column was manufactured using reinforced fiber and that buoy was attached to the top of the submerged fad (FEDs). These submerged fads were deployed in selected locations in both Sinnapaduwa and Weligama by use concrete anchors. Fishing community was participated to the deployment activities.

During the first quarter of 2018, 32 submerged FADs were deployed in Sinnapaduwa area and 5 deployed in Weligama area. During the second quarter of the year 5 submerged fads were deployed Weligama sea area. No any of Fads was deployed in 3rd quarter due to bad sea condition of the year and 8 structures were deployed in 4th quarter of the year in Weligama area. Totally 50 FEDs were deployed as 32 and 18 in Sinnapaduwa and Wligama respectively.

Data collection

During the year 2018, 3 trial fishing programs were conducted around the deployed submerged FADs in Sinnapaduwa area to determine the fish aggregation around FADs.

Visual observation method also used to determine the composition of fish around the Fads and rough quantification of fish aggregation. Research diver equipped with underwater camera was used to determine the fish identification around the structures.

Results and Observation

After the deployment visual observation method was applied for the identification of aggregated fish species around the submerged FADs. Following fish species were identified from the visual observation survey.

Malabar Grouper- *Epinephelus malabaricus* , Coral hinder - *Ceplalophalis miniata* , Sweet lips -*Plectorhinchus spp* Rainbow runners- *Elagatis bipinnulata*, Indian fin scard - *Decapterus russelli, Trigger fish* - Canthidermis maculate, Long nose trevally - Carangoides chrysophrys, Sphyraena jello : Pickhandle barracuda were observed during visual survey in high quantities. Same as some other species also record in on and off in small quintiles.

Three trial fishing were conducted around the deployed Fads and following results were obtained.

Several species were contained in the harvest and following species shows highest quantities.

Experimental Trial Fishing	**Eye Estimated Catch (Kg)** **(By Diverse)**	**Actual Catch (Kg)**						
		Carangidae sp	*Sphyraena obtusata* (Barracuda)	Lutjanidae (Snappers)	Epinephelidae sp (Goupers)	Plectorhinchus ceylonensis (Sri Lanka sweetlips)	Catch (kg)	Value (LKR) (Average price of fish 350LKR per kilogram)
Trial 01 (2018/4/05)	3000 – 3500 Kg	22	1582	32	39	62	1737	607950.00
Trial 02 (2018/6/28)	2000 – 2200 Kg	212	119	0	0	881	1212	424200.00
Trial 03 (2018/9/26)	4500 – 5000 Kg	1872	12	4	7	81	1976	691600.00

Table: 01 Illustrate the highest quantity recorded fish species during the trial fishing activities in Sinnapaduwa area year 2018 and monetary value of fish considering the average retail price.

According the above results Carangid sp, Barracuda and Sri Lanka sweetlips were contributed significantly to the total catch of the fishing practice.

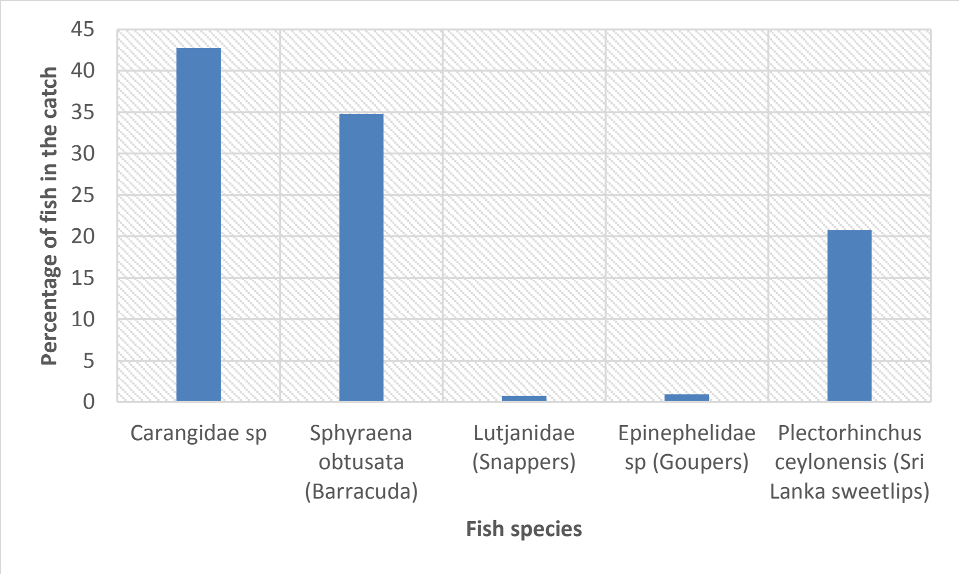


Figure 01: Percentage of fish species contributed to the totat fish catch during the trial fishing practices in Sinnapaduwa area.

Cost benefit analysis

For the above project capital allocation was 1.6 million. Average value of total fish caught from fishing trials conducted by NARA was more than 1.4 million. Therefore the income is greater than the cost of the project. Not only the but also fishing community have been fishing in the location of FADs. They also get income by fishing around the FADs. Therefore the true value of deployed FADs is greater than the total cost of the project. Therefore deployment of submerged FADs and FEDs are cost effective method to enhance the coastal fishery.

Discussion and conclusion

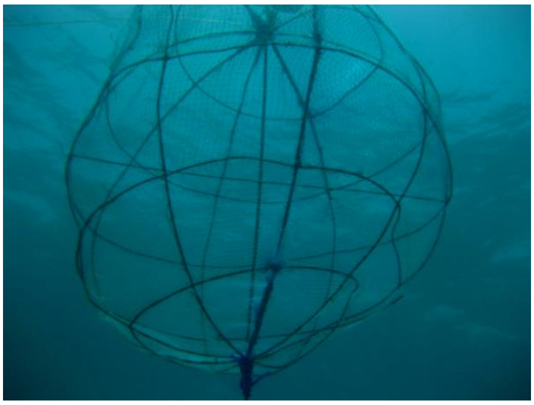
These types of fish aggregating devices deployed first time in Sri Lanka in Sinnapaduwa area to enhance the fishy and fish catching rate of artisanal fishermen. Because artisanal fisherman does not have good power to go technology to fishing in deep sea and general they are conducting one day fishing activities. Most of they are starting fishing at night and bring the catch to the land in the morning. By deploying this type of submerged fish aggregating device, fisherman does not have to waste their time to find the fishing ground. Indirectly it reduces the fuel cost for the fisherman. Enhancing of fish using submerged fish aggregating devices is a long term process. Because it takes time to create new habitat around the FADs and to create food webs around the FADs. However when create food webs those are long last until fads live in the sea.

These submerged FADs also have several advantages than floating FADs, because it encounters less number of harmful events from floating debris of the sea and fishing boat and vessels. Because these Fads are lie near the the sea floor.

Generally there is an initial cost for the manufacturing process and operation cost. But these costs can be recovered by fishing around the devices. Last year research team of FTD/ NARA conducted trial fishing activities around the devices and monetary value of harvested fish was greater than the cost of the project. Not only NARA, but also fisherman fishing around the aggregating devices. So the actual value of the FADs is greater than two, three times of the cost of the project. Also fisherman can get benefits from these FADs several year continuously.

Therefore more fish aggregating device recommended to deploy to enhance the coastal fishery of country.

Color Plates : Construction, deployment and experimental fishing











Habitat enhancement for "Big Fin Reef Squid's spawners" (*Sepioteuthis lessoniana*) at their own breeding ground.

Project No : 1.1.2

Officers responsible : N.B.P.Punyadewa

Introduction

One of the major environmental issues is habitat destruction by several anthropogenic and natural disasters in marine sector. It affects adversely to the production of the marine sector especially in marine fisheries. Climate change, Volcanoes in the sea (not in Sri Lanka), ocean acidification are the major natural events which are increased environmental problem in sea. Not only natural events but anthropogenic activities also damage the marine ecosystem severely. Use of destructive fishing practices, damages of coral reef by boat activities, and dispose of plastic debris in to sea are the top level effects which affect the health of marine environment. Fisherman uses various kinds of destructive fishing gears, explosive and sometime use toxic compounds to catch fish and other species from the sea. These are negatively affected to the health of ecosystem. By enhancing of habitat artificially, these matters can overcome up to significant level.

Sri Lankan fisherman harvests various fish species. They have different economic value. While some species are over harvesting some are still in underutilization level. Some species harvest for human consumption and some are harvest for ornamental purpose. *Sepiothetus lessoniana* (big fin reef squid) is one of squid species harvested in several area in Sri Lanka but in underutilization condition. It has high economic value in foreign market.

Therefore by conducting this project artificial habitats were introduced to the squids and other marine organisms. Habitat enhancement for “Big Fin Reef Squid’s spawners” (Sepioteuthis lessoniana) at their own breeding ground project was conducted during year 2018, in Weligama and Sinnapaduwa fishing area with community participation. Currently marine habitats of the Sri Lanka coastal area are depleting due to human and natural events. Some of fisherman use destructive fishing methods to catch more fish, waste oil from fishing boats, ocean acidification, changes of ocean currents are the kind of reasons to deplete the marine habitat and marine fish stock around Sri Lanka. Therefore fish and other marine organisms have lost their habitat for the reproduction, rearing juveniles and feeding. Thus fish stock is reducing and fish migrate away from coastal area of Sri Lanka.

Big Fin reef squids (***Sepioteuthis lessoniana***) are an economically valuable species and underutilized resource. It has high economic value in the export market. As well as it is a good aquarium organism for marine aquarium. Due to the habitat destruction squids have lost places for spawning process. Sometime squids laying them eggs even on the fishing net. They have lost substrate and protective environment to egg laying process. By conducting this project it enhanced the marine habitat for all of marine organisms while providing substrate to the squid’s egg laying process. At present progress of squid egg laying ability on these structures were monitored by the divers.

Objective

- Enhancing habitat for fish and other marine organisms
- Providing breeding area for squids and other marine biota and protection for juveniles
- Restoring, mitigating or offsetting damage to or loss of natural reefs or habitats
- Supporting aquaculture or marine ranching

Material and method

Site selection

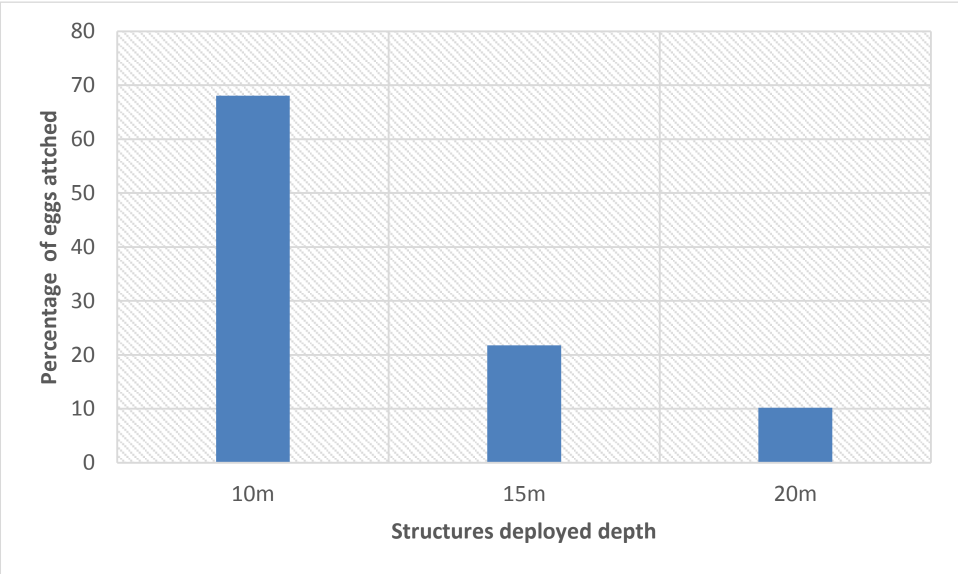
For enhance marine habitat and support to the spawning process of the big fin reef squids “Sepioteuthis lessoniana”, structures were deployed at selected area in both Sinnapaduwa and Weligama with participation of fisherman.

Construction and deployment

Conical shape artificial structures were building using 10mm iron bars and applied anticorrosive paint for protection. During the project period artificial structures were deployed at three depth 11m, 15m and 20m depth, under the calm sea condition. In Sinnapaduwa area sea area 12 new egg laying structures were deployed during the first quarter of the year while 17 new structures were deployed at Weligama sea area during the rest of the year. Project work at Sinnapaduwa sea area were interrupted by the South West Monsoon (May to September).

Results

Data of squid's egg attachment data were collected and number and type of attached squid's eggs were recorded. At the same time aggregated fish species around the structures were monitored.



After the deployment of structures squids started to lay their eggs on structures and still continuing. When consider the both places, according to the results structures deployed at 10m depth shows highest egg counts (68%) and number of eggs lay on the structures also have increased with the time. Furthermore monitoring are conducting.

Several fish species also recorded associate the structures both food and ornamental.

Mangrove red snapper - *Lutjanus argentimaculatus* , Black spat snapper- *Lutjanus fulviflamma* ,Malabar Grouper- *Epinephelus malabaricus* like food fish species and Lion fish, Powder blue surgeonfish, Moorish idol, Emperor angelfish, Trevallies, Yellow fin /Stripe surgon, like marine ornamental fish also observed.

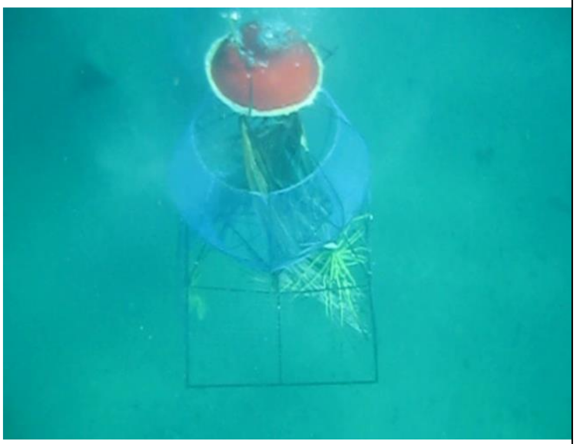
Discussion and conclusion

Based on monitoring results large number of fish species and squids were preferred to use these structures as breeding places in shallow area than deep area. Therefore, more structures need to be deployed around the coastal area of Sri Lanka at the selected locations to enhance the fish stock by enhancing the marine habitat.

As well as these structures provide substrate to squids egg laying process. It will enhance the squid population around the Sri Lankan water. This kind of artificially developed structures are effective method to enhance the marine habitat which have destroyed by natural and anthropogenic activities.













Institute of Post Harvest Technology

IPHT

Assessment of quality of fish in newly built multiday boats (>55 feet in length), Central Fish Market and selected retail places (Dedicated Economic Centers)

Project No : 4.1.1

Officer Responsible : G.J. GanegamaArachchi, K.W.S. Ariyawansa, PavithraGinigaddarage, AchiniSubhashi, ThushiniHemachandra, S. Thiruchenduran

Justification

This project address the quality of fish including utilities such ice and water at different fish handling locations. This information will be used to identify main aspects to be developed and find remedial measures to reduce high fish quality losses in fish supply chains.

It is required to make scientific investigations to report if fish quality losses has been reduced after infrastructure facilities of local multi-day boats have been upgraded to facilitate better handling and storage of fish during fishing trip. This study investigated microbiological and biochemical quality fish from 55 feet long multi-day boats since boats larger than this size are encouraged by MRARD for deep sea fishing.

Quality of fish sold at Central Fish Market and at selected Dedicated Economic Centers that play a major role in fish supply chains in Sri Lanka was also investigated. Fish and fishery products available for local consumption are supplied by both local fish harvest and imported lots. However, base line information on contamination levels of toxigenic radioactive residues in edible fish in Sri Lanka is not available. This study planned to investigate, therefore, if radioactive residues are present in imported fish and fishery products by analyzing about 300 samples at Sri Lanka Atomic Energy Board (SLAEB) in 2018.

Scientific information generated by this project will be submitted to Competent Authority and extended or transfer suitable technology guaranteeing safe quality of fish to relevant stakeholders. Under this project following four studies have been conducted.

Objectives

To collect samples from newly made/ modified multi-day boats and analysis of samples for fecal contaminations, pathogenic bacteria and biochemicals

To collect samples from Central Fish Market and selected dedicated Economic Centers and analysis of samples for fecal contaminations, pathogenic bacteria and biochemical

To analyze ice available for fisheries from Ice Plants located in selected areas of Sri Lanka

To collect and analysis of representative fish samples for radioactive residues

To conduct technology transfer programs

Locations

- Three fishery harbours: Dickowita and Negombo
- Dedicated Economic Centers: Narahenpita and NuweraEliya
- Ice plants: Jaffna, Mulathive, Trincomalee, Batticaloa and Mannar

Component 1: Study on handling practices and quality of yellowfin tuna in multi-day boats larger than 55 feet in length.

Fish handling practices of multi-day boats (MDBs), >55 feet in length: Five boats which were anchored at Dickowita and Negombo fishery harbours have been surveyed using a structured questionnaire. Table 1 shows summary of handling practices adhered in MDBs (> 55 feet in length). Information found by survey are summarized Table 1. Pre-chilling of eviscerated large fish which is one of most important unit operation on board to maintain export quality of large size tuna, is not practiced before storing of fish in ice. Fish storing days in boat is about 35-39 days. Shelf life of highly acceptable quality Yellowfin tuna in ice is about 14 days. Therefore fishers should be encouraged to unload fish before expire the shelf life of that high quality fish. Presently, boats are cleaned using detergents only and disinfectants are not used (Table 4). Fishing crew needs to encourage adopting proper cleaning practices in their MDBs.

Table1. Fish handling practices and multi-day boat (>55 feet)

Characteristics	Numbers/Amount/Practice
Crew size	8-9

Boats usage duration (yrs)	2.25
Pre-processing of yellow fin tuna (YFT):gilling and gutting	yes
Pre-chilling of YFT in chill -bath before storing among ice in fish hold	No
Ice blocks (50 kg block ice)	670- 800
Total fish catch (kg)	5000 – 10,000
Yellowfin Tuna (kg)	250-4200
Storage period of fish (days)	35-39
Unloading surface	To pier or directly to refrigerated-transport vehicle
Detergents are used for personal care of Crew	yes
Cleaning/sanitation of fish hold: Detergents/ Disinfectants	Used Vim only/No disinfectants are used
Fish washing water	Harbor basin water
Properly trained Crew	No certificates/other proof

*Data collected from structured questionnair; number of boats, n=4

Histamine levels of flesh of yellowin tuna: Samples were obtained from multiday boats (MDBs) larger than 55 feet in length. Eighty two flesh (core) samples from yellowfin tuna (weighed over 25 kg) which were unloaded from three MDB at Dickowita and Negombo were collected and stored at – 80 °C in laboratory of Institute of Post Harvest Technology (IPHT). Analysis of histamine levels in these core fish samples could not be completed in 2018 due to technical failure of analytical instruments and part of sample analysis results are given in Table 2. Sample analysis of large size Yellowfin tuna for histamine levels will be completed in first quarter of 2019.

Table 2. Level of histamine in flesh of export –quality-Yellowfin tuna unloaded from MDB (>55 feet) **at Dickowita Fishery Harbour, October 2018**

Sample No. (Yellowfin tuna)	Amount of histamine in flesh (Core sample) of fish (ppm)
1	7.11
2	10.44
3	3.66
4	8.73
5	4.83
6	8.04
7	11.49
8	5.76
9	6.99
10	14.25
11	28.08
12	33
13	19.44
14	20.04
15	39.39
16	21.12
17	47.82
18	40.14

Table 3. Level of bacterial contamination of surface fish skin, water and ice in MDB from July to December 2018

Sample type	Location	Microbiological parameter		
		Faecal coliforms	*E. coli*	*Salmonella*

Swab on skin of one YFT **(n=4)	Dickowita	13 – 130 MPN/50 cm^2	13 –130 MPN/50 cm^2	Absent/50 cm^2
Ice used in fish	Dickowita	17 – >1800 MPN/100ml	11 – >1800 MPN/100ml	Absent/100 ml
	Negombo	14 – 1600 MPN/100ml	55 – >1800 MPN/100ml	Absent/100 ml
Harbour basin water *	Dickowita	70 – 1600 MPN/100ml	70 – 170 MPN/100ml	Absent/100 ml
	Negombo	>1800 MPN/100ml	14 MPN/100ml	Absent/100 ml
Bilge water collected from fish hold	Dickowita	80 – 1600 MPN/100ml	35 – 1600 MPN/100ml	Absent/100 ml
	Negombo	>1800 MPN/100ml	80 MPN/100ml	Absent/100 ml

* Water from harbour basin is used to clean fish and boats

** Yellowfin tuna

Recommendations

- Develop chill bath facilities which are convenient and economic for pre-chilling of large size Yellowfin tuna in multi-day boats (>55 feet)
- Shorten the fishing trip duration of MDBs (> 55 feet)
- Use of food grade water and ice for cleaning boats and fish
- Use if disinfectants to clean in boats

Component 2:

Investigation of quality of fish, ice and water used in Central Fish Market and three dedicated Economic Centers

Quality of fish collected from Dedicated Economic Center in Narahenpita: Thirty five fish samples including Bullet tuna, Sail fish, Yellowfin tuna, Indian Scad, prawns, Skipjack, Sardinella species, Herring, and Mackerel species were collected in four field visits from February to September, 2018 (Table 4). Five fish samples were marginally acceptable due to contamination with *E. coli* counts >500 MPN/g (900 - 1800 MPN/g). Another 9 samples which also contained both high and low counts of *E. coli* were found contaminated with *Salmonella. Salmonella* species found were *Salmonella mbandaka, Salmonellamontevideo, Salmonella corvallis, Salmonella braenderup, Salmonella poona.*

Table 4. Microbiological quality of fish, water and ice samples collected from Dedicated Economic Center at Narahenpita

Sample type	Total number of samples analysed	Number of samples (range of *E. coli*)		*Salmonella*
Fish	35	5 (>500 MPN /100ml)	3 (Not detected)	9
Water	7	7 (13 – 350 MPN /100ml)	-	1
Ice	5	5 (39 – 1800+MPN /100ml)	-	-

Quality of fish collected from Dedicated Economic Center in NuweraEliya: Seven fish samples including Sail fish, Catfish and mullet were collected in three field visits from September to December, 2018 (Table 5). Fish contained low counts of *E. coli* while some fish were not contaminated with *E. coli*.

Table 5. Microbiological quality of fish, water and ice samples collected from Dedicated Economic Center NuweraEliya

Sample type	Total number of samples analysed	Number of samples (range of *E. coli*)		*Salmonella*
Fish	7	2 (3 - 4 MPN /100ml)	5 (Not detected)	-
Water	3	1 (7 MPN /100ml)	2 (Not detected)	-

Ice	4	4 (11 – 350 MPN /100ml)	-	--

Quality of fish retailed at Central Fish Market sampled by Public Health Inspector:

Twenty six samples (Indian Scad, Herring, Sardinella, Tilapia, Sprat, Crabs, Sail fish, Skip jack, Frigate tuna, Mullet species, Travelly species, Bullet tuna, Indian mackerel etc.) in five sampling dates between February and November, 2018 (Table 6). Nine samples did not contaminated with *E. coli* (MPN/g). Two samples were marginally acceptable due presence of 1100 MPN/g of *E. coli*. Two fish sample collected in one sampling day was positive for *Salmonella Paratyphi B varJava* and *Salmonella Corvallis.* Total Volatile Base Nitrogen and histamine levels of these fish sampled remained at <6 mg/100g and 27 mg/kg, respectively.

Table 6. Microbiological quality of fish retailed at Central Fish Market, Peliyagoda in 2018

Date	No	Fish Type		*Salmonella* present/absent	Ecoli count	TVBN (mg/100g)	Histamine level
04/05/2018	1.	Linna	Indian Scad	Absent	3.6	2.6	23
	2.	Linna	Indian Scad	Absent	ND		
	3.	Hurulla	Herring	Absent	3.6	2.3	27
07/06/2018	4.	Salaya	*Sardinella* spp.	Absent	3.6	5.9	
	5.	Squid	Squid	Salmonella Paratypi B var. Java	1100	2.11	
	6.	Salaya	*Sardinella* spp.	Absent	460	3.1	
	7.	Squid	Squid	Absent	93	2.36	
	8.	Korali	Thilapia	Absent	3.6	2.51	

	9.	Halmassa	Sprat	Salmonella Corvallis	23	1.46	
	10.	Salaya	*Sardinella* spp.	Absent	9.2	2.24	
	11.	Linna	Indian mackeral	Absent	3.6		
	12.	Crabs	Crabs	Absent	23		
	13.	Piyamassa	Flying fish	Absent	3.6		
	14.	Squid	Cuttle fish	Absent	93		
	15.	Thalapath	Sail fish	Absent	9.2	4.59	
17/9/2018	16.	Alagoduwa	Frigate mackeral	Absent	ND	3.04	20
	17.	Balaya	Skipjack	Absent	ND	3.55	23
	18.	Galmalu	Mullet	Absent	ND	3.9	
	19.	Alagoduwa	Frigate mackeral	Absent	ND	3.71	20
10/02/2018	20.	Salaya	*Sardinella* spp.	Absent	21	2.46	
	21.	Kumbalawa	Indian mackerel	Absent	38	2.62	
	22.	Ginnatipara w	Travelly spp.	Absent	23		
	23.	Moralla	Halfbeak fish	Absent	23		
	24.	karalla	Silverbelly	Absent	23	2.09	
	25.	Paraw	Travelly	Absent	3.6	3.16	
	26.	katugoi		Absent	15		

Recommendations

- Make available food grade ice and water for fish handling
- Improve fish selling infrastructure
- Operate best fish handling practices in fish retailing places
- Further investigations on presence of different *Salmonella* species in fish retailing places and find efficient disinfect protocols.

Component 3 – Investigation of microbiological quality of ice produced in selected Ice Plants in Sri Lanka

Samples were collected from 44 Ice Plants located in 14 districts (Trincomalee, Batticola, Jaffna, Mulathive, Anuradhapura, Dambulla, Puttalam, Chilaw, Kalpitiya, Mannar, Polonnaruwa, Galle, Ampara, Monaragala) on March to December,2018. Ice making water (Municipal water, well or tube well water), ice from Store and crushed Block ice were sampled from each Ice Plant, these samples were transported to NARA and were analyzed at NARA laboratory for Faecal coliforms, *E. coli* and *Salmonella.*

Ice making water and ice produced from Two Ice Plants were found in acceptable quality (Table 7). Ice and ice making water from many other of Ice Plants (42 Plants) were in contaminated with fecal origin bacteria and unacceptable to be used in food industry. Faecal coliforms and *E. coli* present in the range from 1 to 1800+ and 1 to 1800+ MPN/100ml, respectively.

Salmonella species were found in 12 samples which obtained from ice making water, ice from store or crushed ice (Table 02).*Salmonella* species identified were *Salmonella brunei*, *Salmonellakentucky*, *Salmonellatananarive*, *Salmonellaedinburg*, *Salmonellakentucky*, *Salmonellawilmington*, *Salmonellaagon* and other two *Salmonella* isolates remaining to be characterised for species level.

Table 7. Summary of total Ice plants investigated for microbiological quality of ice making water and ice

Total number of Ice	Number of Ice Plants produce	Sample types	Number of Ice Plants

Plants studied	acceptable quality/Unacceptable quality ice				
			Faecal coliforms (MPN/100 ml) present	*E. coli* (MPN/100 ml) present	*Salmonella* spp. (100 ml) present
44	42 (Unacceptable quality ice)	Water/ Tube well	31	24	3
		Ice from Store(-18^{o}C)	35	34	3
		Ice from Crusher	40	38	6
	2 (Acceptable quality ice) (Coolman Ice Factory in Batticola and Ave Mariya Ice Factory in Mannar	Water/Tube well	-	-	-
		Ice from Store	-	-	-
		Ice from Crusher	-	-	-

Recommendations

Results of this study indicates urgent need of encouraging to produce and dispatch food grade ice in ice plants by practicing good manufacturing methods and upgrading infrastructure facilities in Ice Plants.

Component 4

Investigation of toxigenic radioactive residues in imported fish and fishery products

This study planned to investigate if harmful radioactivity levels of radio nuclides were existed in most common imported fish and fishery products available in local market by analyzing total of 300 number of samples. This study was conducted as collaborative work with Sri Lanka Atomic Energy Board (SLAEB) whichanalysed samples for radio nuclides in fish samples at a concessional Testing fees. Samples were analyzed for radioactivity of five Radio Nuclides (K^{40}, Cs^{137}, Pb^{210}, Ra^{226} and Th^{232}).

Samples of imported frozen fish (Marlin and Sail fish) were collected by NARA from Ceylon Fisheries Corporation and one private company. Imported dried fish (Dried Queen fish, Cat fish, sail fish and two shark species) were collected from whole sale and retail places in Colombo. Canned fish (Mackerel fish species) were sampled from Supermarkets and Lanka Sathosa Ltd.

Total of 265 samples comprising 65,100 and 100 of imported frozen fish, dried fish and canned fish, respectively, have been purchased from above places from March to September 2018. Fish samples were pre-processed in laboratories at NARA. Frozen fish samples were deskinned, heat-coagulated, deboned, dried at 100 ^{o}C and ground in to powder. Dried fish were deskinned, dried at 100 ^{o}C and ground in to powder. Canned fish were drained, dried at 100 ^{o}C and ground in to powder. The pre-processed samples were submitted to SLAEB for analysis of radio activity. Out of 265 samples, analysis of 65 samples has been completed in 2018 (Table 8).

Thirteen samples of the total samples analyzed up to now, contained radio activity of Cs^{137} at level of 1.0 ± 0.1 Bq/Kg and one sample contained Ra^{226} at level of 2.6 ± 0.8 while these 14 samples radioactivity of Pb^{210}, Ra^{226} and Th^{232} were not detected. Rest of samples did not show radioactivity for any of four toxigenic radio nuclides except presence of radioactivity of K^{40} nuclide. However, all 65 frozen fish samples showed radioactivity of K^{40}in a range of 290 to 590 Bq/Kg. These results indicate there is no health risks due to consumption of imported fish and fishery products.

Table 8. Radioactive levels of five Radio Nuclides (K^{40}, Cs^{137}, Pb^{210}, Ra^{226} and Th^{232}) of frozen fish samples imported for local consumption

Sample code (Name of fish)	Local Importer	State of frozen	Country of origin	Radio Nuclide				
				K-40	Cs-137	Pb - 210	Ra-226	Th-232
RA/NARA/01 Marlin	Company 1	Sea frozen	Spain	454±45	ND	ND	ND	ND
RA/NARA/02 Sail fish	Company 1	Land frozen	Yemen	378±37	ND	ND	ND	ND
RA/NARA/03 Sail fish	Company 1	Sea frozen	Taiwan	465±46	ND	ND	ND	ND
RA/NARA/04 Marlin	Company 1	Land frozen	Seychelles	320±32	ND	ND	ND	ND
RA/NARA/05 Sail fish	Company 1	Sea frozen	Taiwan	450±45	1.0 ±0.1	ND	ND	ND
RA/NARA/06 Sail fish	Company 1	Land frozen	Yemen	400±40	ND	ND	ND	ND
RA/NARA/07 Marlin	Company 1	Sea frozen	Nederland	459±49	1.0±0.1	ND	ND	ND
RA/NARA/08 Marlin	Company 1	Sea frozen	Nederland	386±38	ND	ND	ND	ND
RA/NARA/09 Marlin	Company 1	Sea frozen	Nederland	491±49	ND	ND	ND	ND
RA/NARA/10 Sail fish	Company 1	Sea frozen	Taiwan	409±41	ND	ND	ND	ND
RA/NARA/11 Sail fish	Company 1	Sea frozen	Taiwan	360±36	ND	ND	ND	ND
RA/NARA/12 Sail fish	Company 1	Land frozen	Yemen	362±36	ND	ND	ND	ND
RA/NARA/13 Sail fish	Company 1	Land frozen	Yemen	347±34	ND	ND	ND	ND
RA/NARA/14 Sail fish	Company 2	Sea frozen	Taiwan	359±49	1.0±0.1	ND	ND	ND

RA/NARA/15 Sail fish	Company 2	Sea frozen	Taiwan	40.0±2.0	ND	ND	ND	ND
RA/NARA/16 Marlin	Company 2	Sea frozen	Taiwan	417±48	1.0 ±0.1	ND	ND	ND
RA/NARA/17 Sail fish	Company 2	Sea frozen	Taiwan	449±55	ND	ND	ND	ND
RA/NARA/18 Marlin	Company 2	Sea frozen	Taiwan	522±64	ND	ND	ND	ND
RA/NARA/19 Marlin	Company 2	Sea frozen	Taiwan	590±72	ND	ND	ND	ND
RA/NARA/20 Marlin	Company 2	Sea frozen	Taiwan	467±58	ND	ND	ND	ND
RA/NARA/21 Sail fish	Company 2	Sea frozen	Taiwan	503±62	ND	ND	ND	ND
RA/NARA/22 Marlin	Company 2	Sea frozen	Taiwan	550±64	ND	ND	ND	ND
RA/NARA/23 Sail fish	Company 2	Sea frozen	Taiwan	483±74	1.0± 0.1	ND	ND	ND
RA/NARA/24 Sail fish	Company 2	Land frozen	Taiwan	341±55	ND	ND	ND	ND
RA/NARA/25 Sail fish	Company 2	Land frozen	Taiwan	742±96	ND	ND	ND	ND
RA/NARA/26 Sail fish	Company 1	Sea frozen	Yemen	465±63	ND	ND	ND	ND
RA/NARA/27 Sail fish	Company 1	Land frozen	Yemen	307±48	ND	ND	ND	ND
RA/NARA/28 Sail fish	Company 1	Sea frozen	Yemen	397±50	ND	ND	ND	ND
RA/NARA/29 Sail fish	Company 1	Land fozen	Yemen	310±57	ND	ND	ND	ND
RA/NARA/30 Sail fish	Company 1	Land frozen	Yemen	316±52	ND	ND	ND	ND

RA/NARA/31 Sail fish	Company 1	Land frozen	Yemen	340±53	ND	ND	ND	ND
RA/NARA/32 Marlin	Company 1	Sea frozen	Yemen	462±57	ND	ND	ND	ND
RA/NARA/33 Marlin	Company 1	Sea frozen	Yemen	490±62	ND	ND	ND	ND
RA/NARA/34 Marlin	Company 1	Sea frozen	Yemen	437±51	1.0 ±0.1	ND	ND	ND
RA/NARA/35 Marlin	Company 1	Sea frozen	Yemen	472±59	ND	ND	ND	ND
RA/NARA/36 Sail fish	Company 1	Sea frozen	Yemen	432±52	ND	ND	ND	ND
RA/NARA/37 Sail fish	Company 1	Seaq frozen	Yemen	443±50	1.0± 0.1	ND	ND	ND
RA/NARA/38 Marlin	Company 2	Sea frozen	Taiwan	534±63	ND	ND	ND	ND
RA/NARA/39 Marlin	Company 2	Sea frozen	Taiwan	466±64	1.0± 0.1	ND	ND	ND
RA/NARA/40 Marlin	Company 2	Sea frozen	Taiwan	537±23	1.0 ±0.1	ND	ND	ND
RA/NARA/41 Sail fish	Company 1	Sea frozen	Yemen	412±63	ND	ND	ND	ND
RA/NARA/42 Sail fish	Company 1	Sea frozen	Yemen	345±15	ND	ND	ND	ND
RA/NARA/43 Marlin	Company 1	Land frpzen	Yemen	412±15	ND	ND	ND	ND
RA/NARA/44 Marlin	Company 1	Land frozen	Yemen	410±18	ND	ND	ND	ND
RA/NARA/45 Sail fish	Company 1	Sea frozen	Yemen	352±16	ND	ND	ND	ND
RA/NARA/46 Marlin	Company 1	Land frozen	Yemen	500±15	ND	ND	2.60 ±.8	ND
RA/NARA/47 Marlin	Company 1	Sea frozen	Yemen	565±17	ND	ND	ND	ND

RA/NARA/48 Marlin	Company 1	Sea frozen	Yemen	513±22	1.0± 0.1	ND	ND	ND
RA/NARA/49 Marlin	Company 1	Sea frozen	Yemen	553±16	ND	ND	ND	ND
RA/NARA/50 Sail fish	Company 1	Land frozen	Yemen	376±14	ND	ND	ND	ND
RA/NARA/51 Sail fish	Company 1	Land frozen	Yemen	349±16	ND	ND	ND	ND
RA/NARA/52 Sail fish	Company 1	Land frozen	Yemen	418±14	ND	ND	ND	ND
RA/NARA/53 Sail fish	Company 1	Land frozen	Yemen	403±13	ND	ND	ND	ND
RA/NARA/54 Sail fish	Company 1	Land frozen	Yemen	375±17	ND	ND	ND	ND
RA/NARA/55 Sail fish	Company 1	Land frozen	Yemen	290±13	ND	ND	ND	ND
RA/NARA/56 Marlin	Company 2	Sea frozen	Taiwan	608±18	ND	ND	ND	ND
RA/NARA/57 Marlin	Company 1	Sea frozen	Taiwan	502±15	ND	ND	ND	ND
RA/NARA/58 Marlin	Company 1	Sea frozen	Taiwan	527±23	ND	ND	ND	ND
RA/NARA/59 Marlin	Company 1	Sea frozen	Taiwan	477±21	ND	ND	ND	ND
RA/NARA/60 Sail fish	Company 1	Sea frozen	Taiwan	594±25	1.0± 0.1	ND	ND	ND
RA/NARA/61 Sail fish	Company 1	Sea frozen	Taiwan	675±29	1.0 ±0.1	ND	ND	ND
RA/NARA/62 Sail fish	Company 1	Sea frozen	Taiwan	547±16	ND	ND	ND	ND
RA/NARA/63 Sail fish	Company 1	Sea frozen	Taiwan	546±16	ND	ND	ND	ND
RA/NARA/64 Sail fish	Company 1	Sea frozen	Taiwan	622±17	ND	ND	ND	ND

RA/NARA/65 Sail fish	Company 1	Sea frozen	Taiwan	552±27	1.0± 0.1	ND	ND	ND

This study to be continued in 2019 since analysis of rest of pre-processed analytical samples to be completed by Sri Lanka Atomic Energy board by 2019. In, addition another 35 Frozen fish samples to be analyzed for radio activity of toxigenic radio nuclides in 2019 since this study planned to analyzed total number of 300 samples.

Reduction of contaminants(mercury) presence in fish muscle

Project No : 4.1.5 Component 1

Officer Responsible : Suseema Ariyarathana

Fish is a nutrient rich health food but not always. Some time it is possible to contaminate with chemical and microbiological containment in addition to the deviation of freshness. Presence of chemical contaminant in the fish muscle can be lead to critical health problem to the consumer. Therefore this study was planned to reduce unacceptable mercury levels in to acceptable level in particular fish muscle by several treatments. Objective of the study was to find the suitable method to reduce the amount of mercury in fish muscle up to acceptable limit and uses it for the product processing.

Six number of selected Swordfish (*Xiphias gladius*) samples with high mercury levels were used for the study. Three type of treatment were carried for the fish samples contaminated with mercury. Under first treatment, samples which were cut in to a small chunk and dipped in a solution made with garlic paste and 5% cysteine. Second treatment was conducted using solution made with Garlic paste and third one was done with 5% cysteine. Same size small chunks about 4*4 cm kept under the 5.0 ^{0} C for 24 hours during all treatments. Fish to solution ratio was about 1:10 and pH of the solution was about 3.0. After treatments, the mercury values were reduced by 34.78%, 24.64% and 5.95% respectively.

It is very important to ensure the consumer safety as well as Maximum usage of food resources therefore reduction of mercury in fish muscle to acceptable limit will be help to achieve both objectives. These results proved that ability of reduction of mercury level in fish muscle by treatment for a safety level. Study should be continue to find most suitable and low cost method reduce the mercury level in fish muscle and use the product development.

2 Construction of smoking unit :-

Budget allocated:Rs. 7 million (Funded by MAFARD under project no. V-5070)

We have completed the construction of 12 number of smoking unitsin the areas of Padaviya, Namaloya, Minneriya, Kalawewa,Hambegamuwa,Hadapanwila,Parapangadal, Iranawila,Udawalawa ,DiganaRakawa and Batatha under the above project. Smoking unit can be used to production of smoked dried fish, smoked fish and maldive fish. Those units were constructed according to the FAO Thyeario technology which was design to reduce the PAH accumulation on smoked fish during smoking that can leads the risk of cancer.

Site Selections were done by the recommendations of National Aquaculture Development Authority (NAQDA) and Department of fisheries. Ten units were established for the inland fisheries societies and two units for the coastal area.

Twelve number of Awareness programme were conducted for the selected members of each fisheries society regarding the production of smoked dried fish, smoked fish and maldive fish using the establish unit. More than 500 people were trained and provided the booklet which can be use as guide

Nanoparticles Using Aquatic Resources

Project No : 4.1.5 Component 2

Officers responsible : S.Thiruchenduran

Objectives

1. To synthesize and characterize chitosan and metal oxide nanoparticles using seaplants
2. To synthesize and characterize glucosamine from chitosan
3. To utilizes nanoparticles to miter food deterioration

Quarterly Financial Plan

Financial plan	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Equipments	0	40	10	0
Field visits/Transport	20	10	10	10
Boathire	20	10	0	0
OT /Holiday pay	25	12	13	11
Chemicals	0	50	50	0
Consumables/Ingredients	50	30	50	30
Laboratory Testing services	30	90	90	30
Stationery	7	6	3	4
Accomodation	6	5	3	0
Workshop/Training/Conference/Exhibition	0	50	0	25
Monthly Total	158	303	229	110
C	158	461	690	800

Physical Progress:

Anlytical plan/Activity plan				
Product development	0	2	0	0
Waste characterization	0	0	3	0
Chitosan characterization	14	8	8	0
Glucosamine production	0	3	0	0

Glucosamine characterization	0	2	1	0
Fish oil characterization	3	0	0	0
Nanoparticle characterization	10	12	0	12
Microbiological activity	0	18	9	15
Seaweed characterization	19	0	12	12
Secondary data collection and survey	0	2	4	2
Product characterization	0	0	2	2
Total Numbers	46	47	39	43
Monthly Progress %	26.28571	26.85714	22.28571	24.57143
Cumulative Progress %	26.28571	53.14286	75.42857	100

Year End Physical Progress : 70%

Year End Financial Progress : 100%

Location of the project : NARA

Outcome of the Poect :

Identification of seaweed bioactive compounds

Identified seaweed species and locations they grow

Succesfully prepared glucosamine hydrochloride and method optimized

Successfully synthesized chitosan nanoparticles

Nanolaminated Fish oil characterized

Aqueous environment is the single richest environment with obnoxiously plentiful resources. The aqueous environment in its nature provides mankind with anything and everything for a better sustainable propagation and to provide care for the earth. Residing at the top level of the decision making power, it is the responsibility of the scientist to innovate or discover new methods and resources which satisfies the needs of the people and other living begins and enriches the natural environment for a sustainable use. Further, the application of modern technologies such as nanotechnology, to increase effectiveness of the resources has paved the path for efficient use of natural resources.

The aim of the project as described above pursue to explore the available and nourish able seaweed species in Sri Lankan territorial waters and identify their characteristics for food, feed and drug use. Further, nanotechnology was used to enhance the efficiency of the products in a manner that the applications would not affect the ecosphere in a devastating manner. In addition as a continuation of the previous year's project the project also aimed to synthesize chitosan and glucosamine using efficient methods and applications were carried out using chitosan nanoparticles.

Sub Component 1: Identification of potential seaweeds for nanoparticle synthesis

Activity 1. Identification of Seaweed Locations and Collection of samples

45 samples of seaweeds were collected from different locations including Killinochchi, Kalpitiya, Chilaw, Negombo, Kaikavala, Beruwela, Boose, Koggala, Roomassala, Devundara, Nilwella, Seethagalla, Sallitheevu, Moothur and Trinco harbor surroundings.

Activity 2. Identification of the seaweed species

The identification of the seaweed species were carried out with the help of "Seaweed Flora" reference at the Herbarium at Peradeniya Botanical Garden. Further, seaweed identification keys were used found online in Algal Base and FAO guide book. Reference to several online reports were used such as ABC Taxa, Seaweed identification guide of Kuwait, Identification guide to algal species – Canada.

The 25 identified species were *Ceratodictyonvariabile, Scinaiacarnosa, Halimedaopuntia, Cladoporopsissundanensis, Ulvareticulate, Sarcodiamontagneema, Sargassumcrassifolium, Dictyotaceylanica, Sargassumilicifolium, Sargassumpolycystum, Sargassumwightii, Caulerparacemosavarpeltata, Ulvalactuca,, Ulvaprolifera, Padinaboregensis, Caulerparacemosavarracemosa, Janianetalensis, Sarcodiumantaneana, Padinaantillarum, Pterocladiaheteroplatos, Gracilariacorticata, Gracilariahikkaduwensis, Caulerparacemosavarmacrophysa, Caulerpasertularioides*and*Gellidium species.* There are few more species yet to be identified.

Activity 3. Samlpe preparation for the extraction

A shade dry rack was constructed using NARA resources and technicians. The rack was used to shade dry the samples which is necessary to store them at room temperature before extraction. Samples were shade dried and kept in airtight bags in storage box.

Activity 4. Identification of compounds groups in seaweed extracts

Before further tests it is essential to identify the presence of compound groups in seaweeds, For this a method called phytochemical screening was executed. The process is time consuming and require careful experimental procedures. Phytochemical screening was conducted on seaweed samples.

Activity 5. Extraction of bioactive compounds from seaweeds

Solvent combinations were used to extract polar and nopolar bioactive compounds from seaweed samples.

Activity 6. Measurement of antioxidant activity of the seaweed species.

Antioxidant activity of the seaweeds were measured using different methods

Terpenoids, steroids, phenolic compounds, flavonoids, saponins and alkaloids were present in all three species in detectable levels. Anthocyanosideswere not detected in any of the species extracts. Considering overall DPPH radical scavenging activity, methanolic extract of Caulerparacemosa has shown significantly higher activity with a mean of 54.41% and methanolic extract of Ulva reticulate has shown a significant lower activity with a mean of 36.76%. Methanolic extracts have shown significantly higher activity C.racemosa and S.crassifolium whereas ethyl ether has shown significantly higher activity with U.reticulate and S.crassifolium. Water has shown poorer radical scavenging activity for all species. (alpha

=0.05). Based on the above results it is evident that even though all three species have radical scavenging phytochemicals, C.racemosa contained more polar and less non—polar radical scavenging compounds and S.crassifolium contained vice-versa. U.reticulate radical scavenging activity is due to its non-polar compounds.

Sub component 2: Utilization of shrimp shells for the synthesis of chitosan and glucosamine and characterization

Activity 1. Pretreatment of shells before extraction

Shrimp shells were collected from shrimp processing factories and processed for the isolation of shells from the crude waste.

Activity 2: Method optimization using mixture models and response surface methodology

The chitosan extraction and glucosamine extraction was optimized using mixture models and response surface methodology.

Microwave method

The yield of chitosan extracted from shells was 13.6% (w/w). Residual calcium (Ash), nitrogen content (N) and degree of deacetylation (DDA) were used to calculate the optimized conditions; deminerealization (DM), deproteinization (DP) and deacetylation (DA) processes. The optimal condition derived for DM - T_{irr} 7.43 mins, 1/25 S/L and 1.06 M cHCl; for DP - T_{irr} 6 mins, 1/21 S/L and 1.92 M cNaOH and for an DDA of estimated 89.6% the optimized DA conditions are T_{irr} 6.41 mins, 30.56 % cNaOH and 1/29 S//L. The estimated cost for laboratory scale processing of crab shells in to chitosan is approximately 10000 Rs. Thus the optimized microwave processing method is a viable method for industrial adaptation of chitosan processing.

Low cost method

The results obtained from this study show that optimized Demineralization conditions were 1.92 molarity of Hydrocloric acid, 1/20 solid to liquid ratio at 28 hours : optimized Deproteinization condition were 1.26 molarity of Sodium hydroxide, 1/19 solid to liquid ratio at 46 hours and 3 minutes : Deacetylation conditions were 50% concentration of Sodium hydroxide, 1/15 solid to liquid ratio in 3 days and 12 minutes and optimized Degree of deacetylation was 71.07 . Cost of the production of chitosan was Rs. 1729.00 per kilogram

Activity 3. Nanoparticles synthesise and characterization

Nanoparticles were synthesized and characterized using chitosan and applied to mitter fish oil rancidity development.

Three-layered fish oil droplets stable against particle aggregation, creaming and oxidation. can be prepared by chitosan, caseinate and pectin by encapsulation and mitter the oxidative rancidity.

Activity 4. Glucosamine was successfully characterized upto industrial and pharmaceutical grade

Glucosamine properties were identified using different methods and compared with a pharmaceutical and industrial grade glucosamine.

The optimal conditions for glucosamine synthesis was using 31% HCl concentration at a acid to substrate ratio of 7:1 and for 5hrs heating at 100 deg C. Approximate yield of glucosamine from chitosan is 25%. This glucosamine showed good antimicrobial properties and antioxidant properties.

Sub component 3 Fish paste preparation

Sample 1

Following conclusions can be made with the results obtained.A sensory acceptable fish paste can be produced using the recoverable edible fish portions of Linna (*Decapterusrusselli*) processing line for canning with the incorporation of 2.5% *Gracilariaedulis*paste for optimizing the textural quality.The fish paste developed is shelf stable at refrigerated (4°C) for 14 days.The fish paste has a high protein content of 22.45%.

Sample 2

Result revealed that 10% *G.edulis* seaweed added fish paste has high significantly preference than other samples. Proximate analysis for the 10% (w/w) incorporated fish paste showed that

Moisture=66.83%±0.26, Dry matter= 33.17%±0.26, Crude protein = 22.45%±0.53, Crude fat= 4.19%±0.0.08, Crude fiber= 0.74%±0.005, Salt= 1.22%±0.009 and Ash= 4.15%±0.022. In the shelf life study, sensory evaluation showed there was no significant ($p<0.05$) deterioration in the sensory properties of the product up to 14 days. On the 20th day, Total Plate Count (TPC) was 3.34 x 10^6 CFU/g exceeded the acceptable TPC limit (10^6). Even though there has been a significant ($p<0.05$) increase in peroxide value, the level was well below the maximum acceptable limit (10). There was a notable significant ($p<0.05$) reduction in solubility of the product. There was no significant ($p<0.05$) change in pH and water activity of fish paste. Complying with the above results the shelf life of 10% (w/w) *G.edulis* incorporated fish paste was estimated to be 14 days. The study concludes that value-added sensory acceptable shelf stable fish paste can be prepared from recoverable edible portions of *D. russelli*with the incorporation of *G. edulis*.So; this is a better value addition product in Sri Lanka.

Sub component 4: Fish oil Extraction

Fish oil was extracted from Yakshalaya but yet to complete the analysis.

Sanitary survey and assurance of safety of edible bivalve mollusks

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Project No	:	4.1.3
Officers responsible	:	Sujeewa Ariyawansa

Activity 1: Monitoring the microbiological quality of Oysters (*Crassostreamadrasensis*)

Introduction

Oysters are a nutritious seafood item which is consumed predominantly in raw and to lesser extent cooked. Due to the filter feeding and estuaries living habit, they are concentrating and accumulating pathogenic microbes and toxic chemicals, hence subjected to stringent food safety standards. Lagoons in Kalpitiya and Puttalam areas have identified as potential sites for oyster cultivation and farming has already commenced. If these farms are to produce oysters for local or export market, they should be in compliance with the microbial standards. The aim of the present study is therefore to evaluate the microbial quality of the oysters harvested from different areas in lagoons namely Gangewadiya, KandakuliyaKalpitiya and Noradiya.

Objectives

- Monitoring the microbiological quality of bivalves (oysters and clams) and water from growing areas

- Provide necessary information on safety of bivalves to competent authorities in order to facilitate exports and local sales
- Monitoring the microbiological quality of water from Puttalam lagoon in order to find out suitable areas for natural relaying and culturing of bivalves

Materials and Methods

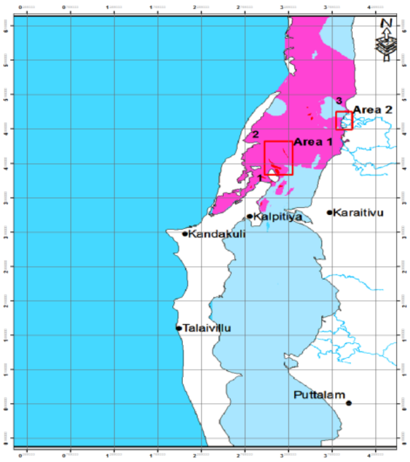
Oysters(*Crassostreamadrasensis*)and watersamples were collected from harvesting areas (Gangewadiya, KandakuliyaKalpitiya and Noradiya), and analyzed for microbiological parameters including pathogenic bacteria namely total coliforms, faecalcolifoms, *E.coli*, *Vibrio cholerae*, *Vibrio parahaemolyticus* and *Salmonella*spp.Oyster samples (n=95) and the water samples (n=39) were collected in sterilized bags and sterilized bottles respectively from sampling areas,placed in *ice* and *transported to the quality controllaboratory for analysis.*The microbiological quality of oyster and water samples was tested using standard techniques as mentioned in table 1 and 2. All samples were taken aseptically for the analysis.

Table 1: Methods for microbiological analysis of oyster

Parameter	**Method**
Total bacterial count	SLS 516-1-Sec,1:2013 ISO 4833-1:2013 (E)
Total coliforms	SLS 516-3-Sec,1:2013 ISO 4831-2006 (E)
Faecal coliforms and *E.coli*	SLS 516-12:2013 ISO 7251:2005(E)
Salmonella *spp.*	SLS 516 part 5:2013 ISO 6579:2002
Vibrio cholerae *Vibrio parahaemolyticus*	SLS 516-7-sec,1:2013 ISO/TS 21872- 1:2007(E)

Table 2: Methods for microbiological analysis of water

Parameter	**Method**
Total bacterial count	SLS 516-1-Sec,1:2013 ISO 4833-1:2013 (E)
Total coliforms, Faecal coliforms and *E.coli*	SLS 1461 Part 1/Sec 3:2013
Salmonella *spp.*	ISO 19250:2010 (E)
Vibrio cholerae *Vibrio parahaemolyticus*	SLS 516-7-sec,1:2013 ISO/TS 21872- 1:2007(E)



Study area for collection of oysters   Study area for collection of water fromPuttalam lagoon

Results and Discussion

Oyster samples contained Aerobic Plate Count (APC) in the range of 1.8 x 102to 4.2 x107 cfu/gand 72% of samples had less than5 x 105cfu/g (thresh hold value). Faecal coliforms varied between not detected (ND) to >1100 MPN/g whereas E.coli ranged from ND to >1100 MPN/g. Faecal coliforms were not detected in 44% oyster samples. E.coli were detected in 45% of oyster samples while unacceptable levels (>2.3 MPN/g) were detected in 28% of these samples. APC of water samples ranged from 1.8 x 102 to 3.8 x 105 cfu/ml. E. coli varied from ND to 900 MPN/100ml. Faecal coliforms and E.coli were not detected in 28% and 36% of water samples respectively. Vibrio cholerae and Vibrio parahaemolyticuswere not detected in any of oyster or water samples. Of alloyster and water samples tested twooyster samples were found to be positive for Salmonella spp.

Water samples were collected from Puttalam lagoon and microbiological quality of water was monitored in 3 months intervals (n=28). Duration: January 2018 to October 2018. Parameters. Aerobic plate counts (Range 7.0 x 101 –2.3 x 103), total coliforms(ND – 35 MPN/100mL), faecalcolifoms(ND – 35 MPN/100mL), E.coli(ND–25 MPN/100mL), Vibrio cholerae(Not Detected), Vibrio parahaemolyticus(Not Detected)and Salmonella spp. Faecal coliforms and E.coli were not detected in 57% and 64% of water samples respectively.

Conclusions

It can be concluded that the oysters from these areas have exceeded the level of microbial safety standards, showing the need of depuration or cooking by approved methodsbefore consumption.

Microbiological quality of lagoon water in areas where samples were taken is suitable for culturing and natural relaying of bivalves.

Activity 2: Studying prevalence of antibiotic resistant microorganisms in shrimp culture environment

Introduction

Antimicrobials are a precious group of medicines which are used to treat infections caused by bacteria, viruses, fungi and parasites. Antimicrobial resistance (AMR) occurs when microorganisms such as bacteria, viruses, fungi and parasites change in ways that make treatments ineffective. AMR is a major concern because drug-resistant infections can kill, spread to others, and impose huge costs on individuals and society.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.Indiscriminate use of chemicals and drugs often lead to problems like drug resistance, tissue residues, adverse effect on speciesbiodiversity, etc, which ultimately affect the cultured shrimp, human and environment.Antibiotics could leave residues in shrimps, culture environment of shrimps and ornamental fish which could have implications in human health.Hence it is important to be aware about the gravity of the situation in Sri Lanka and to take prompt action.

Objectives

- Study the prevalence of antibiotic resistant microorganisms in the shrimp culture environment(status and trends, over time and place)

Materials and Methods

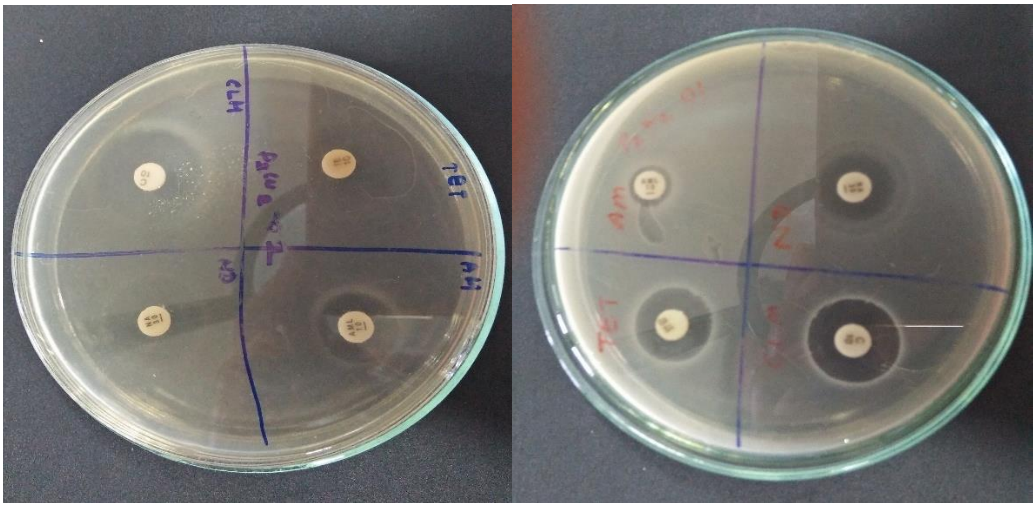
- Shrimps (n=16), water (n=16)and sediment(n=16) samples were aseptically collected from shrimp farms in North Western Province,placed in *ice* and *transported to the quality controllaboratory*. *Samples were*analyzed for total Vibrio species (APHA 2011) and Salmonella spp. (in shrimp ISO 6579:2002, in waterISO 19250:2010)using standard techniques. All samples were found to be negative for Salmonella spp.Kirby–Bauer disk–diffusion technique **(**Bauer et al. 1966) was used to assess antibiotic sensitivity of the bacterial isolates of Vibrio spp. Muller Hington Agar was used as media for antibiotic sensitivity study. Following six routinely used broad-spectrum antibiotics contained impregnated discs was used for the study. Amoxicillin(10µg), Oxytetracycline(30µg), Tetracycline(10µg and 30µg), Nalidixic acid(30µg), Chloramphenicol(10µg), Nitrofurazone(10µg and 30µg).

Collection of samples from shrimp culture ponds

Results and Discussion

- All samples were detected with thepresence of sucrose fermenting and non fermenting Vibrio spp and sucrose fermenting and non fermenting microbial loads was between $1.4x10^{2}$- $1.9x\ 10^{5}$and $7.0x10^{1}$- $1.9x\ 10^{5}$ respectively.

- 84 Vibrio isolates were tested and 30% showed resistance to Amoxicillin.The majority of isolates tested were susceptible to all of the antibiotics such as Oxytetracycline, Tetracycline, Nalidixic acid, Chloramphenicol, and Nitrofurazone.



Antibiotic sensitivity study

Conclusions

This study shows the detection of antibiotic resistance *Vibrio* spp.in the shrimp farming environments.Pathogenic species are in the genusof*Vibrio* and resistance development in aquatic environmentposes a threat to human health.

Abstracts

W.W. Rukshan, M.R. Perera, K.W.S. Ariyawansa and N.P.G. Pushpith. (2018). Production of natural oyster sauce by utilizing Indian oyster (*Crassostreamadrasensis*). Proceedings of the National Aquatic Resources Research and Development Agency, pp. 64.

- A Technology transfer programme was conducted on value added products from clams for 20 women in Kalpitiya

Technology transfer programme on value added products from clams

Investigation of incidences of histamine forming bacteria in chilled Yellowfin tuna (*Thunnusalbacares*) in export fishery industry of Sri Lanka

Project No : 4.1.2

Officers responsible : Pavithra Ginigaddarage

Recent studies done in Sri Lanka have found that about 40% of Yellowfin tuna being rejected for exports due to bad quality (Unpublished data, NARA, 2017). Elevated histamine content and improper handling practices are some of the reasons for those rejections. Since histamine is formed due to the presence of bacteria, identification of histamine formers and investigation of their sources can help to control histamine formation in fish. Control of histamine formation may result in more opportunities to export good quality fish.

This study aims on isolation, characterization and controlling of histamine forming bacteria in fish, multi day boats, ice and fish processing plants. Isolation of histamine forming bacteria from fishery harbours and fish processing plants was started in the year 2018 and this will be continued for the next year followed by finding methods, controlling bacteria and risk assessment.

Methodology

Fish Samples, ice samples and swab samples were collected from boats from Dikkowita fishery harbor and from fish processing plants.

Samples were collected according to the following sampling plan. Three samples were drawn from each sampling point at all times.

Fish processing plant

- Ice from freezer truck
- Swabs from fish surface
- Fish samples
- Processing floor
- Ice from processing plant
- Swabs from freezer truck

Fishery harbours

- Ice from fish hold
- Ice from factories
- Swabs from fish holds
- Swabs from boat decks
- Swabs from skin of fish

Collection of swabs

Collection of swabs were done according to ISO 18593 - Microbiology of food and animal feedingstuffs — Horizontal methods for sampling techniques from surfaces using contact plates and swabs standard.

The samples were brought to the Quality Control laboratory (Microbiology Unit) at NARA for analysis.

Isolation and identification of histamine forming bacteria

To isolate histamine-forming bacteria 1 ml of the sample dilute was spread on Nivens medium fortified with L-histidine (Niven, Jeffreg and Corlett,1981). 10^{-1}, 10^{-2} and 10^{-3} dilutions were carried out and incubated at 35°C and 22 °C agar plates for 4 days. Colonies with blue or purple color on the plates were picked and streaked on trypticase soy agar (TSA) for further analysis.

Histamine formation by bacterial isolates

Histamine production by the bacterial isolates was determined in duplicate by AOAC 977.13 method. One loop full of bacterial culture on TSA slant was inoculated into 10 mL of Tryptone Soy Broth (TSB) supplemented with 1% histidine and 3% NaCl and incubated at 37°C for 24 h. The bacterial culture broth (1 mL) was added into 9 mL of 75% methanol and heated at 60 °C for 15 min to extract histamine. Extracted histamine was then subjected to column elution, OPT derivatization, and determination of fluorescence intensity.

Colonies which gave blue colour on Nivens medium were further confirmed by amplifying DNA to detect histidine decarboxylase gene (hgd). Cultures which gave positive results for hdg and histamine formation were further confirmed by amplifying and sequencing approximately 1400 bp of the 16S ribosomal DNA (rDNA) for bacteria.

DNA extraction of bacteria was done using boil method as described in Sujeewa*et al*., 2009.

Histamine isolates will be identified using PCR by confirming the presence of histidine decarboxylase gene (709 bp) as described in Takashi *et al*., 2003

Primers for histidine decarboxylase gene

hdc-f - 5'-TCH ATYARY AAC TGY GGT GAC TGG RG-3'

hdc-r - 5'-CCCACA KCA TBA RWG GDG TRT GRC C-3'

Primers 16S ribosomal DNA (rDNA) for bacteria (Huang *et al*.,2010)

UNI-L - 5'-AGAGTTTGATCATGGCTCAG-3'

UNI-R – 5' - GTGTGACGGGCGGTGTGTAC-3'

Obtained sequences analyzed with the available data base and used for the identification of each bacterial species.

Results

Table 1. Sample types, number of samples collected and isolated bacteria from fishery harbours and fish processing plants

1.1 Fish processing plant

Sampling point	**No of samples**	**Bacterial isolates**
Ice from refrigerated truck	15	-
Ice from fish processing plant	15	-
Fish loin samples	12	*Aeromonas*sp., *Alcaligenes* sp. , *Citrobacter* sp. , *Shewanella* sp.
Swabs from floor of the Processing plant	14	-
Swabs from fish skin surface	15	*Pseudomonas* sp. , *Psychrobacter* sp., *Aeromonas*sp. ,Enterobacteriaceae sp.,
Swabs from refrigerated truck	14	*Aeromonas*sp.,*Staphylococcus* sp. ,*Shewanella* sp.

Swabs from skin of fish surface (Rejected from processing plant)	06	*Aeromonas* sp., *Psychrobacter* sp.

1.2 Fishery harbours – samples were collected from Dikkowita fishery harbour

Sampling point	**No of samples**
Ice from fish hold	09
Ice from factories	12
Swabs from fish holds	09
Swabs from boat decks	09
Swabs from skin of fish	12

Table 2 : Amount of histamine produced by some of the isolated histamine forming bacteria

Bacterial isolate	**Amount of histamine produced (ppm) at 35°C**
Aeromonas sp.	12.75
Aeromonas sp.	107.19
Psychrobacter sp.	343.26
Aeromonas sp.	192.51
Enterobacteriaceae sp.	26.55
Aeromonas sp.	841.62
Aeromonas sp.	27.66
Alcaligenes sp.	23.7
Citrobacter sp.	550.35
Aeromonas sp.	23.88
Aeromonashydrophila	84.9

Staphylococcus sp.	24.93

Table 3: Amount of histamine detected in fish loin samples and histamine forming organisms isolated.

Fish sample	Weight (kg)	histamine (ppm)	Isolated organisms
1	42.5	49	-
2	41.0	28	*Aeromonas* sp.
3	30.0	28	-
4	59.0	07	-
5	64.0	04	-
6	40.0	10	-
7	-	06	*Psychrobacter*sp. , *Pseudomonas* sp.
8	-	05	-
9	-	07	*Aeromonas* sp.
10	46.5	09	Enterobacteriaceae sp.
11	60.0	11	*Aeromonas* sp.
12	39.5	10	*Shewanella* sp., *Citrobacter* sp., *Alcaligenes* sp.

In addition to above mentioned bacteria histamine formers were also isolated from swab samples collected from surfaces of fish and ice samples collected refrigerated trucks at the Dikkowita fishery harbor. Identification of species of these bacteria is to be carried out.

From the results obtained up to now, it can be seen that the histamine forming bacteria are present in skin surfaces of rejected fish, fish loin samples, Surface of fish skin, Swabs from refrigerated truck and ice. Therefore it is necessary to control the presence of these bacteria to avoid formation of histamine in fish.

These organisms will be further studied and characterized for histamine formation and modified atmospheric conditions.

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Development of carrageenan incorporated jelly candy sweet for replace of gelatin

Project No : 4.1.5 component 03

Officers responsible : Pradeepa Shayamali Jayasinghe

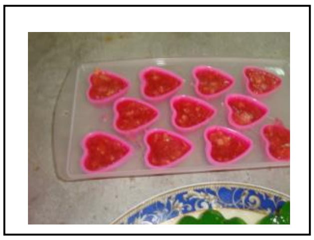
Awareness programs was conducted

The two awareness programs were conducted to introduce to seaweed based value added products to the "Healabojun" business members. The thirty business women were participated to the program. The five seaweed based products were introduced

Carrageenan were extracted from four different extraction methods using seaweed *kaphaphycusalverazii*. The best method was selected according to the highest yield and gel strength. The method obtain 75% yield of carrageenan was selected as best method. This method further used for carrageenan extraction.

Carrageenan incorporated Jelly candy sweets, (jujubes) were prepared to replace of gelatin. .The five different carrageenan percentages were used to prepared jujubes. The five percentages were 2.5%, 3%,4%,5%6%. The sensory properties were evaluated for jujubes. The highest mean overall acceptability was obtained in 2.5% percentage. The gel strength was compared with market available jelly candies, (jujubes) with laboratory prepared jujubes. Jujubes prepared in the laboratory incorporating carrageenan indicated lower gel strength (954 g/cm^3) than market available jujubes (2390g/cm^3)

Further the experiment was focus on improved the gel strength by incorporated with other plant hydrocolloids. The incorporated other plant hydrocolloids were affect the setting point and texture of the product. But, it wasn't enhanced the jelly strength effectively.



Physical progress

70%

1. The examination board of the Ph. D. was recommended to carried out moderate changers in the thesis within the six month period.
   Title of the thesis "Evaluation of quality characteristic and utilization of locally available seaweed species of Industrial Potential". The thesis corrections were done during January to July six month period of the year 2018.

Environmental Studies Division

ESD

Study on pollutant behavior in Kelani River basin

Project No : 5.1.2

Responsible officer : A.A.D.Amaratunga, S.R.C.N.K. Narangoda
N.D. Hettige, M.D.S.R. Maddumage, and R.H.N.S. Alwis

Surface water is recognized as the most important natural element for the sustainable economic and social development in countries around the world. There is a disparity between the rainfall seasons and water demand in arid and semi-arid regions. Reservoirs are constructed to collect and store water during seasons of rainfall and to use water when there is water scarcity (Eslamian *et al.*, 2017). Lakes and reservoirs are hold 90 % of world's fresh water. The growth of human population in the world increased the need of water resource (Karmakar & Musthafa, 2013). Anthropogenic activities threaten to aquatic environment due to over used and untreated waste water/fertilizer/pesticide/waste/ etc. direct discharge in to streams and rivers in Sri Lanka and finally end up in Reservoir sediment or in the coastal zone in the country.

Sri Lanka has 103 river basins with perennials and seasonal rivers. The rivers are starting from central highlands with radial pattern. Many studies focused on large rivers and there are less attention on small scale rivers. These rivers basins are rich with high biodiversity and many are less studied. Presently, many incidents happen such as diarrhea, chronic kidney disease, etc., are due to fresh water resources being polluted by industrial wastes and sewage run off as well as agricultural runoff. Also, many studies reported that, recent past and various factors were identified as the contributing factors in deteriorating water quality in rivers and reservoirs in Sri Lanka (Sureshkumar *et al.*, 2007; Weerasekera *et al.*, 2010; Amarathunga *et al.*, 2010; Azmy *et al.*, 2010; Amarathunga *et al*, 2013a; Amarathunga *et al*, 2013b). Also many researchers reported that, agrochemicals led to increases of chronic kidney disease in Sri Lanka. There are less studies on river water quality behaviour and pollutions. Therefore it is very important to understand the quality of drinking water and mitigate to possible impact to human through fisheries/aquatic resources and drinking water. Higher populations' growth led to increases the agricultural activities; eventually peoples used various agrochemicals to increases of productions. The pesticide and other pollutants highly impact to aquatic health as well as to human health. Behaviors of such pollutant in the aquatic environment poorly understand and it required to study of chemical, physical and biological behaviour and impacts. Also, in Sri Lankan context, there is less attention on rivers specially large and small scale river basins. It is very important to understand about pollutant behaviour in large and small scale river systems. Therefore, study focused to; evaluate existing environments in large river basin (Kalani River), study the possible consequences to aquatic health using selected aquatic animals.

Objectives

- To assess water quality, pollutant & toxic agents and diversity of the different faunal categories in the river basin
- To facilitate the improvement of inland/coastal aquatic environment using new methodologies/technologies

Methodology

Study area

Kelani River basin is located in wetzone which belong to Colombo, Gampaha, Kegalle, Rathnapura and Nuwara Eliya District in Central and Western provinces of Sri Lanka (Figure 3.1).

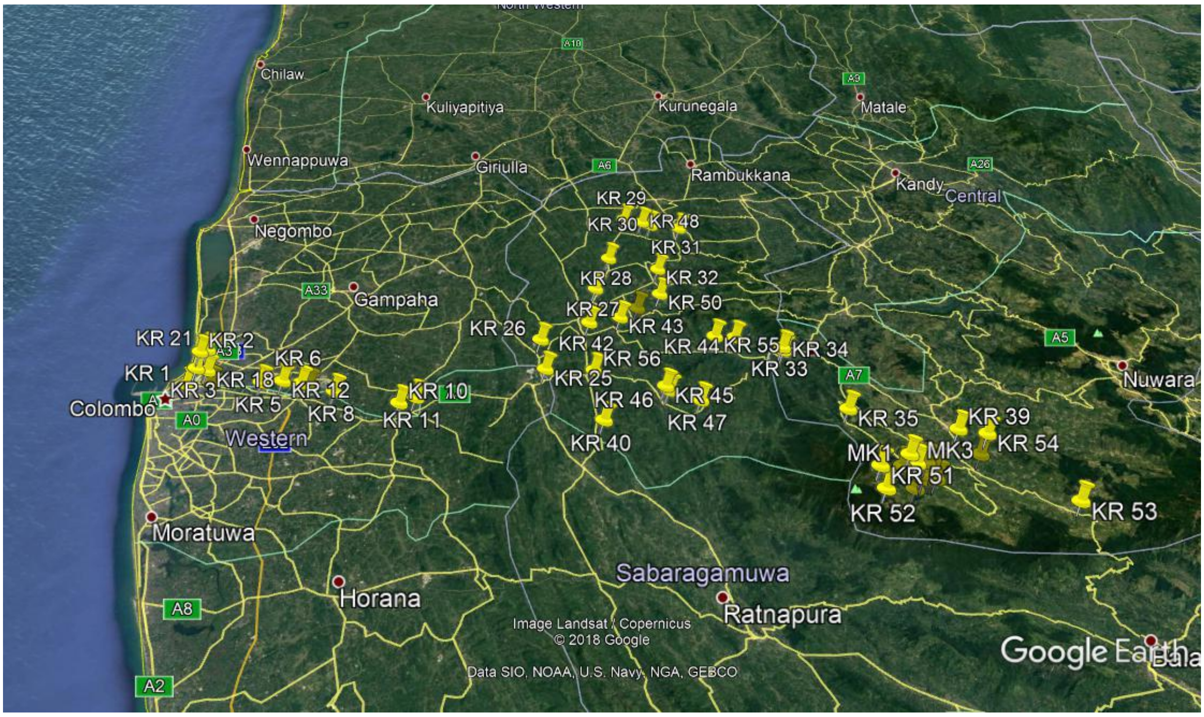


Fig. 1. Sampling Locations

In-situ analysis of water samples

Several water quality parameters were measured in situ. For certain parameters, primary data was collected in situ by using calibrated portable instruments. The measured in-situ water quality parameters were water temperature, pH, dissolved oxygen, turbidity, electrical conductivity, total dissolved solids, water pressure in surface water and initial dissolved oxygen for biological oxygen demand which are explained in Table 1.

Table 1: Principles and methods for in situ water quality analysis

(APHA, 2012)

Ex-situ analysis of water samples

Water samples were collected into pre-cleaned polypropylene bottles from each sampling sites and kept temporally at four degree of Celsius in dark during transportation to the laboratory.

Parameter	**Principle**	**Equipment**
Water temperature (°C)	Thermometric	Orion 260A portable pH meter
pH	Potentiometric	Orion 260A portable pH meter
Dissolved oxygen (mg/L)	Electrometric	Orion 830A portable dissolved oxygen metrer
Electrical Conductivity (mS/cm)	Electrical Conductometric	AD 332 EC-TDS-TEM portable meter
Total dissolved solids (ppm)	Electrical Conductometric	AD 332 EC-TDS-TEM portable meter
Turbidity (NTU)	Nephelometric	Hach 2100P portable turbidity meter

The collected water samples were measured in the laboratory. Water quality parameters, such as biological oxygen demand, chemical oxygen demand, total suspended solids (TSS), alkalinity, total hardness, calcium hardness, chloride, nitrite nitrogen, nitrate nitrogen, ammonical nitrogen,ortho-phosphate and chlorophyll analysis were determined in the laboratory according to the standard methods for the examination of water and wastewater (APHA 2012) Above mentioned laboratory water quality parameters are explained in Table 2.

Table 2: Ex-situ analysis methods of water quality parameters

Parameter	**Principle**	**Method**
Total suspended solids (mg/L)	Gravimetric	Total suspended solids dried at 105°C
Biological oxygen demand (mg/L)	Titrimetric	Winkler method
Chemical oxygen demand (mg/L)	Titrimetric	Closed reflux method
Nitrite – Nitrogen (mg/L)	Spectrophotometric	Colorimetric method
Nitrate – Nitrogen (mg/L)	Spectrophotometric	Cd Reduction method
Ammonical – Nitrogen (mg/L)	Spectrophotometric	Phenate method
Ortho Phosphate (mg/L)	Spectrophotometric	Ascorbic acid method
Chlorophyll (µg/L)	Spectrophotometric	Multi lambda method
Alkalinity (mg/L)	Titrimetric	H_2SO_4 Titration method
Total Hardness (mg/L)	Titrimetric	EDTA Titrimetric method
Calcium hardness (mg/L)	Titrimetric	EDTA Titrimetric method
Chloride (mg/L)	Titrimetric	Argentomeric method

(APHA, 1998)

Also, Pesticide adsorption experiment were conducted to understand the pollutant patterns with the particles.

Results and Discussion

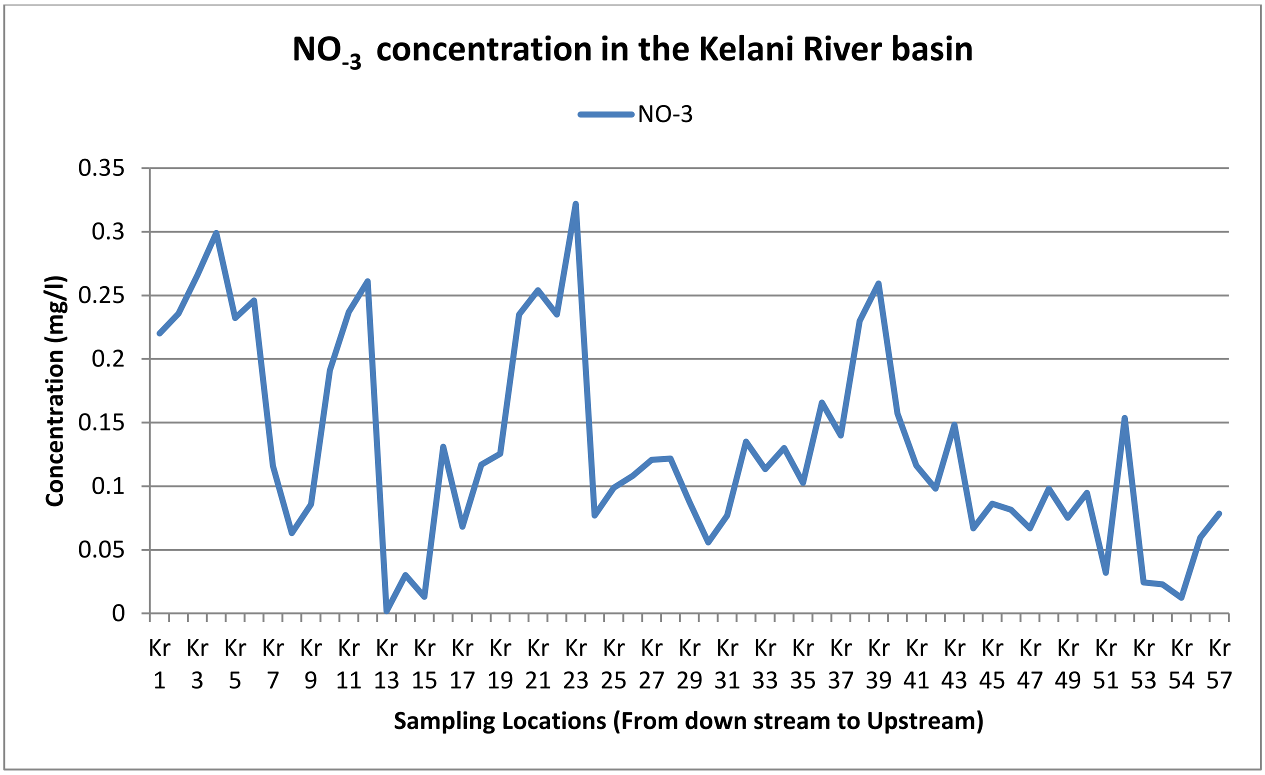
The main sources of water pollution in Kelani river is the land based sources such as treated and untreated industrial effluents, agricultural runoff, domestic and municipal effluents. The gravity of water pollution is apparent when examining water quality measurements of Kelani

River, which meets a major part of the demand for pipe borne drinking water supplies of Colombo. Kelani River is an important source of drinking water for the Colombo District and there is a water supply intake point at Ambatale, 14 kilometers from the river mouth. However, sewage from low-income settlements and industrial effluents (especially from tanning and metal finishing and processing industries) from a large number of industries are discharged conveniently to the Kelani River.

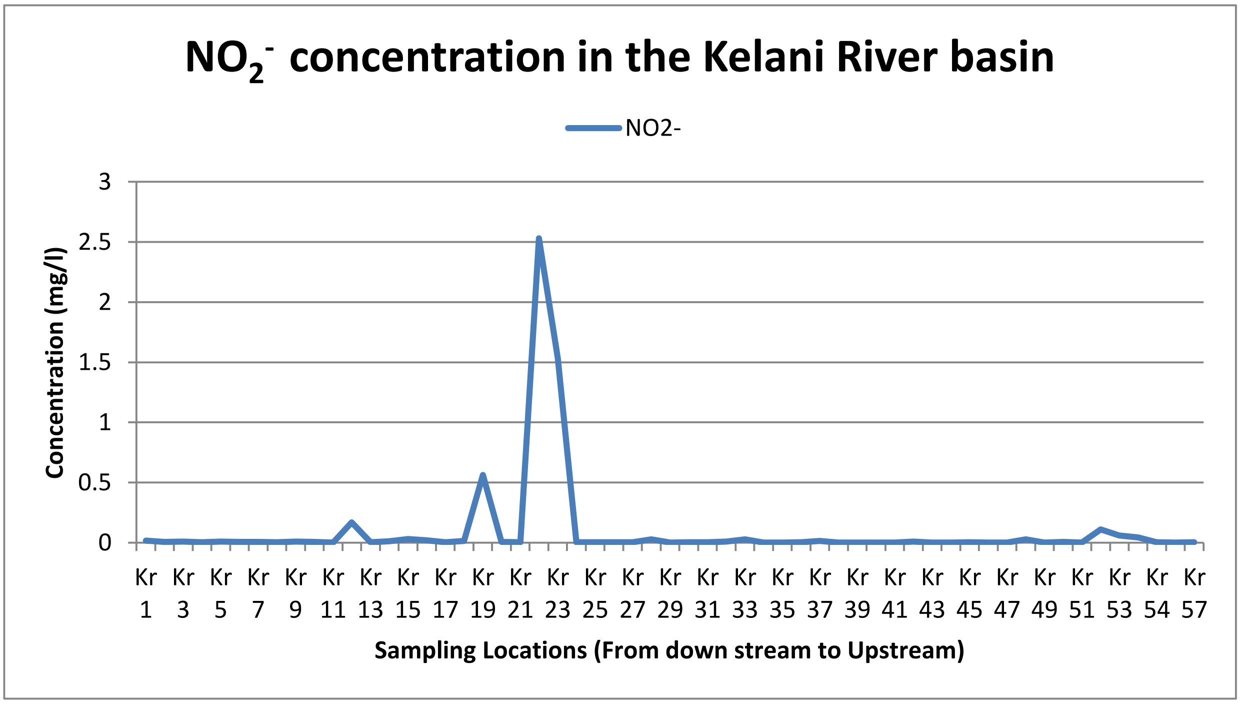
The pollution status of the Kelani river and some of its tributaries were investigated in 2018 with respect to pH, Electrical conductivity, Turbidity, DO, BOD,COD, Chloride, and nutrients. Including the major river, collectively 56 sample locations were selected for this study. According to the results, Thotalaga, Kolonnawa and Orugodawaththa were identified as most polluted locations and Upcot, Bogawanthalawa and Gartmore detected as minimum contamination level among the selected sampling locations.

According to the results obtained for the different chemical parameters, it is clear that Orugodawaththa, Thotalaga and Kolonnawa locations are highly polluted when comparing to the other sampling locations examined in the Kalani river basin. The mean concentration values received for ammonia-N and dissolved phosphate for the Orugodawatta, Thotalanga and Kollonnawa locations are as 4.17±0.71 mg/l, 3.12±0.22 mg/l, 1.12±0.6 mg/l; and 0.25±0.17 mg/l, 0.34±0.08 mg/l, 0.10±0.05 mg/l respectively. However, the lowest mean ammonia-N, and mean dissolve phosphate values were observed as 0.08 ± 0.09 mg/l, 0.08 ± 0.04 mg/l and 0.01 ± 0.01 mg/l, 0.03 ± 0.01 mg/l in Nallathanni and Upcot sampling locations respectively. In addition, high turbidity values were recorded in Orugodawatta, Thotalanga and Kollonnawa sampling location as 32.39 ± 2.43 NTU, 26.03 ± 6.27 NTU and 18.05 ± 1.5 NTU respectively. Although, lowest turbidity value of 0.75 NTU was recorded in Nallathanni Sampling location.

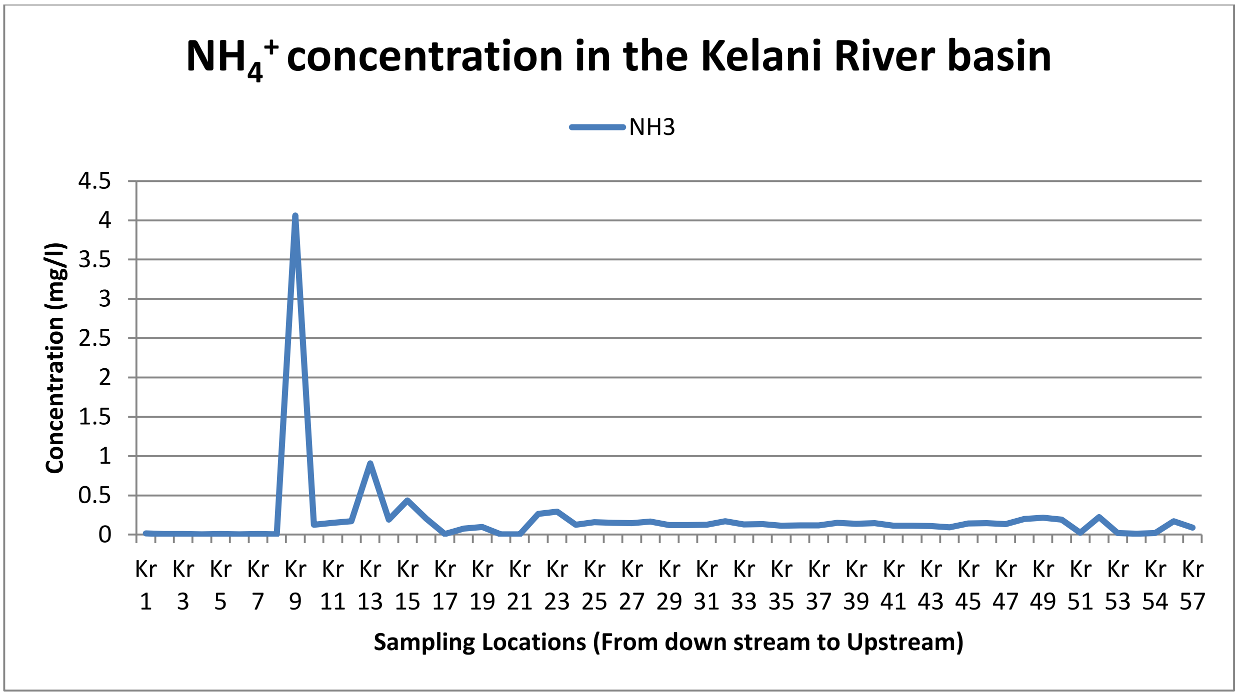
The following graphs illustrated the different water quality status along the river basin and its catchment (a- Nitrate Nitrogen concentration, b- Nitrite Nitrogen concentration, c- Ammonia Nitrogen concentration and d- Dissolve Phosphate Concentration) a)


NO-3 concentration in the Kelani River basin
NO-3
Concentration (mg/l)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Kr 1 Kr 3 Kr 5 Kr 7 Kr 9 Kr 11 Kr 13 Kr 15 Kr 17 Kr 19 Kr 21 Kr 23 Kr 25 Kr 27 Kr 29 Kr 31 Kr 33 Kr 35 Kr 37 Kr 39 Kr 41 Kr 43 Kr 45 Kr 47 Kr 49 Kr 51 Kr 53 Kr 54 Kr 57
Sampling Locations (From down stream to Upstream)

b)

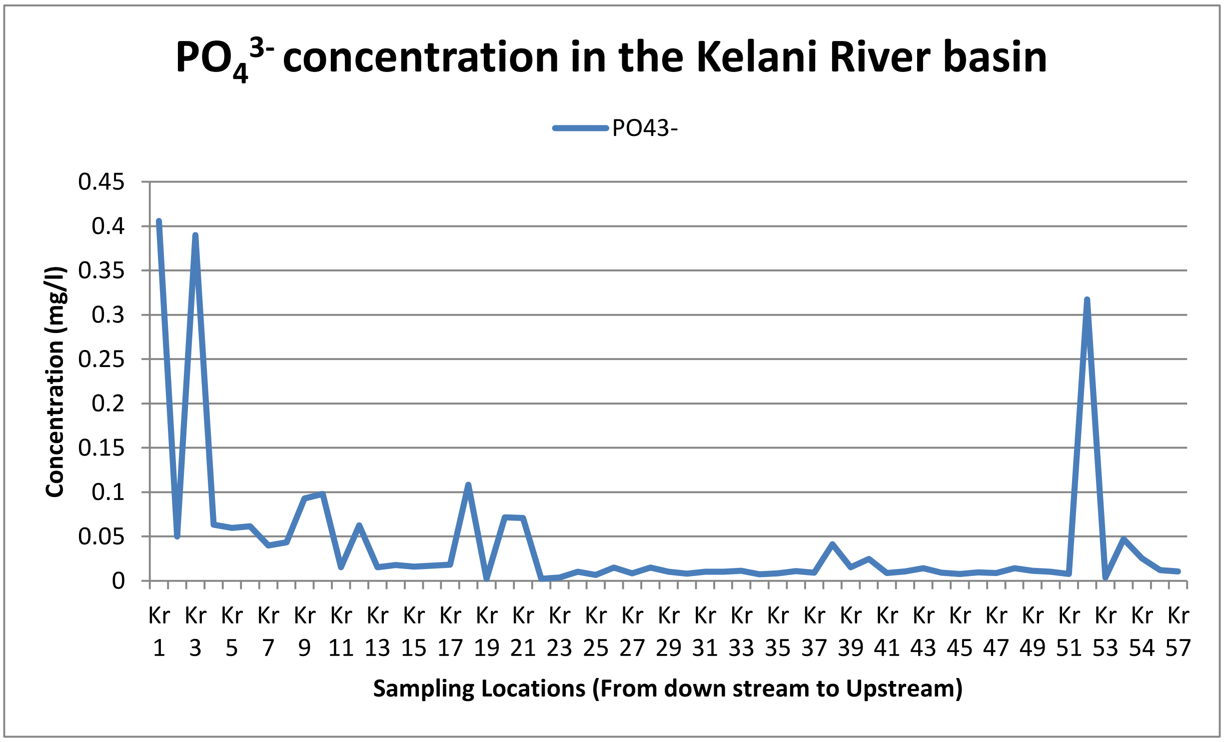

NO2- concentration in the Kelani River basin
NO2-
Concentration (mg/l)
3
2.5
2
1.5
1
0.5
0
Kr 1 Kr 3 Kr 5 Kr 7 Kr 9 Kr 11 Kr 13 Kr 15 Kr 17 Kr 19 Kr 21 Kr 23 Kr 25 Kr 27 Kr 29 Kr 31 Kr 33 Kr 35 Kr 37 Kr 39 Kr 41 Kr 43 Kr 45 Kr 47 Kr 49 Kr 51 Kr 53 Kr 54 Kr 57
Sampling Locations (From down stream to Upstream)

c)



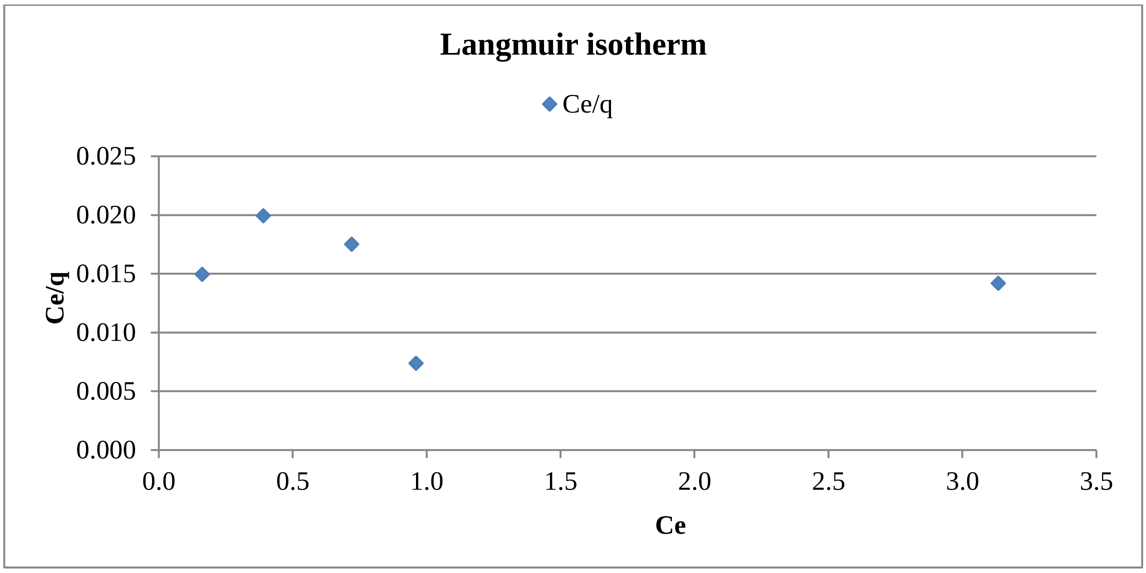
NH4+ concentration in the Kelani River basin
NH3
Concentration (mg/l)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Kr 1
Kr 3
Kr 5
Kr 7
Kr 9
Kr 11
Kr 13
Kr 15
Kr 17
Kr 19
Kr 21
Kr 23
Kr 25
Kr 27
Kr 29
Kr 31
Kr 33
Kr 35
Kr 37
Kr 39
Kr 41
Kr 43
Kr 45
Kr 47
Kr 49
Kr 51
Kr 53
Kr 54
Kr 57
Sampling Locations (From down stream to Upstream)

d)



PO43- concentration in the Kelani River basin
PO43-
Concentration (mg/l)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Kr 1
Kr 3
Kr 5
Kr 7
Kr 9
Kr 11
Kr 13
Kr 15
Kr 17
Kr 19
Kr 21
Kr 23
Kr 25
Kr 27
Kr 29
Kr 31
Kr 33
Kr 35
Kr 37
Kr 39
Kr 41
Kr 43
Kr 45
Kr 47
Kr 49
Kr 51
Kr 53
Kr 54
Kr 57
Sampling Locations (From down stream to Upstream)

In addition, tests were conducted to understand the pesticide behavior with organic matter in the basins. The results suggest that high amount of pesticide retaining with respect to organic carbon concentration. The following graphs illustrate the pesticide adsorption rate under Longmire and freundlich isotherms.



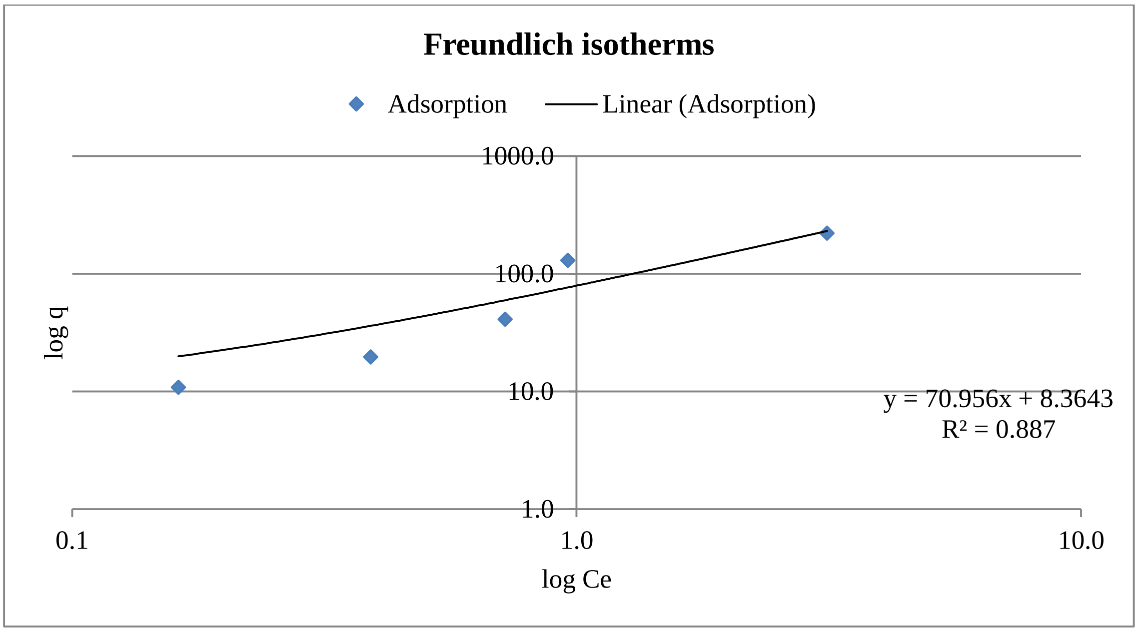


Fig. 1: Longmire and freundlich isotherms

This will reflect the pollutant adsorption to particles in the water. Therefore, it can predict that pollutant in the most upper part can be transported to lower part of the basin without any disturbance through the sediment particles and then release in to waters in lower part.

Plate 1: Sampling at different locations of Kalani river basin

Conclusions and Recommendations

- Nutrients parameters are comparatively high in Maskeliya Oya sampling location, In addition, higher amount of solid waste observed in the Maskeliya Oya sampling location due anthropogenic activities, Therefore, should be introduce proper system to minimize the illegal dumping of solid waste in to stream and otherwise it will negatively impact to Maussakele Reservoir also.
- In addition, macro plastic was observed in most upstream part of the river such as Gartmore and Nallathanni area. Therefore, implementing of proper dumping plan and awareness programme are urgent.
- Ammonia nitrogen in the bottom samples were observed in Maaussakele reservoir and need to be further study for sediment, sedimentation rates and existing sedimentation condition in the reservoir.
- Most of the lower basin which are connected to industrial areas were observed poor water quality.

Investigation of causes for emergency incidents such as oil spills, algal bloomsand fish kills (emergency studies).

Project No : 5.1.3

Officer Responsible :K.A.W.S.Weerasekara, A.A.D.Amarathunga, N.D. Hettige, B.R.C.Mendis, M.D.S.R. Maddumage, J.K.P.C.Jayawardena, S.R.C.N.K. Narangoda and R.H.N.S. Alwis

Background

Environmental emergencies are sudden occurrence of Fish kills, pollution of rivers with toxic chemicals, oil spills, algal blooms etc. These kinds of incidents are associated with sensational media headlines and mass public protests. Their effects can be devastating and long lasting, and it is the world's responsibility to prevent them where possible and deal with them quickly when they occur. NARA receives many requests from public to investigate and provide scientific reports based on the site inspection and field/laboratory experiments This project is being doing by the Environmental Studies Division as a continues project with collaborating the other divisions as well. Therefore, the 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.

Justification

A high number of aquatic resource pollution incidents in recent years due to fish kill incidents were recorded specially in the reservoirs and lagoons of Sri Lanka. Several fish mortalities have been recorded each year eg. Mass fish mortalities in Wattawan Lagoon (Batticoloa),Beruwala silliya Ela,Beire Lake,Aththidiya Canal(Ratmalana) & Dandugam Oya due to various water pollution incidents . Also, about 300 commercial vessels daily travel through Indian Ocean around Sri Lanka. Since there is a huge possibility for occurrence of emergency situations such as oil spills and environmental problems due to discharges into ocean waters. All this could cause problems of water pollution resulting in degradation of aquatic resources causing environmental and economic damage as well as public concern and the potential for social unease.

Scope

The purpose of conducting emergency environment investigation is to prevent adverse impact to aquatic organism and to aquatic health of the water bodies.

Proposed Action Plan

Conducting emergency studies such as fish kill incidents, oil pollution, harmful algal bloom, ballast water impact to Sri Lankan waters etc, in order to protect aquatic resources in the country to future development.

Within the 2018, total of two emergencies were informed to NARA to investigate. The summary of each incident is given in the following table.

MONTH	PLACE	INCIDENT	OBSERVATIONS	CONCLUSION
January	Welikada	Fish kill	All the dead fishes were identified as the *Oreochromis niloticus*	Low Dissolve Oxygen
March	Malwana	Fish kill	Many dead fish were observed	High Chemical and Biological Oxygen Demand levels
October	Bundala Lagoon	Fish kill	Many dead fish were observed	High salinity level
October	Puttlam Lagoon	Changes in water quality	Reddish colour water were observed	Soil mix with water

Investigation of mortality of Aquatic organisms in a water body at Welikada, Rajagiriya

The study was conducted on 11th January 2018, as per the request done by Welikada Police Station, Sri Jayawardenepura Kotte. Aquatic organisms (fish, tortoises, common water monitors...etc) in a water body near Welikada Police Station, started dying unexpectedly since a week ago to the investigation and the police reported the public complain. A preliminary report was produced based on the results of initial field investigation and laboratory tests carried out by a team of officers from Environmental Studies Division of National Aquatic Resources Research and Development Agency (NARA). The objectives of the investigation were as following;

1. To investigate the causes for mortality of aquatic organisms and understand the prevailing condition of the environment.
2. To provide recommendations of future remedial actions in order to avoid such situations.

According to the site observations and physiochemical parameters of water quality carried out, the results revealed that, the mortality of fish and other animals was due to respiratory problems caused by very low levels of dissolved oxygen together with acute ammonia poisoning.

Water body was completely covered with common duckweed species

Wastewater outputinto the water body

A comprehensive report with indicating the causes for mortality of aquatic organisms and the recommendations was forwarded to the welikada police station and the Central Environmental Authority.

Fish kill incident at Dompe, Malwana Pahuru Oya

The water samples and fish samples were received from public health inspector at Malwana, in order to investigate the courses for emergency fish kill incident happened at Malwana Pahuru oya. According to the physiochemical parameters of water quality and fish sample analysis carried out at the laboratory, the results revealed that because of high Chemical Oxygen Demand and low pH value caused the death of fish due to problems occurred in respiration. A letter was sent to the Malwana public health inspector with all the water quality results and recommendations.

Fish kill incident at Bundala lagoon

The investigation was carried out by Environmental Studies Division and Rakawa regional centre of NARA. Due to a sudden fish kill incident happened in the Bundala lagoon, the fisherman were unable to carried out their routine fishing activities. They believe that the incident was happened due to the high saline water release by the salt factory situated near to the lagoon area. It was evident that the high salinity results were received for the water samples collected within the first two days of the incident was happened.

Fish kill incident at Bundala Lagoon

Reddish colour high saline water

A report was forwarded to the divisional secretariat Hambanthota and Department of Wildlife Bundala.

Fish kill incident at Puttalam lagoon

According to the request made by the Department of Fisheries on 23/10/2018, the environmental studies division of NARA carried out a field investigation on 25/10/2018. According to the results obtained for the physiochemical parameter, the turbidity levels of water samples were high when compared to the water quality standards proposed by the Central Environmental Authority. The people of vicinity said that the incident was happened due to the high rainfall occurred followed by the removal of vegetation during that period.

Sand extraction at Puttlam Lagoon

Assessment of current water pollution status and accumulation of heavy metals in selected edible fish species in Bolgoda Lake

Project No : 5.1.4

Officer Responsible :K.A.W.S. Weerasekara, S.R.C.N.K. Narangoda, M.D.S.R. Maddumage, N.D. Hettige, J.K.P.C. Jayawardhane

Problem Statement/Justifications:

Bolgoda Lake is the largest natural fresh water body (347 km^2) in the Western Province. This lake system is situated in the low country wet zone of Sri Lanka. The depth of the lake is said to range from 20-50 feet. Lake has two major parts, [Southern and Northern lake] connected by a narrow stream known as the Bolgoda Ganga. It is currently used by the local community for various purposes including traditional fishery.

Since the lake is located in an urban area, it receives industrial waste, automobile waste and human waste and there is a possible risk of contamination of fish with heavy metals, Polycyclic Aromatic Hydro Carbons (PAHs) & micro plastics. These can be toxic at very low levels and ultimately affect the human health those who consume contaminated fish. However, there are few reports on above pollutants including metal levels in some food fishes collected from the Bolgoda Lake (*Oreochromis mossambicus* [Tilapia,], *Etroplus suratensis*, *Mystus gullio* [Anguluwa]. Therefore, the study aimed to assess the current water pollution status and accumulation of heavy metals & PAHs in selected edible fish species in Bolgoda Lake.

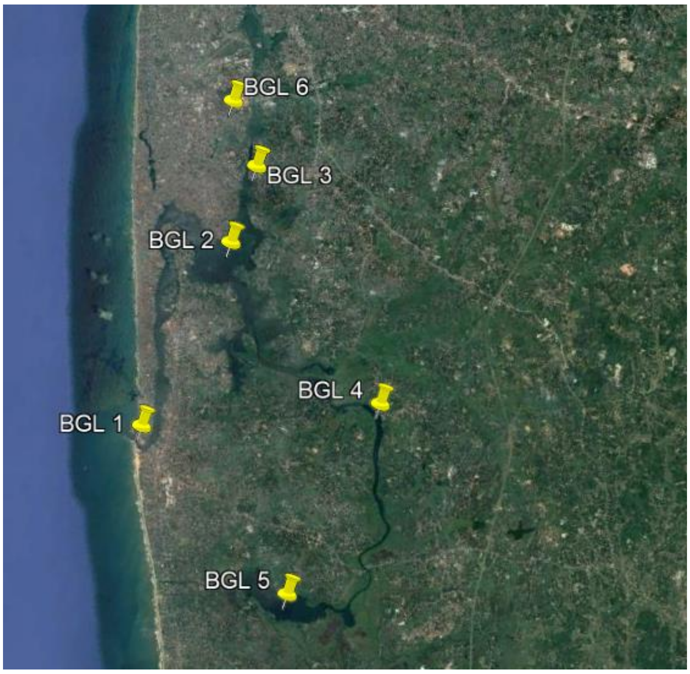
Project Objective/s:

- To characterize the quality of lake water using physico-chemical methods.
- To assess associations between contaminant load and health status of the feral fish in the Lake.

Methodology

Water, fish, sediment and phytoplankton samples were collected from five selected locations (Figure 1) representing the entire lake system i.e. Bolgoda North lake, South lake, Bolgoda Ganga, Weras Ganga and Estuary mouth at Panadura from February to December 2018. Physico-chemical parameters (water temperature, pH, electrical conductivity (EC), salinity, turbidity, dissolved oxygen (DO), total suspended solids (TSS), ammoniacal-N, ortho-phosphate, nitrate-N, nitrite-N, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), oil and grease) of water were measured according to standard methods.

Heavy metals namely Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Zinc (Zn) and selected Polycyclic Aromatic Hydrocarbons (PAH) were measured in lagoon water, fish tissues and sediments. Five (05) fish samples of each *Mystus gullio* (Anguluwa) and *Mugil cephalus* (Godaya) were collected in 03 months and weight, total length, standard length measurements were taken before analysing. Both phytoplankton and zooplankton samples were collected using 20 µm and 180 µm plankton nets and preserved with Lugol's solution and 4% formaldehyde. Identification and Enumeration of plankton was done using Seidgewick Rafter Counting Chamber Method and standard identification keys.



Plankton sample collection

Mugil cephalus(Godaya) fish collected

Sediment sample collection

Figure 3: Sampling locations in Bolgoda Lake

Results and Observations

Heavy metals As, Cd and Pb in fish tissue were below their Limits of Quantitation (LOQ) of 0.02 mg/l, 0.01 mg/l and 0.04 mg/l respectively. However, Hg (<0.2 mg/kg) was detected in 02 *Mystus gullio* (Anguluwa) fish samples and Chromium (Cr) (4.2 mg/kg) in one *Mugil cephalus* (Godaya) fish sample. Cu and Zn metals were detected in most of the fish samples and Zn recorded in higher values. Average Cu concentration in *Mystus gullio* was1.37±0.3 mg/kg where as in *Mugil cephalus* (Godaya) was 1.39±0.9 mg/kg. Average Zn concentrationin *Mystus gullio* was52.2±72.2 mg/kg where as in *Mugil cephalus*was 11.6±12.5 mg/kg.

None of the sixteen selected USEPA PAHs were detected in water, sediment and fish tissue samples as the concentrations are below the Limits of Report (LOR) of 0.001mg/kg.

Zn concentrations <2 mg/l were detected in 04 water samples though, all other tested heavy metals in water were less than their LOQ (As<0.02 mg/l; Cd<0.005 mg/l; Cr<0.01 mg/l; Cu<0.01 mg/l; Pb<0.04 mg/l; Hg<0.001 mg/l).

Relatively higher concentrations of heavy metals i.e. As, Cr, Cu, Pb and Zn were recorded in sediments whereas level of Cd and Hg were below the limit of quantitation (Cd- 0.01 mg/l; Hg- 0.01 mg/l).

According to ambient water quality standards for inland waters in Sri Lanka (2001), by Central Environmental Authority, the dissolved oxygen and Biochemical Oxygen Demand (BOD) in water should be >3 mg/l and <5mg/l to sustain healthy aquatic life. Also, Chemical Oxygen Demand (COD) should not be >15mg/l. However in this study, dissolved oxygen, ammoniacal nitrogen ($N\text{-}NH_4^+$), BOD and COD of Weras ganga and near Karadiyana waste dump site did not satisfy the above standards. In addition, nitrate nitrogen (NO_3^-), nitrite nitrogen (NO_2^-) and dissolved phosphorous levels in water were high in the same locations compared to other locations.

Pediastrum duplex, Microcystis aeruginosa were recorded as dominant phytoplankton species which are known as pollution tolerant species. Perhaps, waste inputs may come from Weras Ganga and Karadiyana dumpsite in to the Bolgoda lake system that would endanger the good health of the Bolgoda Environmental Protection Area (EPA). Therefore, measures should be taken to prevent direct discharges of waste into Bolgoda EPA.

Observations

Illegal encroachments along river banks

Solid waste disposal at the river bank

Fishery in Bolgoda

Rapid growth of aquatic plants blocking the transportation

Conclusions

Copper (Cu) and Zinc (Zn) metal concentrations in *Mystus gullio* (Anguluwa) and *Mugil cephalus* (Godaya) were high.

Dissolved oxygen, ammoniacal nitrogen ($N\text{-}NH_4^+$), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in water at Weras ganga and near Karadiyana dump site were poor and not within the standard limits.

Rapid growth of aquatic plants (*Aponogeton crispus, Nymphaea*, *Nelumbo nucifera*, *Salvinia molesta*, *Eichhornia crassipes* etc.) which blocks the boat transportation in the lake system can be an indication of nutrient enrichment (nitrogen and phosphrous) in water.

Some parts of the Bolgoda River and the lake are illegally encroached by the urban dwellings and hotels thus, natural ecosystem is degraded.

Comprehensive study on impacts of semi-intensive shrimp farming on Mundel Lagoon and its surroundings

Project No : 5.1.5

Officer Responsible : N.D. Hettige, J.K.P.C. Jayawardhane, R.H.N.S. Alwis, K.A.W.S. Weerasekara, M.N.D.F. Abeykoon, K.H.M.L. Amaralal

Background and Justification

Mundel Lagoon extends approximately 3,100 ha with an average depth of 0.75 m which is located in Puttalam District in North-Western Province. Aquaculture farms are the most conspicuous development activity around the lagoon while a small-scale subsistence fishery can also be found. The lagoon and its environs are disturbed as a result of injudicious utilization of resources beyond sustainable limits (CEA, 2006). There are complaints from Mundel lagoon fishermen that shrimp farm effluents with chemicals, waste and dead and diseased shrimp aredirectly released to the lagoon thus, fish kills occur yearly. According to fishermen, per capita fish harvest is declining throughout the past years and their livelihood is vulnerable as a consequence. In addition, some disease outbreaks due to viral infections of shrimp have been recorded in the past. Therefore, identification of environmental and socio-economic impact of intensive shrimp farming in the area is important to provide recommendation measures to mitigate the impacts in order to ensure the sustainable lagoon fishery. The project was conducted by Environmental Studies Division in collaboration with Socio-Economic Division and Inland Aquatic Resources and Aquaculture Division.

Objectives

Component 1-

- To determine current status of water quality and identify pollution sources to Mundel lagoon
- To identify selected indicator species in Mundel lagoon
- To recommend suitable management measures to mitigate the pollution impacts to the lagoon

Component 2 –

- To assess socio-economic impacts of intensive shrimp farming to Mundel lagoon and its surrounding community.
- To identify means and ways to improve socio-economic benefits of shrimp farming to the farmers and community in the area.

Methodology

Component 1 -

Water and plankton samples were collected at eight selected locations (figure 1) in the lagoon and from surrounding shrimp farms (figure 2) in Udappuwa and Mangala eliya area monthly from February to November 2018. Physico-chemical parameters (water temperature, pH, electrical conductivity (EC), salinity, turbidity, dissolved oxygen (DO), total suspended solids (TSS), ammoniacal-N, ortho-phosphate, nitrate-N, nitrite-N, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) of water were measured according to standard methods. Heavy metals namely Copper (Cu), Lead (Pb), Chromium (Cr) and Mercury (Hg) were measured in lagoon water. In addition, *Vibrio cholera, Salmonella* and alkalinity were determined in water samples collected from twelve shrimp farms in August. Shrimp samples collected from the lagoon were testedfor *Vibrio cholera* and *Salmonella* as well.

Figure 4: Map of selected sampling locations in the Lagoon

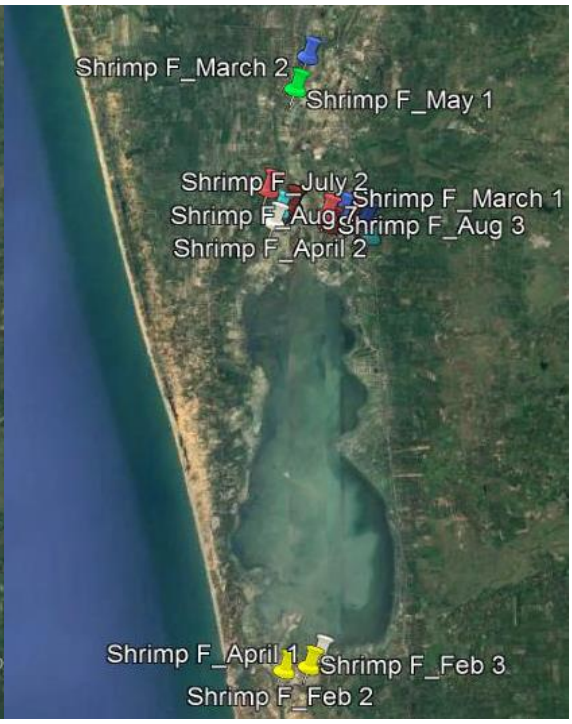


Figure 5: Map of selected Shrimp Farms

Sediment samples were collected in selected locations from May to July using Grab sampler to identify benthic macro invertebrates. Benthic macro-invertebrates were sorted and identified to the nearest possible taxonomic category using standard identification keys provided by Jessup et al, (2002) and Bouchad (2002). Both phytoplankton and zooplankton samples were collected and preserved. Identification and enumeration of phytoplankton was done using standard identification keys.

Component 2 –

Study area:

The GN divisions located around the Mundel lagoon within 500 m boundry was taken as the study area because 500m boundry is considered as the buffer zone of the lagoons in Sri Lanka (Coastal Conservation Department of Sri Lanka). There were 11 GN divisions under the selected area (figure 3, table 1).

Figure 6 : Selected GN Divisions around Mundel lagoon

Table 1 : Description of the selected GN divisions

DISTRICT	DS Division	GN Division	GN code	MC_UC_PS_N	No. of HHs
Puttalam	Mundalama	Udappuwa	594B	Arachchikattuwa PS	683
Puttalam	Mundalama	Andimunai	594A	Arachchikattuwa PS	613

Puttalam	Mundalama	Pulichchakulama	593	Arachchikattuwa PS	1090
Puttalam	Mundalama	Poonapitiya	597A	Kalpitiya PS	390
Puttalam	Mundalama	Kattakaduwa	597	Kalpitiya PS	549
Puttalam	Mundalama	Kottanthievu	598	Kalpitiya PS	532
Puttalam	Mundalama	Kudirippuwa	610D	Puttalam PS	324
Puttalam	Mundalama	Mundalama	610	Puttalam PS	258
Puttalam	Mundalama	Karathanvilluwa	610C	Kalpitiya PS	414
Puttalam	Mundalama	Mangalaeliya	610A	Puttalam PS	358
Puttalam	Arachchikattuwa	Battuluoya	591	Arachchikattuwa PS	370

Sampling

Preliminary study was conducted to identify the different type of lagoon users and major livelihood activities in these 11 GN divisions. Lagoon fishery, marine fishery, shrimp farming, Agriculture & livestock and salt production were identified as the major livelihood activities of the study area. Data were collected from people living in the study area as representing the major livelihood activities. Random sampling was used to select the respondents.

Data collection

Key informant interviews, questionnaire survey and PRA were used to collect data. Data were collected from January to July 2018. Relevant information were taken from two Fishery instructors of Mangala Eliya and Baththulu oya FI divisions, Additional director of fisheries in Puttalam district, Economic development officers in selected GN divisions and community leaders in the study area through key informant interviews.

Data on socio economic status of shrimp farmers, problems faced by shrimp farmers and other information related to shrimp farming were collected through a questionnaire survey. There were 304 registered shrimp farmers in the study area (NAQDA) and data were collected from 32 shrimp farmers, selected on random basis.

Data on lagoon and marine fishery, impact of shrimp farming to lagoon and marine fishery were gathered from a PRA. 40 fishermen participated representing the 11 fishery societies of the two fisheries districts (Baththulu oya and Mangala eliya) around the Mundel lagoon.

In order to gather data on impact of shrimp farming to other livelihood activities, another PRA was conducted with the participation of 30 people living in the study area and engage in other major livelihood activities.

Interviewing a shrimp farmer

Shrimp farm land

PRA with lagoon fishers

PRA with crop and livestock farmers

Results

Physiochemical characteristics of lagoon water:

Physico chemical parameters such as water temperature (> 30°C), salinity (> 50 ppt) of lagoon water were significantly high during dry period i.e. February, March and April thus hypersaline conditions were recorded. Average salinity level was decreased up to 15.5±1.4 ppt in May and 14.4±1.6 ppt in November with the receipt of heavy showers however it gradually increased up to the average salinity of 30.3±17.3 ppt. Average pH value of water was 6.7±3.5. Mean dissolved oxygen level of water was greater than 6 ppm which was good. Average depth of the lagoon varied between 2- 4 ft. The locations with sea grass beds recorded highest dissolved oxygen in water. Mean concentrations of nitrate nitrogen (0.007±0.01), nitrite nitrogen (0.01±0.01) and dissolved phosphorous (0.01±0.01) were within the acceptable range. Highest nitrate concentration was recorded in sampling location 1, 8 and 3 which could be due to release of waste from shrimp farms through Puttalam lagoon side and Chilaw Lagoon side of Dutch canal.

However, ammoniacal nitrogen values were slightly high (average: 0.13±0.08 ppm). Free ammonia is the gaseous ammonia or unionized ammonia (NH_3) which is highly toxic to fish. Free ammonia values in lagoon water were calculated using ammoniacal nitrogen concentration, pH and temperature. Calculated average Free Ammonia concentration in lagoon water was 0.03±0.01 ppm. According to the Thumb rule, free ammonia concentration in the water affect the fish and aquatic life as follows;

Safe	0.001 - 0.020 mg/L
Alert	0.020 – 0.050 mg/L
Alarm	0.050 – 0.2 mg/L
Toxic	0.2 - 0.5 mg/L
Deadly	>0.5 mg/L

According to the results, free ammonia concentration of the lagoon water had reached the ‘Alarm level’ to fish in certain sampling locations in months May, June and July (Figure 1). Free ammonia concentration would be changed due to pH, water temperature and total ammonia concentration. However, the existed level was not toxic to fish and aquatic life.

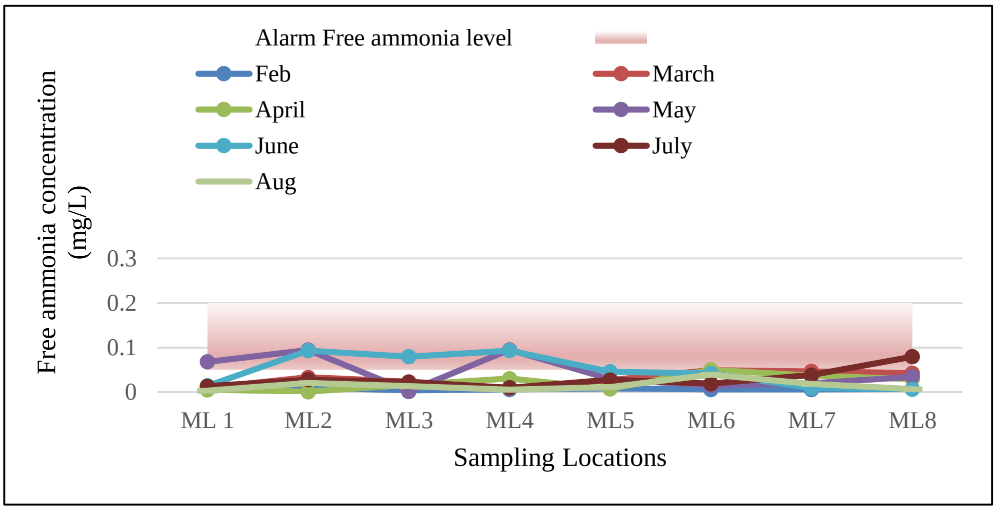


Figure 7: Free ammonia concentration in Mundel lagoon water

Heavy metals in lagoon water:

The level of heavy metals i.e. Copper (Cu), Lead (Pb), Chromium (Cr), Mercury (Hg) in lagoon water was below their Limit of Quantification (LOQ) in July. The LOQ of Copper (Cu), Lead (Pb), Chromium (Cr), Mercury (Hg) were 0.01 mg/L, 0.04 mg/L, 0.005 mg/L and 0.001 mg/L respectively.

Infectious agents in lagoon water and shrimp farms:

The *Vibrio cholera* and *Salmonella* was not recorded in the water samples collected from selected twelve shrimp farms in the month of August. The *Vibrio cholera* and *Salmonella* was not detected in the shrimp sample which collected from the lagoon in the month of July.

The Disease (IHHNV and WSSV) in shrimps were identified in collected shrimps in farms surrounding of the Mundel lagoon by Inland Aquatic Resource and Aquaculture Division. According to shrimp farmers, diseases have been lower than the previous years. Shrimp farmers are allowed to farm according to 'Crop calendar' introduced by National Aquaculture Development Authority (NAQDA) to minimize the environmental impact and to reduce spread of diseases.

Plankton

Pseudo-nitzchia sp., *Thalassionema* sp., *Asterionella* sp., and *Rhizosolenia* sp. were the abundant diatom species recorded in lagoon water. Dinoflagellate species were identified with high abundance. Some potentially toxin producing dinoflagellate species were identified among them i.e. *Ceratium furca, Alexandrium tamarense*, *Dynophysiscaudata*, *Dynophysis acuminata*, *Pyrocystis* sp.

The Polychaete larvae are the dominant zooplankton in the lagoon during the study period. Furthermore, Bivalve Veliger larvae, Crustacean nauplius larvae, *Favella campanula, Calanoid copepods, Cyclopes* sp., *Harpecticoid copepod, Nauplius larvae, Acrocalanus gibbler* were found in the lagoon water. Crustacean nauplius larvae, *Acrocalanus gibbler* Polychaetelarvae, *Harpecticoid copepod, Favella campanula, Nauplius larvae, Calanoid copepods, Cyclopes* sp. were found in the shrimp farm water. Among them, *Acrocalanus gibbler* is the dominant zooplankton species in the shrimp farms water. Thus, *Acrocalanus gibbler* was identified as indicator species in the shrimp farms. Polychaete larvae, Daphnia sp. and Nauplius larvae were identified as indicator species in the lagoon. However, Nereidid sp. and Pilargidiid sp. was recorded only as polychaete of macrobenthos. Polychaete larvae may be destroyed due to pollution condition of the lagoon.

Benthic Invertebrates

Altogether 12 species of benthic invertebrates belonging to 11 families were recorded during the study period. Among them were 2 species of polychaetes, 2 species of bivalves, 7 species of gastropods, and one species of decapods.

Physiochemical characteristics of Shrimp farm water:

Salinity (mean 33.7±8.1 ppt) of shrimp farm water during dry period i.e. February, March and April 2018 was very high hence, farm owners use tube well water to reduce salinity. Recorded Total Suspended Solids (TSS) (mean: 66.9±51.9 mg/l) values are very high in selected shrimp farms water than the acceptable range (2-14mg/l) of water quality for shrimp culture. Furthermore, ammonaical nitrogen concentration, Biochemical Oxygen Demand (BOD_5) (18.6±11.4mg/l; acceptable range <10mg/l) and pH (8.6±0.6) was higher in some shrimp farms water than the above acceptable range. However, Temperature, DO, Nitrate, Nitrite were within the acceptable range of water quality for shrimp culture at the sampling period in selected shrimp farms water.

The average BOD_5 in lagoon water was 10.14 ± 8.72 mg/L due to release of organic matter from the shrimp farms. The average COD was 497.83 ± 381.34 mg/L in lagoon due to use and discharge of several chemicals forrecap process of shrimp farming activities.

Vicinity of the farms

Vicinity of the water discharge location

Water collected tank in farms

Water discharging to the surrounding canals

Eutrophication in shrimp farms

Shrimp farm after harvesting

Socio-economic impacts of intensive shrimp farming

Status of fishing in Mundel lagoon

Lagoon fishing is being practiced in Mundel lagoon from the ancient time and currently there are about 1000 households that depend solely on lagoon fishing. 2 or 3 people from each family engage in fishing activities. Majority of other fishers engage in marine fishing while engage in lagoon fishing as a part time activity. Most of the fishers participated in the PRA had 20-30 years of experience in lagoon fishing. Shrimp, Anguli, Korali and Theppili are the main fish varieties catch in the lagoon. Shrimps are caught using cage nets and the daily catch is around 5-10 kg. For other fish, fishing nets are laid around 3 to 4 p.m in the evening and taken them in the next day morning around 6 a.m. Average daily fish catch is around 6 kg.

According to the PRA data, shrimp farming has been started in year 1988 and after that many changes have been taken place in the lagoon fishing in the study area. These changes are listed below.

- Due to releasing of chemical mixed water from shrimp farms into the lagoon, the color of lagoon water has been changed from blue color to yellow/green color.
- Get skin itches after being in lagoon water
- Lagoon water has contaminated by the water released from shrimp farms and this has caused dying of immature fish and lowering the fish growth
- Water level of the lagoon has reduced due to pumping lagoon water into shrimp farms
- Some of the fish varieties have been disappeared (e.g. Magura) or their population has declined (e.g. Thepppili)
- The ways to reach the lagoon by fishermen has interrupted due to the shrimp farms located around the lagoon

Lagoon Fishers stated that their income level has not changed from past years to present. Before shrimp farms were started, the fish catch was high in the lagoon but the fish prices were low. Conversely, at present the fish catch is less but the fish prices are comparatively higher that the past. Therefore the income level kept constant before and after shrimp farming. However lagoon fishers further stated that their living standards have decreased by 75% after the shrimp farms were started. Their monthly expenditure for food is around Rs. 30,000 and when the fish catch is low they have to borrow money to cover their daily expenditure.

From the PRA, it was revealed that there are environmental and social problems arise due to the shrimp farming.

Environmental problems:

- Drinking water scarcity in the study area (Ground water table has been reduced due to pumping water from deep tube wells for shrimp farms)
- High salinity in drinking water
- Depth of the lagoon is decreased due to sedimentation, siltation etc.
- Breeding habitats of lagoon fish have destroyed due to construction of shrimp farms around the lagoon
- Reduction in the growth of plants in home gardens
- Difficulty in rearing animals (cattle, goat etc) due to the water scarcity
- Fading wall paints of the houses in the study area

Social problems:

- Conflict between lagoon fishers and shrimp farmers due to the interruption of ways of lagoon fishers to reach the lagoon
- Dispute between lagoon fishers and shrimp farmers due to misunderstanding of shrimp farmers that lagoon fishers are coming to steal shrimps while fishers passing the shrimp farms to reach lagoons
- Shrimp farmers hire labors to low wages from the outside of the village and it reduces the job opportunities for the villagers
- Illegal fishing in the lagoon, practiced by the outsiders coming to work in shrimp farms

Increasing the number of lagoon fishers, discharging contaminated water from shrimp farms to the lagoon and declining the water level in the lagoon were mentioned as the major causes for reduction in fish catch in the lagoon. According to the lagoon fishers, shrimp farmers and the government are benefitted from the shrimp farming while no benefit to lagoon fishers. However lagoon fishers do not have strong opposition on shrimp farming if it can be done without any harm to lagoon fishing.

Following suggestions were made by the lagoon fishers in order to have a sustainable fishing in the Mundel lagoon.

- Remove silt in the lagoon
- Treat wastewater of shrimp farms before discharging to lagoon

➢ Stocking of fingerlings (Shrimp, Thilapiya, Vekkaya, Magura) in the lagoon during the rainy season in November -December

Awareness programme and discussion with lagoon fishery society

An awareness programme and a discussion were conducted with Mundel lagoon fishery society in September 2018. There, the fishermen were educated about the outputs of this project and further discussed with them to identify their problems and solutions were proposed.

Figure 8: During awareness programme in Mundel

Recommendations

According to the results obtained from the study following recommendations are suggested.

- Awareness programs about the method of lagoon pollution should be conducted for fishermen and shrimp farmers.
- When discharging industrial effluents into water bodies, given standards limit for discharge of effluents lagoon waters should be thoroughly followed by shrimp farmers.

- Proper coordination should be created among government and nongovernmental organizations to minimize the effect of pollution from the shrimp farm activities.

- Regulation should be implemented to minimize pollution from shrimp farms activities.
- Proper wastewater treatment should be implemented using experts' knowledge with the coordination of NARA and NAQDA.

- Proper monitoring programs should be initiated by NAQDA for identification of water pollutant sources during the farming activities for the registered shrimp farms and actions should be taken to prevent further damage to the surrounding environment.

Study of Marine Litter inputs from North western, Western and Southern Marine Coastal areas of Sri Lanka. (Continuous Project)

Project No	:	5.1.6
Officer Responsible	:	B.R.C.Mendis, A.A.D.Amaratunga, and R.H.N.S. Alwis

Justification

The sea around the Western 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 will increase the amounts of organic and inorganic waste input into the system and would have an impact on the overall coastal ecosystem. Sources of plastics include waste disposal from plastic industries, plastic garbage from ships, and litter on beaches. Therefore, dump plastic and polythene waste into marine environment harming the marine environment and the organisms living in it. Therefore, identification of waste input status helps in management and conservation biological and fisheries aspects.

Project Objectives

- ❖ To identify dumping of plastic and polythine waste inputs.
- ❖ To give recommendations to implement conservation measures to prevent waste management.

Methodology

In this study, marine debris (>2.5 cm in size) were surveyed on selected sites mainly in river discharge outlet, estuary mouths and tourist destination sites along the North - Western (Negombo and Chilaw) Western (Kalutara) and Southern (Bentota and Gintota) employed in selected coastlines (Table 1).

Table 1. Proposed sampling locations and importance

Coastal stretch	Proposed sampling location	Importance
North-western	Negombo	Sea mouth
	Chilaw	River mouth of 'Deduru oya'
Western	Crow Island/ Modara	River mouthof 'Kelani ganga'
Southern	Bentota	Bentota river mouth
	Gintota	River mouth of 'Gin ganga'

Results

The results indicated that marine debris collected from the study were mainly impact of anthropogenic inputs like domestic and boat waste.Significantly higher amount of debris found at Negombo sea mouth sites, which reflect the adverse impact of urbanization. The composition of debris was dominated by packaging material (40%), consumer products (25%), fishing items (15%) and plastic bottles (10%), Caps/lids and food wrappers/containers contributed 5% in each respectively. This study revealed that the urbanization in Negombo area has resulted water pollution and heavy load of marine debris.

Recommendations

Increase awareness of the people, not to deteriorate the environment that they are living and carrying out their livelihood activities. 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.

Enforce existing environmental regulations as required to overcome discharge of waste debris by the local people into the natural water bodies.Laws must be enforced to punish the people who violate the laws in coastal resource management.

Outcome

- ❖ Environmental friendly area, North western, Western and Southern coastal areas in Sri Lanka.
- ❖ Increased institutional strengthening for proper environmental management.
- ❖ Scientific publications

Expected output

- ❖ Number of plastic and polythine samples analyzed
- ❖ Waste sources identified

Number of research papers/leaflet published

National Institute of Oceanography and Marine Sciences

NIOMS

Oceanographic observations around Sri Lanka

Project No : 6.1.1(1)

Officers responsible : Akila Harischandra

Research Vessel Samudrika was not available for the survey through the year.

Integrated oceanographic investigation of coastal upwelling in Southern Sri Lanka

Project No : 6.1.1 (2)

Officers responsible : Dr.H.B.Jayasiri

Introduction

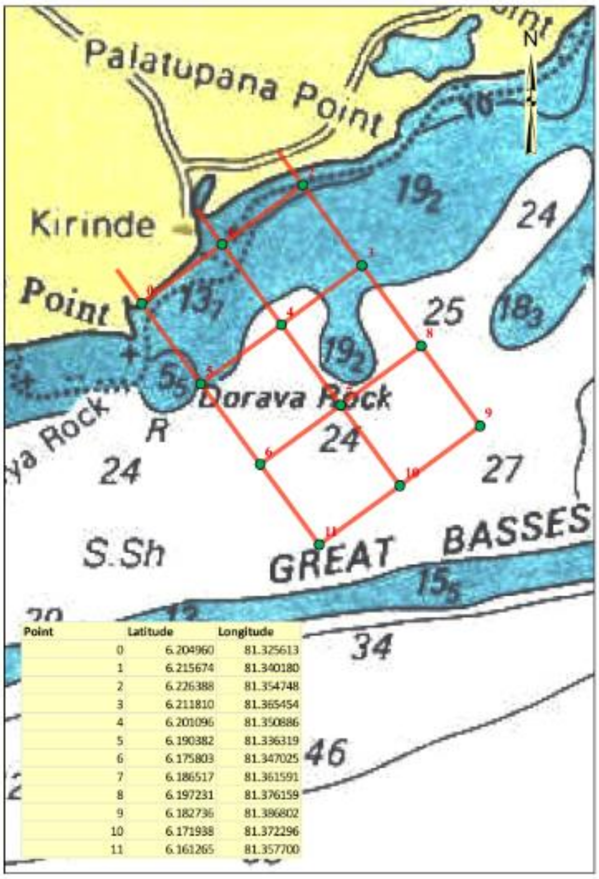
The southern coast of Sri Lanka is an important transitional passage between Arabian sea and the Bay of Bengaland one of most productive and very dynamic oceanic region in the Indian Ocean because of its geographical orientation. Therefore it is important to asses the productivity of this region through physical processes and biogeochemical properties. Fixed station includes a routinely collection, interpretation and presentation of data from the ocean and atmosphere with the purpose of giving a reliable explanation of the actual conditions of the ocean. Occurrence coastal upwelling due to southwest monsoon wind increases the productivity of the ocean which directly influence on fish productivity. The available information on southern upwelling is based on satellite derived data but lack of field observations hinders the understanding real status. Also, establishing a marine database from which time series and statistical analysis can be obtained for descriptions of trends and changes in the marine environment and providing predictions for the future developments associated with coastal region.

Phytoplankton is a key component of marine ecosystems and act as a potential bio-indicator of water quality alterations in response to local and global impacts.Some species of phytoplankton can have harmful effects on organisms at different trophic levels. Blooms of some otherwise-harmless species result in massive fishkills by depleting dissolved oxygen or by clogging the gills of fish.At least 90 of these cyst producing species are known to be harmful (Sournia 1995) and a minimum of 45 species are considered as toxic (Sournia 1995; Smayda 1997; Hallegraeff 2003).At certain times, the occurrence of a toxin-producing species of phytoplankton may affect wildlife, causing illness or death. Human consumers of certain seafood items (especially bivalve shellfish) are also at risk in the absence of adequate monitoring programs. This study provides the valuable information on phytoplankton community structure in coastal waters, off west-coast.

Objectives

- To provide field evidences for the existence of a wind driven coastal upwelling system that establishes during summer monsoon (SW) period along the southern coast of Sri Lanka.
- To estimate the productivity and identify the upwelling area in relation to climate change
- To evaluate spatial and seasonal patterns of abundance, diversity and composition of phytoplankton in relation to nutrients
- To identify and quantify the toxic dinoflagellates in coastal waters

Methodology



Point	Latitude	Longitude
0	6.204960	81.325613
1	6.215674	81.340180
2	6.226388	81.354748
3	6.211810	81.365454
4	6.201096	81.350886
5	6.190382	81.336319
6	6.175803	81.347025
7	6.186517	81.361591
8	6.197231	81.376159
9	6.182736	81.386802
10	6.171938	81.372296
11	6.161265	81.357700

Fig. 1. Study area showing sampling sites and locations

A total of 10 sampling sites in off Kirindawere selected for sampling (Fig. 1). Field surveys were carried out quarterly except 3rd quarter during SW monsoon due to rough sea condition. To study the nutrient levels, water samples were collected at the depth of 0.5 m from the surface and analyzed by standard methods for Nitrate, Nitrite, Phosphate and Silicate (Grasshoff et al., 1999). Further, water samples were collected to analyse the chlorophyll-a (Parsons & Strickland, 1963). Phytoplankton sampling was carried out using a net with a mesh size of 10 µm. Phytoplankton samples were analyzed for density, diversity and species composition. Zooplankton samples were collected using WP-2 net with a mesh size of 180 µm and analyzed for density, diversity and species composition

Results

Phytoplankton community at Kirinda was dominated by diatoms with 88% followed by dinoflagellates(12%). Phytoplankton abundance in the area varied from 12 to 197 no./l.). In General, the phytoplankton abundance decreased towards the offshore. A total of 43 phytoplankton species were reported in the area. Among 43 species, 7sps.were reported as toxic species. Diatom species of*Chaetoceros*sp. (36%),*Nitzschia*sp.(14 %)and*Bacteriastrum*sp. (8%) are dominatedin in the area and that indicate the possibility of blooms of these diatom species at Kirinda.

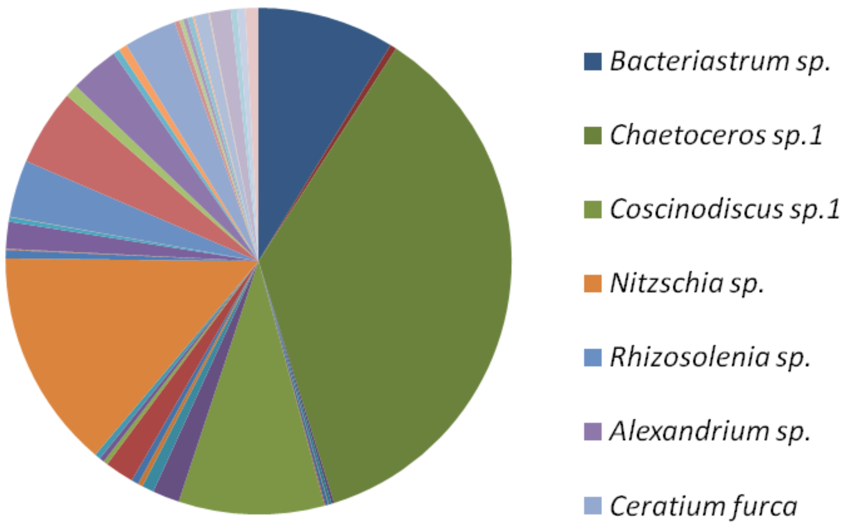


Fig. 2. Dominant phytoplankton species in Kirinda

Chlorophyll-a content varied from 0.55-1.51 µg/l with a mean of 0.93±0.31 µg/l. TSS level of the area varied from 2.70-22.10 mg/l with a mean of 7.38±6.98 mg/l. Nitrate-N concentration varied from 0.01-0.012 mg/l. Phosphate-P and Silicate-Si varied 0.022-0.32 mg/l and 0.025-0.211 mg/l respectively.

Table 2.Reported toxic dinoflagellates

Alexandriumcatenella
Alexandriummonilatum
Gymnodiniumsanguineum
Protoperidiniumdepressum
Protoperidiniumcurtipes
Prorocentrummicans
Prorocentrumredfeildil
Dinophysiscaudate
Noctilucascintillans
Gymnodiniumsp.

Table 3.Pearson's bivariate correlations of phytoplankton and bio-chemical parameters

		Dinoflagellates	Toxic sps.	Chl-a	TSS	NO_3^--N	PO_4^{3-}-P	SiO_4^{4-}-Si
Total abundance	r	0.78**	0.71**	0.60**	0.24	0.77**	0.16	0.14
	p	0.00	0.00	0.00	0.21	0.00	0.40	0.47
Dinoflagellates	r	1	0.97**	0.79**	0.20	0.44*	0.42*	0.39*
	p		0.00	0.00	0.31	0.02	0.02	0.03
Toxic sps.	r		1	0.79**	0.21	0.45*	0.46*	0.44*
	p			0.00	0.27	0.01	0.01	0.02
Chl-a	r			1	0.34	0.44*	0.69**	0.66**
	p				0.07	0.02	0.00	0.00
TSS	r				1	0.39*	0.38*	0.33
	p					0.04	0.04	0.08
NO_3^--N	r					1	0.14	0.10
	p						0.47	0.62
PO_4^{3-}-P	r						1	0.93**

	p	0.00
SiO_4^{4-}-Si	r	1
	p	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Total Phytoplankton abundance significantly correlated with dininoflagellates, toxic sps., chlorophyll-a and nitrate-N at p=0.01.Dinoflagellatessignificantly correlated with toxic sps., chlorophyll-a and nitrate-N at p=0.01.Toxic sps.significantly correlated with chlorophyll-a at p=0.01 and nitrate-N, phophate-P at p=0.05 (Table 3).

Publications

Abstracts

- *R.A.M. Jayathilaka, J.S. Jayanatha, W.K.Suwandahannad, N. D. Hettige and* ***H.B. Jayasiri, 2018*** Diversity of flora and fauna in Rekawa Lagoon, Southern coast of Sri Lanka. International Scientific Sessions of NARA, 25-26 July 2018. NARA auditorium, Colombo 15.

- ***H.B. Jayasiri*** *and S.U.P. Jinadasa. 2018.* Eulerian currents at surface waters of selected sites of off ColomboInternational Scientific Sessions of NARA, 25-26 July 2018. NARA auditorium, Colombo 15.

- *W.R.W.M.A.P. Weerakoon, T.B.D.T. Samaranayake,* ***H.B. Jayasiri*** *and K. Arulananthan , 2018.* Quantitative analysis of Micro-plastic contamination in beach sand at the western and south-western coastal stretches in Sri Lanka. International Scientific Sessions of NARA, 25-26 July 2018. NARA auditorium, Colombo 15.

- *H. P. S.Jayapala,* ***H.B. Jayasiri,*** *R. R. M. P. K. Ranatunga and C. Amarasiri. 2018. Marine debris and its potential impacts on mangrove ecosystem in Negombo Lagoon.* International Scientific Sessions of NARA, 25-26 July 2018. NARA auditorium, Colombo 15.

- *A.M.G.A.D.Athawuda,* ***H.B. Jayasiri****, S.C Jayamanne, W.R.W.M.A.P.Weerakoon, .G.N.Thushari and K.P.G K.P.Guruge. 2018.* Plastic litter enumeration and characterization in coastal water, off Colombo, Sri Lanka. International Scientific Sessions of NARA, 25-26 July 2018. NARA auditorium, Colombo 15.

- A.M.G.A.D Athawuda, **H.B Jayasiri**, S.C Jayamanne, W.R.W.M.A.P Weerakoon, K.P.G K.P Guruge and G.N.N Thushari 2018. Microplastic contamination in surface water of west coast -off Colombo, Sri Lanka. 2nd International Conference on Oceanography in the Bay of Bengal. 10-11 January 2018, Cinnamon Grand Hotel, Colombo. pp. 33.
- K.W. R. R. Amaraweera, **H.B Jayasiri** and V. Pahalawattaarachchi, 2018. An attempt on selection of prospective aquaculture sites based on selected biophysical attributes in Rekawa Lagoon, Southern Sri Lanka. International Scientific Sessions of NARA, 25-26 July 2018. NARA auditorium, Colombo 15.
- G. Kandasamy, D. K. Weerakoon, A. Sivarubanand **H.B. Jayasiri**.2018. Status of watrbirds in Kavutharimunai in the northern province, Sri Lanka, International Scientific Sessions of NARA, 25-26 July 2018. NARA auditorium, Colombo 15
- A.M.G.A.D.Athawuda, **H.B. Jayasiri**, S.C Jayamanne, W.R.W.M.A.P.Weerakoon, . K.P.G K.P.Guruge and G.N.Thushari 2018. Plastic litter enumeration and characterization in coastal water, off Colombo, Sri Lanka. Proceedings of the 2ndInternational Research sysmposium, 1-2 February 2018. UVA Wellassa University, Badulla.

Improvement of fishing ground forecasting and information dissemination system

Project No	:	6.1.2(1)
Officers responsible	:	Dr.J.K.Rajapaksha/ Mr. S. S. Gunasekara

Introduction

Total marine fish production of Sri Lanka in 2016 amounted to 456,990 tons while offshore and high seas fishery contributed 182,830 tons, 40 % (MFAR, 2017).Coastal fishery is still the major contributor to fish production of the country which is contributedaround 60% to the total marine fish production while 51.6% to the total fish production of thecountry. The fisheries sector contribution to the Gross Domestic Production (GDP) at constant pricein year2016 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 longline, gillnets and ring net or combination of them. Longline fleets mainly targeting large pelagic species such as yellowfin 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 2016, 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 thermocline 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 yellowfin 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 thermocline 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 longline. 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. Yellowfin tuna are known to preferentially occupy the surface mixed layer above the thermocline (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 thermocline variability is significant. As a result, longline deployment is uncertain and experienced low catch rates. Therefore, prediction of temperature vertical profiles was a challenge. Thus, amethodology 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 forecast to multi-day fishing vessels

Outputs

- Improved fishing ground forecasting system
- Updated databases for offshore fishery and oceanographic data

Outcomes

- Increased economic efficiency of offshore fishery sector and reduce the fishing pressure on coastal fishery resources.

Methodology

Project areas

Project area consist of the Indian Ocean where large pelagic fishing operations conducted by Sri Lankan fishermen from all coastal districts.

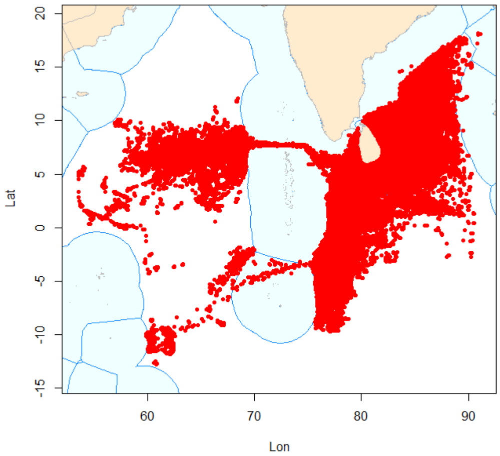


Figure 1: Fishing extent of Sri Lankan fishing vessels in Indian Ocean

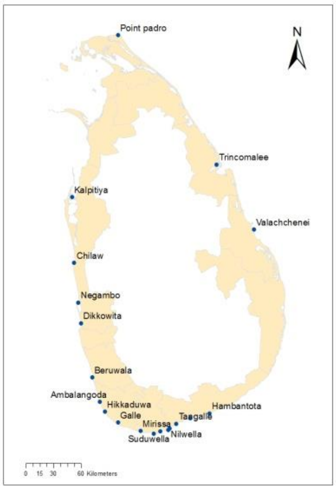


Figure 2: Fisheries harbors for data collection

Materials & Methods

Materials

Fisheries logbook data

DFAR had introduced logbooks since 2012 as a systematic approach to develop a database which was initiated in 2015. Logbook data has been seen as a source of fisheries data since it became widely recorded and compiled. In many instances the catch data is used for scientific research when none is available (Thomas-Smyth, 2013). However, the logbook information has been continuously argued as unreliable and not verified as accurate. There was no cost-effective alternative to validate accuracy of fisheries logbooks until VMS is introduced.

Vessel Monitoring Systems (VMS) data

VMS identity, position, speed, and heading data from SL vessels fishing in all areas are transmitted to the Department of Fisheries and Aquatic Resources (DFAR). Ping interval is set to default value of 4 hours to compliance with IOTC minimum requirements (IOTC, 2015).

Satellite data

Sea Surface Temperature

Sea surface temperature data obtained from GPM Microwave Imager (GMI). The Global Precipitation Measurement (GPM) satellite has a microwave radiometer onboard called GMI (GPM Microwave Imager). GMI data are produced by Remote Sensing Systems and sponsored by NASA Earth Science funding. Data are available at www.remss.com.

Absolute Dynamic Topography / Sea Surface Height

GLOBAL OCEAN GRIDDED L4 SEA SURFACE HEIGHTS AND DERIVED VARIABLES NRT product from CMEMS is used obtain Sea Surface Height. This product is processed by the SL-TAC multimission altimeter data processing system. It serves in near-real time the main operational oceanography and climate forecasting centers in Europe and worldwide. It processes data from all altimeter missions: Jason-3, Sentinel-3A, HY-2A, Saral/AltiKa, Cryosat-2, Jason-2, Jason-1, T/P, ENVISAT, GFO, ERS1/2.

Sea surface chlorophyll

The Sea surface chlorophyll data acquire from HERMES web interface (http://hermes.acri.fr/) of Globcolour project. GlobColour data (http://globcolour.info) used in this study has been developed, validated, and distributed by ACRI-ST, France.

Global Ocean Model data

The Copernicus Marine Services (CMEMS) provides regular information on the physical state and dynamics of the global ocean. Global ocean ¼° physics analysis and forecast product is updated daily and provide temperature of 43 vertical levels. Global physical analysis and coupled forecasting product includes daily mean files of temperature, salinity, currents, sea level, mixed layer depth and sea ice parameters. It is freely available for registered users at Copernicus Marine Service website (http://marine.copernicus.eu). This product is generated from the UK Met Office Global Seasonal coupled forecast system (GloSea5) which is used to provide 7 days of 3D global ocean forecasts, at ¼ degree, updated daily (MacLachlan *et al*. 2014). This forecast product is assimilated observations from satellite SST data (Advanced

Very High Resolution Radiometer (AVHRR)data and MetOp satellites supplied by the Global High-Resolution Sea Surface Temperature (GHRSST) project), In-situ SSTs (from moored buoys, drifting buoys and ships), Sea level anomaly observations (from Jason2 and CryoSat2) and Sub-surface temperature and salinity profiles (from Argo profiling floats, underwater gliders, moored buoys, marine mammals, and manual profiling methods).The Global Ocean output files are displayed with ¼°horizontal resolution with geographic projection. It also provides 43 vertical levels ranging from 0 to 5500 meters (Table 1).

Table 1: Depth levels and intervals of Global ocean ¼° physics analysis and forecast product

Depth range (m)	0-50	50-100	100-250	250-300	300-1500	1500-3500	3500-5500
Interval (m)	5	10	25	50	100	250	500

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 longlines were collected using TDR sensors for 6 months and the data are available from June 2012.

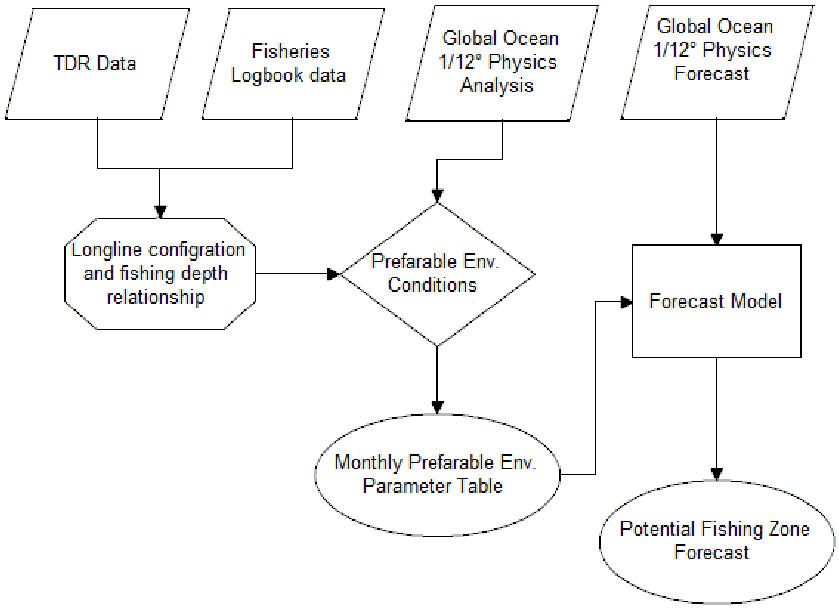


Fig.1 Flowchart of the Methodology

TDR and related fisheries data will be used to obtain relationship between longline configuration and fishing depth. This relationship can be used to predict fishing depths that useful to adjust longline 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.

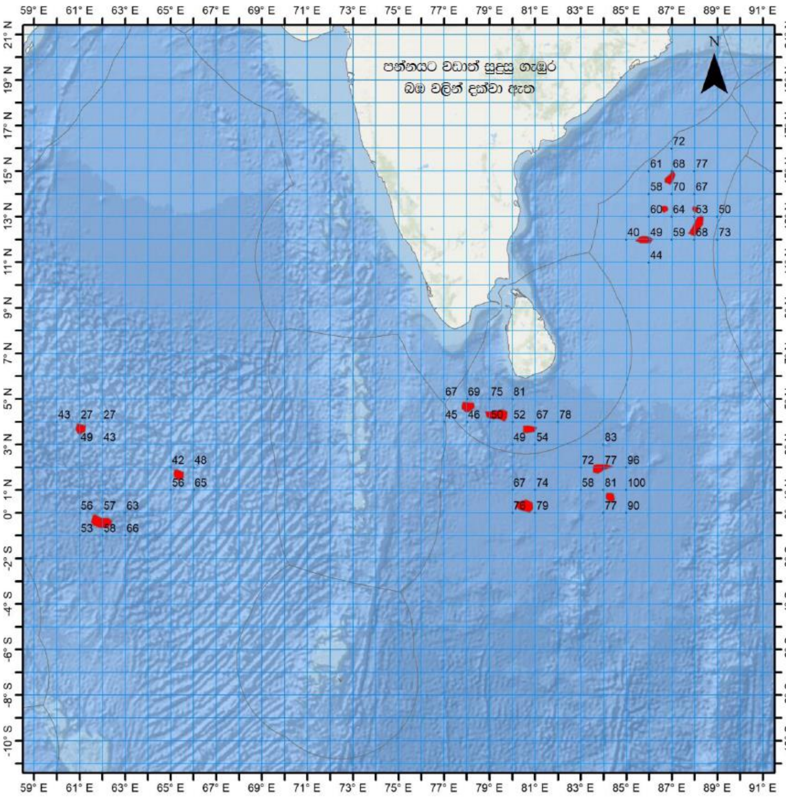
Activities

1. CMEMS ocean model data download and analysis
2. Fishery data collection: VMS data fisheries data
3. In-situ data collection (TDR, oceanographic data)
4. Model development
5. Generating fishing ground forecast maps
6. Validation of results
7. Disseminate information by TP, fax and internet to the users
8. 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.



ගැඹුරු මුහුදේ ධීවර කර්මාන්තය
සඳහා නිර්දේශිත ප්‍රදේශ

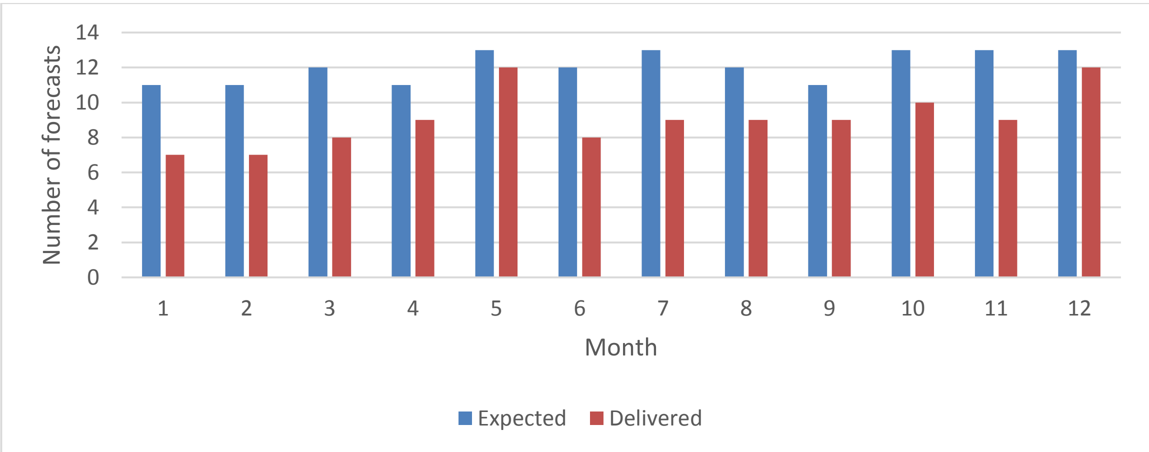
නිකුත්කල දිනය: 17.12.2018

අක්ෂාංශ			දේශාංශ			පන්න ගැඹුර
අංශක	මිනිත්තු		අංශක	මිනිත්තු		බඹ
14	39	N	86	52	E	69
13	21	N	86	38	E	62
13	18	N	87	58	E	53
12	34	N	88	07	E	68
11	57	N	85	48	E	45
04	39	N	78	04	E	55
04	19	N	79	30	E	50
03	38	N	80	42	E	51
01	58	N	83	46	E	77
00	18	N	80	31	E	76
03	43	N	61	02	E	49
01	44	N	65	20	E	54
-00	23	S	61	44	E	58

මෙම නිර්දේශය වලංගු වන්නේ නිකුත් කල
දින සිට දින 3-5 දක්වා පමණි.

National Aquatic Resources Research and Development Agency

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 providers' maintenance and breakdowns caused to interrupt project activities. Those events can't be avoided as NARA hasn'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 2018.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 2019.

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 2019.

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.

Publications produced

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Appendixes

THERMOCLINE VARIABILITY AND ITS IMPACT ON CATCH RATES OF TUNA AND TUNA-LIKE FISH SPECIES IN THE INDIAN OCEAN

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Abstract

Tuna fishery is an important source of income, exported to Japan and EU. Yellowfin tuna harvest is associated with thermocline layer thus, its seasonal changes cause vertical migration of fish schools. This study reveals fish catch rates of large pelagic fish species due to seasonal and intra-seasonal variability of subsurface temperature. Oceanographic datasets were obtained from Copernicus Marine Environmental Monitoring Service and analysed with fish catch data obtained from Sri Lankan longliners. Monthly mean datasets for four years from 2012 were used to extracted temperature profiles at fishing locations. Temperature profiles were fitted into 5-parameter sigmoid model to determine model parameters, the representative properties of the profiles. Fish catch data during the period from July 2012 to February 2014 were collected with temperature-depth recorders randomly fixed on longlines. Temperature-depth recording sensors were used to determine depth penetration levels of hooks by means of sag caused by slack of the main line between two buoys. Based on sensor data and catch records, fishing depth and corresponding temperatures were obtained from corresponding temperature profiles. Most commonly, 6-7 hooks per basket have been used in longlines while total number of hooks were 800-1000. Buoy-lines and branch-lines lengths were ranged between 20-30 m and 40-45 m respectively. Based on the hooks per basket, the depth penetration close to buoy-line is ~65 m while it is ~90 m at the middle of a basket. Sagging variability of hooks in a basket have shown a linear relationship (r2 = 0.9967) with the hook-number starting from buoy-line to the middle of a basket. Catch per unit effort was ranged between 1.5-7.0 (kg/100 hooks) based on thermocline depths which is varied between 100-125 m during the study period. The developed model is capable of predicting fishing depths based on the vertical temperature profiles and, thus the longline configuration can be adjusted for successful fishing operations.

Key words: Yellowfin tuna, Longline, Sigmoid model

Effect of lunar phase on swordfish (Xiphiasgladias) catch rates in the Indian Ocean

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Abstract

Swordfish (Xiphiasgladias) is billfish which primarily oceanic, epipelagic species cosmopolitan in tropical and temperate waters. Swordfish are caught by mainly longline fisheries in the Indian ocean. It is still a debate the impact of lunar phase for catches of swordfish and other billfishes. The purpose of this study was to investigate potential relationships of lunar cycle and catch rates of swordfish in Sri Lankan offshore/high-seas fishery. Fishing operations from 2006-2012, consisting 821 catch events were used in this study. Since most longline fishing is done at night, the proportion of the illuminated lunar disk was used as a proxy for relative light levels during the fishing operation. One-way ANOVA statistical analysis was conducted using R-statistical software. Results of ANOVA revealed that there is no significant difference ($p > 0.05$) between the catch rates of billfishes due to the lunar cycle. Geographical locations, fishing methods, fluctuations of environmental parameters and differences in feeding strategy may be contributing for the catch rates.

Keywords: swordfish, Xiphiasgladias, lunar effect, Indian Ocean

Analyses of vessel monitoring system (VMS) data to investigate its possible applications

Project No	:	6.1.2(2)
Officers responsible	:	Dr.J.K.Rajapaksha/ Mr. S. S. Gunasekara

Introduction

Sri Lanka has implemented a Vessel Monitoring System (VMS) in 2015 to monitor fishing activities of offshore and high seas fishing activities. VMS provides information on fishing activity at large spatial scales. The information includes vessel positions with time updated every 4 hours. A logbook is given to record fishery operational and catch information.

Coupling logbook and VMS data has already shown that its strength to describe the spatial distribution of the marine biota habitat at a much finer spatial and temporal resolution (Hintzen et al. 2012). VMS are primarily used for fisheries management, but it is also useful for improvements of various applications such as accuracy assessment of fish stocks, incomplete coverage of vessel activities, lack of catch information, long duration between position records, (Chang and Yuan, 2014; Bastardie et al., 2010).

In 2016, NARA has initiated a research project to use VMS data to investigate the accuracy of logbook recorded fishing activities and made first publications on VMS in Sri Lanka.

Objectives

1. Aanalysis of VMS and logbooks data
2. For fisheries management and development.
3. To validate fishing ground forecast maps using VMS and logbook data.

Outputs

Research publications, reports, forecast maps

Outcome

Improvement of efficiency of offshore/high sea fishery of Sri Lanka

Methodology

The flowchart (Fig.2) shows the main steps of the methodology.

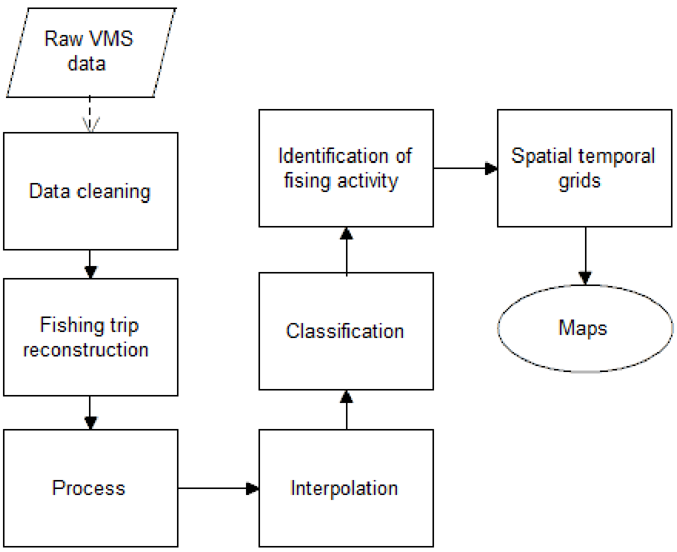

Fig.2 Flowchart of the Methodology

Activities

1. Raw VMS and logbook data acquisition
2. Oceanographic and survey data acquisition
3. Model development
4. Generating fishing effort maps
5. Validation of results
6. Awareness programs for fishermen, vessel owners and other stakeholders

Project areas

Project area consist of the Indian Ocean where large pelagic fishing operations conducted by Sri Lankan fishermen from all coastal districts.

Results and discussion

Fisheries logbook data was validated with VMS data. 10444 VMS cruise reports of year 2016 has been checked, quality controlled and input into MySQL database.2017 and 2018 raw vms file conversion has been completed up to date.

R program was developed to input, quality control and extraction of VMS data. Operation manual was created to follow each step accordingly.

Limitations

•Due to technical issues of Department of Fisheries, VMS information was not received since May 2018.

•Final report could not deliver yet as analysis in progress.

•Major limitation of this research project is lack of expertise know how. Therefore, trainings are essential to improve the knowledge.

Conclusions

VMS and fisheries data analysis are incomplete and need to be continued to next year to provide final findings.

Sea level observation and prediction of the short-term and long-term sea-level changes

Project No : 6.1.2(3)

Officers responsible : Dr.K.Arulananthan/Dilekha Samaranayake

Component 02: **Prospecting sand deposits in major fishery harbors in Southwestern coast**

Responsible Officers: Dileka Samaranayake

Introduction

There are twenty fishery harbors around Sri Lanka and around half of them are located in Southwest coast. Currently most of them are experiencing becoming silted due to sedimented sand and mud which making them too shallow for navigation. The main objective of this study is to identify the sediment thickness in the fishery harbors, most silted locations for maintenance dredge purpose. More on, the dredged sand can be used to filling and construction purposes if they suitable after processing.

Beruwala and Hikkaduwa Sri Lanka are important fishery harbors located in the south western coast. This study is proposed to cover those three fishery harbors as a pilot project.

Objectives

- To study the surface geology of the harbor
- To study the sediment thickness map
- To study the mean grain size distribution and energy properties

Sample collection

1.1 Beruwala fishery harbor

Total no of 36 collected from the harbor and 36 samples collected from the beach nearby the fishery harbor

1.2 Hikkaduwa fishery harbor

Total no of 21 samples were collected from the harbor and 10 samples collected from beach nearby the fishery harbor

Results

a. Harbor samples

1.3 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 collected using Van- Veen grab and analyzed for grain size distribution, statistical and textural parameters. Based on visual observations, most of the samples except in harbor mouth contain silt and mud. The samples near harbor mouth contain sand.

Mechanical sieve analysis was done at 1/2 phi intervals and statistical parameters were obtained using GRADISAT software following Folk and Ward (1957) method for classifications.

1.3.1 Beruwala Fishery harbor

The mean grain size vary from 280.37 µm to 54.6 µm and the average is 129.049 µm indicating most of them are belonging to the fine to very fine sand range according to the Udden (1914), Wentworth (1922) and Friedman and Sanders (1978) classifications.

The sorting index of the sediment varies from 2.704 -1.262 µm while the average is 1.684 µm indicating most of them are moderately well sorted.

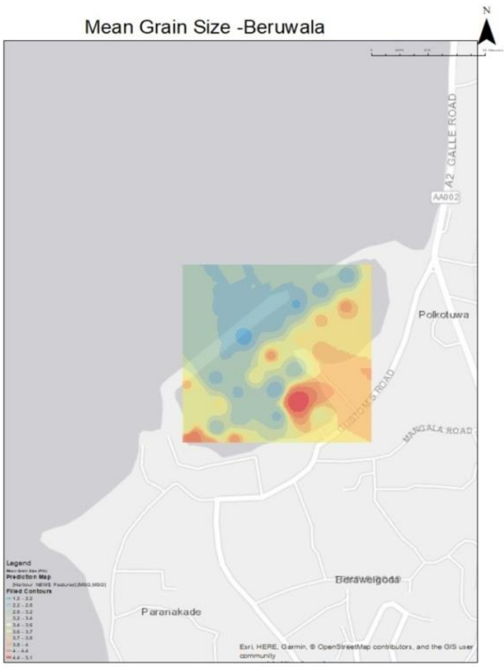

Fig 01. Mean grain size in Beruwala harbor

1.3.2 Hikkaduwa Fishery harbor

The mean grain size vary from 453.81 µm to 164.8 µm in and the average is 221.4 µm in indicating most of them are belonging to the fine to very fine sand range according to the Udden (1914), Wentworth (1922) and Friedman and Sanders (1978) classifications.

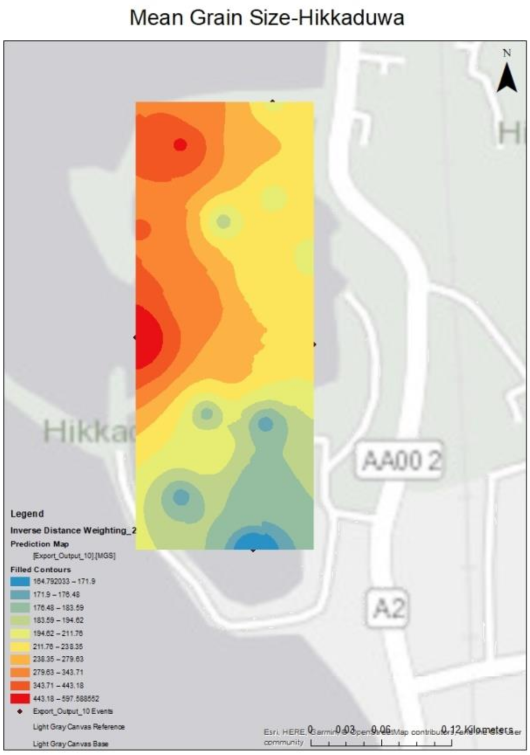

Fig 02. Mean grain size in Hikkaduwa harbor

b. Beach Samples

Surface sediment samples were collected from selected locations near the two harbors.The mean grain size of the sediment near Hikkaduwa fishery harbor 181.1-382.2µm while the average grain size is 270.2 µm .

The mean grain size of sediment near Beruwala harbor is 137.3-792.8 µm while the average grain size is 352.0 µm.

1.4 Sediment thickness Analysis

Sub bottom profiling will be conducted to estimate the thickness of the area. Sub bottom profiler Innomar "SES -2000" sediment parametric echo sounder is the instrument which will be occupied to investigate the subsurface geological structures such as thickness of sub surface strata and extension of the area. SESWIN and ISE 1.2 are the software which will be used for data acquisition and processing and thickness estimation respectively. The sub bottom profiler consists of dual frequency sonar head with 50 m penetration depth. However, depth of penetration is limited by the type of the sediment and the environment condition of the area.

Frequency use for data acquisition for the investigation is 8 kHz, while pulse repetition rate is 4. Differential Global Positioning System (GDPS) with the accuracy +/- 20 cm is integrated to the instrument during data acquisition. The average sand layer thickness is used to estimate the sand volume. Isopatch map will be prepared using the thickness obtained where ArcGIS software occupied and surface sediment distribution map will be prepared using Surfer software.

1.4.1 Beruwala fishery harbor

The average water depth of the harbor is 2.96 m and the minimum water depth is 1.07 m while the maximum is 3.83 m.

(The map is being preparing)

1.4.2 Hikkaduwa fishery harbor

The average water depth of the harbor is 2.42m while the minimum and maximum water depth is 0.83m and 4.52 m respectively.

Water Depth _Hikkaduwa

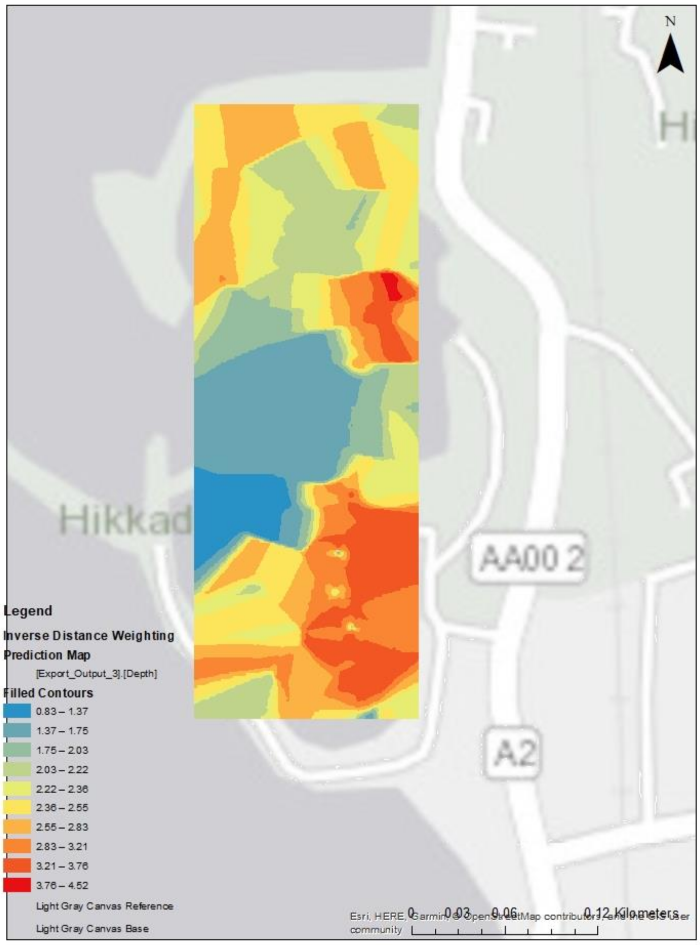

Fig 03. Water depth in Hikkaduwa harbor

Conclusion

The sand excavated during dredging process could be used as an aggregate for construction industry or filling material. The sand suitable for construction should be in 62.5-2000 µm (Sing, 2004-2005).Since the mean grain size of the sediment in Beruwala harbor varies from 54.62 µm to 280.37 µm it cannot be used as construction aggregate. However, the mean grain size of Hikkaduwa harbor varies within the given limit and the sand is moderately well sorted (1.56 µm),hence it may be used for construction sand after purifications.

Since the sorting of the sediment is in well sorted to moderately well sorted range and it can be assumed all sediment particles has approximately same density (as most of the sediment particles are derivative of quartzite) , it can be concluded that energy is generally constant in both Beruwala and Hikkaduwa harbors.

The average water depth of Beruwala and Hikkaduwa fishery harbors are 2.96 and 2.42 m respectively. The maintenance dredging should be done in some points in both harbors (indicated in the map)

The sediment thickness of both harbors being preparing with reference to the depth of the same measured before.

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Modeling of Coastal Sediment Dynamics on the WesternCoast of Sri Lanka

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Project No : 6.1.2(4)

Officers responsible : R.M.R.M.Jayathilake

Background

This section describes what inspires to the above chosen study, the literature (references are provided), and the uniqueness of the intended research.

Most of the erosion prone areas between the coastal stretches of Matara to Puttalam were identified under NIOMS-NARA project in 2016. According to the results, the Coastal stretch from Negombo to Udappuwa clearly indicates that erosion is dominant over the last 10 years (2005 to 2014). During last 10 years, the coastal belt between Marawila and Chilaw is subjected to severe erosion, with the values of 186 000 m3/year which is more than 20 times greater than the erosion volume in recorded in 1956 to 2005. The coastal section from Chilaw to Udappu shows the second largest increased of erosion rate after Marawila and Chilaw, with the values of 96 000 m3/year and it is 4 times increased compared to the erosion volume in 1956 to 2005. Net yearly erosion rate (m/year) along this coastline shows more than 8 m/year for some spots (Jayathilaka, 2015).

The Colombo International Financial City (CIFC) development built as an extension of the Central Business District of Sri Lanka's vibrant commercial capital, Colombo. Spanning 269 hectares of reclaimed land from the sea is located south to these erosion prone areas. The proposed sand extraction site for CIFC Project extends from Hendala to Basiyawatta. The area is mainly consisted with a sandy seabed and hard bottom habitats. The GSMB has estimates the total potential sand deposit at the proposed site 1 at about 44 million cubic meters while it is 68 million cubic meters at the proposed dredging site 2. The required sand quantity for the purpose of reclamation is about 60-65 million cubic meters. This sand is being used to land reclamation works on port city project (Supplementary Environmental Impact Assessment Report, 2015).

The effects of this intense mega sand extraction and the vicinity of large breakwater in Colombo harbor on adjacent coastline are only poorly known.

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.

Study Area:

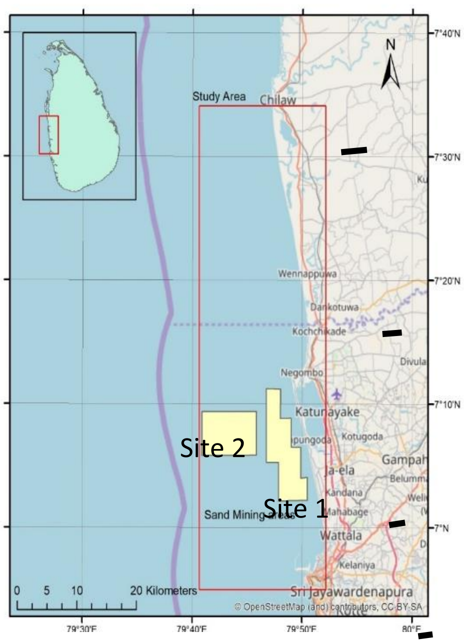


Figure 1. Map showing the study area for the proposed project. The transacts (black line) along with the proposed locations for beach profiling, sediment concentration and deploying current meter.

The study area extends approximately 80 km along the coastal stretch from Colombo to Chilaw. Deduru Oya and the Maha Oya are also located along this coastal belt and the ongoing Port City project is situated south to study area.

Material & Methods

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).

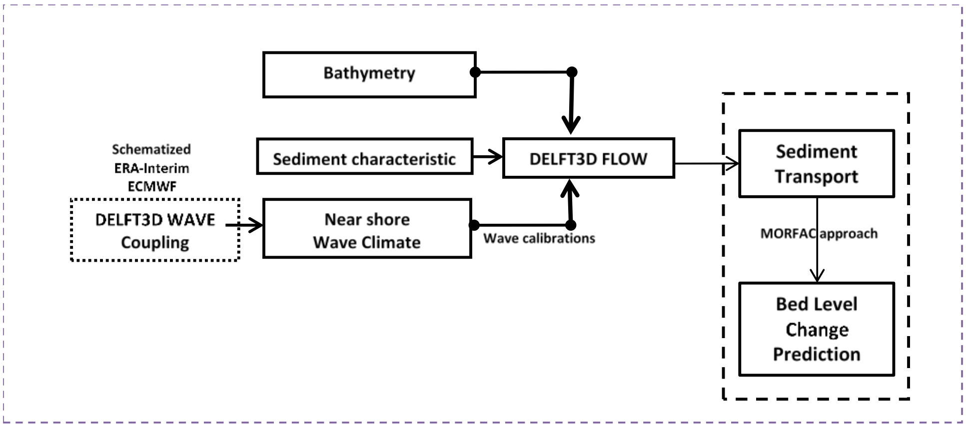


Figure 2. Flow chart of morphodynamic modeling.

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.

Expected Output

1. Potential sediment transport pattern along western coast of Sri Lanka.
2. Erosional and depositional areas for the western region of Sri Lanka.
3. Seasonal changes of cross-shore profile.
4. Spatial/temporalchanges of grain size of beach profiles.

Performance Indicators

1. Completion rate of activities as against the plan.
2. Number of sediment samples analysed/cross-shore profile surveys.
3. Length of coastlinemodelled .

Results

Wind/Wave analysis

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 37 years (from 1979 to 2016) of ERA-Interim data to schematize the wind/wave climate for boundary conditions. Figure 3 shows the wind/wave roses off Colombo. 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.

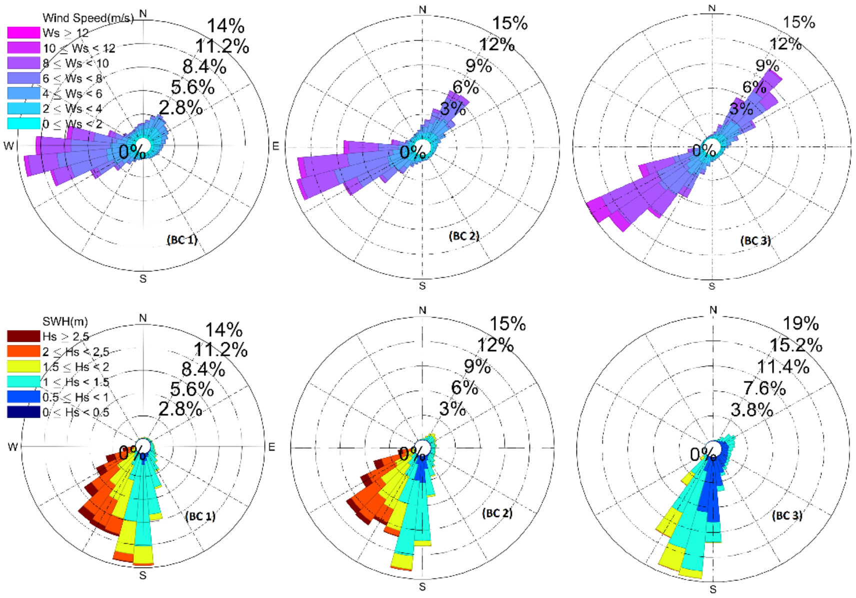


Figure 3. Spatial variation of off-shore wind/wave climates along the offshore boundary BC1-3, wind speeds (m/s)(top) and significant wave heights (m) (bottom).

According to the wind climate study, wind is coming from NE direction from November to March with the angle 40^0-60^0while it changes to SW direction with the angle 220^0-240^0 from May to September. During SW monsoon, the wind speed varies between 7-11 m/s while it varies between 1-5 m/s during NE monsoon. The total number of wind/ wave events studied here is 54053 during 1979 and 2015. Our wind analysis for extreme events found 43 and 65 events for wind speeds greater than 12 m/s at BC2 and BC3 respectively. More than 95% of such events occurred during SW monsoon period.

Analysis of wave climate indicates that the significant wave height varies between 0.5 m to 3 m having most probable wave heights around 1.5 m. The distribution of wave direction is mostly from 210^0-250^0 (SW) and from 30^0-80^0 (NE). Total number of wave events greater than 3 m recorded at offshore point of BC2 is 149 and we found no such an extreme waves events at BC3. The SW monsoon experiences the highest probability of occurrence of higher wave events than in NE monsoon.

Wave transformation (SWAN)

The annual wave climate has schematized to 16 wave conditions in which accompanied by the relative morphological acceleration factors that represents the net transport occurring in one-year period (Table 1). The wave chronology plays a significant role in process based modelling (G. R. Lesser, 2009). In our study, the schematized wave climates were repeated for reducing the ‘chronology effect’ (G. R. Lesser, 2009). For example, in our wave climates there is a wave condition that represents 72 days out of the year (See table 2). This condition was divided into three pieces during the simulation. The number of wave conditions to analyses remains the same (16), but the effect of the wave condition in the morphology is alternated with other wave conditions, similar to the natural environment.

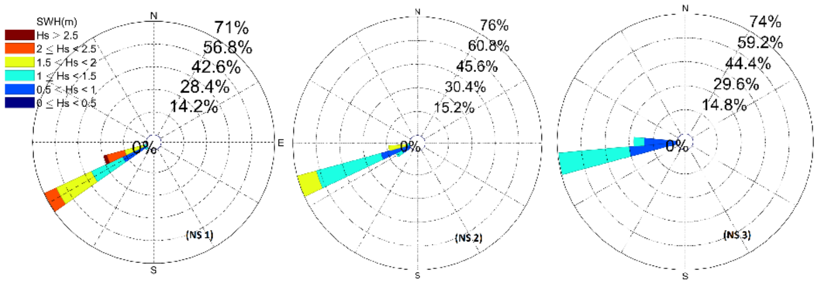


Figure 4 Near-shore Wave roses along the south-west coast of Sri Lanka extracted from output of Delft3D-WAVE results (at 10 m depth)

Locally, wave data were extracted for representative locations depths ranging between 10 m and 15 m (always larger than local closure depth). Average significant wave height and occurrence of different wave directions for these representative points (NS1-3) are shown in figure 4. The decreased in wave heights and gradual change in wave direction are observed along the coastline from NS1 to NS3 (northward). The distribution of near-shore wave direction at NS1 is mostly directed from 230^0 to 250^0 whereas it is varying between 260^0 and 290^0 at NS3. These changes are explained by spatial distribution of wave heights for different offshore wave conditions as shown in figure 5.

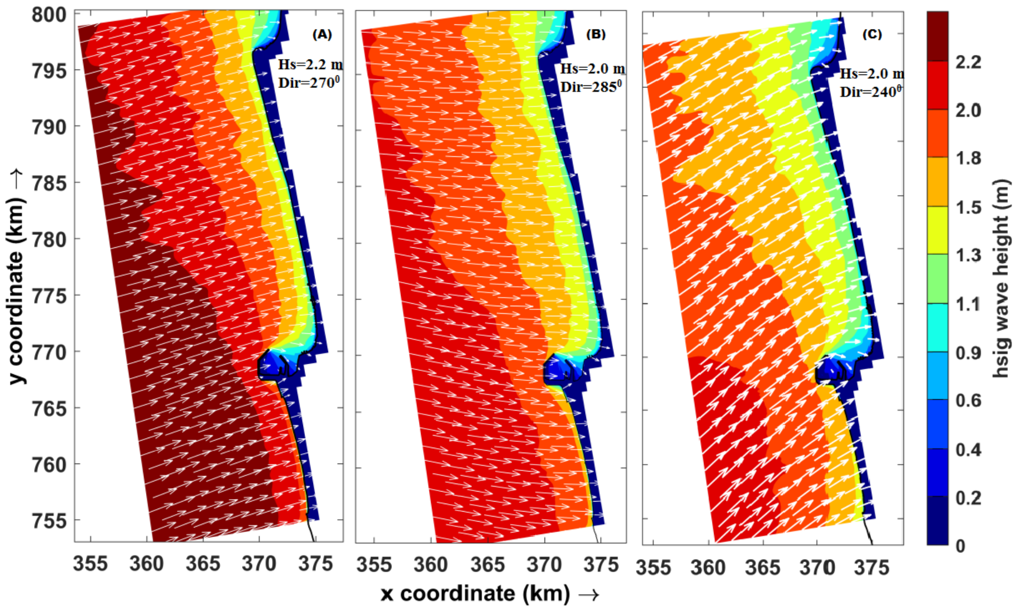


Figure 5. Numerical results of significant wave height and its spatial distribution for different offshore wave conditions. The arrows show the direction of the wave and the color indicate the wave heights. For off-shore boundary, (A) Hs=2.2 m, Dir=270 (B) Hs=2.0 m, Dir=285 (C) Hs=2.0 m, Dir=240

The local wave climates depend on the shoreline orientation and steepness of the cross-shore profile due to wave shielding which is clearly visible in wave transformation in figure 5. Just north of Negombo (section P30-35, Fig. 11) the coast is shielded from waves approaching the southern directions due to the sudden change in coastline. Moreover, the effect of swell wave decreases and the influence of onset of NE monsoon are visible in the northward of the coast line. Therefore, relatively small values of wave heights observed in this section are particularly due to the attenuation of wave's heights over the shallow and mild slop in the area and further shielding from the tip of Negombo. The sector is experiencing rather small values of the average wave heights, ranging from 0.50 m to 1.2 m at NS3 (Fig. 3). The wave analysis for point NS3 indicates that for waves over 1 m height the dominant direction is from south. The average significant wave height in the section is 0.8 m, the lowest from the entire studied zone.

The Colombo-Negombo section (P12-30, Fig. 7) is a straight coastline having 30 Km long and 2500 degree to shore normal. The waves approaching from the SW directions dominate the wave climate. This sector is sheltered against the southern wave directions by 2 km long breakwater arm of Colombo port which would increase the wave shadow, extending it northwards. As a consequence, wave conditions in this area (probably up to Uswatakeiyawa) would become calmer. This region is identified as a severely eroding coastline (CCD, 2004; Jayathilaka, 2015). This sector is experiencing the average wave heights, ranging from 0.80 m to 1.8 m at NS2. The average significant wave height in the section is 1.2 m and gradually decreasing northwards.

Mount Lavinia-Colombo is experiencing rather higher values of the average wave heights, ranging from 1.0 m to 2.7 m at NS1 (Fig. 3), reached the average wave height of 1.8 m which is the highest from the entire studied zone as this sector is exposed to all wave directions. The distribution of wave directions in this section shows the same major direction as for the Colombo-Negombo sector. Particularly, waves over 1.5 m height are predominant from the SW direction, which already suggests that the dominant alongshore current is oriented towards the north. This sector is sheltered against the weakly northern waves by breakwater arm of Colombo making further calmer the section during NE monsoon.

Sediment transport and morphological evolution

The calibrated wave model was then forced with the sediment transport and morphology module of Delft3D-Flow which supports both bed load and suspended load transport of non-cohesive sediments and suspended load of cohesive sediments. The simulation with the best model performance required a computational effort of 2 days on a HP Core i7 CPU machine (at 8 GHz).

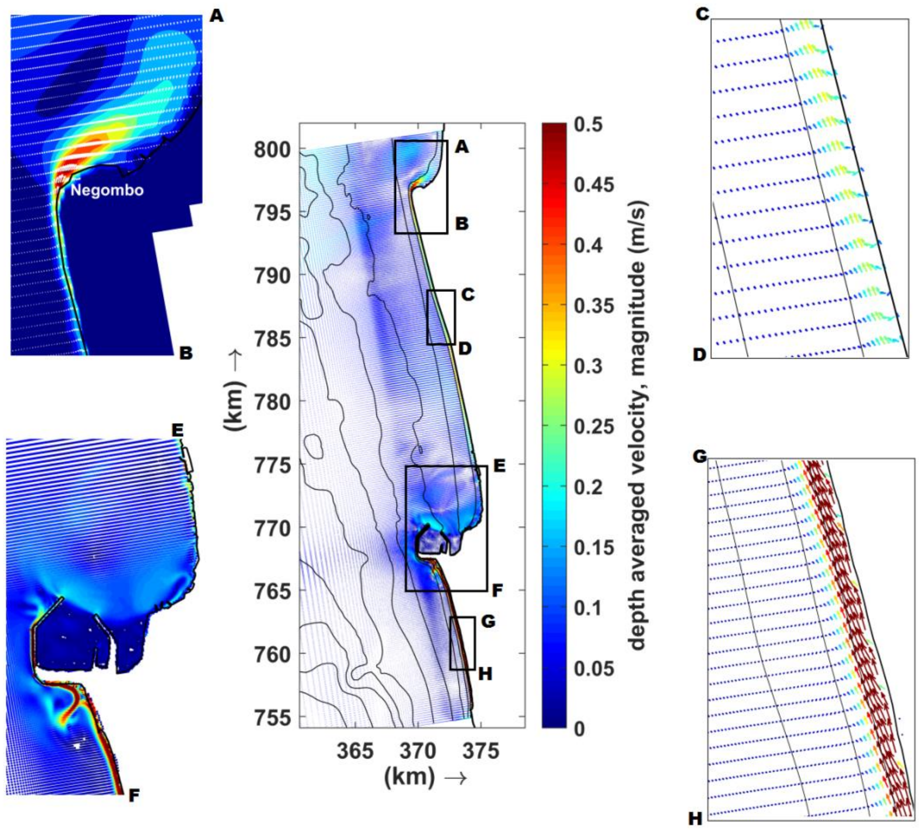


Figure 6. Numerical results of depth average velocity (m/s) and their spatial distribution for the offshore wave height of 2.2 m and direction of 240 degree. The arrows show the direction of the current and the colour indicate the magnitude of the current. (A-B) P28-35 (C-D) P22-36 (E-F) P08-15 (G-H) P03-06

The numerical results of depth average velocity (m/s) shows northward oriented. It is observed that with the increase of off-shore wave heights and direction (shore normal angle) the depth average velocity is increasing. The flow velocity outside surf zone decreases towards the off-shore (it suddenly decreases to compensate for the increased water depth or continuity of mass). In the breaker zone, within 5 m contour line, the flow velocity is significant and became maximum as the wave break. As a result, the lose energy and momentum is transferred to the alongshore current. Mount Lavinia-Colombo is experiencing rather higher value of d.a velocity which is the highest from the entire studied zone as this sector is exposed to higher wave conditions (Fig. 6 G-H). The d.a velocity around Colombo port showed rather complex behavior due to wave shielding and sand accumulation around the area (south to breakwater), at the downstream end, it takes few kilometer distance to pick up the current again. On the other hand, the leeside of the Colombo port faces smaller wave highs over shallow milder slop of the basin, makes it further weaken the down drift current. Thereafter, d.a. velocities increased to 0.3 m/s showing rather constant from Pegasus reef (P14) to the tip of Negombo (P29) where the coastline changes suddenly. As we can see in fig 7, the breakwater structure has a strong effect on current pattern and thereby on the local morphology. Around the convex shape of Negombo coastline, a complex pattern in d.a. velocity is observed (Fig 6 A-B). There is a strong longshore current that is diverted away from the coast and dissipate in magnitudes at the downstream side (between P30 and P35).

Figure 7 shows the computed net yearly sand transport rates through 35 cross-shores transects between Mount Lavinia and Wallaweediya. The transects run from approx. the -16 to the +3-meter MSL contour in order to integrate all transport magnitude within the closure depth which is computed by Hallermeier equation (Hallermeier 1981, 1983). The letters P1-35 indicate the cross-shore transects used to compute the net annual sediment transport shown in Fig 7 b. Positive values of transport indicate the northward transport while negative values give southward transport. This transport was then used to derive sediment transport gradient (Fig 7 c), positive values indicate the increase of transport (erosion) while negative values indicate a decrease of transport (accretion).

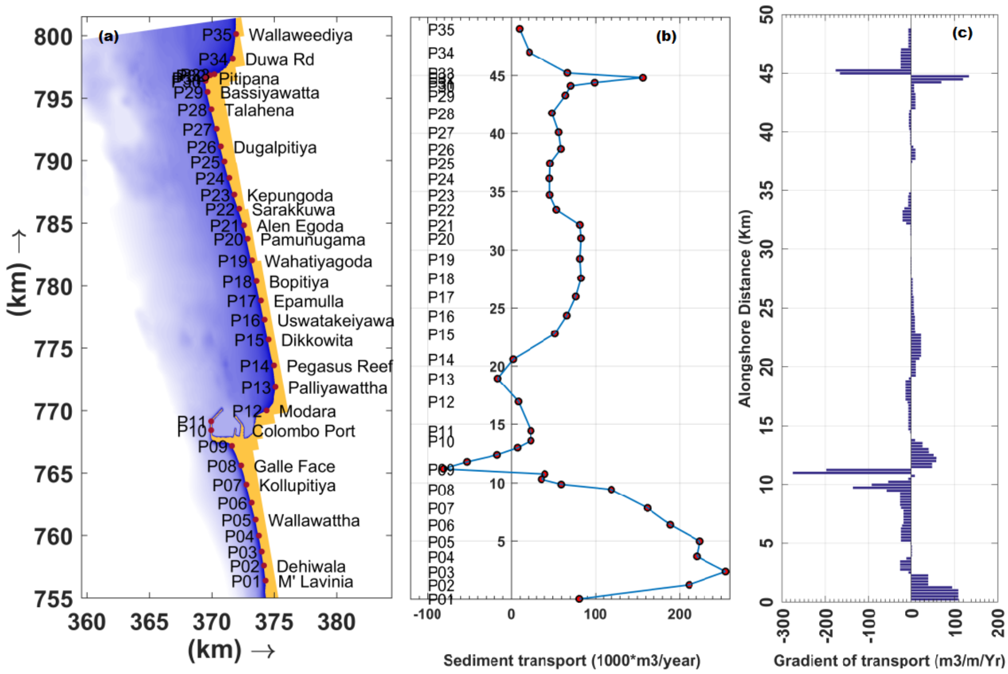


Figure 7. (a) Overview of study area indicating points in which to calculate sediment transports. (b) Net alongshore sediment transport through the cross-shore transects up to 25 m depth contour (P01-25). (c) Sediment transport gradient (m3/m/year)

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 a large role in 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.

In overall, the net transports rates through the cross-shore transect are directed to the Northward. A review of several publications and technical reports about sediment transport along SW coast of Sri Lanka indicate northward transport (Ansaf, 2012; CCD, 2004; Jayathilaka, 2015; Laknath & Sasaki, 2011). 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 M' Lavinia (P1) and Colombo (P8) shows the maximum value of the transport capacity for the whole studied area is reached, 255 000 m3/year (P3) and then gradually decreased to 90 000 m3/year near Galle Face (P8). In this sector the wave climate and, subsequently, the gross alongshore transport reach the highest values indicating a relative dynamic environment. The two important factors contributing to this are the full exposure of the southern side of the island to swell and wind waves during the SW monsoon and the rather steep slope of the beach comparing to Colombo (P10)-Negombo (P35) coastline (Jayathilaka, 2015).

The transport rates in M' Lavinia-Colombo is in general less than the transport rates shown by previous studies (Ansaf, 2012; Jayathilaka, 2015). According to CCD-GTZ Coast Conservation Project in 1992, the estimated along shore transport rate in this section varies between 460,000 m3/year to 1,180,000 m3/year. The separate studies of MIKE21 and UNIBEST ST showed same magnitudes of the northward net transport rate along same coastline (Anfas 2012, Jayathilaka 2015). The main reason for these higher values of transport rates was the absence of including the presence of reefs and the beach rock which laying parallel to M' Lavinia-Colombo coastline. The greater width of non-mobile topology which decease the sediment transport due to the roughness, plays a significant role on calibrating modeled sediment transport to actual sediment transport. In the present study, we have introduced spatial varying roughness parameter (JONSWAP coefficient) to estimate coastal transport rates for the various coastal segments between M' Lavinia-Colombo and Colombo-Negombo as discussed in model validation.

The southern breakwater arm of Colombo South Port (2 km long) shows the strong effect on transport gradient (Fig 7 c). The shoreline upstream of the structure accretes rapidly and coast downward shows rapid erosion. The seaward end of the breakwater will be in about 18 m depth of water, which is far deeper than the depth of closure where most of sediment transport occurs. Therefore, a significant proportion of sand transport is captured by the breakwater arm in which accumulate against the breakwater. Over time the area of accumulation will extend both seawards and southwards along the coast where the ongoing port city development project is located. The behavior on the down drift side of the breakwater is depending on the process of the building of the longshore current. The slow building of the longshore current leads the long area of extends for erosion. Fig 7.c shows positive values in sediment gradients between Modara (P10) to Uswatakeiyawa (P16). This region is identified as a severely eroding coastline (Bureau, 2005; CCD, 2004; Jayathilaka, 2015; Wijayawardane, Ansaf, Ratnasooriya, & Samarawickrama, 2013). Master Plan for Coast Erosion Management Summary, the erosion rate was identified as 2.5 m/year for 70% of the coastline from Palliyawatte (P13) to Uswetikeiyawa (P16). Decrease in sand supply from the Kaleni river located between P12 and P13 is said to accelerate the down drift erosion north of the river mouth (CCD, 2004). A nodal point, the transport direction changed and building is observed behind Pegasus Reef. Thereafter, 55 000 m3/year rate of transport shown in Dikkowita (P15) and to reached 90 000 m3/year near Pamunugama (P20) with a milder gradient along the straight coastline. Then the coastline bends slightly extending to Bassiyawattha (P29) and afterwards the coastline exhibits in a convex manner. In the area between Bassiyawattha (P29) and Pitipana (P33) the transport is increasing with a steep gradient, suggesting intense erosion (fig 7.c). The convex shape of the coastline shields the down drift side of Pitipana from wave action, preventing much longshore drift where waves are not strong enough to move the sediment along the coast.

Conclusion

The main contribution of this work is the quantitative determination of a near shore wave climate, the alongshore sediment transport along 55 km long coastal belt between M' Lavinia and Negombo. Delft3D-FLOW, a process-based model model together with input reduction and morphological acceleration techniques has been used to estimate the long shore sediment transport rates and related morphodynamics. The important of near shore wave transformation is highlighted in conclusions. In data poor environment, this is achieved by transforming offshore wave time series (schematized) to near shore locations (SWAN model). The final reduced set of forcing conditions (16 conditions) is supposed sufficient enough to capture the morphological change to its full extent. However, certain low probability, high-energy conditions responsible for alongshore sediment transport can also be included to better model results. The simulated wave climate based on wind records proved to be reliable despite the lack of precise data. The numerical results can very well be related to the accuracy of bathymetry or measured wave buoy data or both. Default parameter settings and coefficients in Delft3D such as depth induced breaking; non-linear triad interactions and bottom friction applied during simulation shows quite unrealistic results and has to tune accordingly. Increased coverage and accuracy of wave measurements would probably provide the greatest improvements in future studies. Therefore, at least one wave buoy should deploy between Colombo and Negombo where the shoreline orientation changes abruptly.

The wave model is calibrated and reproduces nearshore waves well. Analysis of model results indicated that the Southwest monsoon has greater influences having the highest probability of occurrence of higher wave events on the near-shore wave climate thus sediment transport in the study area. More than 95% of the extreme events occurred during the SW monsoon periods. However, the effect of swell wave decreases and the influence of onset of NE monsoon are visible when it goes to the northward of the coast line. Mount Lavinia-Colombo coastline shows the highest wave heights from the entire studied area thus rather higher value of d.a velocity than in Colombo-Negombo coastline. Numerical results of the alongshore sediment transports gradients clearly indicate the potential erosion/accretion prone areas, emphasizing the important of detailed coastal morphological studies and quantitative risk assessments at vulnerable coastal areas along the coast of M' Lavinia-Negombo. The study shows the Colombo-Negombo coastline is naturally subjected to erosion due to its coastal orientation and wave actions. To compensate the erosion rate, important of steady sand supply from Kalani river is highlighted. The reduction of sand supply from Kaleni river due to extensive sand mining is a contributory factor that accelerate the coastal erosion in that area. In addition, the break water of Colombo port has a partial effect on changing the local erosion/accretion rates in the area extending to adjacent coastal areas. Sand nourishment in the down drift area is a natural friendly method to restore the regional sediment budget in the area. This requires the complete stop of sand mining in rivers and sea-sand dredging within the closure depth.

Major findings

1. The coastal belt between Marawila and Chilaw is recorded as most eroded area for last 10 years.
2. The annual alongshore sediment transport capacity computed between Mount Lavinea and Negombo oriented northward comply very well with the observations.
3. Coastal belt between Mount Lavinia and Colombo, the wave climate and, subsequently, the annual alongshore transport reach the highest values indicating a relative dynamic environment.
4. Colombo-Negombo coastline is naturally subjected to erosion due to its coastal orientation and wave actions.
5. To compensate the erosion rate, important of steady sand supply from Kalani river is highlighted. The reduction of sand supply from Kaleni river due to extensive sand mining is a contributory factor that accelerate the coastal erosion in that area.

Publication

- R.M.R.M. Jayathilaka, M.C.S. Fernando "Numerical modelling of the spatial variation of Sediment Transport using Wave Climate Schematization method" proceeding of Journal of Water Science and Engineering, 2018
- R.M.R.M. Jayathilaka," 2D numerical modeling of flow and sediment transport using wave climate schematization method - a case study of West coast of Sri Lanka", NARA scientific session 2018

Trainings needed

1. D-Flow Flexible Mesh: Introduction to the new hydrodynamic simulation engine'.
2. Marine GIS Applications for Coastal Zone Management.

Plastic and Polythene Debris in Land and Ocean around Sri Lanka

Project No	:	6.1.4(1) (component 1)
Officers responsible	:	Mr.W.R.W.M.A.P.Weerakoon

Executive Summary

This project was a continuation and an expansion of the project 1.6.3. (2017). Plastics and polythene debris have become a major global environmental crisis at present due to evidences of their ubiquity, bio-availability and ability to carry toxic chemicals. This study quantified plastic and polythene litter in surface sea water and coastal sand in the North-western, Northern, Eastern and Southern coasts during 2017. Sampling was done at selected sites, based on vital demographical, socio-economic and environmental factors. Both physical and chemical methods were used for the analysis, in which the average seasonal abundance of plastic and polythene debris was calculated in terms of (i) number of particles per m^3 and (ii) weight of particles in gm^{-3} whereas the above values of different categories were compared. The results disclosed that the vast majority of plastic debris in both surface sea water and beach sand were micro-plastics, whereas the majority of those were in the category of fragments. Beaches in North-western coast were highly polluted compared to others. The results disclosed that there are spatial variations in the distribution of plastic and polythene debris where beaches adjacent to fishery harbours, populated residences, and water channel openings, especially in the Western, North-western and Southern coasts seem to contain significantly a large amount of debris. Moreover, beaches located in popular tourist destinations contained more debris compared to others. Since pollution control in all locations is crucial, relevant authorities may pay attention to waste disposal around fisheries harbours, markets, water canals and popular beaches by residents and industries. Furthermore, waste recycling infrastructure in needed in at least a few locations near the coast. 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.

Introduction

Over the past decade, plastic debris, as a major marine and coastal litter has 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 waste matters 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.

Materials and Methods

2.1. Collection of Samples

Surface Water Samples were collected along the hydro-graphic transects in selected positions. At each position, the surface layer was sampled with a floating trawl-net, with a mesh-size of 300 µm and two buoys affixed to keep it balanced at the surface during the tow. Trawls were hauled horizontally at the surface at a speed below 2 ms^{-1} to a distance of approximately 100 meters. The counts of a manual flow-meter attached in 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 boat. Once the trawl-net was recovered to the boat, the water samples were taken in to bottles and stored until transported to the laboratory. **Beach Sand Samples** were collected in between the high-tide line and the wrack-line, by scraping the upper layer of a volume of 50 x 50 x 2.5 cm^3, into bottles using a steel-made collector and a quadrant.

2.2. Analysis of Samples

Surface Water Samples were washed in fresh filtered water over a sieve with a mesh-size of 180 µm. All residuals were subjected to a wet peroxide oxidation (WPO) using 20 mL of aqueous 0.05 M Fe(II) and 20 mL of 30% hydrogen peroxide, and heating to 75°C 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 plastic items were then placed on a gridded Petri-dish for the examination under the microscope, photographed and, to the extent possible, also measured and described (*e.g.* width, length, shape, type and colour). Simultaneously, visually identified material were confirmed as 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 the control samples to reduce the risk of contamination and to remove all possible contaminants from samples. The sorted micro-plastic particles were washed with freshwater and dried in pre-weighed aluminium foil in a drying cabinet at 30 ^{o}C. After sufficient drying, the contents were packed in glass bottles and stored in room temperature until transported to a laboratory where the samples were studied in more detail. After removing the plastics the remaining parts of the samples were 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. **Beach Sand Samples** were incorporated in to a pure Sodium chloride solution (5 M) to separate plastics and polythene debris by floating. The easily identifiable large particles were separated. All other floating solids were separated and a procedure similar to the analysis of surface water samples was followed.

Project Progress

During the study in 2018, a total of 160 sea surface water samples and 80 beach sand 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 130 sea surface water samples (81.2% of the collected) were analysed, and the rest were preserved in glass bottles 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 Samples Analysed (Chemical)
North-west	10	40	28	12	06
North	10	40	34	06	06
East	10	40	32	08	08
South	10	40	36	04	05

A total of 61 beach sand samples (76.2% of the collected) were analysed, and the rest were preserved in glass bottles to be analysed in the future (Table 3.2).

Table 3.2. Summary of collection and analysis of Beach sand samples

Region	No. of Locations	No. of Samples Collected	No. of Samples Analysed (Visual)	No. of Samples to be Analysed (Visual)	No. of Samples Analysed (Chemical)
North-west	10	20	20	00	06
North	10	20	12	07	07
East	10	20	15	05	05
South	10	20	14	06	05

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 %

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, are more polluted with plastics and marine debris compared to the East coast, especially due to the highest abundance of debris found in the North-western and the Western coast lines.

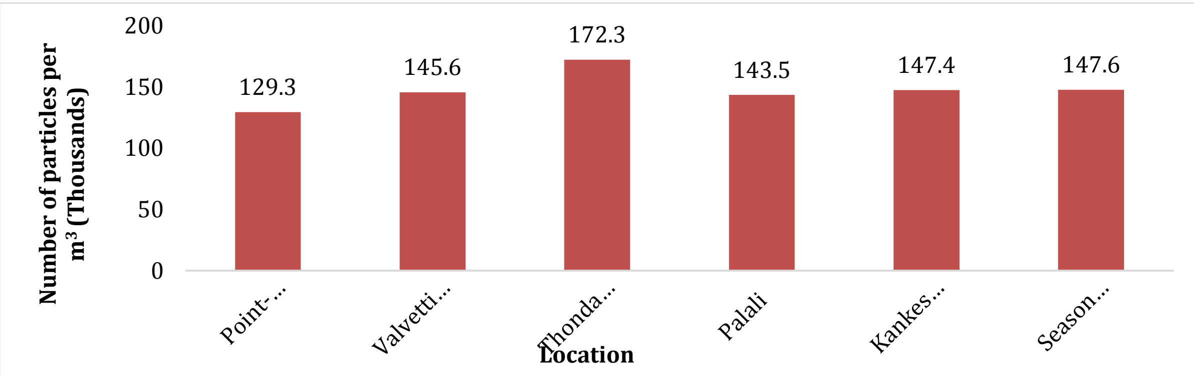


Figure 4.1: Estimated abundance of plastic & polythene debris in the Northern coast (based on preliminary results), for selected sampling stations

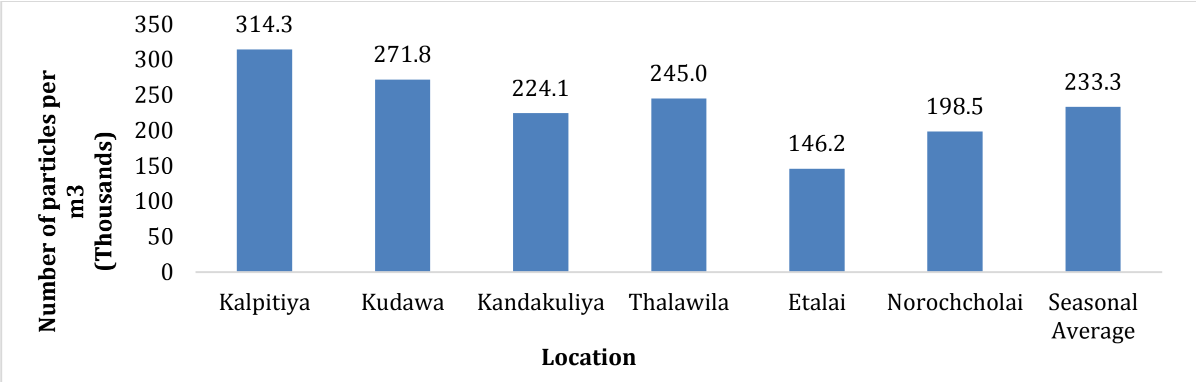


Figure 4.2: Estimated abundance of plastic & polythene debris in the North-western coast (based on preliminary results), for selected sampling stations

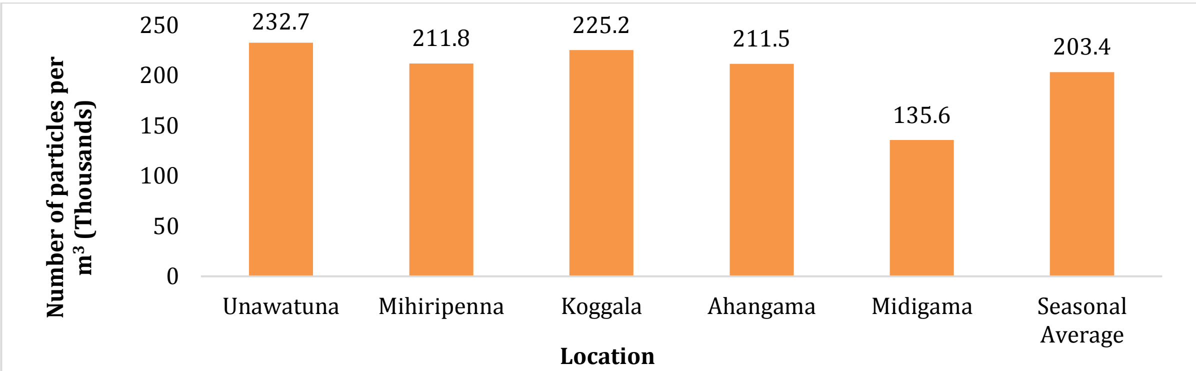


Figure 4.3: Estimated abundance of plastic & polythene debris in the Southern coast (based on preliminary results), for selected sampling stations

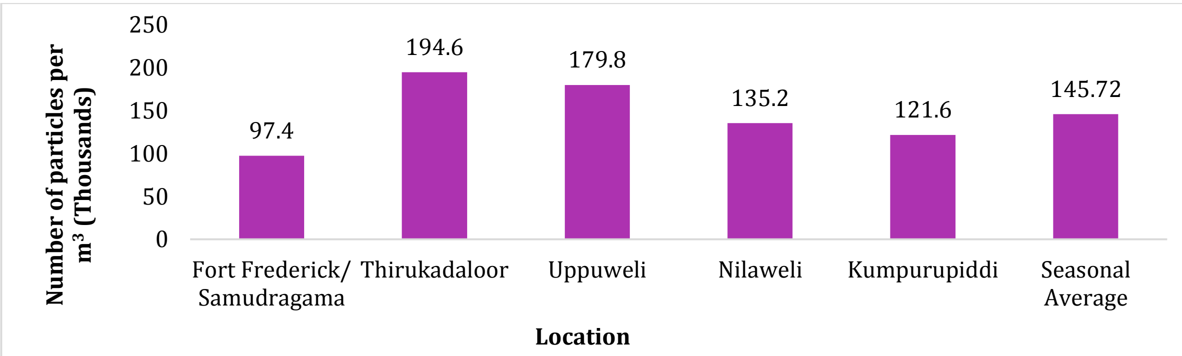


Figure 4.4: Estimated abundance of plastic & polythene debris in the Eastern coast (based on preliminary results), for selected sampling stations

4.2. Categorical Distribution of Plastic and Polythene Debris

In reference to all locations, the majority of plastic and polythene debris found over the island 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 amount of fragments were recorded from the Eastern and the North Western locations.

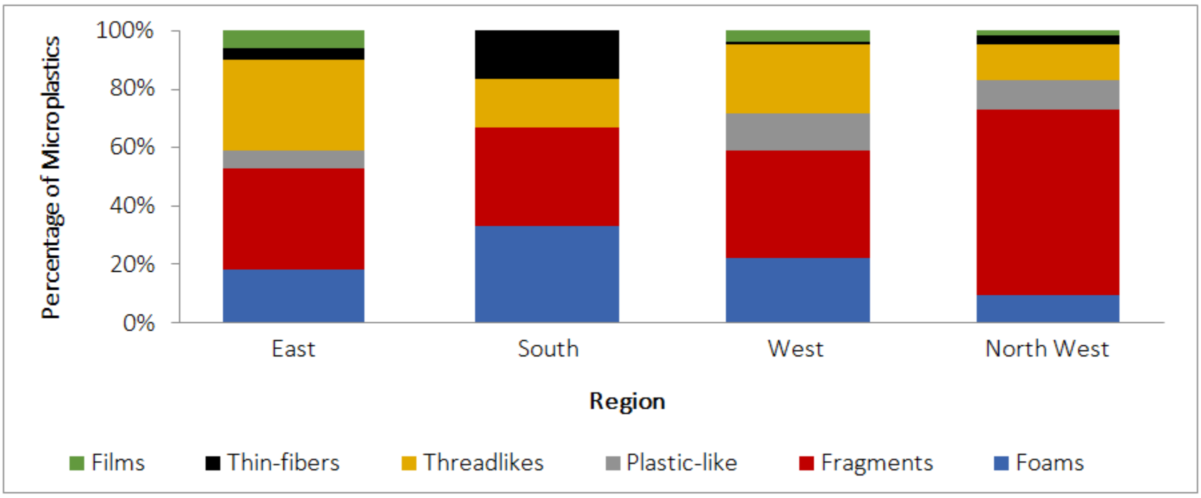


Figure 4.5: Different categories of micro-plastics found in four different coasts

4.3. Color composition of Micro-plastic Particles

In all six regions, the majority of micro-plastic particles were blue in color, where white, green, transparent and brown plastic particles are abundant in large quantities in different regions.

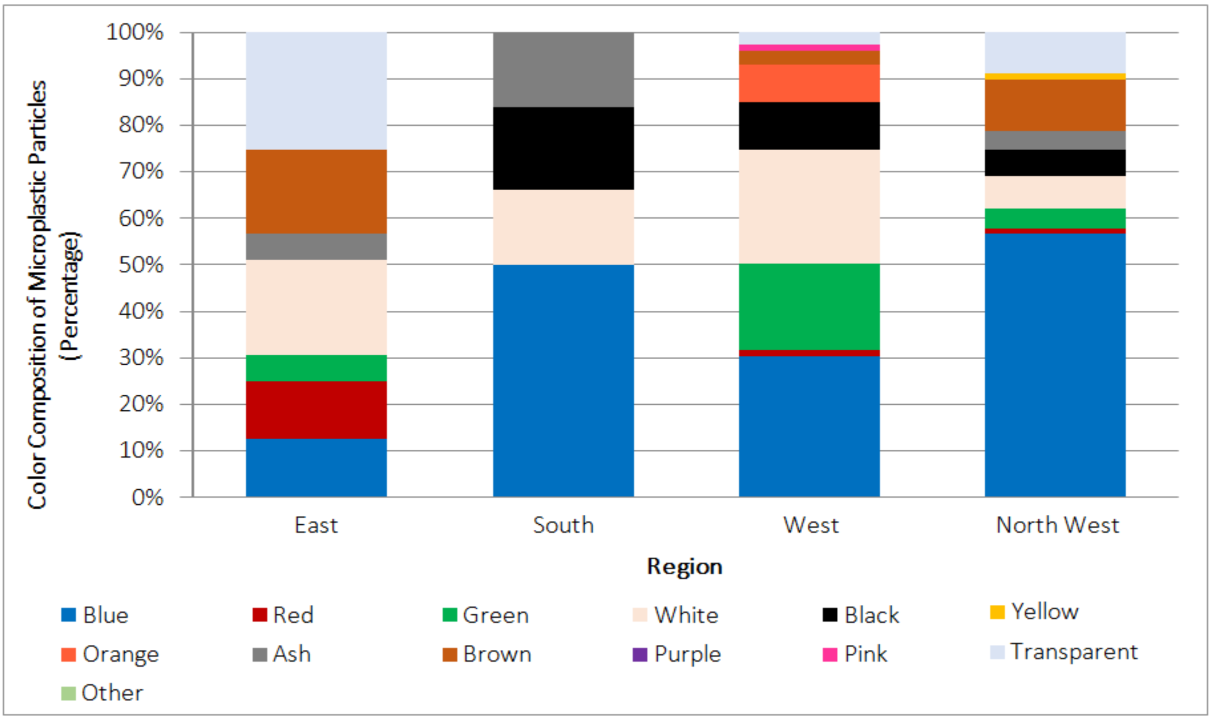


Figure 4.6: Different categories of micro-plastics found in four different coasts

4.4. Physical Size of Plastics and Polythene Debris

The average size of smaller plastic particles was 1.26±1.18 mm. This reveals the vast diversity in size of micro-plastic 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 ~0-0.5 mm in width, and ~0-4 mm in length. Notably, there were tiny micro-plastics lengthier than 30 mm.

4.5. Surface Properties of microplastics

Most of the microplastics (>60%) had rough surfaces at the time of observation. 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%), whereas filement type was the second most abundent shape. A very few number of particles were trianguar and round in shape with an abandance of 1.07% and 0.27% respectively. Plastic particles with other geometrical shapes were not found in the samples analyzed. Most of the plastic particles were three dimensional in their geometric shapes. A few images of samples obtained from diferent stations are shown below.

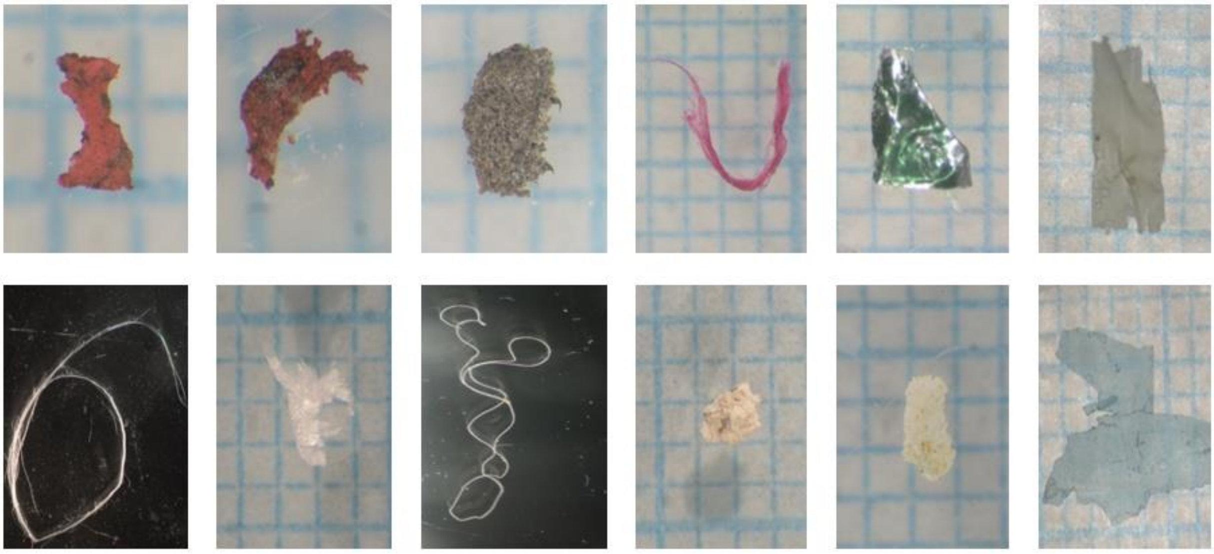


Figure 4.7: Microplastic particles of diferent types, characteristics, structures and sizes

4.8. Special Cases

A major incident that numerous plastic debris stranded on the North-western coast during June to September, 2018. These debris were with an Indian origin and belonged to different sources including beverage packaging, pharmasuiticles, medical waste, drinking water bottles, fishing gear/ nets, cosmetics and personal care products.

Figure 4.8: Plastic and polythene debris stranded on the North-western coast

A few beaches in the east coast had small plastic particles which can be presumed to be strandard on the beachers from outside of the country. Virgin micro-plastic pellets were observed and large plastics with identifiable lables from countries along the bey of bengal including india, thailand etc. This indicates the potential of ocean currents, especially thebengal current to transport plastics and other marine debris to Sri Lankan waters.

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 types were notable in the results, 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.

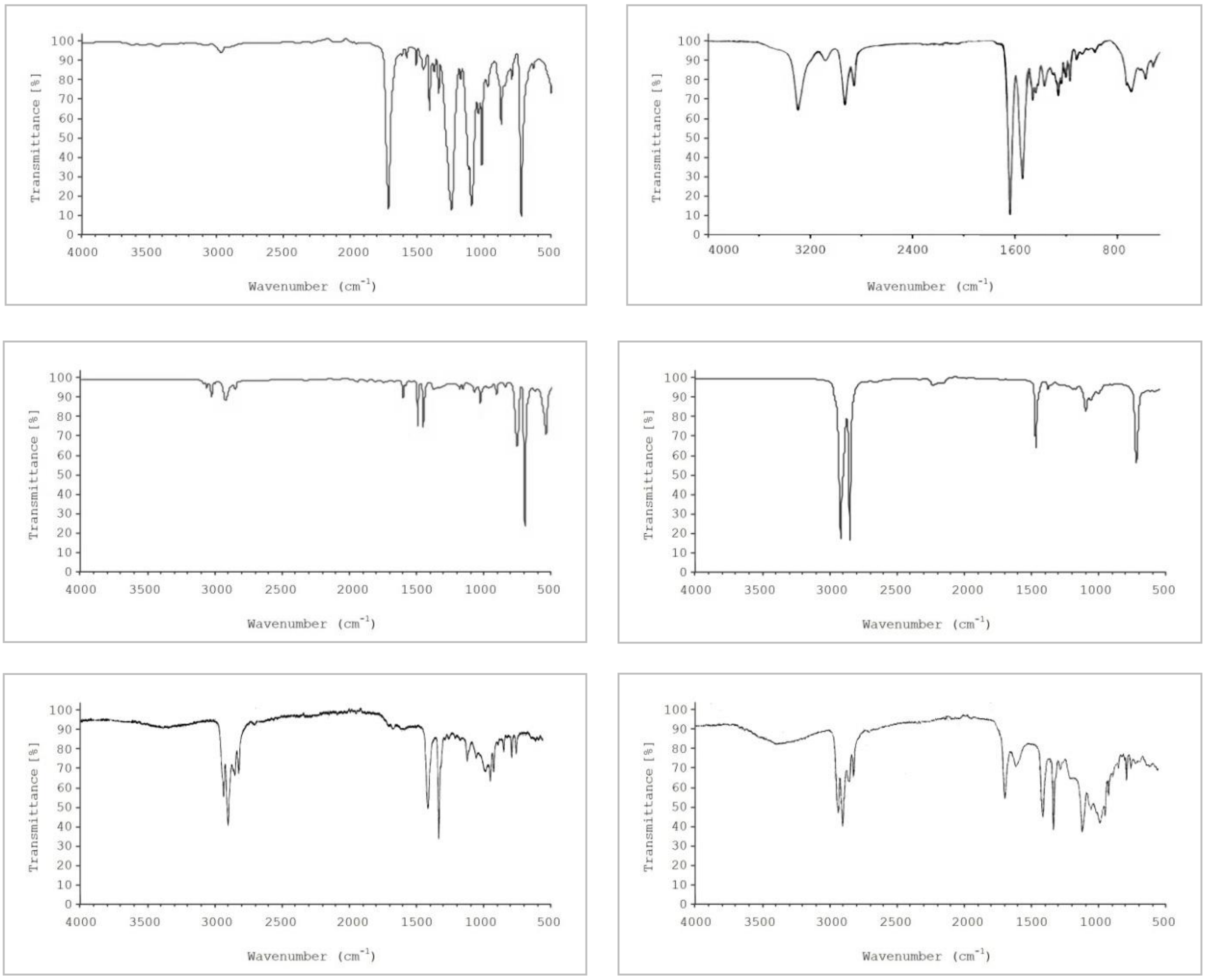


Figure: FTIR-ATR Spectra of Selected plastic and polythene litter particles from selected samples

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 majority of 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, covered merely 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.

Future research

The project 6.1.4 (1) may be further continued and be expanded for monitoring and maintaining a proper database with time series data.

The results of 6.1.4 (1) may be compared with results of the subcomponents, conducted by the Environmental Sciences Division of NARA

Resources Needs

7.1. Technological resources: Technology based resources needs are at the highest priority for Sri Lanka at present. Although basic research have been conducted, advanced techniques such as FTIR, FTIR-ATR, Raman Spectroscopy, and Dissecting microscopes based microscopy are needed at NARA so as to conduct advance, comprehensive and interdisciplinary research. **7.2**. **Human resources:** Training in advanced and novel technology, research methods (sampling, data analysis) is required for both research professionals and students. **7.3.Institutional Needs:** Furthermore, training and guidance is needed to build interdisciplinary and multidisciplinary professionals to pool resources and coordinate between institutions for the process of developing a viable national policy with “smart” objectives and targets to reduce, prevent and minimize pollution of oceans and inland water bodies in the island in the future. The country needs support in research, and implementing research findings to the real world through an island-wide approach, while developing proper understandings and professional relationships to utilize debris as a resource, to be used for economic and social development.

Research Publications

W.R.W.M.A.P. Weerakoon, T.B.D.T. Samaranayake, H.B. Jayasiri, and K. Arulananthan (2018). Quantitative analysis of micro-plastic contam-ination in beach sand at the Western and South-western coastal stretches in Sri Lanka. International Scientific Sessions of NARA – 2018.

A.M.G.A.D. Athawuda, H.B.Jayasiri, S.C. Jayamanne, W.R.W.M.A.P. Weerakoon, K.P.G.K.P. Guruge, and G.N.N. Thushari (2017). Micro-plastic contamination in surface water of west coast, off Colombo, Sri Lanka. In proceedings of the 2nd International Conference on Oceanography of the Bay of Bengal, 2018.

A.M.G.A.D. Athawuda, H.B.Jayasiri, W.R.W.M.A.P. Weerakoon, S.C. Jayamanne, K.P.G.K.P. Guruge, and G.N.N. Thushari (2017). Quantitative Estimation of the Abundance of Micro-plastics in surface water, off Colombo, Western Coast of Sri Lanka. In proceedings of the International Research Symposium (IRS-UWU), 2018, Uwa Wellassa University of Sri Lan

Impact of temperature on coral reefs in east and west coast of Sri Lanka

Project No	:	6.1.4(2)
Officers responsible	:	Mr.Akila Harishchandra

Expected Objectives

- Study the temporal (hourly, daily, weekly, monthly, annual, inter seasonal, intra seasonal or decadal) temperature variability at two coral reef hot spots in Sri Lanka.
- Understand the impact of temperature variability on coral reefs of these sites.
- Improve predictability of coral mass bleaching during El-Nino periods.

Expected Output

- In-situ temperature dataset in east and west coast of Sri Lanka.
- Major coral reef species composition in those two sites and their growth rate in natural environment.
- Blended sea temperature product.
- Reports and scientific publications based on temporal and spatial ocean temperature variability around Sri Lanka and its impact on coral growth rates.
- Coral mass bleaching prediction system for Sri Lanka.

Number of field visits scheduled: 6 for 2018

Actual number of field visit made: 8

Number of sample proposed to collect: Hourly ocean temperature values from two depths (5m and 10m) at two sites (Bar reef and Pigeon Island)

Actual number of sample collected:

14524 hourly ocean temperature data from Bar reef site and 10556 hourly ocean temperature data from Pigeon Island.

Major finding in 2018:

Results of two sensors moored in Bar reef

- Data logging was initiated on 24/01/2018 09 a.m. Data are recorded in one hour interval and logged to the internal memory. Data retrieval was ended up for 2018 year on 17/11/2018 at 07 a.m.
- Maximum recorded temperature at 5m was 30.99 ^{o}C recorded on 16/10/2018 at 06 p.m. Minimum recorded temperature at the same depth was 28.25 ^{o}C recorded on 03/02/2018 at 09 a.m.
- Maximum recorded temperature at 10m was 31.01 ^{o}C recorded on 12/10/2018 at 06 p.m. and recorded minimum temperature was 25.98 ^{o}C recorded on 04/02/2018 at 09 p.m.
- During several time periods shallow area temperature became lesser than the 10m temperature. The recorded highest cooling (-0.9^{o}C) was on 26/10/2018 early morning

07. This surface cooling occurred all over the year during night time, but stronger day time cooling events observed during May and November month.

Results of two sensors moored in Pigeon Island

- Data logging was initiated on 18/03/2018 at 11 a.m. and for 2018 year last temperature data was collected on 24/10/2018 at 08 a.m.
- Maximum temperature at 5m depth in Pigeon Island sea area was 31.1 oC which was recorded on 12/05/2018 at 03 p.m. and the lowest (26.25oC) at 5m depth was recorded on 17/08/2018 at early morning 02 a.m.
- Maximum temperature at 10m in Pigeon Island was 30.85 oC which was recorded on 12/05/2018 06 p.m. and the lowest temperature was 25.13 oC as recorded on 21/07/2018 early morning 3.
- A significant surface cooling was observed in the PINP ocean area as in Bar reef area too. Observed highest cooling was -0.47 oC which was recorded on 22/08/2018 02 p.m. But this surface cooling was not significantly seasonal as in Bar reef, despite few strong cooling events a regular night time seasonal cooling was observed in PINP.
- At both locations, recorded maximum temperature at 5m (where most coral reefs established well) depth did not exceeded the bleaching threshold value as per the calculations done using NOAA-AVHRR OISST data. Thus the temperature variability at ocean at Bar reef and Pigeon Island did not make harmful effects to the coral reefs in same area during 2018.

In-situ data comparison with ancillary data

- 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.
- HYCOM data were much compatible (R=0.8) with the in-situ data thus the freely available 7 day HYCOM products can be used to predict the temperature variability at 5m depth level at these two sites

Limitation/Conclusion/Recommendation

- To understand the ocean process in both locations, more data such as salinity and tide data are essential. Using mere ocean temperature data to analyze the ocean process is not practicable. Thus more sensors are required to be installed in the same locations to collect more data (salinity and water level) to understand the long term ocean variability at Bar reef and Pigeon Island ocean area.

Rather than using a global forecast product, it is desirable to use a regional forecast product to simulate the ocean temperature and compare with in-situ data.

National Hrdrographic Office

NHO

Data Acquisition for Nautical Chart of Trincomalee to Kudremalai Point

Project No : 6.2.1

Officer responsible : A.N.D.Perera

The nautical chart of Trincomalee to Kudremalai Point is covering about 550 km along the coastal stretch from East to West of Sri Lanka covering whole Jaffna Peninsula. The total coverage is about 30,000 sqkm. The hydrographic surveys were planned in two phases to produce the fair sheet of this chart.

Data collection was completed up to 40% of planned stretch of Trincomalee to Point Pedro as the phase I according to the action plan of 2017.Due to unavailability of RV. “Sammudirka”, surveys from Trincomalee to Point Pedro which are deeper than 200 m couldn’t completed as scheduled in 2018.

The surveys are conducted during 2018 as the phase II to collect bathymetry of covering the Jaffna Islands. These data is utilized to produce an additional nautical chart of Kankesanthurai to Delft Island with the scale of 1:75,000. Thus, the chart will fulfill the requirement of safe navigation, aquaculture and Mari culture farming and environmental studies. The physical progress of the year 2018 at the second phase is 100%. The Nautical Chart of Kankesanthurai to Delft Isalnd is available print on demand.

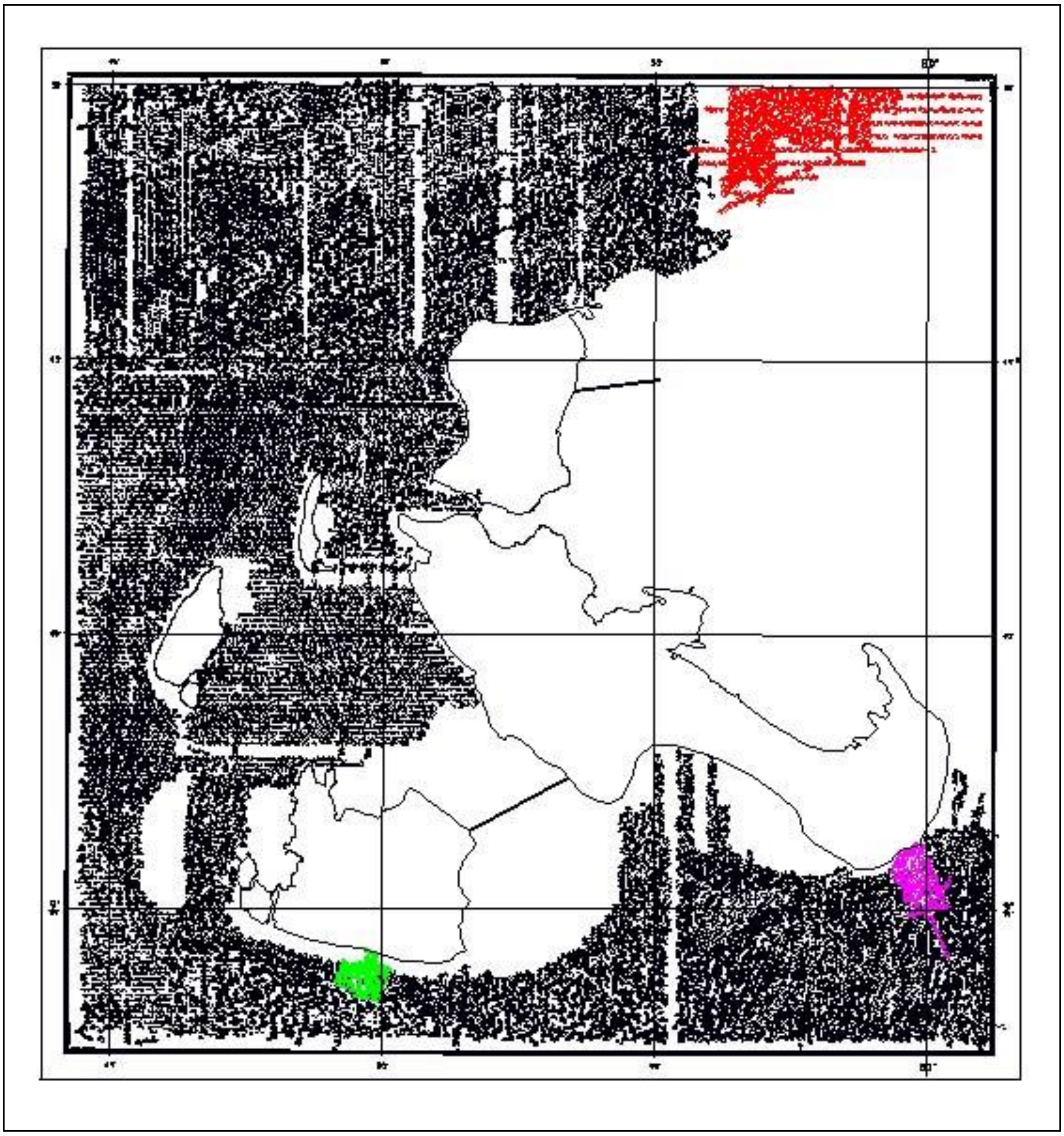


Figure 1.1 : Fair Sheet of Kankesanthurai to Delft Island

Figure 1.2 : Field works for Nautical chart from Kankesanthurwi to Delft Island

1.1.1 Nautical Chart of KankesanthuraiHarbour

The Kankesanthurai harbor is to be developed as the third international harbor after Colombo and RuhunuMagampura. Therefore, the nautical chart of this area is a prime requirement to fulfill the obligations to ensure safe access to this harbor. Kankesanthurai is the main port situated in Jaffna District Northern Province of Sri Lanka and it is the nearest port for all eastern ports in India as well as for Myanmar and Bangladesh. Rapid development was started in war affected areas by government to uplift the living conditions of the civilians. Under this project provides hydrographic data to facilitate development of coastal passenger transport and fishing activities.

As planned in the NHO action plan of the year 2017 and according to the Memorandum of Understanding between National Hydrographic office of NARA and SL Navy, both parties were involved for the bathymetric data acquisition to produce KKS harbor chart. The fair sheet of the Nautical Chartof KKS harbor was completed during 2018.

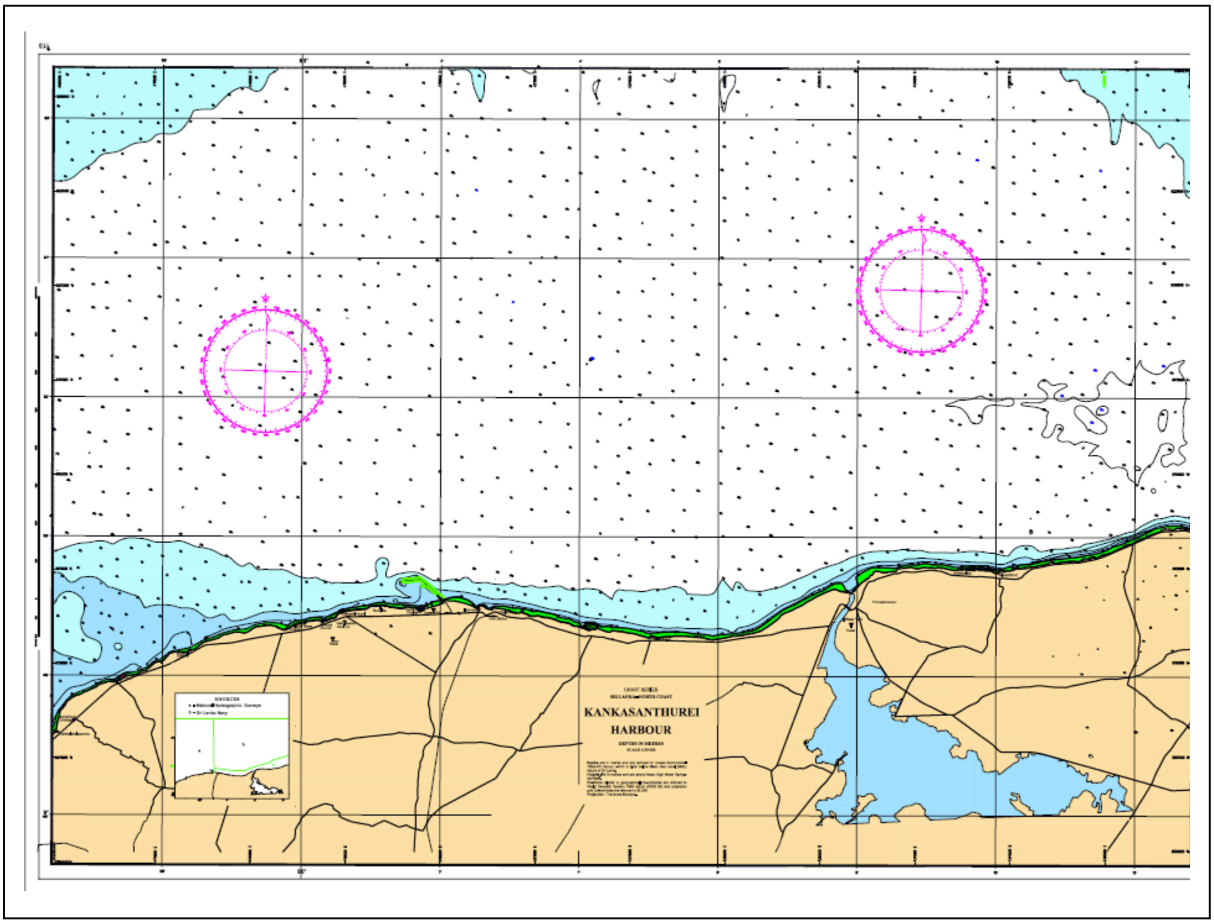


Figure 1.3:KankesanthuraiHarbour Chart

Data Acquisition for Nautical Chart of Little Basses Reef to Pulmoddai Roads.

Project No : 6.2.1

Officer responsible : A.N.D.Perera

According to the National Nautical Chart Index, total coastal belt of Sri Lanka covers with five small scale charts. The "Little Basses Reef to Pulmoddai Roads" is one of the above. This covers 250 km coastal stretch from South to East of the island. The total area will be surveyed in two phases. In phase one, it was scheduled to conduct the surveys in 2018 from 200 m isobaths by using RV Sammudirka up to the chart limit. Due to unavailability of RV Sammudirka, the data collection couldn't completed as planned.

Bathymetric data acquisition for Coastal ChartWeligama to Colombo

Project No : 6.2.1

Officer responsible : A.N.D.Perera

Up to 2017, 60 % of the surveys of the above chart is completed. NHO intended to complete surveys for remaining area of this nautical chart by the end of 2018.

Only 10% of the surveys are completed due to unavailability of R.V. "Samuddrika".

Request has made to Sri Lanka Navy to obtain remaining portion of bathymetric data beyond 200m depth up to the chart limit.

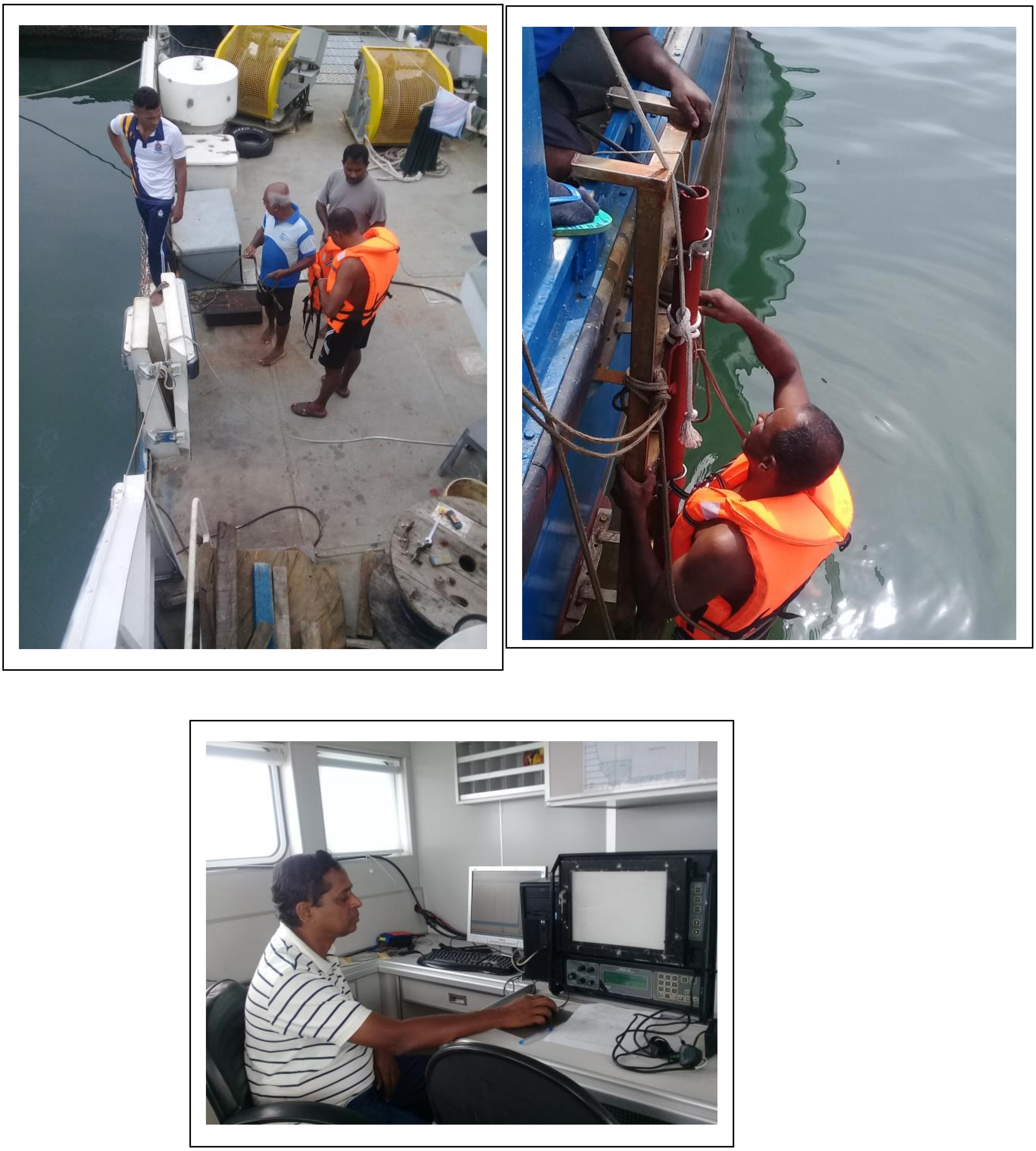


Figure 1.4 : Bathymetric data collection onboard RV ""Samuddrika""

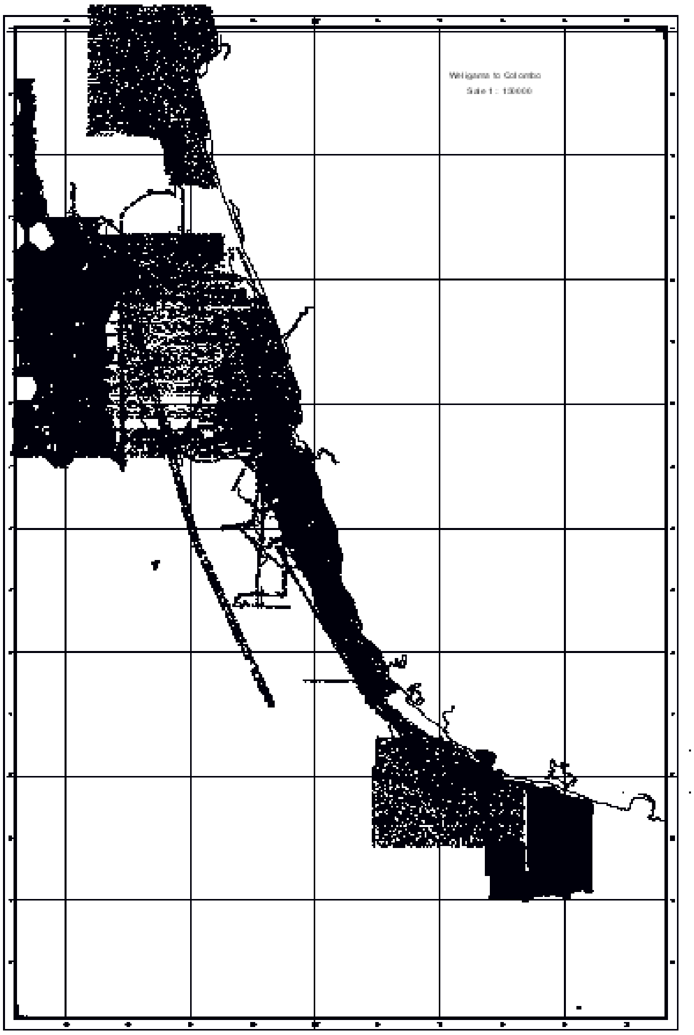


Figure 1.5 : Bathymetric Survey from Colombo to Weligama

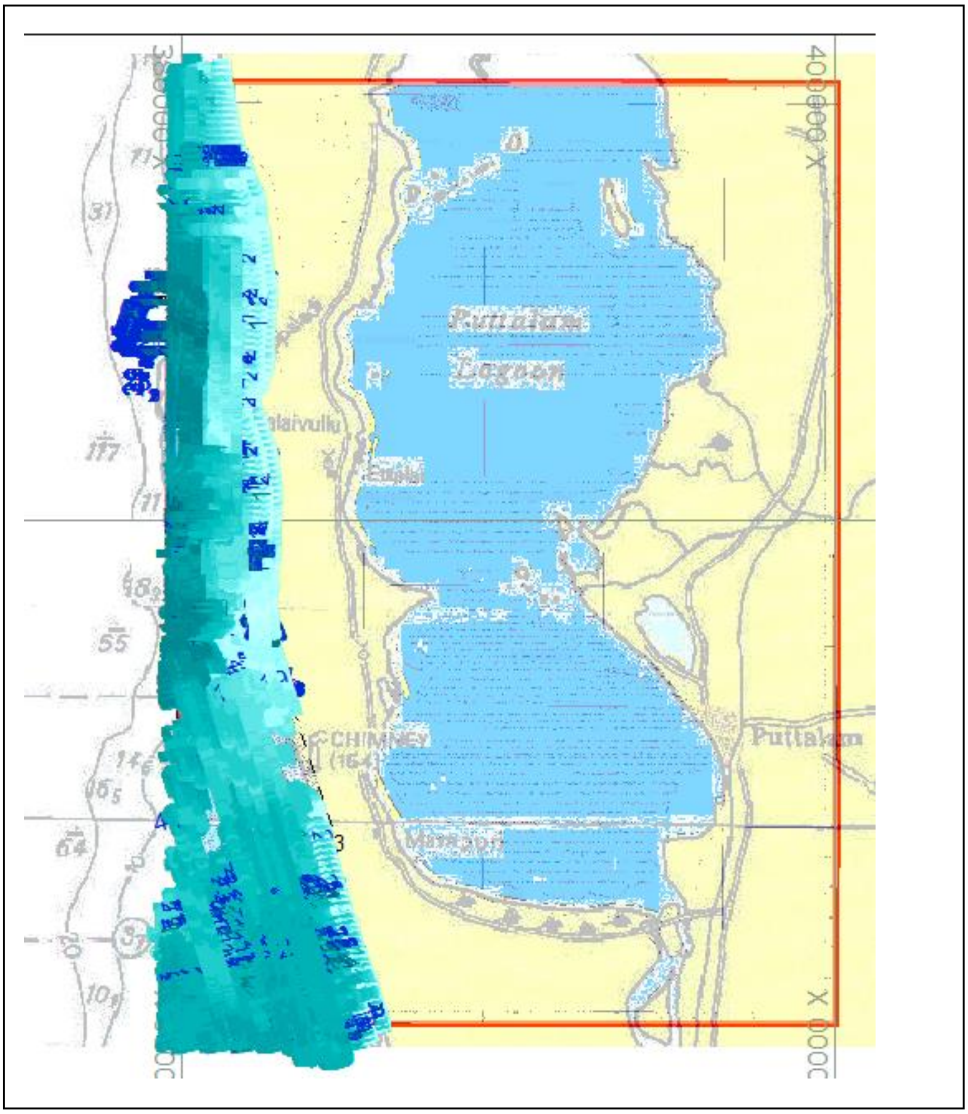
Nautical Chart of Kalpitiya Lower

Project No : 6.2.1

Officer responsible : A.N.D.Perera

National Hydrographic Office of NARA collected the bathymetry in Kalpitiya lagoon in 2011. Due to the unsecure situation prevailed in the country, this survey stopped at its middle under the instructions of Military. By considering the importance of having bathymetry at lagoon for development purposes, NHO started to collect bathymetric data for producing a nautical chart of Kalpitiya Lower. In 2017, the physical progress of collecting bathymetric data was 40% due to the mobilizing of survey team for the environment profile survey of lagoons which was initiated by the Ministry of Fisheries. The physical progress of the year 2018 is around 100%.

Figure 1.6: Nautical Chart of Kalpitiya Lower



Upgrading the published Nautical Charts

Project No :6.2.1

Officer responsible : A.N.D.Perera

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).

Upgrading the published Nautical Charts

Project No :6.2.1

Officer responsible : A.N.D.Perera

- Data processing for KKS harbor chart data is completed and the chart is available print on demand.
- Data Processing for the acquired bathymetry of the phase II from Kankesanthurai to Delft Island of Coastal Chart Trincomalee to Kudreamalai Point is completed. A fair sheet of Kankesanthurai to Delf Island is available print on demand.
- Data Processing for the acquired bathymetry for Coastal Chart Weligama to Colombo is completed.

Data Processing for the acquired bathymetry for Nautical Chart of Kalpitiya Lower is completed and the fair sheet for Nautical Chart of Kalpitiya Lower is available print on demand

Socio-Economic and Marketing Research Division

SED

Application of indigenous knowledgefor coastal fisheries managementin Sri Lanka

Project No : 7.1.3

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

Introduction

Traditional knowledge or indigenous knowledge or local knowledge refers the knowledge, innovations and practices of indigenous and local communities. Indigenous knowledge is unique to a given culture or society and it is evolved for centuries from generation to generation and one of the knowledge systems which is universal and utilized for the management of agriculture, fisheries, food preparation, education, medicine and social sciences.

Fisheries management has become a key concern in Sri Lanka due to numerous reasons such as increasing the demand for fishery resources, increasing population, over exploitation of resources, use of destructive fishing gears as well as requirements for the sustainable resource management. In the past periods, fishery management has begun with community knowledge and understanding and later it was institutionalized using various rules and regulations for the betterment of the industry. Currently, international institutions also strongly believed that traditional knowledge in fisheries management should be included into policies; programs and activities for sustain natural resources and human welfare. Therefore, it is important to identify indigenous fishing practices that have been using by the fishers for coastal fisheries management in Sri Lanka. To achieve the research objectives, this study further focused on beach seine fishery and stake seine fishery (Kattudel fishery).

Objective of the study

- To explore the indigenous knowledge practices in coastal fisheries and fisheries management in Sri Lanka.

Methodology

This study was based on both primary and secondary data sources. Descriptive research design was used to identify traditional knowledge used in beach seine fishery in Southern province and Mullative district and stake seine fishery in Chilaw and Negombo . The rationale for using this approach in the research was to describe the experiences, knowledge and practices used for fisheries management. The primary data which was collected through a field survey, observation and focus group discussions. In addition to that participatory rural appraisal (PRA) technique was also conducted. The data were qualitatively analysed and supplemented by descriptive statistics.

The project was undertaken during the time period of January to December, 2018. The total sample for the beach seine fishery was 30 while it was 15 for Kattudel fishery. In addition to that 03 PRAs were conducted for the Kattudel fisheries in Negombo and Chilaw.

Research Findings

The study mainly found that over 90% of beach seines in the Mulative district was operated using winch attached to the tractors, while 100% of Sothern province beach seines were operated mannually. Motorized boats (OFRP) used together with wallam (non mechanized-boat) to lay the fishing net in Mulative district. However, OFRP boats were not used for the beach seine fishery in the Sothern province. Number of Nylon ropes (hauling rops) used for the beach seine in the Mulative district were around four (4) time higher compared to the ropes that were used (3-10 per side) in Sothern province. The number of net owners in a site are few in Mullative but that of large in Sothern province.

Beach seine-Mulative Fishery District Beach seine- Sothern Province

Beach seine were traditionally operated only in Southern province. Fishers follow their traditional practices for the rotation of the beach seines *(MadalPadu and* income-sharing in Sothern province. But in Mulative district fishers were paid salaries who are engaged in beach seine operations. There were around four types of beach seines belonged to the owner of the beach seine fishers in Mulative fishery district, while mots probably one beach seine was belonged to a beach seine owner of the Sothern province.

Under the owner there are five or six share holders who are doing major activities of beach seine fishery such as preparation of net for fishing, cleaning the net after fishing, lay the net for fishing and so on. Especially there is a leader (*Mannadirala, Marakkalahe)* for the beach seine. Mannadi Rala has sound understanding on beach seine and especially current pattern and the sea bed of the location. Half of the profit of the beach seine goes to the owner of the beach seine and rest of the half goes to the share holders of the beach seine (Including MannadiRala). People who help the beach seine receive fish for their contribution for the hauling the net.

Major Findings

- Traditional beach seine system is better income distribution system compared to the mechanized beach seine fishery.
- More than 30 persons engage in a traditional beach seine during the of beach seine seasons (September to April – Southern Coast and North West coast, March to October-Northern and Eastern Coasts).
- Traditional beach seine fishers use less no of hauling rope than the Mechanized beach seine fishers. Therefore, it is better resources sharing system among different types of fishers (non-mechanized costal fishers who practice different fishing gears)
- There are some rocks, wooden parts in the sea bed of the beach seine sites. It is one of the major barrier for proper function of the beach seine.
- As a result of high price and difficulties to find core ropes for the beach seine nets (wings), fishers have shifted to the nylon ropes.
- Majority (more than 80%) of the beach seine fishers (helpers and owners) are elders (more than 45 years old). The young generation do not willing enter into beach seine fishery as a result of low income.
- Traditional fishers believe that practicing rituals such as pray of gods and offer something to gods (milk rice) help for better harvest. As a result, some beach sine fishers practice these types of rituals in the southern cost.
- It is observed that the traditional practices (specially rituals) are diminishing from the beach seine fishery.

Recommendations

- It is recommended that traditional method of income sharing system should be applied beach seine fisher irrespective of operating system.
- It is recommended that irrespective of seine operation fishery management regulations should be followed.
- It is recommended that beach seine sites should be properly maintained and provided with relevant infrastructure.

Stake net fishery

Stake net fishery is a traditional fishing practiced in Negombo and Chilaw lagoons which was originated in Negombo by three families called Mihindukulasuriya, Kurukulasuriya and Warnakulasuriya. Later the fishery was introduced into Chilaw lagoon by migrated fishers from Negombo. The ownership rights has come generation to generation. Only males can claim for the ownership rights both in Negombo and Chilaw lagoons.

Prawn is the main catch species. It has two wings and cod end which is called "Thuriya". At present, the average length of the stake net is around 11-12m. In 1800s, the stake nets were prepared using hemp and cotton but now they are nylon meshed. The nylon nets are easy to operate and durable more than twenty years. Kattudel fishers are working on a wooden outrigger canoes. Generally, two or three fishermen work in a canoe. Stake net fishing is operated in evening and it takes six hours to collect the harvest. During the operation, Kattudel fishers use kerosene lamps as the lighting sources to attract prawns into cod end. Stake net fishery is based on tidal flow of the sea mouth to fix the net. The tidal waves carry matured prawns from the lagoon to the sea. In full moon days and heavy rainy days, shrimp production is high due to influence of the tides. The stake nets are operated in specific locations which are called as "Kattudel Padu"."Pelle" is the meeting that Kattudel sites are allocated for the members of Kattudel associations. In Negombo lagoon, the padu system is decided through a lottery system to select the best places to operate fishing nets. Stake fishers have identified three famous padu in Negombo lagoon namely Kongaha, Mankuliya and Pitipana. In Chilaw lagoon, the traditional Kattudel fishery association have decided the fishing days and schedule.

Kattudel fishers experience many challenges that impact on their traditional knowledge and sustainable resource management. Hence, studying of how to protect traditional fishing technique and provide solutions for the challenges is timely important and needed.

Conclusion and recommendations

Kattudel fishery is an ancient traditional fishery dominated by one fishermen group in the area based on ownership rights. Usage of craft and fishing gears has changed than past but community based management is still important in this fishery. In order to protect their traditional knowledge and resource sustainability, following actions should be taken into consideration.

- It is recommended to demarcate the lagoon boundaries and to increase the depth of the sea mouth
- It is recommended that Community based fisheries management should be strengthen to sustain the livelihoods of the Kattudel fishers
- Operation of motorized boats in the lagoon should be limited and speed limit should be imposed during the fishing operation time of Kattudel fishery
- Pollution, garbage dumping and unauthorized constructions should be immediately banned and punished for the people who engaging that types of works
- It is recommended to implement rules and regulations against the shrimp farmers who release the chemical mixed waste water into the lagoon
- Study is recommended to conduct awareness programs for stake net fishers before implementing developments activities in the lagoon
- It is needed to protect the traditional fishing technique by appreciating indigenous people in the community and provisioning economic and social welfare
- Co- management committee should be strengthen in decision making process with relevant agencies for sustainable management of fishery resources.

Photo evidence

Study Value chain analysis and developmentof Lobster, Crab, Giant Fresh waterprawns and Clam Fisheries in Sri Lanka

Project No : 7.1.2

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

Introduction

Crabs, lobster and fresh water prawns are considered as high valued fishery products which have higher potentials for bringing foreign exchange to the country. Value chain analysis is one of the best tools to be used to evaluate all activities and processes involve in any industry from the production until it reaches the end consumer in order to identify the key players and their major roles, economic efficiency, potentials, constraints that limit the development and growth of the industry, governance structures, institutional frameworks etc. Therefore studying of value chain of crab, lobster and fresh water prawn fisheries is very much important to amplify the economic gain through these particular fisheries. Further value chain analysis helps to identify the development needs along the value chains and assist the value chain actors to upgrade their lives, quality and safety of foods and generate employment opportunities.

Objectives of the study

I. To analyze the value chain of crab, lobster, clam and fresh water prawn fisheries in Sri Lanka.

II. To identify required skills and development support for the development of value chain for the sustainable utilization of resources.

Methodology

This study was conducted using several data collecting techniques including direct interviews using pre tested semi structured questionnaires and unstructured interviews, in-depth interviews and PRAs. Secondary data sources were also used to collect background information. Totally 101 Field surveys (113 fishers, 11 sea food company agents, 25 local assemblers) and 04 PRAs were conducted during the time period of January to December, 2018. Data were collected in Southern coast, Eastern coast, South west coast and North Central province of the country.

Key finding

Lobster: There were three main fishing methods practiced in lobster fishery, namely bottom set gill netting (BSGN), scuba diving and skin diving. Majority of fishers were engaged in skin diving for lobster harvesting. The annual average catch of bottom set gill net fisher was 218 kg per year per net. Scuba divers collect 285 kg lobster whereas skin diver can collect 120Kg per year. Lobster prices vary from Rs. 2500 to 2900 per kg at the fishermen level. Bottom set gill netting fishermen was earned Rs 307,901 of net income per annum and fishers engaged in scuba diving and skin diving earned a net income of Rs. 327,873 and Rs. 308,625 per year respectively. There were main two types of intermediaries to purchase the lobster catch from fishermen namely beach level collectors and sea food exporting company agents. Beach level collector offers Rs. 75-125 lower prices to the fishermen than that of company agents. The number of beach level collectors was higher than that of number of company agents. They have employed their own vehicles to collect lobsters from fishermen and have become an easy access to fishermen to sell their daily catch without delaying and with no transportation cost. Further they provide financial support for fishermen when they are in difficulty. Because of such reasons beach level collector plays a big role in between the fishermen and Sea Food Company. The daily handling quantity of lobster by beach level collector was 20 Kg on average. The average selling price of the beach level collector was found as Rs.3100 per Kg. The annual average net income of the beach level collector was Rs.740 000. Lack of boat landing sites, lower productivity of fishery, lack of training on occupational safety for diver fishers, difficulty in net maintaining and price fluctuation were the key problems stated by lobster fishery as the constraints they face in their livelihood. The lobster market is an oligopolistic market at the level of collecting and exporting. Since the lobster fishery is a capture fishery where the total landings and the market quantities are quite small, there is no room in the market for too many collectors and suppliers, which is the main blockade faced by potential entrants.

Crab: The Sri Lankan Blue Swimming Crab fishery is a coastal fishery, which operates in the relatively shallow waters along the South-west coast and exclusively done using gill net fishing from small OFRP and NTRB crafts. Blue Swimming crab fishery is very important for both high end local markets and export markets and even found with village level retailers and mobile vendors depend on the size, weight and gender. Blue swimming crab catch vary between 40-50 Kg per craft per day during the peak season and 2-4 Kg/craft per day during the lean season with annual average of 21Kg/craft per fishing trip and the average number of days a fisherman engaged in crab fishery was 145 day/year. Average price of BSC was Rs 375 at fishermen level and average annual net income was Rs. 398, 250. Usually the daily price was set by the sea food companies. The beach level collectors offer low price between Rs.30-75 per Kg than that of sea Food Company. Daily average BSC handling quantity of beach level collector was 293Kg. The average selling price of the beach level collector was found as Rs.420 per Kg and the net annual income of the beach level collector was Rs. 639,420Unavailability of the market information, use of illegal fishing gears like monofilament nets, indebtedness to the beach level collectors, opaqueness in price setting, resource depletion and pressure on fishery were identified as the key problems of fishermen engaged in BSC fishery.

Mud crab is very important fishery which has a higher demand in foreign markets and high end local hotels and restaurant chains. Mud crab catch vary between 4-6 Kg per craft per day during the peak season and many zero catch days were reported during the lean season with annual average of 1.5Kg/craft per fishing trip. The average number of days a fishermen engaged in crab fishery was 118 day/year. Fishermen did not solely depend on mud crab fishery because the availability of mud crab is declining rapidly. Therefore fishermen do shift their choice of fishery based on the availability of other fish species in the lagoon. Average price of mud crab was Rs 3600/Kg at fishermen level and average annual net income of fishing unit was Rs. 111, 300. Usually the daily price was set by the sea food companies. The beach level collectors offer low price between Rs.150-250 per Kg than that of sea Food Company. Companies are hesitated to buy soft crabs because it is not valuable in crab business. Therefore as a practice just-molted crabs (water/ mud crabs) from wild catch were kept in cadges for 2-3 weeks and allow to mature before harvesting. This was practiced by fishermen himself or by the village level collector. The daily handling quantity of mud crab by beach level collector was 35Kg on average. The average selling price of the beach level collector was found as Rs.3800 per Kg. The net annual income of the beach level collector was Rs. 229,350. Significantly low harvest than past, large number of zero catch days, harvesting of immature/soft crabs and high operational cost were the key problems that highlighted by fishermen occupied in crab fishery. The main problem that encountered by the collector was molting of crabs after purchasing. While soft crabs keep for fattening due to the cannibalistic nature they tend to cause damages to each other and very hard to earn a satisfactory gain.

Other than these two fisheries under this research, problems of improving the value chains of giant fresh water prawn fishery and clam fishery were studied.

The giant fresh water prawn fishery has a huge potential to develop as high value export products but following issues haphazard the industry growth. The main issues raised were insufficient release of post larvae, huge mortality rate of fingerlings after releasing, unfavorable water management practices in reservoirs (conflict between agriculture and fishery), undeveloped market channels due to uncertainty of regular supply and poor infrastructure facilities (roads, landing sites).

Clam:Clam fishery is a traditional type fishery practiced in Puttalam lagoon in Kalpitiya peninsula. It is dominated by fisherwomen and it is a seasonal fishery. Fishery season is started in early May and ends in mid-September. Clam is available throughout the year but this seasonal practice is carried out as a measure for resource conservation and enhancement. Clam fishery has a very simple value chain which includes fisherwomen, clam meat collector and village level retailer. Fisherwomen sell their daily catch to the collector after removing shell. Collector sells daily collection to the village level retailer after makes it in to dried form. There is a monopoly market at retailer level and no power on price setting and bargaining. Since there is no value addition price at fisherwomen level also not competitive. Since this fisher folk have no access for training on value addition techniques, they were not aware about the potential high value products that can be made of fresh clam.

Recommendations

- It is recommended that adequate formal and informal awareness programs on value addition and product development should be conducted for all value chain players for the sustainable utilization of fisheries resources.
- It is recommended that establishment of ICT based market information network to pave the way for making competitiveness of market activities.

- It is recommended that expansion of market infrastructure facilities to improve local and export market share for fishery products.

Output

- Mapped 4 value chains for selected fisheries
- Conducted 6 awareness programs and trainings (Padaviya, Kalpitiya, Polhena, Panama, Rekawa, Negambo) conducted.
- Final Report.

Study on Production Cost of MarineFisheries in Sri Lanka

Project No	:	7.1.1
Officer Responsible	:	K. P. G. L. Sandaruwan

Introduction

Marine fisheries sector is an important and the large sub sector (85%)of fishery industry in Sri Lanka and incur varies of cost factors in fishing operations .At present information on the nature and structure of operational cost in fishing operations are little known or unknown which hindered making development plans and policy decisions for fisheries. Therefore, this study is timely important for the information and data which may be helpful for all stakeholders as well as planers and policy makers for the development of the sector.

Objectives of the study

The main objective of the study is to explore production cost of marine fishing operations in Sri Lanka.

Methodology

The data was collected through face to face interviews with skippers and boat owners during January to November of 2018. The samples were selected to cover main fishery harbours and anchorages of nine fisheries districts as follows Matara, Negombo, Colombo, Tangalle, Batticaloa, Kalutara, Galle, Puttalam and Trincomalee. The total sample was 247 and that composed with145 of multi-day boats and 115 of coastal fishery boats. The data was analysed by using SPSS (22-version)

Outcome : - Availability of developed real time data base of production cost of marine fishing operations. The key findings were presented to the skippers in skipper training program conducted by welfare project of SED. The key findings were submitted for fisheries ministers, central bank and researchers who requested cost of product information.

Output : - 1.Final report

2. Data base

Results

Key finding

Deep Sea Fishing Operations:-

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 1).

Profitability:-The highest net income of Rs. 4,077,096was enjoyed by boats in group 33-40 ft length and the lowest Rs. 2,426,979 by the boats belonged to 28-32 ft while that of Rs. 4,202,594for the larger boats, 41-60 ft.

Coastal Fishing Operations:-

Production Cost: -The production cost has had positive correlation with the type of the boat, mechanized or non-mechanized, in coastal fishing operations. The mechanized boats incurred higher cost of production due to consumptions of fuel.

Profitability:-The annual net incomes variation has observed among different types of coastal fishing boats. The highest net income of Rs 455, 782 was earned by Out-boat engine fiber reinforced Plastic boats (OFRP) and the lowest, Rs145, 785 by Non-mechanized traditional boats (NTRB) while that of Rs. 202,644formechanized traditional boats (MTRB).

Table 1 :Annual Averages of Catch, Income, Variable cost, Gross and Net profit (Rs)

	Deep sea Fishery (Craft length categories ft.)			**Coastal fisheries (craft types)**		
Description	**28-32**	**33-40**	**41-60**	**OFRP**	**MTRB**	**NTRB**
Catch (Kg)	21,713	27,041	32,584	5,790	3,497	1,451
Income (Rs.)	8,365,211	12,141,469	17,269,596	2,425,560	1,159,538	503,527
Variable cost (Rs.)	4,861,061	6,520,187	10,800,546	1,683,288	834,479	286,221
Gross profit (Rs.)	3,504,150	5,621,282	6,469,050	742,272	325,059	217,306
Net profit (Rs.)	2,426,979	4,077,096	3,901,434	455,782	202,644	145,785
Multi-day boats (IMUL) ,Out-boat engine Fiber reinforced Plastic boat (OFRP) Non-mechanized Traditional Boat (NTRB) and mechanized traditional crafts (MTRB)						

Source: Socio-economic survey/SED/NARA/2018

Recommendations

- It is recommended to control the cost of production of fishing crafts that in operation in deep sea fisheries through applying the low cost concept by integrating scale of economies in operation.
- 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.
- 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.
- It is recommended to persuade skippers and owners to undertake on board fish processing and value additions to increase the price of fish.

Community Welfare and Skillsdevelopment of fishers

Project No	:	8.1.7
Officer Responsible	:	K.H.M.L Amaralal

Introduction

Enhancement of socio-economic status of the fishing community and their dependants is immense important for the sustainable livelihoods. 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 and facilities for pre-school and school children and equipments that help to add value to the products have been provided for the community.

According to the requirement of the Ministry of fisheries and to comply with international requirements, skippers who are engaging fishing activities in IMUL boats were selected for the training. Accordingly, 200 skippers of Multi-day fishing boats have successfully been completed the training programme. The training was scheduled as seven day training and lectures of the NIFNI conducted the training programme.

Skipper Training Tangalle

Based on the requirements and the request done by the fishing community, pack of school equipments (school bag, water bottle, books) were distributed among 501 preschool and school children in Mannar (weidathalative), Matara (Kapparathota), Hambanthota (Rakawa), Puthtlum (Kalpitiya,Baththalangunduwa,Uchchamunei,Janasavipura,Kurichchumpitiya) and Monaragala (Hambegamuwa,) fishery districts.

School kits distribution for Preschool and School children

Product development with value added help to increase the demand and the price of the products. Therefore, fishers' organization (women fisher) was established in Kalpitya Fisheries Inspector (FI) division for train them to supply high quality products to the market. Fish women who collect the clam are the member of the organization. According to the requirement and request of the organization training and facilities (equipments) were distributed among the members of the clam fishery organization in Kalpitiya.

Clam Fishery organization - women in Kalpitiya FI division

Identified further requirements

Fishers, who use OFRP boats requested 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. Therefore, fishers requested training programme for them on engine repairer.

Common buildings, anchorage and roads to the landing sites are not in good condition. (some of them have not such a facilities for their villages) Therefore, fishers request support for renovate existing facilities (above mentioned) and request the facilities for development of fishing industry.

The fisheries information centre(FIC) of NARA

Project No : 8.1.6

Officer Responsible : H.P.D.A Lakmali

Introduction

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 2018, a total number of 427 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

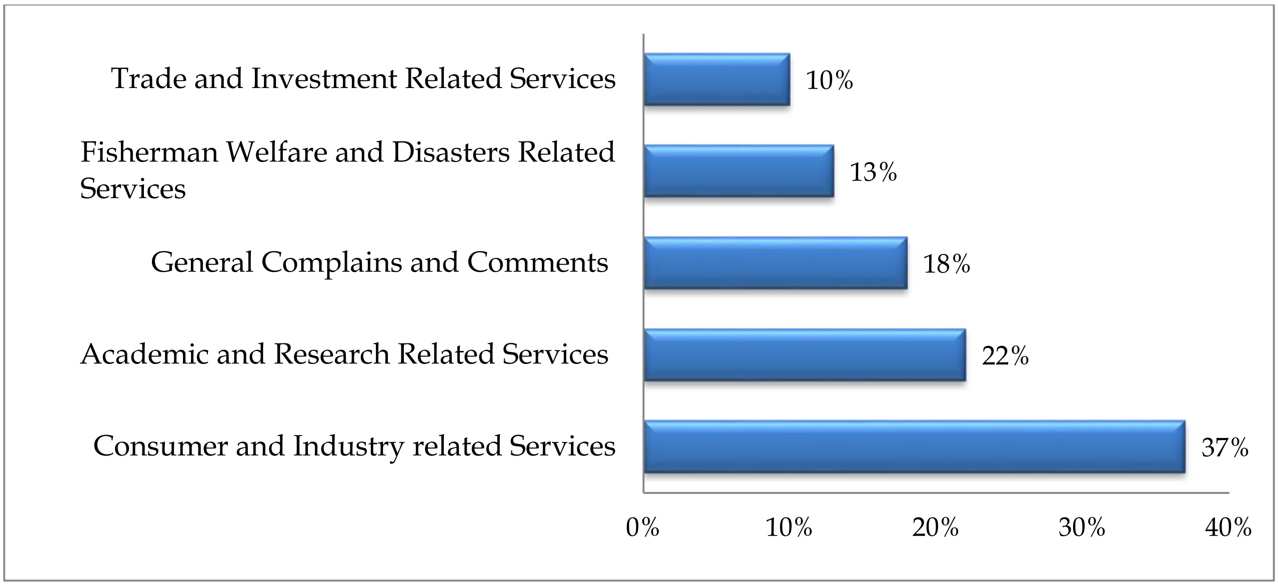
Posters will be displayed in the places where fishers are gathered (FI offices, community hall etc.)

Numbers of queries and the percentages under each information criteria

Information criterion	Number of calls received	Percentage
Consumer and Industry related Services	158	37%
Academic and Research Related Services	92	22%
General Complains and Comments	78	18%
Fisherman Welfare and Disasters Related Services	54	13%
Trade and Investment Related Services	45	10%
Total	427	100%

Source: Socio-economic survey/SED/NARA/2018

Number of calls received



Source: Socio-economic survey/SED/NARA/2018

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.