

2022

ANNUAL REPORT & ACCOUNTS



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NATIONAL AQUATIC RESOURCES RESEARCH & DEVELOPMENT AGENCY

1. CORPORATE INFORMATION

The National Aquatic Resources Research and Development Agency (NARA) is the principal national institution charged with the responsibility of carrying out and co-coordinating research development and management activities on the subject of aquatic resources in Sri Lanka. NARA was established in the year 1981 by restructuring the Research Division of the Department of Fisheries. In the restructuring process Research Division was amalgamated with the institute of Fish Technology which existed in the present premises of NARA at Crow Island, Mattakkuliya, Colombo15 to establish a fully fledged research agency, under an Act of Parliament, National Aquatic Resources Agency Act No. 54 of 1981 and amended subsequently by National Aquatic Resources Research and Development Agency Act No. 32 of 1996. The following Vision, Mission, Goals/Objectives as the highlights of the NARA functions as a statutory body under the Ministry of Fisheries and Aquatic Resources Development are as follows.

Our Vision

To be the premier institution for scientific research in conservation, management and development of aquatic resources in the region.

Our Mission

To provide innovative solutions for national development issues in the aquatic resources sector utilizing scientific and technological knowledge & resource base.

The main objectives and functions of the Agency:

- To ensure application and utilization of Scientific and Technological expertise for the implementation of national development programs.
- To promote and conduct research activities directed at identification, assessment, management and development of living and non-living aquatic resources.
- To co-ordinate and provide advisory and consultancy services on matters relating to exploitation, management and development of aquatic resources.
- To undertake collection, dissemination and publication of scientific research information on aquatic resources & related subjects.
- To provide training related to fisheries and aquatic resources fields.

Governing Board

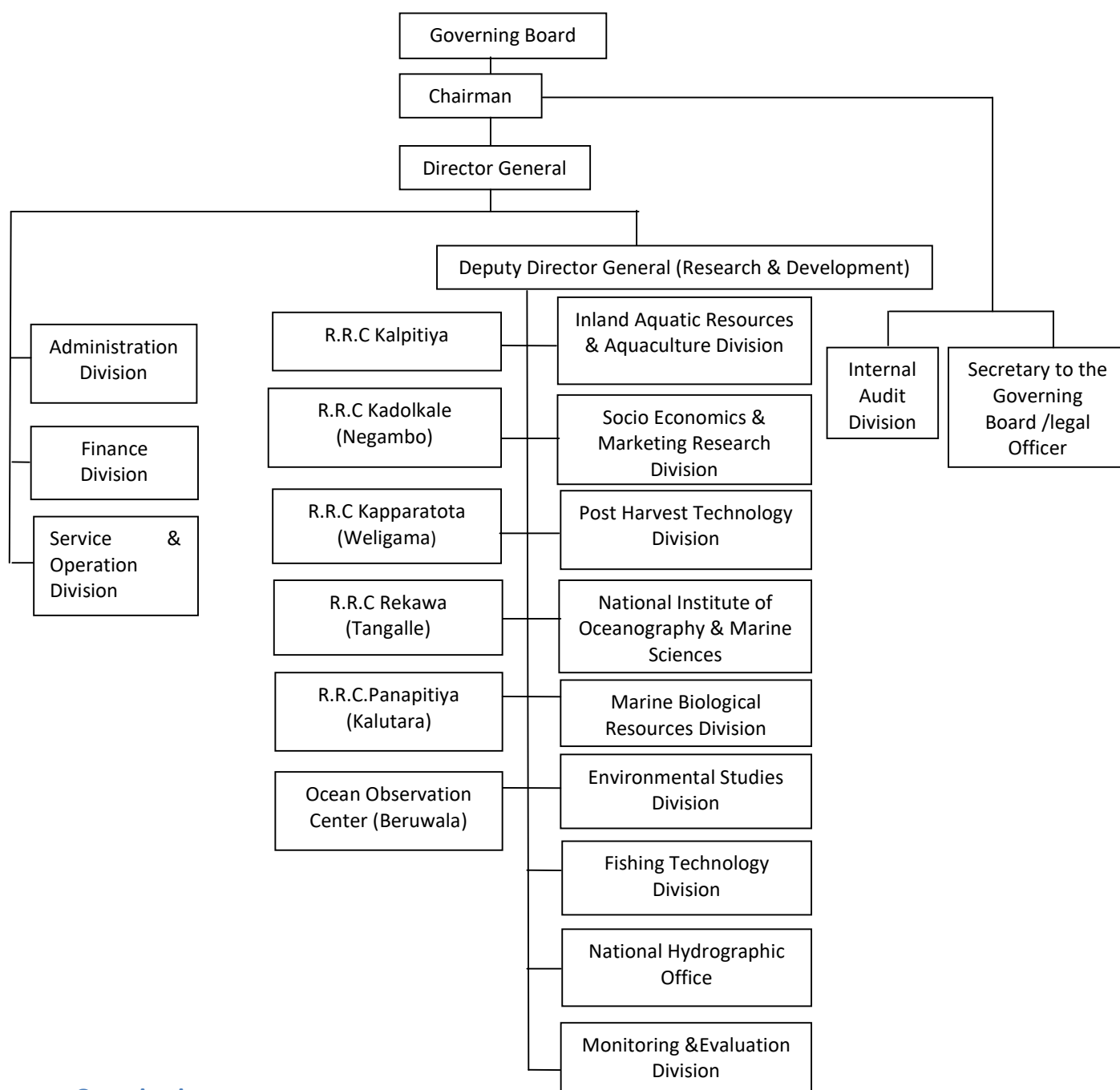
The Governing Board consists of Eight (08) Appointed Members and Eight (08) Ex officio members in accordance with the Section 6 of the National Aquatic Resources Research & Development Agency Act No 54 of 1981 as amended by Act No 32 of 1996. The following members served as the members of the Governing Board during the year 2022 and ten (10) Board Meetings were held during the year.

The Governing Board Members of NARA 2022			
Members who appointed by the Minister			
The Name and Address	Designation		Period of the service
Senior Prof. M. J. S. Wijeyaratne, Chairman, National Aquatic Resources Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	The Chairman	The Governing Board	From 01 st January 2022 to 31 st December 2022
Dr.Kamal Tennakoon Director General (Acting), National Aquatic Resources Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	The Governing	Board	From 22 nd November 2022 to 31 st December 2022
Mr. Selvendran Salivan de Marian No. 17/2, Uyarappulam, Anaikoddai, Jaffna.	The Governing	Board	From 01 st January 2022 to 31 st December 2022
Mr. Gizal Chinthan de Silva No. 273, Stanley Road, Jaffna No 3/9,Railway station Road, Colombo 04.	The Governing	Board	From 01 st January 2022 to 31 st December 2022
Mr. Dilan Fernando, Taprobane Sea Foods (Pvt) Ltd, Bubulla Watta, Haldanduwana, Dankotuwa.	The Governing	Board	From 10 th February 2022 to 01 st June 2022
Mr. N. M. P. Chaminda Fernando, Secretary, Sri Lanka Aquaculture Development Alliance, 53B, Singhapura Road, Chilaw, 61000	The Governing	Board	From 10 th February 2022 to 31 st December 2022
Prof. Upali S. Amarasinghe, Department of Zoology & Environmental Management University of Kelaniya, Kelaniya	The Governing	Board	From 01 st January 2022 to 31 st December 2022
Dr. Asha De Vos No.14, Malalasekare Place, Colombo 07.	The Governing	Board	From 01 st January 2022 to 31 st March 2022
Dr. (Mrs.) J. M. Asoka, Director General, National Aquaculture Development Authority of Sri Lanka, No. 41/1, New Parliament Rd, Pelawatte, Battaramulla	The Governing	Board	From 01 st January 2022 to 31 st December 2022
Dr.Kamal Tennakoon No.15, Visaka Road, Gampaha	The Governing	Board	From 02 nd June 2022 to 23 rd November 2022

Prof. S. Kuganathan Department of Fisheries Science, University of Jaffna	The Governing Board Member	From 02 nd June 2022 to 15 th November 2022
Dr. Augustine Soosai Sihivaithasan	The Governing Board Member	From 09 th December 2022 to 31 th December 2022
Ex-Officio Members		
The Name and Address	Designation	Period of the service
Dr. H.M.P. Kithsiri National Aquatic Resources Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15.	Director General The Governing Board Member	From 01 st January 2022 to 21 st November 2022
Dr.Kamal Tennakoon No.15, Visaka Road, Gampaha.	The Governing Board Member	From 23 rd November 2022 to 31 st December 2022
Mr. T.A.C.N Thalangama Additional Secretary Ministry of Ornamental Fish, Inland Fish and Prawn Farming, Fishery Harbour Development, Multiday Fishing Activities and Fish Exports New Secretariat, Maligawatta,Colombo 10.	The Governing Board Member	From 01 st January 2022 to 31 st December 2022
Ms. K.D.A. Munasinghe, Additional Director General, Department of Project Management & Monitoring, Ministry of Finance, Economy and Policy Development, The Secretariat, Colombo 01.	The Governing Board Member,	From 01 st January 2022 to 28 th February 2022
Mr. A.P Kurumbalapitiya, Additional Director General (Acting), Department of Management Audit, Ministry of Finance, The Secretariat, Colombo 01.	The Governing Board Member,	From 28 th February 2022 to 31 st December 2022
Mr.A. Disanayake Surveyor General, Survey Department of Sri Lanka 150, Kirula Road, Narahenpita, Colombo 05.	The Governing Board Member,	From 01 st January 2022 to 31 st December 2022
Ms. K.N. Kumari Somaratne Additional Secretary (Development), Ministry of Ports & Shipping, No. 19, Chaithya Road, Colombo 01.	The Governing Board Member,	From 01 st January 2022 to 31 st December 2022

Rear Admiral Y.N.Jayarathne Director General Operations Naval Headquarters, Colombo 15.	The Governing Board Member	From 01 st January 2022 to 21 st June 2022
Rear Admiral K.A.P.S.K Kariyapperuma Commander South Eastern Naval Area, Chief Hydrographer, Sri Lanka Navy	The Governing Board Member	From 22 nd June 2022 to 31 st December 2022
Mr. S.J. Kahawatta Director General Department of Fisheries & Aquatic Resources Development, Maligawatta Sec, Colombo 10	The Governing Board Member,	From 01 st January 2022 to 31 st December 2022
M.M.G.K. Meegahakotuwa Director General State Ministry of Development Vocational Educational Research and innovation 3rd Floor, Sethsiripaya Stage I, Battaramulla	The Governing Board Member,	From 01 st January 2022 to 31 st December 2022

Organizational Structure



Organization

Prof. M.J.S. Wijeyaratne, functioned as the chairman , Dr. H.M.P. Kithsiri and Dr T.K.D.Tennakoon functioned as the Director General and Dr. Geevika J Ganegama Arachchi functioned as the Deputy Director General (Research and Development) during the year under review. In order to perform the mandated functions of the Agency the organization had been designed to constitute nine Research and Technical/Services Divisions, Environmental Studies, Fishing Technology, Hydrographic Office, Inland Aquatic Resources & Aquaculture, Monitoring & Evaluation, Marine Biological Resources, National Institute of Oceanography & Marine Sciences, Socio-Economic and Market Research, Institute of Post Harvest Technology divisions. Supported divisions were, Administration, Services & Operations and Finance Divisions.

Following officials officiated as Heads of Divisions during the year 2021.

Research Divisions

	Name	Division
1	Ms.K.A.W.S.Weerasekara	Environmental Studies Division
2	Dr.W..N.C. priyadarshanie(Actg.)	Fishing Technology Division
3	Mr.S.R.C.ranaweera	Hydrographic Division
4	Dr.Prajani Hennatigala	Inland Aquatic Resources & Aquaculture Division
5	Dr.S.S.K.Haputhantri (01.01.2022 – 04.10.2022) Dr.R.P.P.K.Jayasinghe (05.10.2022 – 31.12.2022)	Marine Biological Resources Division
6	Dr.K.Arulananthan	National Institute of Oceanography & Marine Sciences
7	Dr.K.W.S.Ariyawansa	Institute of Post Harvest Technology
8	Mr. K. H. M. L.Amaralal	Socio Economics & Market Research Division
9	Mr. A. B. A .K. Gunaratne	Monitoring & Evaluation Division

Support Services Divisions

Mr.R.D.P.P.Ranasinghe	Administration Division
Mr.N.S.Hewagama	Finance Division
Mr.S.K.S.Liyanaarachchi	Services & Operation Division
Ms.K.G.L.Iranganie(Actg) (01.01.2022 – 24.03.2022) Ms. Thushari pradeepika (01/11/2021 – 31/12/2021)	Internal Audit Division

2. RESEARCH HIGHLIGHTS-2022

Inland Aquatic Resources and Aquaculture Division

A study on fish feed formulation for sea bass (*Lates calcarifer*) revealed that olein palm oil could be used as a substitute for the fish oil. Use of molasses in biofloc systems found that it is the most suitable carbon source for rearing *Cyprinus rubrofuscus* post-larvae and high growth performances of *Oreochromis niloticus* fingerlings can be obtained from fermented medium prepared with *bacillus* spp. High survival rate of about 96.75% was reported for pearl oyster which were relocated in Trincomalee / Cod Bay area proving as a suitable site for pearl oyster culture in the East coast. Trichodina infection was the most common parasitic infection existed among ornamental fish farms in Kaluthara and Gampaha Districts. White spot syndrome viral disease was prevalent in the vannamei shrimp culture systems in Western and North Western Provinces. A mass production of *Devario pathirana* was successful using tank systems as a low-cost breeding technology. Using L-Ascorbic acid in breeding trials increased the fish survival rate and increased hatching rate while reducing hatching time of barb fish. The double dose of Ovulin (0.7mg/kg) for female and single dose for male could be used to breed oranda goldfish successfully. In-vitro shoot generation and multiplication of *Aponogeton* could be successfully induced by using 2mg/L BAP:0.5 mg/L IBA and 3mg/L IBA:3 mg/L IBA, respectively. The callus generation of *Nymphaea* was occurred when using combination of four growth regulators (2mg/L BAP: 1mg/L TDZ: 0.5mg/L IBA:0.5mg/L kinetine). Commercial prawn diet was effective as feed guppy in co-cultured with *Bacopa* plants in simple floating raft aquaponic recirculation system. A study confirmed using local seaweed extracts as a natural fertilizer additives and growth promoter for some commercial crops.

Marine Biological Resources Division

The biomass of key small pelagic species including spotted sardinella (*Amblygaster sirm*) stock has been adversely affected, especially in the west coast owing to the current over exploitation levels with increased fishing efforts by fishing boats. A strong management measures are needed for rebuilding the spotted sardinella stocks which are at a critical stage over the rapid depletion of its wild stocks. Conversely, a positive effect has been observed in the recovery of the stocks that showed due to an unexpected reduction of fishing effort in coastal small pelagic fishery because of the COVID-19 pandemic and the X-Press Pearl ship disaster. The total production of tuna and tuna like species of which 80% was caught in the EEZ of Sri Lanka, was 87546 mt in year 2021. Skipjack tuna followed by yellow fin tuna had provided the highest contribution including a significant amount of Sword fish catch also to the total production of large pelagic fish. The highest proportion of catch was harvested by long line followed by gill net in both high seas and within EEZ. Expansion of large pelagic fishery needs to be limited to quite a few fish stocks in the Indian Ocean in order to comply with existing IOTC resolutions. The expansion of pole and line targeting skipjack fishery in Sri Lanka as an alternative to gillnet fishing gear could only be practical with a suitable harvesting technique for live bait, upgrading of vessels that can reach the distance of free tuna fishing grounds and technical skill development.

Institute of Post Harvest Technology

A multi-day fishing boat was modified as a model to reduce post-harvest quality losses by installing cooling system with proper storage facilities in collaboration with National Engineering Research and Development Centre (NERDC). The boat was introduced to fishers at a launching ceremony with the presence of Hon. Prime Minister, Hon. Fisheries Minister and other distinguished officials. The division conducted fish quality assessment studies prior to introducing cooling system. Economic feasibility to be done to determine the impact of this modification. Concentrations of commercial disinfectants that contain quaternary ammonium compounds (20-25%), hydrogen peroxide (8-35%), and sodium hypochlorite (5-10%) were effectively sanitized fish contact surfaces in boats against histamine producing bacteria. Investigations found that *Klebsiella aerogenes* formed high amount of histamine 15°C, but no histamine formation was detected at 2°C. Highly acceptable jaddi of Trigger fish was developed using recipe containing 500g of fish, 500g of salt, and 100g of garcinia. A vegan candy which received higher preference ratings from a sensory

panel, was developed using 10% of carrageenan extracted from *Kappaphycus alluverrazii* by combining and 5% pectin with 250 mL of water, 0.5g of citric acid, 75mL of liquid glucose, 250g of sugar, and 8.4 mL of rose water. In collaboration with NERDC, CEYNOR and the private sector, IPHT has developed a set of innovative equipment for the hygienic production of Maldivian fish; and distributed them among six beneficiaries enabling to produce high quality products. Selected staff members of IPHT underwent training as a part of the food loss and waste project funded by FAO, and played an active role in conducting surveys to gather information to evaluate post-harvest fish loss in eight fishery harbours. IPHT Laboratories has enhanced its quality system to adhere to the updated ISO/IEC 17025:2017 standard, and the microbiology unit underwent a compliance audit in December 2022 by the Sri Lanka Accreditation Board.

Socio Economic and Marketing Division

A survey with a total of 80 randomly selected samples of subjects (65 divers, 10 collectors and processors; and 5 exporters) revealed that the majority (32%) of value chain actors had about 11-20 years experience in sea cucumber fishery but almost all in edible oyster fishery had a few years experience. Presently, value chain of edible oyster fishery was underdeveloped and value chain actors include farmers/ collectors, middlemen and local tourist hotels. The average profit per month of a diver and middleman involved in sea cucumber value chain was about 77,400 and 286,860 LKR respectively. The export price of sea cucumber was ranged between 20,000 and 30,000 LKR per Kg while Singapore, China, Hong Kong, and Taiwan were major export destinations. Banning on night diving, lengthy procedures adopted in issuing the management license, high fuel price, poor market linkages, lack of skills of value chain players and poor post-harvest handling, were the major constraints. It is recommended, constraints should be resolved under value chain upgrading concept.

Environment Studies Division

Five fishery harbours were found containing highly polluted water as indicated by sample analysis values series of water quality parameters including water temperature, pH, salinity, electrical conductivity (EC), dissolved oxygen (DO), and turbidity were measured. Ammonia, ortho-phosphorus, Nitrate and Nitrite concentrations, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), Oil & Grease, Faecal Coliform, Total Coliform, and *E.coli* and plankton diversity. Beruwala and Mirissa harbour were the most polluted fishery harbour out of the selected five fishery harbours for the study and some of the parameters of the other three harbours were also found beyond the stipulated standard limits for the sea waters given by Central Environmental Authority. Analysis of plankton reveals that, *Tropidoneis* sp. and *Protoperidium* sp. are the most abundance plankton species among all harbours. Based on the sample analysis, it was found that, discharge of burned oil and bilge water from fishing vessels, production of load of organic wastes derived from fish degutting, market floor runoff, cleaning and garbage dumping, accidental oil spillage during refueling, solid waste derived from boat repairing, untreated sewage from toilets and defecation inside the harbor premises were the identified main sources and activities which increase the pollution in the harbours. In the same way PET bottles and polysac bags become severe threat in some harbours specially Kudawella. Abundant and broken boats can be seen in every harbor and it may cause a severe problem as the fiber is non-degradable.

Fishing Technology Division

Study found that tuna gillnets boats operated from Negombo and Beruwala area, have buoy ropes length from 2- 6 m and complied with IOTC resolution that specifies minimum submerged depth of gillnets as 2 m. Buoy rope of gillnets operated in Southern coasts is around 4 m in length and enable 2 m submerge. Drift gill nets operated in Eastern coast are deviate from the resolution as drift nets do not carry buoy rope. The expansion of Pole and Line fishery as alternative fishing gear to gillnets in Sri Lanka, could only be practical subjected to the following preconditions: A suitable harvesting technique for live bait; vessel upgrade which can reach the free tuna fishing grounds located beyond 10 NM; technology/skill development of fishers; to establish bait management zone for sustainable bait management.

National Institute of Marine Sciences

NARA had commenced experimental forecast of skipjack tuna fishing grounds for multi-day vessels using gillnets 02nd May 2022. The forecast maps will be issued three days per week (Monday, Wednesday, and Friday). The forecast maps are issued for sea areas between -2° South to 12° North latitudes and 75° East to 90° East longitudes. The forecast for longline fishing had continued. Fishing ground advisories were started to disseminate via WhatsApp, and 400 vessel owners and DFAR officers have received the advisories. Projects Facebook page (www.facebook.com/tuna.forecast) and Department of fisheries registered skippers Facebook group (ඩිවර දෙපාර්තමේන්තුවේ ලියාපදිංචි නියමු එකතුව) were used to disseminate advisories effectively. Dialog Sayuru project also disseminate fishing ground advisories via TV screens at 8 fisheries harbours and through their Facebook page.

Kirinda and Point Pedro sea level stations were commissioned. Thus, total number of operational sea level stations, including Colombo, Mirrissa and Trincomalee are five. The annual sea level rise on the west coast of Sri Lanka is estimated as ~ 2.9 mm. Offshore sand exploration for the construction industry is conducted off Ambalangoda and, Balapitiya. Out of the two offshore areas surveyed, the sand properties of the Ambalangoda area compatible with the standards (Except the chloride content) defined by British Standard Limits. However, the grain size of the sediment was found to be too fine for the construction purpose in some locations. The estimated sand quantity for the respective area is 22.5Mm^3 . It was found that off-Balapitiya area is not suitable for sand mining as the bottom sediments consist of shell and coral fragments. The average occurrence of non-biodegradable particulate pollutants including microplastics has increased on the Western coast, where the average occurrence levels of both nurdles and non-nurdle microplastics remained a higher value compared to a state before the spill caused by the cargo vessel X-press pearl. The occurrence levels of non-nurdle microplastics ranged approximately from 2 to 350 particles/ m^3 of surface waters. The highest occurrence level was recorded during the Southwest monsoon. Shallowness disseminates the tidal amplitude by more than 90%, resulting in poor water exchange and flushing, especially during dry season of Lankapatuna Lagoon (Ullackalie Lagoon). Lagoon mouth completely closes for up to two months during the southwest monsoon, which result in rapidly reducing water quality. A management plan is essential for the sustenance of the lagoon.

National Hydrographic Office

Under the National Charting Programme, Hydrographic Surveys were carried out to ensure safe and efficient navigation in Sri Lankan waters. This is a mandatory requirement of full filling the obligation of the International Convention for the Safety of Life at Sea (SOLAS). Due to the Survey teams were allocated for the bathymetric survey projects based on the priority and the requirements of the national development projects, Nautical chart of Colombo to Negombo could not be completed. The project of Establishment of Database and online data processing unit for crowd sourced bathymetry parallel with the “Sea Bed 2030” global mapping project of General Bathymetric Chart of the Oceans (GEBCO)/ Nippon foundation to map the Indian Ocean using crowd sources bathymetry and maintain and updating the data base and disseminate data for marine management, spatial planning and research in marine geology, ecology and oceanography is a continue project until 2030.

Regional Research Center - Kadolkelle

A water quality survey was conducted to find out the main reasons underlying the mass fish mortality that occurred in the cage cultures in Negombo Lagoon. Water quality parameters (pH, EC, salinity, total dissolved solids, water temperature and resistivity) were within the growth range of sea bass (*Lates calcarifer*). Nearly 3000 kg of fish have died in June due to salinity dropping to zero and a bio-toxic algae (*Noctiluca*) bloom. The main constraints in the cage culture in Negombo Lagoon are the cost of transport and low-quality fingerlings, as well as the lack of high quality, low cost effective feed. On the other hand, steps should be taken to minimize conflicts with other resource users. Further studies are required to assess water quality parameters to make appropriate recommendations.

Regional Research Center - Rekawa

The cultivation of *Macrobrachium rosenbergii* post-larval was carried out. The result revealed that, it is for extended period of about 45 days in net cages at density of 694 larvae/m³ over 45 days resulted in high weight gain (average 649 mg) and about 60% of survival. Post larvae of *Macrobrachium rosenbergii* gained average 400 mg of weight at density of 67 larvae/m³ over 54 days in net pens (20×25×1.5m, mesh size of 2mm) with approximately 50% survival in Kattakaduwa reservoir. Rearing of 15-day old post larvae of freshwater prawn for additional 45 days more in cages or pens and then stocking will increase freshwater prawn production in reservoirs. There were four net cage sizes of 2×2 m introduced to two selected fishermen in the Rekawa lagoon, and initially, 500 fingerlings were stocked as an alternative livelihood activity.

Regional Research Center - Panapitiya

Koi carp and other popular ornamental fish were bred at Panapitiya Regional Research Center and sold to small scale ornamental fish farmers. Three types of formulated ornamental fish feed (nursery, grower/02 mm and grower/5 mm) were produced, which is about 2,123 kg including Grower Feed/02 mm (1750 kg) and Nursery Feed/5mm (770 kg). The income earned from selling fish feed to consumers was Rs. 947,517.00. Advisory services on ornamental fish farming, feed processing and water quality control were provided to ornamental fish farmers and small-scale ornamental fish feed producers in Kalutara District. A practical training on “Production of Ornamental Fish Feed” was conducted for 20 small scale ornamental fish farmers and small-scale fish feed manufacturers in Kalutara District.

Regional Research Center - Kalpitiya

Gastropod fisheries, an export-oriented fishery in Sri Lanka, were studied in Kalpitiya and Mannar areas. In Kalpitiya, three species of gastropod named *Pleuroploca trapezium* (horse conch); *Chicoreus ramosus* (branched murex); and *Turbinella pyrum* (Sacred chank/ divine conch) are harvested. In Mannar, there are four species, including the three mentioned above and the *Lambis truncate sebae* (Giant spider conch). The species of *C. ramosus* and *P. trapezium* have high economic value in the market due to their edible flesh. More than 95% of the harvest consists of *P. trapezium*, which is about 201±43 shells per boat per day. Currently, the gastropod market is based on wild capture, so long-term conservation management plans are needed.

Fyke nets established in seven fishing grounds along the shallows of Puttalam Lagoon revealed that *Penaeus merguensis*; *P. indicus* and *P. semisulcatus* contribute to 46%, 24% and 14% respectively to the annual shrimp production. In all seasons, fyke net catches were larger than targeted shrimp catches. Bycatch species in fyke nets included *Cyganus sp* as a major fish with marketable, very small in size (2 - 10 cm and less than 20 g) in the catches in all seasons. Therefore, proper management plans and awareness of fishers are very important to conserve the wild fish stock while exploiting the resources at a sustainable level.

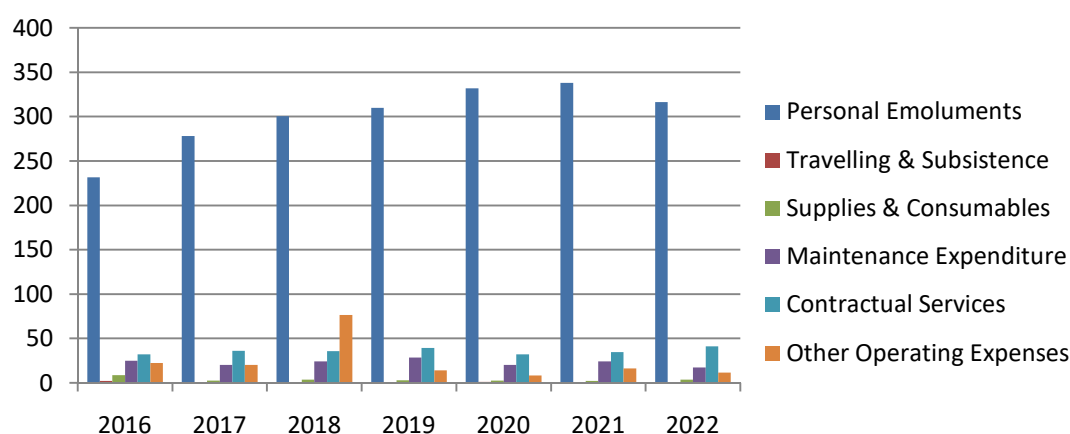
Regional Research Center - Kapparahota

Tuna longline fishery in Sri Lanka have been largely contributed to the fish export in Sri Lanka; although significant catch loss has been occurred due to the depredation of hooked tuna by some marine mammal species. The estimated loss for the fishing boat per trip operated in high seas and EEZ are consecutively Rs 2.08 and 0.627 million.

3. FINANCIAL HIGHLIGHTS - 2022

Recurrent Expenditure

Rs. Million							
Description	2016	2017	2018	2019	2020	2021	2022
Personal Emoluments	231.524	278.110	300.533	309.714	331.910	338.14	316.26
Travelling & Subsistence	2.300	0.298	0.406	0.747	1.179	0.74	0.166
Supplies & Consumables	8.525	2.366	3.760	3.025	2.665	2.3	3.485
Maintenance Expenditure	24.850	20.133	24.059	28.535	20.114	24.3	17.39
Contractual Services	32.250	36.211	35.635	39.310	32.047	34.7	41.083
Other Operating Expenses	22.450	20.091	76.583	14.222	8.396	16.23	11.659
Total Rs. Million	321.899	357.209	440.976	395.55	396.311	416.41	390.043

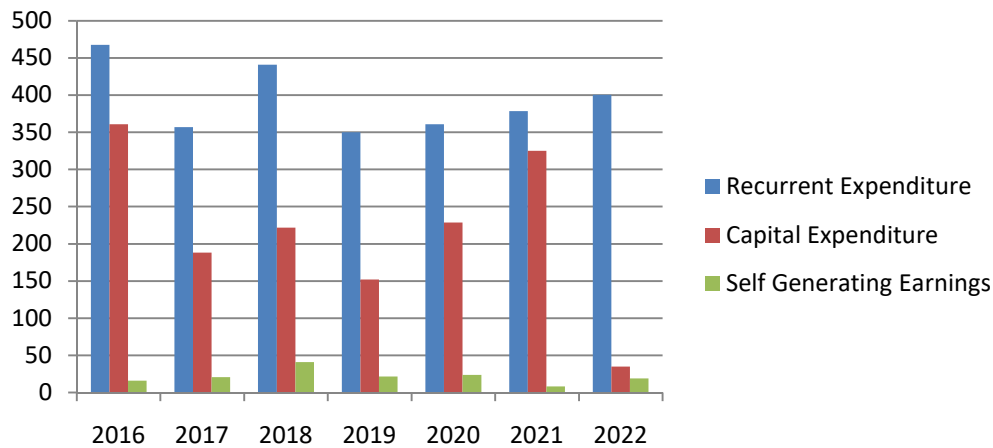


In the year 2022, the amount paid for personal emoluments, travel expenses and subsistence and maintenance expenses has decreased compared to the previous 2021 and 2020. Also, the expenses incurred for contractual services, supplies and consumables has increased compared to the previous years 2020 and 2021. The amount incurred for other operating expenses increased in 2022 compared to 2020.

Treasury Allocation & Self Earnings

Rs. Million

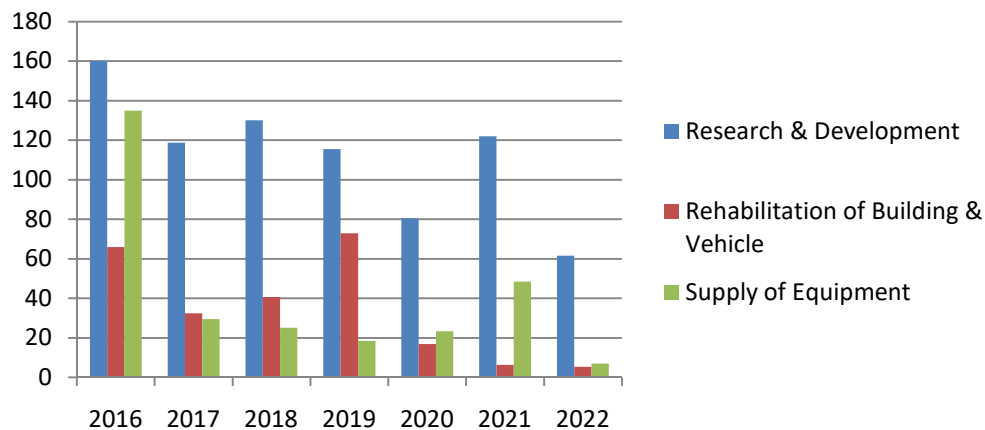
Description	2016	2017	2018	2019	2020	2021	2022
Recurrent Expenditure	467.598	357.209	440.970	350.000	360.905	378.6	400.5
Capital Expenditure	361.000	188.000	222.000	152.000	228.600	325.0	35.0
Self Generating Earnings	16.000	20.810	40.814	21.678	23.900	8.2	19.00
Total Rs. Million	844.598	566.019	703.784	523.67	613.405	711.8	454.5



Capital Expenditure

Rs. Million

Description	2016	2017	2018	2019	2020	2021	2022
Research & Development	160.000	118.829	130.047	115.538	80.482	122.02	61.524
Rehabilitation of Bldg., Vehicle & Material	66.000	32.456	40.590	72.94	16.923	6.30	5.367
Supply of Equipment	135.000	29.530	25.173	18.477	23.346	48.5	6.914
Total Rs. Million	361.000	180.815	195.810	206.95	120.751	176.82	73.805



In the year 2022, compared to 2021 and 2020, the research and development expenses, the amount spent for building and vehicle renovation as well as the acquisition of equipment decreased.

4. HUMAN RESOURCES INFORMATION

Recruitments

No	Name	Designation	Permanent/ Contract/ Casual	Date of Appointment
01	Mr. H.P.K.E. Gunarathna	Research Assistant	Contract	25.10.2021 to 24.04.2022 26.04.2022 to 25.10.2022 31.10.2022 to 30.04.2023
02	Prof. M.J.S. Wijeyaratne	Chairman	Contract	10.02.2022
03	Dr. T.D.K.D. Tennakoon	DG (Acting)	Contract	23.11.2022

Departures

No	Name	Designation	Permanent/ Contract/ Casual	Departure Date	Reason
01	Mr. M.N.H.C.W. Mihiranga	Technical Officer (Mechanical)	Permanent	06.01.2022	Resigned
02	Mrs. Dr. H.C. Chalanika De Silva	Scientist	Permanent	30.01.2022	Resigned
03	Mr. B.Y.T. Dhanushka	Hydrographic Surveyor	Permanent	31.01.2022	Resigned
04	Ms. J.C.R. Ramu	Development Officer	Permanent	21.02.2022	Resigned
05	Mrs. A.D.K.R. Priyadarshani	Helper	Permanent	07.04.2022	Resigned
06	Mr. K.B.S.S.J. Ekanayaka	Scientist	Permanent	08.05.2022	Resigned
07	Mr. K.M. Mudithasena	Helper	Permanent	10.06.2022	Retired
08	Mr. W.A.A.P. De Silva	Technical Assistant (Electronic)	Permanent	28.06.2022	Retired
09	Ms. B.M.L.P. Jayasekara	Scientist	Permanent	09.08.2022	Resigned
10	Ms. D.I.D. Withanage	Management Assistant	Permanent	12.09.2022	Resigned
11	Ms. A. Gunawardena	Management Assistant	Permanent	14.11.2022	Retired
12	Ms. W.K.A.M.T.S. Aththanayaka	Scientist	Permanent	17.11.2022	Resigned
13	Ms. M.M. Subasinghe	Scientist	Permanent	22.11.2022	Resigned
14	Dr. H.M.P. Kithsiri	DG	Permanent	22.11.2022	Retired
15	Mr. D.C. Wickramasinghe	Cartographer Data Analyst (GIS)	Permanent	04.12.2022	Resigned
16	Mr. N.W. M.V. Rajitha Harshana	Senior System Analyst programmer	Permanent	14.12.2022	Resigned
17	Mrs.S.Liyanaarachchi	Librarian	Permanent	23.12.2022	Retired
18	Mr. S.M. Illesinghe	Engineering Artificer	Permanent	31.12.2022	Retired

19	Mr. K.A.C.J. Wijesiri	Fabricator	Permanent	31.12.2022	Retired
20	Mr. Palitha Fernando	Helper	Permanent	31.12.2022	Retired
21	Mrs M D C Jayanthi	Management Assistant	Permanent	31.12.2022	Retired

Foreign Trainings/Seminars and Workshops

No	EPF No	Name & Designation	Time Period	Visited Country
1	80295	Dr.H.M.P.Kithsiri Director General Director General Office	2022.05.22 - 2022.06.15 DFAT KLIE Project : A Scoping study to develop a plan for sustainable marine aquaculture in Sri Lanka NARA/ADM/F.T/Nom/2022/11	Australia
2	420	Mr.P.A.D.A.Kumara Scientist IARAD		
3	766	Ms.S.R.C.N.Narangoda Scientist ESD	2022.05.22 - 2022.06.11 Blue Carbon Training Fellowships (TBC) Commonwealth Scientific and Industrial Research Organization (CSIRO) 22 nd May 11 th June 2022 Australia	Australia
4	949	Ms.G.K.Achini Wasantha MBRD		
5	935	Mr.P.V.D.Tharanga Hydrographic Surveyor NHO	2022.06.13 - 2022.06.17 IORA - UNITAR Training Programme in Geospatial Information Technology (GIT) to be held in Mauritius from 13 th - 17 th June 2022 NARA/ADM/F.T./NOM/2022/04	Mauritius
6	748	Ms.T.B.D.T.Samaranayaka		
7	509	Mr.K.W.Indika Scientist NIOMS		
8	744	Mr.K.G.S.Nirbada Scientist IPHT	2022.10.02 - 2023.04.28 UNESCO GRO Fisheries Training Programme (GRO-FTP) (06 month Post-graduate fellowship programme) 02 nd October 2022 - 28 th April 2023,	Island
9	194	Dr.K.Arulananthan Principal Scientist NIOMS	2022.11.15 - 2022.11.18 Oceanographers and Hydrographers Conference 15 th November to 18 th November 2022	India
10	637	Ms.K.H.K.Bandaranayaka Principal Scientist MBRD	2022.12.03 - 2022.12.10 Letter of Credentials of Sri Lanka to attend in the 25 th Session of the Indian Ocean Tuna Commission Scientific Committee 05 th - 09 th December 2022, Seychelles (2022.12.05 - 2022.12.09)	Seychelles
11	856	Mr.W.R.W.M.A.P. Weerakoon Scientist NIOMS	2022.09.18 - 2022.09.23 The 07 th International Marine Debris Conference Busan Republic of Korea 18 - 23 September 2022	Korea

12	991	Dr.M.J.S.Wijayarathna Chairman	2022.07.10 - 2022.07.18	Armenia
13	991	Dr.M.J.S.Wijayarathna Chairman Chairman Office	2022.10.04 - 2022.10.07 Participation at the International Conference on Productivity Accreditation and Certification 05 th - 06 th October Islamabad Pakistan.	Pakistan
14	479	Dr.R.P.P.K.Jayasinghe Principal Scientist MBRD	2022.10.16 - 2022.10.22 EAF - Nansen Programme Forum and Field visit	Senegal

Courses and Programs Online - 2022

No	Name and Designation	Organizing body	Matter	Period
01	Ms.M.N.D.F.Abeykoon Scientist	JICA Online	Value Chain Development for Sustainable use of Fisheries Resources (JFS 2020) (Online Program)	17.01.2022 28.01.2022
02	Ms. Shynuga Thirukeswaram Scientist	Singapore Cooperation Programme Online	Law of the Sea and Climate Change	07.01.2022 11.02.2022
03	Mr.K.R.W.W.M.A.P.Weerakoon Scientist	IORA Online	2 nd Workshop on Development of IORA Declaration on Combating Marine Debris and a Strategic Framework of Action on Marine Debris in the Indian Ocean	2022.03.08
04	Mr. M. Pramodya Hendawitharana Scientist	IORA Online	2 nd Workshop on Development of IORA Declaration on Combating Marine Debris and a Strategic Framework of Action on Marine Debris in the Indian Ocean	2022.03.08
05	Mr.S.S.Gunasekara Scientist	Commonwealth Blue charter Champion of the Ocean Observation Action Group Online	Using R to analyse and interpret ocean observational data	2022.03.28 2022.03.29
06	Mr. K. Weligamage Indika Scientist	Commonwealth Blue charter Champion of the Ocean Observation Action Group Online	Using R to analyze and interpret ocean observational data	2022.03.28 2022.03.29

07	Mr. R M R M Jayathilaka Scientist	Commonwealth Blue charter Champion of the Ocean Observation Action Group Online	Using R to analyze and interpret ocean observational data	2022.03.28 2022.03.29
08	Mr.K.R.W.W.M.A.P.Weerakoon Scientist	Commonwealth Blue charter Champion of the Ocean Observation Action Group Online	Using R to analyze and interpret ocean observational data	2022.03.28 2022.03.29
09	Ms. Mythily Kesarajan Scientist	Fujian Institute of Oceanography Online	Training Course on Mariculture Technology for Developing Countries from 07 to 27 April 2022	2022.04.07 2022.04.27
10	Mr. A. M. C.Pradeep Kumara Scientist			
11	Ms.(Dr) N.D. Hettige Senior Scientist	Commonwealth Blue Charter Trade Oceans and Natural Resources Directorate Online	Expert Seminars for Commonwealth Country officials on Marine Protected Area (MPA) implementation	2022.04.11. 2022.04.12
12	Mrs.(Dr) A.A.S.H.Athukorala Senior Scientist			
13	Ms.(Dr).W.B.W.M.R.Y.C. Aluwihare Scientist			
14	Ms.T.C.Balawardane Scientist			
15	Ms. G.K.A. Wathsala Fernando Scientist			
16	Ms. H.M. Udari Ayeshya Scientist			
17	Ms. L. Dilukshani Gayathri Scientist			
18	Mr. M. Pramodya Hendawitharana Scientist			
19	Mr.K.H.M.L.Amaralal Senior Scientist	The COFI Sub – committee on fish trade Online	Invitation to the 18 th Session of the COFI sub- committee on fish trade	2022.04.08 – 2022.05.08 & 2022.06.07, 08,09,20
20	Mr.K.H.M.L.Amaralal Senior Scientist			
21	Ms.(Dr).N.D. Hettige Senior Scientist	Fujian Institute of Oceanography Online	Training Course on Marine Biotech and Marine Biodiversity for Developing Countries	2022.05.05 - 2022.05.25
22	Mrs.(Dr) P.P.M.Heenatigala Senior Scientist	Government of Malaysia Online	MTCP: Public Private Partnership in Malaysia	2022.06.13 - 2022.06.16
23	Mr.A.B.A.K.Gunarathna Dy.Director General (R&D)	Indian Ocean Rim Association (IORA) Mauritius Online	International Virtual Workshop on Role of Science technology and innovation (STI) in Achieving Sustainable Development Goals -2030	2022.05.24 2022.05.25

24	Ms.(Dr).N.D. Hettige Senior Scientist	Technical Cooperation among Developing Countries (TCDC) Online	MTCP: Effective Marine Protected Areas (MPAs) 2022	2022.06.13 2022.06.17
25	Mr. M. Pramodya Hendawitharana Scientist			
26	Ms. L. Dilukshani Gayathri Scientist			
27	Ms. H.M. Udari Ayeshya Scientist			
28	Ms.W.B.W.M.R.Y.C.Aluwihare Scientist			
29	Mr.M.M.A.S.Maheepala Senior Scientist	Maritime Institute of Malaysia (MIMA) Online	MTCP: Malaysia's Insights on the policy Economy & Investment in Maritime industry	2022.07.12 - 2022.07.15
30	Mr.W.A.K.Prabath Scientist			
31	Mr.(Dr) R.P.P.K.Jayasinghe Principal Scientist	Singapore Environment Institute Online	SCP: Managing Coastal Biodiversity under urbanization pressures	2022.07.18 2022.07.22
32	Mr.H.M.T.C.Madusanka Scientist			
33	Mr. Santhalingam Thanusanth Scientist			
34	Ms. W. K.A.M.T. Sachiyhrangi Aththanayaka Scientist			
35	Ms.K.H.K.Bandaranayake Senior Scientist	FAO Online	The Food and Agriculture Organization (FAO) PSMA Project: Gap Analysis Workshop	2022 July First Week
36	Mr.K.R.Dalpathadu Scientist			
37	Mr.M.M.A.S.Maheepala Senior Scientist	Economic and Commercial Office, Chinese Embassy in Sri Lanka Online	Seminar for state Owned Enterprises Executives of Developing Countries (Online)	2022.06.22 2022.07.12
38	Mrs.P.P.M.Heenatigala Principal Scientist	Seminar on Aquatic Animal Health Management and Quarantine for the Maritime Silk Road Countries	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.06.29 2022.07.19
39	Dr.A.D.W.R.Rajapaksha Senior Scientist			
40	Dr.A.A.D.Amaratunga Senior Scientist	.03 Seminar on Fishery Development and Management for the silk Road Countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.07.06 2022.07.26
41	Mr. S.K. Sameera Premarathna Scientist			
42	Ms.W.B.W.M.R.Y.C. Aluwihare Scientist			
43	Ms.T.C.Balawardane Scientist			
44	Ms.J.K.P.C.Jayawardane Scientist	.05 Seminar on Green Fishery Development for Developing countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.07.28 2022.08.17
45	Mr.K.R.Dalpathadu Scientist			
46	Ms. L. Dilukshani Gayathri Scientist			

47	Mr.K.P.G.L.Sandaruwan Scientist	JICA knowledge Co – creation Program (Online) Value – Chain Development for Sustainable Use of Fisheries Resources	Japan International Cooperation Agency (JICA)	2022.08.15 2022.09.30
48	Ms.M.D.S.R.Maddumage Scientist	08. Training Course on Green Aquaculture Technology for the belt & Road Countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.09.01 2022.09.30
49	Ms.J.K.P.C.Jayawardane Scientist			
50	Mrs.(Dr) P.S.Jayasinghe Senior Scientist	09.Seminar on Value-added fishery Development and market system Establishment for Developing Countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.09.07 2022.09.27
51	Mr.(Dr). R.P.P.K.Jayasinghe Principal Scientist	02 nd Meeting of IORA Core Group on Fisheries Management (CGFM)	IORA	2022.10.27
52	Ms. N. P. H. Deepa Kumari Scientist	10. Training Course on Fish seed production and Feed Development for Developing countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.10.10 2022.11.08
53	Dr.(Dr) A.A.D.Amaratunga Senior Scientist	11. Training Course on Green Fisheries Technology Innovation and Carbon Neutrality for Developing Countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.10.10 2022.11.08
54	Ms.S.R.C.N.K.Narangoda Scientist			
55	Ms.K.L.W.T.Maduka Research Assistant	12. Training Course on Tilapia Breeding and High-Yield Farming Techniques for Developing Countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.10.10 2022.11.08
56	Mr.(Dr) G.S.C.Perera Scientist	Training Course on Fish Seed Production and Feed Development for Developing	Economic and Commercial Office of the Embassy of the People's Republic of China (PRC)	2022.10.10. 2022.11.08
57	Mr. A.J.C.Jayathissa Research Assistant			

58	W.A.L.Wickramasinghe Research Assistant	Countries Online)		
59	Mythily Kesharajan Scientist	13. Training Course on Fish Disease Prevention Control and Quality Safety Control for Developing Countries Online	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC)	2022.11.09 2022.12.08
60	Ms.H.A.T.Perera Research Assistant			
61	Mr.S.B.Kumari Dunusinghe Research Assistant			
62	Mr (Dr) R.Weerasinghe Senior Scientist	Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC) Online	Seminar on Internet of Things Application and Digital Aquaculture for Developing Countries	2022.08.18 2022.09.07
63	Ms. A.M.A.N. Adikari Scientist			
64	Mr.(Dr).R.P.P.K. Jayasinghe Principal Scientist	Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC) Online	Seminar on Green Fisheries Development Policy and Planning for Developing Countries	2022.06.20 2022.06.29
65	Dr.(Ms.) P.P.M. Heenatigala Principal Scientist			
66	Ms. A.A.S.H. Athukorala Senior Scientist			
67	Dr. (Ms.) W.N.C. Priyadarshani Principal Scientist	Ministry of Foreign Affairs (MFA) and Ministry of Agriculture and Rural Affairs (MARA) of the P.R. China Online	2022 Training Workshops on Modern Fishery Technologies for Southeast Asian Countries (Senior Level)	2022.10.11 2022.10.24 (14 day) 2022.07.19 2022.09.16 (60 day)
68	Mr. H.M.T.C. Madhushanka Scientist			
69	Mr. W.A.K. Prabath Scientist			
70	Mr. K.A. Nishan Suranga Research Assistant			
71	Ms. W.M.S. Harshani Development Officer (Ministry)			
72	Dr. (Mr.)M. Gammanpila Principal Scientist	Indian Ocean Rim Association (IORA) Online	Webinar on self-producing aquaculture feed techniques for traditional farmers insect production Training and Video presentation	2022.07.07
73	Dr. (Mr.) R.Weerasingha Senior Scientist			
74	Ms. A.M.A.N. Adikari Scientist			
75	Ms. S.H.U. Chathurani Scientist			
76	Ms. J.M.N.M. Jayasundara Scientist			
77	Mr. K.W.R.R. Amaraweera Scientist			
78	Mr. K.P.G.L. Sandaruwan Scientist	SAQRF Renuka City Hotel Colombo 03	Technical Meeting on the South Asian Qualifications Reference Frame	2022.06.23
79	Ms. K.H.K.L. Piyasiri Scientist			
80	Mr. K.R. Dalpadu Scientist	IOTC	Annotated agenda for the 12 th working party on neurotic tunas	2022.07.04 2022.07.08
81	Ms.M.A.J.C. Mallawaarachchi Scientist	INFOFISH	Mangrove Crab Hatchery & Grow – Out Operations	2022.11.14 2022.11.18

Promotions

No	E.P.F No	Name & Division	Former Designation & Category	Current Designation & Category	Promotion Date
01	667	Mr.M.S.M.Rizab NHO	Survey Helper PL - 1 III Grade	Survey Helper PL - 1 II Grade	22.09.2022
02	668	Mr.B.S.Fernando FTD	Helper PL - 1 III Grade	Helper PL - 1 II Grade	13.06.2022
03	662	Mr.B.W.M.Indika NIOMS	Lab Attendant PL - 2 III Grade	Lab Attendant PL - 2 II Grade	15.12.2021 (Grade Promotion had been given 15.12.2021 back dating with effect from 22.09.2022)
04	577	Ms.G.N.S.Priyangika S & O	Management Assistant (Non - Technical) MA 1 - 2 II Grade	Management Assistant (Non - Technical) MA 1 - 2 I Grade	01.11.2022
05	663	Mr.M.H.M.Kumara NHO	Helper PL - 1 III Grade	Helper PL - 1 II Grade	19.12.2021 (Grade Promotion had been given 19.12.2021 back dating with effect from 22.09.2022)
06	580	Ms.G.L.A.Nilmini NHO	Management Assistant (Non - Technical) MA 1 - 2 II Grade	Management Assistant (Non - Technical) MA 1 - 2 I Grade	29.11.2022
07	622	Mr.K.H.R.Kumara IARAD	Helper PL - 1 III Grade	Helper PL - 1 II Grade	08.02.2020 (Grade Promotion had been given 08.02.2020 back dating with effect from 19.01.2022)
08	614	Mr.H.D.Niyomal SED	Helper PL - 1 III Grade	Helper PL - 1 II Grade	21.12.2021 (Grade Promotion had been given 21.12.2021 back dating with effect from 07.02.2022)
09	565	Mr.S.A.R.Rasanga M & E (Extension unit)	Management Assistant (Non - Technical) MA 1 - 2 II Grade	Management Assistant (Non - Technical) MA 1 - 2 I Grade	09.01.2022

Unfilled vacancies

No	Designation	Salary Code	Approved Cadre	Vacant
1	Dy. Director General (R&D)	HM 2-1	1	1
2	Senior Scientist	AR-2	21	4
3	Senior Hydrographic surveyor	AR-2	2	2
4	Scientist	AR-1	80	31
5	Sociologist	AR-1	1	1
6	Economist	AR-1	1	1
7	Hydrographic Surveyor	AR-1	8	1
8	Senior Land Surveyor	MM 1-2	1	1
9	Senior Cartographer	MM 1-2	1	1
10	Senior System Analyst/ Programmer	MM 1-2	1	1
11	Data Analyst	MM 1-2	1	1
12	Asst. Director(Service & Operation)	MM 1-2	1	1
13	Asst. Director (Admin)	MM 1-2	1	1
14	Asst. Director (Information Technology)	MM 1-2	1	1
15	Senior Librarian	MM 1-2	1	1
16	Senior Extension Officer	MM 1-2	1	1
17	Assistant Director (Vessel Operation & Maintenance)	MM 1-2	1	1
18	Librarian	JM1-2	1	1
19	Technical Officer (Mechanical)	JM1-2	1	1
20	Cartographer Data Analyst (Nautical)	JM1-2	1	1
21	Cartographer Data Analyst (GIS)	JM1-2	1	1
22	System Analyst /Programmer	JM1-2	1	1
23	Skipper	JM1-2	1	1
24	Land Surveyor	JM1-2	1	1
25	Diving Officer	JM1-2	1	1
26	Translator	MA 4	3	1
27	Development Officer (Project)	MA 3	20	11
28	Fabricator	MA 2-2	1	1
29	Technical Assistant (Electronic)	MA 2-2	1	1
30	Assistant Network Administrator	MA 2-2	1	1
31	Field Research Assistant	MA 2-2	13	5

32	Research Assistant	MA 2-2	70	31
33	Cartographic Draughtsman	MA 2-2	2	2
34	Coxwain	MA 2-2	2	2
35	Head Driver/Marine	MA 2-2	1	1
36	Engineering Artificer	MA 2-2	2	1
37	Multi Media Designer	MA 2-2	1	1
38	Diver	MA 2-2	3	3
39	Diver Assistant	MA 2-2	1	1
40	Technical Assistant (Civil)	MA 2-2	1	1
41	Technical Assistant (Electrical)	MA 2-2	1	1
42	Management Asst. (Library)	MA 2-2	2	1
43	Ocean Observation Technician	MA 2-2	1	1
44	Assistant Skipper	MA 2-2	1	1
45	Geological information System Technician	MA 2-2	1	1
46	Radio Officer	MA 2-2	1	1
47	Management Assistant	MA1-2	38	8
48	Hydrographic Assistant	MA1-2	1	1
49	Boatswain	MA1-2	1	1
50	Book-Binder	PL-3	1	1
51	Plumber	PL-3	1	1
52	Electrician	PL-3	2	1
53	Mason	PL-3	2	2
54	Motor Mechanic	PL-3	2	2
55	Driver	PL-3	27	8
56	Boat Operator	PL-3	1	1
57	Deck Hand	PL-3	2	1
58	Marine Mechanic	PL-3.	1	1
59	Video Editor	PL-3	1	1
60	Lab Attendant	PL-2	12	2
61	Caretaker/Cook	PL-2	4	3
62	Helper	PL-1	87	21
63	Survey Helper	PL-1	6	1

Court Cases

I. Cases Filed Against the Agency in the Labour Tribunal

No	The Case Number	The Applicant	The Respondent	Labour Tribunal	The Last Date Was Called the Case	Present Status
01	Case No. LT/M/26/48/2019	Warnakulasuriya Gordiyage Jayaratne	National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	Matara Labour Tribunal	14.12.2022	The case has been fixed for the written submissions of both parties. The next date is 21.02.2023.

II. Cases Filed Against the Agency in the Sri Lanka - Human Rights Commission

No	The Case Number	The Complainant	The Respondent	The Last Date Was Called the Case	Present Status
01	HRC/MT/127/17/5	Mr.J.B.Alahahapperuma No-08, Mudalindha Piriwena Road, Heennatiya, Matara.	Chairman, National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	18/04/2017	The inquiry has completed. Recommendations have not yet been received from Sri Lanka Human Rights Commission.
02	HRC/3222/16	Mr.A.A.Suresh Mr.R.C.C.Perera	Director General, National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	27/04/2017	The recommendation of the Sri Lanka Human Rights Commission has not been received
03	HRC/3573/17	Mr.D.D.P.L.Dahanayake No- 120, Palliya Road, Brandiyamulla, Gampaha	Chairman, National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15 Director General, National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	02/10/2020	The Cases has postponed due to the COVID- 19 pandemic until further Notice.
04	HRC/3432/19	Ms. P.S Jayasinghe 26/2 B, Henawatta, Meegoda	Chairman National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	21.09.2019	The Cases has postponed due to the COVID- 19 pandemic until further Notice.

05	HRC/3562 /19	Mr. P.A.D. Ajith Kumara 104B, Hapugahagama Road, Barawavila, Diulapitiya.	Chairman National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	03.02.2020	The Cases has postponed due to the COVID- 19 pandemic until further Notice.
06	HRC/3561 /19	Mr. N.B.P Punyadewa 447/1 B, Walgama, Kottawa Road, Aturugiriya	Chairman National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	28.02.2019	The Cases has postponed due to the COVID- 19 pandemic until further Notice.
07	HRC/3713 /19	Ms. A.A.S.H Athukorala, No.410/F, Jayamawatha, PolpitiMookalana, Kadana.	Chairman National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	28.02.2019	The Cases has postponed due to the COVID- 19 pandemic until further Notice.
08	HRC/910/ 2021	Ms. W.A. T Pradeepika No 672, IDH Road, Nagoda, Kaluthara	1.Chairman 2.Director General 3.Director Administration & Human Resources National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	The case is not called to hear yet.	The Sri Lanka Human Right Commission has informed the institute that case has been filed however the notice has not been received for the inquiry by HRC.

III. Cases filed by the National Aquatic Resources Research and Development Agency (NARA) in the District Court Colombo

No	The Case Number	The Plaintiff	The Dependent	District Court	The Last Date Was Called the Case	Present Status
01	Case No DMR/393 0/2010	National Aquatic Resource Research & Development Agency, Crow Island, Mattakkuliya, Colombo 15	Dr. N.H Dasanayeka	Colombo District Court	15.03.2019	The first defendant of the case has entered into a settlement with NARA to pay bond value of Rs. 5.932.721/= within five years. As per the above settlement the first defended has been paying the instalments

IV. Cases has filed against the National Aquatic Resources Research and Development Agency (NARA) in the Supreme Court, Colombo

No	The Case Number	The Plaintiff	The Dependent	The Last Date Was Called the Case	Present Status
01	Case No: CA (Writ) Application: No. 383	Withange Don Hemantha Ranjith Sisra Kumara, Wijethunga Appuhamige Herman Kumara, Patharagoda kankanamage , Centre of Environmental Justices (Guarantee) Limited	Dr. H. M. P. Kithsiri Director General of National Aquatic Resources Research and Development Agency. (07 th Respondent)	26 th September 2022	For argument
02	Case No: CA (Written) Application No.463 / 2020	Environmental Foundation (Guarantee) Limited	Prof. A. Navaratnarajah Chairman National Aquatic Resources Research and Development Agency. (05 th Respondent)	21 st September 2022	For Notice returnable
03	Case No: S.C. (F.R) Application No. 277/2021	Most Venerable the Archbishop of Colombo, Most Venerable Cardinal Malcolm Ranjith	National Aquatic Resources Research and Development Agency. (19 th Respondent)	20 th December 2022	For supporting
04	Case No: SC (F.R) Application No.159 A/ 2021	Environmental Justice (Guarantee) Limited, Withanage Don Hemantha Ranjith Sisra Kumara, Anuradha Nirosha Ponnampuruma, Morawakkoralage Don Mahesh Piyawardana	National Aquatic Resources Research and Development Agency. (04 th Respondent)	26 th September 2022	For support
05	Case No: SCFR- 176/2021	Fr.Benedict Iddamalgoda , Sarath Weeramulage Gamini Fernando, and Mr. Warnakulasuririya Kristofer Sarth Fernando	National Aquatic Resources Research and Development Agency (07 th Respondent)	11 th December 2022	Date fix for argument on 20 th January 2022
06	Case No. 91/2022	WikramaArachchige Thushari Pradeepika	National Aquatic Resources Research and Development Agency (1 ST Respondent)	16 th November 2022	For settlement

Welfare Activities

- Christmas day celebrated.
- In addition to that transport facilities provide to the NARA staff to make easy.

5. RESEARCH DIVISIONS

5.1 ENVIRONMENTAL STUDIES DIVISION

Head of the Division: Mrs. K.A.W. S. Weerasekara

Staff Profile

Dr. K.A.W.S Weerasekara	Head / Principal Scientist
Dr. A.A.D Amarathunga	Senior Scientist
Dr. N.D Hettige	Senior Scientist
Ms. M.D.S.R Maddumage	Scientist
Ms. J.K.P.C Jayawardane	Scientist
Ms. S.R.C.N.K Naragoda	Scientist
Ms. K.M.B.P.P Kalaotuwawe	Scientist
Mr. N.K.R.N Jayawardane	Scientist
Ms. S. Tirukeswaran	Scientist
Mr. S.K Pematne	Scientist
Ms. Thilini Piyumali	Research Assistant
Ms. Dushyanthi Rajkumar	Research Assistant
Mr. Sahan Rangana	Research Assistant
Mr. U.S.L.C Perera	Laboratory Attendant
Mr. K.I Thushara	Laboratory Attendant
Mr. T.D.A Kumara	Helper
Mr. P.G.I Namal	Helper
Ms. Shashika Nelundeniya	Management Assistant



Objectives of the Division

- Advancing Research & Development sector in context of aquatic environment for the sustainable stewarding of aquatic resources in Sri Lanka.
- Empowering national science and technology sector through research innovations and interdisciplinary development.
- Advancing the scientific intervention for a sustainable relationship between man and the aquatic environment.
- Scientific innovation for national development asymmetry.
- Invigorating entrepreneurship, technology transfer, and economic development through providing solutions for sustainable utilization of aquatic resources.

Overview

Environmental Studies Division strives to serve as the cornerstone of the aquatic environment related research and development sector of the NARA with the vision to simulate science-based solutions through interdisciplinary research that ensures the sustainability and pristineness of the inland, coastal and marine environment of Sri Lanka. The competent research teams of ESD in coordination with relevant government agencies, private sector institutions, international research organizations, academic institutions, and the industrial sector on science, innovation, technology, education, law, and policy to solve the most challenging environmental issues of Sri Lanka, with marine litter, excess nutrients, untreated wastewater, and maritime disasters continuing to be the focus areas in 2022. Researchers of ESD are frequently tapped for their knowledge and expertise in multiple aspects of aquatic environment such as inland, coastal and marine water quality, eco-toxicology, limnology, water pollution, aquatic ecology, modelling of ecosystem dynamics and policy, chemical and physical dynamics in aquatic ecosystems, hydrology and environmental policy and legislations.

Moreover, the division provides a comprehensive range of environmental monitoring and consultancy services to help industries, developers, businesses, and government authorities to fulfill their legal obligations in terms of Environmental Impact Assessments (EIA), Initial Environmental Examination (IEE), and feasibility studies and to comply with environmental regulations. The expert research team of ESD provides island-wide research coverage and services including site investigation, sampling and analysis, stakeholder discussions, monitoring and evaluation, and consultancy. In addition, water and wastewater quality testing services are provided. ESD has extraordinary capabilities to measure and monitor the water quality, and therefore it is recognized as one of the leading research arm of the country for water and wastewater quality testing. In addition, ESD plays an important role in number of national advisory councils, national technical committees, environmental monitoring programs, and expert committees on environmental emergencies through provision of technical expertise, science-based knowledge sharing, consultancy provision and being part of the policy and legislator framework. During the financial year 2022, ESD has conducted two major research projects and commenced the activities of another two consultancy projects within the context of environmental management, development, and conservation of the fisheries and aquatic resources.

Project Details Summary

Table 1: Summary of the project details for 2022

Project		Budget	Responsible officers	Period	
No	Title	Rs.Mn		From	To
5.1	Assessment of Water Pollution Status of Selected Fishery Harbours in the Southern Province of Sri Lanka (Hambanthota, Tangalle, Mirissa, Kudawalla, Dewundara)	1.0	Dr. A.A.D Amaratunga, Dr. N.D. Hettige Dr. K.A.W.S Weerasekara Ms. M.D.S.R Maddumage Ms. J.K.P.C Jayawardane Ms. S.R.C.N.K Narangoda Ms. K.M.B.P.P Kalaotuwawe Mr. N.K.R.N Jayawardane Ms. S. Tirukeswaran Mr. S.K Pamaratne	Jan 2022	Dec 2022

5.2	Investigation of causes for environmental emergencies (e.g. mass fish kills, oil and chemical spills, algal blooms)	0.5	Dr. K.A.W.S Weerasekara Dr. A.A.D Amaratunga Dr. N.D. Hettige Ms. M.D.S.R Maddumage Ms. J.K.P.C Jayawardane Ms. S.R.C.N.K Narangoda Ms. K.M.B.P.P Kalaotuwawe Mr. N.K.R.N Jayawardane Ms. S. Tirukeswaran Mr. S.K Pamaratne	Jan 2022	Dec 2022
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PROJECT NO: 5.1

ASSESSMENT OF WATER POLLUTION STATUS OF SELECTED FISHERY HARBORS IN THE SOUTHERN PROVINCE OF SRI LANKA

Objectives:

To improve the water safety and quality of a fishery harbor, its pollution level should be thoroughly assessed. Therefore, objectives of the research are to determine the current status of water quality in five selected fishery harbors and collect information on the present status of anthropogenic activities which pollute the harbor.

Project Description:

A fishery harbor is a sheltered area of water, where fishing crafts can anchor, comes alongside jetties or quay walls to unload their catch and obtain necessary services. It has number of general functions which are common to all harbors and characteristic functions which apply to fishery harbors only and can be classified from basic to advance depending on the size of the vessels, duration of the trips, and method of catch (Jayasinghe, 2011).

Discharge of burned oil and bilge water from fishing vessels to harbor waters, production of load of organic wastes which derived from fish degutting, market floor runoff, cleaning and garbage dumping are main causes for the water pollution in fishery harbors (Holmgren, 1994). The use of contaminated water for fish cleaning in the harbors may cause for the post-harvest losses due to spoilage from bacteria and chemical reactions. Therefore, the main research objectives of this project are aimed at addressing these pollution issues in a holistic approach. Sustainable Development Goal (SDG) 14 is exclusively dedicated to “conserve and sustainably use the oceans, seas and marine resources for sustainable development. This project is directly relates to SDG target 14.1 and 14.2 as the data and information gathered during this study helps to reduce marine pollution particularly from land-based activities.

The study was carried out in five selected harbors from 2021 to 2022 and physical, chemical and biological parameters of water quality of harbors were measured. In-situ parameters such as water temperature, pH, salinity, electrical conductivity (EC), dissolved oxygen (DO), and turbidity were measured. Ammonia, ortho-phosphorus, Nitrate and Nitrite concentrations, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), coliform content and plankton diversity were the tests carried out in the laboratory. All the experiments were performed according to the standard methods for Water and Waste Water Analysis given by American Public Health Association (APHA, 2012). All the input canals were also identified.

Research Findings and Recommendations

According to results it was found that the water quality of the harbors have been degraded and they are subjected to severe oil pollution, organic pollution and microbial contamination in terms of fecal contamination. Beruwala and Mirissa harbours were the most polluted fishery harbors out of the selected five harbors for the study and some of the parameters of the other three harbors were also found beyond

the stipulated standard limits for the sea waters prescribed by Central Environmental Authority. Mean BOD (Biochemical Oxygen Demand) ($\text{Max- } 8.1 \pm 4.5 \text{ mg/L}$), COD (Chemical Oxygen Demand) ($\text{Max- } 926.8 \pm 92.8 \text{ mg/L}$) and Oil & Grease levels ($\text{Max- } 16.7 \pm 4.8 \text{ mg/L}$) in the surface waters of Beruwala and Mirissa harbors have exceeded the standard stipulated limits by the CEA. According to the analytical data of the microbiological analysis, all the five harbors are highly contaminated with fecal coliform and e-coli where highest coliform levels were recorded in Galle harbor, Beruwala harbor and Mirissa harbor. *Tropidoneissp.* and *Protoperidiumsp.* are the two most abundant plankton species recorded from all five fishery harbors where few other plankton species were recorded in smaller densities. According to the spatial pattern of physico-chemical data of the water quality of five fishery harbors, the surface water are heavily contaminated with organic matter, chemical substances and oil & grease. Therefore, existing pollution sources have been identified during the field surveys and major sources include, discharge of burned oil and bilge water from fishing vessels, production of load of organic wastes derived from fish degutting, market floor runoff, cleaning and garbage dumping, accidental oil spillage during refueling, solid waste derived from boat repairing, untreated sewage from toilets and defecation inside the harbor premises were the identified main sources and activities which increase the pollution in the harbors. In addition, large quantities of solid waste is dumped into the harbor waters which lead to excessive pollution in water and plastic pollution counts for the larger proportion of contamination by solid waste.



Figure 2: Broken boats anchored in Galle Fishery Harbour



Figure 2: Plastic garbage accumulated in the Mirissa Fishery Harbour



Figure 3: Wastewater discharge from fishing boats to the open waters in Galle Fishery Harbour

PROJECT No : 5.2

INVESTIGATION OF CAUSES FOR EMERGENCY INCIDENTS SUCH AS OIL SPILLS, ALGAL BLOOMS AND FISH KILLS (EMERGENCY STUDY PROJECT)

The aquatic environment is highly sensitive and susceptible to catastrophic incidents, and the majority of them could cause emergency situations such as mass fish kills, oil spills, pollution of water bodies with highly toxic chemicals, sudden algal blooms, and water quality deteriorations. Since these incidents result in severe impacts on environmental health and human well-being, they need to be addressed immediately with relevant recommendations. As a leading national research agency, NARA is responsible for assessing these incidents from a scientific perspective to determine the magnitude of the problem, current and potential impacts, and mitigation measures. Many government organizations, including MEPA, CCD & CRM, CEA, the Environmental Division of SL Police, local authorities, the MOH Department, and many other institutions, coordinate with NARA to provide information regarding emergency environmental incidents/situations requesting scientific investigations. In addition, NARA takes immediate action to respond to the requests from the general public regarding the environmental emergencies and take the necessary actions to manage them. All the technical divisions of NARA are contributing to the emergency studies, depending on the expertise required to handle the situation. Main tasks involved in conducting an emergency project are: field investigations (field sampling, in-situ measurements, making important observations, discussions with relevant people), laboratory analysis of samples, technical report compilation and data analysis, technical meetings, and coordination with other government institutions.

Total of six (06) emergency studies were carried out in 2022 as indicated below;

1. Environmental impact monitoring program for MV Xpress pearl maritime disaster and ship wreck removal activities.
2. Survey to identify the issues in brush pile fishery in Jaffna District.
3. Rapid assessment survey based on the conflict between sea cucumber farmers and capture. Fishers in Mullativu, Kilinochchi, Mannar and Jaffna districts and conducting awareness programme for sea cucumber fishers in those districts.
4. Investigation on discoloration of coastal water in Galle Face beach, Beruwala Fishery harbour and southern coastal area due to sudden algal bloom appeared.
5. Management on Jaffna trawl fishery to maintain the sustainable fishery resources utilization.
6. Participating in a court case filed against the use of illegal fishing gears, as government witness at Batticaloa magistrate court.

PROJECT NAME : SHIPWRECK REMOVAL ACTIVITIES AND ENVIRONMENTAL IMPACT MONITORING PROGRAM FOR MV XPRESS PEARL MARITIME DISASTER

Project Duration : 2021.12.22 to 2022.12.31

Project Description:

This is one of the most significant environmental emergency studies conducted by the NARA in recent years, and the different components of the environmental impact assessment program for the MV Xpress Pearl maritime disaster have been conducted since 2021, including an immediate environmental damage assessment program, a post-incident environmental impact monitoring program, and shipwreck removal activities. NARA is vested with the responsibility to carry out research to assess the impact on the aquatic environment and its resources resulted with the X press pearl maritime disaster. Once the immediate damage assessment program has been finalized, a monitoring program has been planned to assess the short-term, medium-term, and long-term environmental impacts of the disaster incident, and shipwreck removal operations have also been commenced simultaneously. These monitoring plans were focused on

assessing, monitoring and addressing the damages and potential impacts on environmental and biotic resource with special consideration to following expert areas;

- Contaminants and impact on aquatic health
- Fisheries and Aquaculture
- Oceanography and hydrological modelling
- Environmental Management
- Environmental Risk Assessment
- Water Management
- Biodiversity Management

Table 2: Cumulative sampling and monitoring plan for the damage assessment study of the MV Xpress pearl maritime disaster

Water sampling was conducted on a continuous basis from the area of the incident, adjacent offshore

Planning Phase	Study Area	Assessments carried out
Short term (03 months)	Coastal Stretch (17 Sampling Locations)	Assessment of chemical spill and contaminations
Medium term (up to 5 years)	Open Sea (23 Sampling Locations)	Assessment of damages and contamination of environmental and biotic resources with toxic materials
Long term	Negombo Lagoon (11 Sampling Locations)	Assessment of macro and micro plastic contaminations
	Kelani River (05 Sampling Locations)	Assessment of Socio-economic impact on fisher communities, fisheries industry and other socio-economic sectors in coastal and lagoon areas
		Hydrographic Surveys (Side scan sonar survey)
		Bio Monitoring

areas in Southern, Western and North-Western coasts, Negombo Lagoon, Kelani River and other sensitive ecosystems and laboratory analysis for DO, BOD-5, and COD have been continued throughout the year. In addition, sediment samples have also been collected around the ship and adjacent coastal areas for further chemical analysis. Some of the water and sediment samples have been outsourced to the international laboratories of CEDRE (France), Uppsala University (Sweden), ALS (Australia) for the analysis of heavy metals, dioxins, furans, PAHs, PCBs, Perfluorinated alkyls, where important tasks associated with sample outsourcing, such as sample collection, preservation, storing, and labelling, were performed by the NARA teams.

In addition, ship wreck removal activities were commenced on 22/12/2021 and been continued until 31/12/2022 with the involvement of NARA experts. NARA officials also coordinate with the MEPA and Attorney General's Department for the environmental damage cost assessment programs and legal activities related to the damage compensation efforts of the MV XPress Pearl maritime disaster by providing and clarifying the necessary scientific information.



Figure 4: Core Sampling

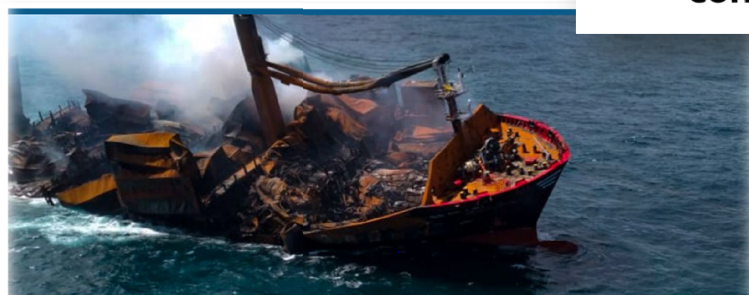
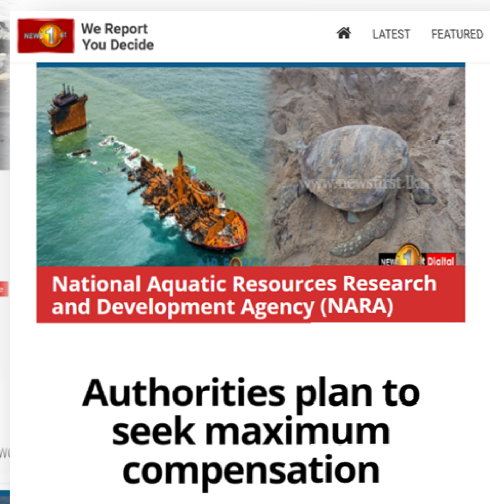
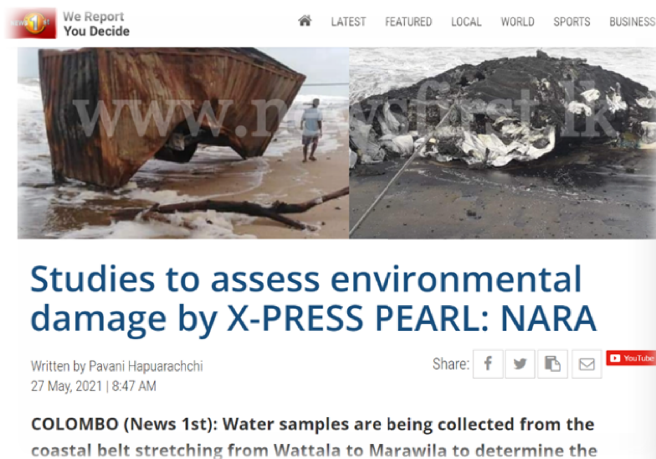


Figure 5: Core Sampling



Figure 6: Laboratory Analysis

News highlights regarding the MV Xpress pearl maritime disaster



Sri Lanka dismisses oil spill claims; but NARA to run tests

Written by Zulfick Farzan
10 Jun, 2021 | 7:50 PM

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PROJECT NAME: RAPID ASSESSMENT OF ON-GOING SEA CUCUMBER FARMING PRACTICES AND THEIR IMPLICATION ON FISHERIES LIVELIHOODS AT KIRANCHI AND PARITITIVU AREAS IN THE NORTHERN PROVINCE OF SRI LANKA AND ASSOCIATED AWARENESS PROGRAMS

Project Duration: Continuing since 18/10/2022

Project Description:

Fisheries sector plays an important role in providing employment opportunities, income generation, foreign exchange earning and provision of protein to the people. Jaffna District accounted for a fishery production of 29,290 metric tons of Sri Lanka in 2016. Contribution from Jaffna lagoon to the total coastal fish production in Sri Lanka was 2% in 2018 (NARA 2018). Fishing is the key livelihood activity of the coastal populations of the area (Silva *et al.*, 2013), and therefore, the fishing industry plays a significant role in the economy of the Northern Province. Coastal aquaculture/mariculture is important not only as alternative income generation methods but also to replenish wild populations of depleted economically important fin fish and non-fin fish stocks. Sea cucumber fattening is being carried out in the Northern Province since ending of the civil war and currently two hundred seventy-five and 254 licensed sea cucumber farms are operated in the Kilinochchi and Jaffna Districts respectively at present. Thirty farms and 100 farms are awaiting approvals in Jaffna and Kilinochchi districts respectively. The objective of this study was to investigate the ongoing sea cucumber fisheries and aquaculture practices in the area and community perception regarding these activities. Rapid field assessment was carried out in Kilinochchi and Jaffna districts from 22nd to 25th November, 2022 to achieve aforesaid objectives. In this study, general conditions required for mariculture of sea cucumbers with respect to biological, limnological/oceanographical, physical and sociological aspects were studied. Secondary data from published literature and NARA's previous records were also used. Seven sites in Poonakary DS Division (Kiranchi area) (Fig. 10) in Kilinochchi District and six other sites in Kayts DS Division (Parititivu Island; (Fig. 11) in Jaffna District were investigated for suitability of coastal aquaculture/mariculture practices. Underwater Visual Census (UVC) was also carried out to study the bottom characteristics and key habitat features suitable for sea cucumber farming. Soil sediment samples were collected using bottom grab and diving.

Sediment quality of soil samples was analyzed by standard sieve fractionation method. Organic content of the sediment samples was determined by combusting weighed samples. Two focus groups discussions were conducted at the Fisheries office and NAQDA office in the Jaffna District. The members of fisheries cooperatives / societies participated at focus group meetings participated at these meetings.



Figure 7 and Figure 8: Sea cucumber pen culture in Northern province

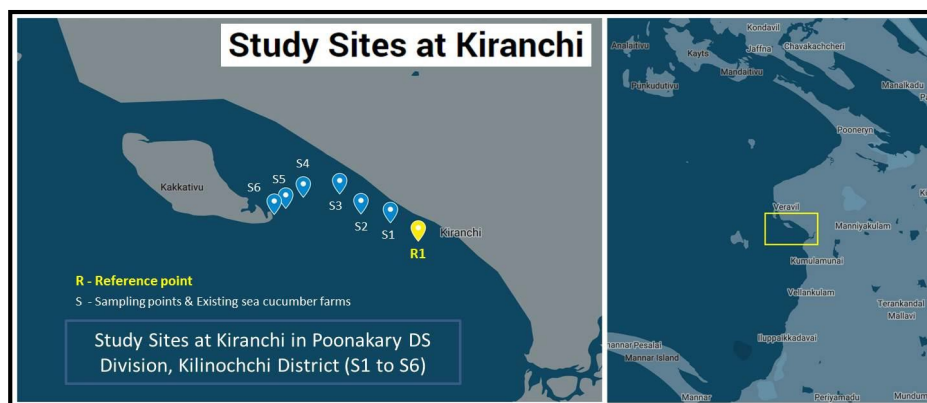


Figure 9: Study area at Kiranchi in Poonakary DS Division.

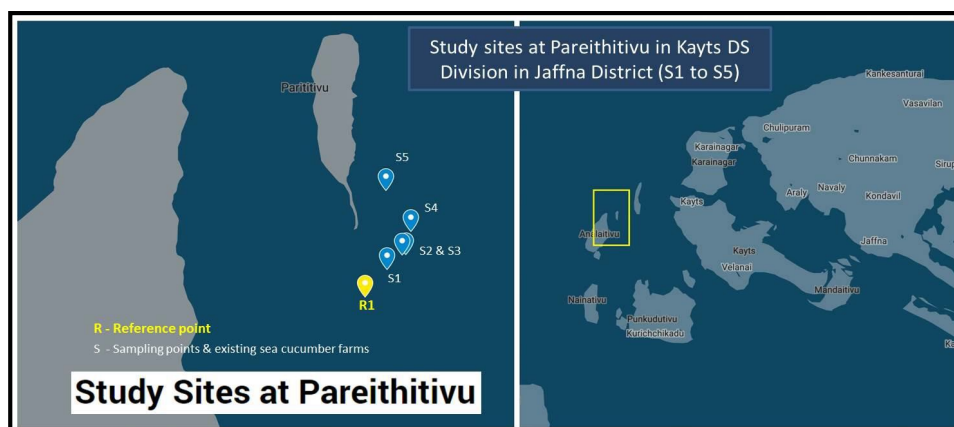


Figure 10: Study sites in Paratithivu Island in Kayts DS Divisions, Jaffna

After carefully analyzing general fisheries characteristics of selected sites of Kiranchi fishing sites, Analathivu island, Elavativu island- Jaffna, characteristics of the sea cucumber farming in Kiranchi and Kayts the general conditions required for mariculture of *Holothuroidea scabrawere* determined. In relation to this biological factors, limnological factors, physical factors, sociological factors, that are affecting the sea cucumber farming activities in the area have also been studied. Number of recommendations have been made by the NARA officials to ensure the sustainable aquaculture are practiced within the area minimizing the impacts on biological, ecological and socio-economical components. At present, as sea cucumber industry in Sri Lanka is largely depending on the wild stocks heavy pressure is created on the existing natural populations. Since there is a potential to expand the industry, it is necessary to develop hatcheries to ensure a steady supply of seeds throughout the year. It is also necessary to limit the number of lagoon and sea pens even for hatchery reared individuals to ensure the better growth of stocked individuals and also to avoid conflicts among different stake-holders who utilize the same area for their livelihoods. Therefore, to sustain the industry and to ensure the wellbeing of the fisher community, it is necessary to assess every mariculture project to determine whether they are technically feasible, economically viable and socially acceptable. Continuous monitoring, surveillance, ground truthing studies and proper dialogue among different stakeholders are highly recommended for sustainability of the sector in order to get maximum benefits to the society.

Limitations of this study: This study was carried out during a very short period. The coastal areas in the Northern Province encounter low precipitation, prolonged drought periods, surges, storms, cyclones and unexpected floods. It is necessary to consider seasonal variation of the climatic conditions and water quality parameters resulting in due to such changes. These could not be addressed due to short period of the study.



Figure 11: Collection of surface water samples



Figure 12: Juvenile sea cucumber at the pen



Figure 13: Under water image of *H. scabra* inhabits at sea cucumber farm in Kiranchi



Figure 14: *H. scabra* pen culture at Kiranchi



Figure 15: Discussion with sea cucumber farmers in Jaffna fisheries district



Figure 16: Discussion with sea cucumber farmers in Kiranchi



Figure 17: Awareness program conducted in Jaffna by NARA officials

PROJECT NAME: SURVEY TO IDENTIFY THE ISSUES IN BRUSH PILE FISHERY IN JAFFNA DISTRICT

Project Duration : 05.04.2022 to 09.04.2022

There was a request from the Department of Fisheries and Aquatic Resources (letter referenced to DFAR/INV&TR/Public Request) to conduct a study to identify issues and provide solutions for the fishers involved in the brush pile fishery in Jaffna district. A field survey was planned and conducted in Jaffna district to identify and address the issues among brush pile fishermen in the area. The AD/DFAR Jaffna district was met, and background information on the aforementioned matter was gathered. 7 sites; namely: Maanmunai, Thaaladi 1, 2, Maradankerni, Ambiganagar, and Punkudithivu, were visited (Fig. 19), and the fishers who had been involved in the brush pile fishery were interviewed to collect background information.

Fishers had placed brush piles targeting squids in deeper waters. Fishing grounds were located about 5 to 20 km distances from shore and depth ranged 25 to 45m. Fishing season prevails from May-July in Thaaladi; May-September in Maradankerni; October-February in Punkudithivu. Squid catch can be 100kg/boat in best fishing seasons. In addition, another field visit was planned to be conducted in the best fishing season to understand the current conditions in the brush pile fishery. However, it was unable to conduct due to the fuel crisis that has prevailed in the country in 2022.



Figure 18: Site map of the study

PROJECT NAME: INVESTIGATION ON DISCOLORATION OF COASTAL WATER IN GALLE FACE BEACH, BERUWALA FISHERY HARBOUR AND SOUTHERN COASTAL AREA DUE TO IMMERGED ALGAL BLOOM

Project Duration : 2022.09.19

Project Description: NARA has been informed about a sudden discoloration (greenish-brown color) observed in the water of Galle Face Beach and the southern coastal area, and a research team from ESD has conducted a rapid inspection visit to the site. Water samples and plankton samples have been collected from Galle Face Beach and the Beruwala fishery harbor. The discoloration was assumed to be the result of a sudden algal bloom and to confirm the source of the emergency situation, laboratory analysis of water and plankton samples has been carried out. High abundance of *Noctiluca scintillans* non-toxic dinoflagellate was observed during the phytoplankton analysis of the samples and it was confirmed to be the source for discoloration occurred in the shore areas. Technical recommendations were provided to the relevant authorities in order to proceed with the further actions.



Figure 19&20: Discoloration observed in the Galle face beach

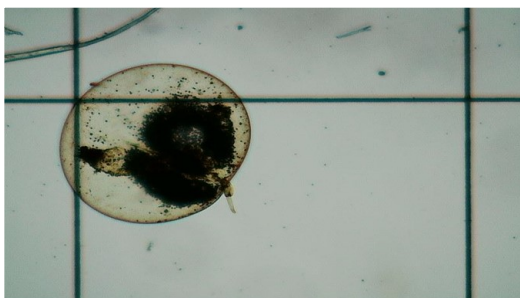


Figure 21: Microscopic view of *Noctiluca scintillans* (4x10x100)

PROJECT NAME: MANAGEMENT ON JAFFNA TRAWL FISHERIES TO MAINTAIN THE SUSTAINABLE FISHERY RESOURCES UTILIZATION.

Project Duration: 2022.08.29 to 2022.09.05

Regarding the Jaffna trawl fishery and its sustainable management, the Ministry of Fisheries instructed to carry out a rapid scientific survey. Therefore, NARA directed a real-time rapid fisheries survey that was aimed at achieving the objectives of studying the trawl fishing gear, an independent trawl survey in specific conditions, biological analyses, socio-economic aspects, and the feasibility of the vessel GPS tracking system. Findings show that about 450 number of 3.5 t trawler boats (30HP inboard engine, 2 cylinder) have been currently available for the trawl fishery with manually hauled trawler nets (01'' cod end mesh). Those operated within two demarcated trawl grounds in Jaffna peninsula (JF I: 139.9 km² & JF II: 228.9 km²). Main target shrimp species is *Penaeus semisulcatus*, which has the highest export-oriented value in the fisheries sector based on its caught size.

According to the experimental trawl hauls conducted in different time periods (day-time and night time), using different gear operational techniques (bottom trawl and mid-water trawl), findings show significant variation between each trail types. Most suitable fishing time period for the shrimp catch (target species of *P. semisulcatus*) in particular defined trawl ground is the night time. Meantime, the mid water trawl operation technique is not suitable for the shrimp catch and bottom trawling technique is only marked as possible way to catch target shrimp species in efficient manner. Initial trail for the tracking and monitoring of trawler boat by using remote sensing GPS tracker also provides positive results. In social wellbeing aspects, trawl fishers stated the importance of trawl fishery and the opportunities that have been created to the Jaffna fishing district. They also stated some suggestions such as legalize the trawl fishery with restrictions and take steps to minimize Indian trawler activities in Sri Lankan waters. NARA also suggested some recommendations, such as that trawl fishery strictly has to be restricted in NARA recommended fishing grounds and all trawling operations should be strictly monitored through suitable electronic monitoring devices introduced by DFAR with the consultation of NARA.

CONSULTANCY PROJECTS

1. STUDY ON THE ENVIRONMENTAL IMPACTS TO MARINE RESOURCES DUE TO LAKVIJAYA POWER PLANT (CONTINUOUS STUDY; 2022- 2023)

Project Proponent : Lakvijaya Power Plant, Ceylon Electricity Board

Budget : Rs. 34,818,380.56

Duration : May 2022 to July 2023

Components:

- Water quality and toxicological analysis
- Marine Biological survey
- Sediment Transport analysis
- Temperature Data Measurement & Numerical Modeling of thermal Effluent
- Bathymetric Survey

Deliverables of the project : Inception report, interim report and final report

Project progress : Inception report was submitted and first interim report is in progress

Project Coordinator : Dr (Mrs). K.A.W.S Weerasekara

Project Activity Coordinator : Mr. N.KR.N Jayawardane

“Study on the environmental impacts to marine resources due to Lakvijaya Power Plant” is a consultancy project awarded to ESD in 2022 for the consecutive secondtime by the Lakvijaya Power station, Ceylon Electricity board. The study was initiated in 2022 and continued to 2023 by the division to conduct a comprehensive survey of the area. This project is a collaborative project involving research studies from the Environmental Studies Division (ESD), Marine Biological Resources Division (MBRD), National Institute of Oceanography and Marine Sciences (NIOMS) and the National Hydrology Office (NHO) of NARA, contribution of each division are provided below.

Research Objectives : To determine the anticipated environmental impacts of the Lakvijaya power plant on the adjacent coastal and marine environment and their biotic and abiotic resources.

Research Strategy : Coal fired power plants are environmentally critical industries and Lakvijaya power plant is located adjacent to the Norochcholai coastal stretch and Puttalam lagoon. Since the area harbours large number of sensitive ecosystems with many aquatic resources the impact of the plant operations such as coal combustion, steam engine operation and cooling water discharge are highly critical for the close by ecosystems and resources. Therefore, careful monitoring and assessment of the environmental health and quality is an essential effort to ensure the safety of environmental components in the area. Therefore, this study aims at identifying and assessing the environmental impacts of the Lakvijaya Power Plant on the immediate aquatic ecosystems. Under this project, some selected physical, chemical, and biological properties of the aquatic system are analyzed, and the results will be interpreted to identify the adverse environmental effects of the Lakvijaya coal plant.

Study was commenced on May 2022 and expected to be conducted until July 2023. Samples are collected from 24 locations in off shore area closer to the Lakvijaya power plant, 2 reference sites at Kandakuliya and Sinnapaduwa, 1 inlet and 3 outlets at power plant during the off-monsoon period. Since the sea is rough during the monsoon period coastal sampling is carried out in 8 selected sampling locations representing 8 transect lines in the coast, 2 reference locations, 1 inlet and 3 outlets in the power plant.

Table 3: Project components and delegated responsibilities among technical divisions

Project Component	Responsible Division	Activity
Marine Biological Survey	MBRD	Study of diversity and density of zooplankton and ichthyoplankton in the adjacent coastal area. Study of ecology of pelagic organisms at selected locations Evaluating the changes in the fish catches before and after the establishment of the power plant Underwater visual survey of reef habitats and jetty area
Water quality and toxicological survey	ESD	Identification of Physico-chemical properties of coastal water adjacent to the power plant Assessment of mobility of toxic substances from coal combustion in coastal water, sediment, and fish/shell fish Study of diversity and density of phytoplankton and in the adjacent coastal area Study of the diversity and abundance of benthos in adjacent coastal area
Assessment of level of thermal stress on the adjacent coastal areas using numerical modeling & in-situ measurements	NIOMS	Assessment of thermal stress in adjacent coastal areas generates by the power plant Assessment of thermal gradient around the discharge point Modelling the thermal plume dispersion and extent (In different seasons) Modelling the vertical stratification of thermal effluent discharge (in different seasons) Elucidating the thermal stress level at the Thalawila reef
Numerical modeling of sediment transport	NIOMS	Determination of sediment transport of Norochcholai Power plant Analysis of sand movement pattern within the project area, including the distribution of the shore covering both seasons Study of wind direction, details of wave heights and direction for given locations Study of current pattern within the project area in low/high tide Identification of shoreline changes/ coastal erosion and beach stability
Bathymetric Survey	NHO	Study of Bathymetry of the coastal area adjacent to the power plant.

By the end of the year 2022, the assessment activities corresponding to 6 months have been completed and sample analysis and enumeration activities were in progress and preparation of first interim report is ongoing.

2. STUDY ON PHYSICAL, CHEMICAL AND BIOLOGICAL PARAMETERS IN PUTTALAM LAGOON (CONTINUOUS STUDY; 2022- 2023)

Project Proponent : Lakvijaya Power Plant, Ceylon Electricity Board

Budget : Rs. 8,002,450.00

Duration : March 2022 to January 2023

Deliverables of the project : Inception report, interim report and final report

Project progress : Inception report was submitted, and first interim report is in progress

Project Coordinator : Dr (Mrs). K.A.W.S Weerasekara

Project Activity Coordinator : Ms. J.K.P.C Jayawardane

“Study on physical, chemical and biological parameters in Puttalam Lagoon” is a consultancy project awarded to ESD in 2022, by the Ceylon Electricity board. The study was initiated in 2022 and

continued to 2023 by the division to conduct a comprehensive survey of the area. This project is a collaborative project involving research studies from the Environmental Studies Division (ESD), Marine Biological Resources Division (MBRD), and National Institute of Oceanography and Marine Sciences (NIOMS).

Research Objectives: To determine the anticipated environmental impacts of the Lakvijaya power plant on the important ecosystems and aquatic resources in Puttalam Lagoon.

Research Strategy : Puttalam Lagoon is one of the largest (32,750 ha) estuaries located in the Puttalam District of the Northwestern Province of Sri Lanka and currently the lagoon site is considered to be an environmentally critical site, since it surrounds number of industrial establishments, agricultural lands, aquacultural sites, and tourism related activities. One of the significant industrial establishments located adjacent to the Puttalam Lagoon is the Lakvijaya Coal Power Plant which involves with environmentally challenging operations. Therefore, this study aims at identifying and assessing the environmental impacts of the Lakvijaya Power Plant on the Puttalam Lagoon. Under this project, some selected physical, chemical, and biological properties of the Lagoon system will be analyzed, and the results will be interpreted to identify the adverse environmental effects of the Lakvijaya coal plant. This project is conducted is upon the request of the Lakvijaya Power Plant of the Ceylon Electricity Board.

Study was commenced on March 2022 and expected to be conducted until March-April 2023. Samples are collected from ten sites which have been selected based on judgemental sampling method and selected sampling locations include Mi Oya and Kala Oya outfalls, which discharge the entire drainage basins of the lagoon, the runoff of Puttalam Municipal limit and surrounding area and the southern and middle basins of the lagoon, focusing only the affected zone of stack emission flume path and one control points. Sampling is carried out on a quarterly basis and 4 sampling occasions have been planned accordingly.

- Middle of the southwest monsoon (May to September-2022)
- Second Inter monsoon (October-November-2022)
- Middle of the Northeast Monsoon (December to February-2022/2023)
- First Inter monsoon (March-April- 2023)

By the end of the December 2022, two sampling events have been completed and the respective sample analysis and report compilation activities were in progress. In-situ water quality analysis have been carried at each sampling location by measuring 8 physico-chemical parameters of water; water temperature (WT), pH, dissolved oxygen (DO), electrical conductivity (EC), turbidity, salinity, total dissolved solids (TDS), and depth. Moreover, surface water samples are being collected for the laboratory analysis of nutrients; Ammoniacal-nitrogen, Nitrate-Nitrogen, Nitrite-Nitrogen, Dissolved Phosphate, and Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Alkalinity, Hardness, Chlorophyll-a. In addition, water samples have been analysed for the abundance, diversity and density measures of phytoplankton and zooplankton in the sampling area.

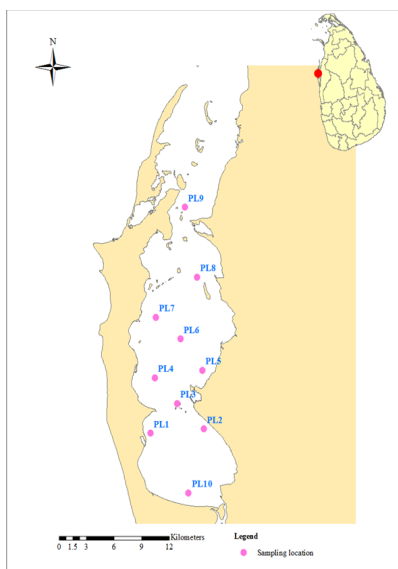


Figure 22: Site map of the sampling locations

Considering the higher level of anthropogenic influence on the lagoon ecosystem, and the numerous sources of heavy metal pollution, water samples collected from the Puttalam Lagoon are analyzed for 10 selected heavy metal(oids); Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Selenium (Se) and Zinc(Zn). In addition, biological samples (fish tissues) of *Mystusgulio*(Anguluwa) and *Mugil cephalus* (Godaya) are analyzed for the Chromium (Cr), Cadmium (Cd), Lead (Pb), Arsenic (As), and Mercury (Hg). Benthic sampling and analysis are also carried out as an integral part of this study where benthos samples are collected from all 10 sampling locations and been sorted and identified in the laboratory to determine their abundance and diversity within the study area.

According to the in-situ parameter analysis conducted during the first 2 filed visits, and respective laboratory analysis water temperature, pH, DO, turbidity, salinity, TDS, total hardness, nutrient levels, BOD-5, COD were all recorded within the stipulated limits of water quality. All the tested heavy metal levels in water and sediment samples in the toxicological assessment were within the stipulated standard limits for the considered standards. However, some of the fish tissue samples were found to be contaminated with heavy metals such as Cd, Cu, Pb, and Hg which exceed the stipulated standard limits of EC (2001). Therefore, further study on the heavy metal contamination of fish in Puttalam lagoon was recommended in the first interim report with the intention of carrying out complete survey to investigate the heavy metal contamination of the fish species in the lagoon given the special consideration to edible fish which are prominent in the local fisheries catch.

Test Services

ESD provides water quality testing services for a range of customer base including government institutions, private companies and industries, and individual clients by measuring the important water quality parameters and comparing them against the stipulated standards by the Central Environmental Authority. Parameters that are being tested in the ESD laboratory include water pH, water temperature, electrical conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity, Salinity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), alkalinity and hardness, nutrient levels (Ammonia-N, Nitrate-N, Nitrite-N and DissolvedPhosphate), and Chlorophyll-a. Total number of 12 test services have been conducted in 2022 and clients include industries, private sector institutions, small and medium scale businesses, and individual clients. 20 water samples have been analyzed concerning these 12 test services and total cost earned through the provision of test services is Rs. 82,650.00 for the year 2022.

Meetings attended and committees represented

ESD officials are representing number of nationally important committees including technical evaluation committees, EIA & IEE report evaluation committees, national steering committees, advisory committees, consultancy groups, expert committees, international environmental monitoring committees, and etc. Meetings and information sessions related to these committee representations are for the year 2022 are listed below.

Date	Meeting	Venue	Category
2022.01.05	Meeting on proposed aquaculture park in Mannar District	Ministry of Fisheries	Technical committee meeting
2022.03.04	Meeting to discuss the comments for the interim report for MV Xpress pearl incident	Marine Environment Protection Authority	Expert committee meeting
2022.03.08	Meeting with Australian legal firm regarding the interim report for MV Xpress pearl incident	Online meeting	Expert committee meeting
2022.07.08	Meeting with center for environmental justice regarding the damage assessment study for MV Xpress pearl incident	Online meeting	Expert committee meeting
2022.07.08	Lead team meeting with MV Xpress pearl expert committee	Online meeting	Expert committee meeting
2022.07.21	Expert committee meeting with MEPA and MOF officials regarding the damage assessment study for MV Xpress pearl incident	Online meeting	Expert committee meeting
2022.07.27	Third preparatory meeting for the IORAC Ad Hoc drafting sub committee	Online meeting	Expert committee meeting
2022.08.02	Meeting on the legal procedures related to the environmental damage caused by the MV Xpress Pearl maritime disaster	Attorney General's office	Expert committee meeting
2022.08.04	Meeting on MT New Diamond fire incident with MEPA and DWLC officials	Online meeting	Expert committee meeting
2022.08.05	MEPA Lead team meeting	Online meeting	Expert committee meeting
2022.08.07	Meeting on MT New Diamond fire incident	Online meeting	Expert committee meeting
2022.08.11	Meeting on MT New Diamond fire incident	Online meeting	Expert committee meeting
2022.08.21	Meeting on the outsourcing of samples collected for MV Xpress pearl damage assessment to international laboratories.	Online meeting	Expert committee meeting
2022.08.23	Meeting with minister Prasanna Ranatunga, MEPA and other stakeholders on the progress of damage assessment studies of MT New Diamond and MV Xpress Pearl	Ministry of Urban Development, Sethsiripaya	Expert committee meeting
2022.09.02	Meeting to discuss short-term and long-term monitoring plans of MV Xpress pearl damage assessment	Online meeting	Expert committee meeting
2022.09.21	Meeting on MT New Diamond fire incident	MEPA Head Office	Expert committee meeting
2022.10.20	IEE report evaluation committee for proposed 270 unit residential apartment project, Kudawaskaduwa, Kalutara	Coast Conservation & Costal Resources Management Department	Technical Evaluation Committee
2022.11.04	Meeting on Disaster Risk Management Plan	MihilakaMedura, BMICH	National Steering committee
2022.11.08	Indo pacific Environmental Security Forum 2023	Online Meeting	Workshop

2022.11.11	Meeting on Capacity Building program conducted by ADB for NARA officials	Online Meeting	-
2022.11.16	Meeting on Capacity Building program conducted by ADB for NARA officials	Online Meeting	-
2022.12.01	Meeting on EIA of proposed Yatimahana reservoir project Mawanalla by Central Environment Authority (CEA)	CEA	EIA Meeting
2022.11.04	Tenth meeting of the Task Force for the restoration of Mangrove Ecosystems in Sri Lanka by Ministry of Environment	Ministry of Environment	Technical Committee meeting
January 2022	Technical evaluation committee meeting on IEE wind power project Mukkuthuduwa by CEA	CEA	Technical evaluation committee meeting
January 2022	Technical evaluation committee meeting on expanding research capacity on Ocean University	Ocean University	Technical evaluation committee
March 2022	Advisory committee meeting at Coast Conservation Department (CCD)	Coast Conservation & Coastal Resources Management Department	Advisory committee meeting
March 2022	Meeting on X Press pearl ship disaster with private legal consultants at Ministry of fisheries	-	Expert Committee meeting
-	Meeting on Environmental Management & Monitoring Programme for Development of Colombo Port (Development of West Container Terminal 1)	Coast Conservation & Coastal Resources Management Department	Advisory committee meeting
-	Technical Evaluation Committee Meeting for the Initial Environmental Examination (IEE) Procedure on Proposed 63 Roomed Secret Beach Resort Project - Paragallawatta, Koparamulla, Mirissa-MSBR Development (Pvt.) Ltd	Coast Conservation & Coastal Resources Management Department	Technical Evaluation Committee Meeting
-	Technical Evaluation Committee Meeting for the EIA Procedure on Proposed Capacity Enhancement to the Existing Thambapavani Wind PowerPlant under Mannar Wind Power Project –Phase 1 Extension – Ceylon Electricity Board	Coast Conservation & Coastal Resources Management Department	Technical Evaluation Committee Meeting
-	Technical Evaluation Committee Meeting for the Initial Environmental Examination (IEE) Procedure on Proposed 35 Roomed Yala Holiday Resort Project SLTDA Tourism Promotion Zone, Palatupana, Yala - Yala Holiday Resort (Pvt.) Ltd.	Coast Conservation & Coastal Resources Management Department	Technical Evaluation Committee Meeting
--	Environmental Management & Monitoring Programme for Development of Colombo Port (Development of East Container Terminal (Phase2))	Coast Conservation & Coastal Resources Management Department	Advisory committee meeting
	Technical Evaluation Committee Meeting for the IEE Procedure on Proposed 20 Storied 145 Units of Residential Apartment Project, No 351, Porutota Road, Negombo	Coast Conservation & Coastal Resources Management Department	Technical Evaluation Committee Meeting
	Technical Evaluation Committee Meeting for the IEE on Proposed 13 Storied of Residential (236 Rooms) and Mixed Development Project, Parrot Junction, Wellaboda, Madampe, Ambalangoda	Coast Conservation & Coastal Resources Management Department	Technical Evaluation Committee Meeting

Held on monthly basis	Coast Conservation & Coastal Resources Management Advisory Council Meeting	Coast Conservation & Coastal Resources Management Department	Advisory Council Meeting
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TRAININGS AND WORKSHOPS

FOREIGN TRAININGS

Training	Duration
Expert Seminars on the implementation of Marine Protected Areas: identification, selection, and designation 1	-
Expert Seminars on the implementation of Marine Protected Areas: management and sustainable financing of MPAs 1	-
Training Course on “Marine Biotech and Marine Biodiversity for Developing Countries” conducted by Fujian Institute of Oceanography, China from 05th to 25th May 2022 (Online)	
Sri Lanka- Australia Blue Carbon Fellowship held at Perth, Dunsborough, Brisbane, Sunshine Coast– Australia	22 May 2022 to 11 June 2022
Online training course on Green Fisheries Technology Innovation and Carbon Neutrality for Developing Countries	10 October 2022 to 08 November 2022
Online training on micro-plastics on sediments, water, and biota organized by Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	March 2022
Online Short Course on PCA and Factor Analysis (using SPSS)” organized by Stac Centre	January 2022
Seminar on Fishery Development and Management for the Silk Road Countries	July 06- 26 2022

LOCAL TRAININGS

Training	Duration
Sri Lanka oil response workshop and exercise organized by Sri Lanka Coastguard and US government from	06 June to 10 June 2022
Training on recording marine litter organized by EAF-Nansen Programme	-
Training on microplastic sampling training organized by Center for Environment, Fisheries and Aquaculture Science	-
2nd Workshop on Development of IORA Declaration on Combatting Marine Debris and a Strategic Framework of Action on Marine Debris in the Indian Ocean	-

PRESENTATIONS & AWARENESS PROGRAMS

Presentation Title/ Awareness Programs	Date
PhD progress review presentation on “Identification of most appropriate freshwater fish species as bio-indicators in lower and upper catchments of Kelani River basin for Environmental pollution assessment” at Faculty of Graduate Studies, University of Colombo.	February 2022
PhD progress review presentation on Assessing Potential Toxicity of Selected Drinking Water Resources in Medawachchiya and Padaviya areas in the North Central Province of Sri Lanka Using Plant and Fish models” at Faculty of Graduate Studies, University of Kelaniya.	April 2022

Nor-Lanka Blue Workshop 2022- Resource Person “ESD, NARA and role of NARA in assessing and addressing the contamination resulted by X-press pearl maritime disaster in 2021”.	April 2022
CSIRO presentation on NARA research activities and blue carbon collaborations.	June 2022
Presentation on Short term and long-term monitoring plans of NARA on X Press Pearl ship disaster, Sri Lanka at Expert committee meeting Marine Environment Protection Authority (MEPA).	September 2022
PhD Viva Voce Presentation on “Water Quality Assessment of Drinking Water Wells in Medawachchiya and Padaviya Reservoir and Health Risk Assessment of Reservoir Fish Consumption: Implications for Chronic Kidney Disease of Unknown Aetiology of the North Central Province, Sri Lanka” at Faculty of Graduate Studies, University of Kelaniya.	October 2022
Presentation on “Assessment of Heavy Metal Pollution in Upper and Lower Catchments of Kelani River basin, Sri Lanka”. - NARA Scientific Sessions 2022.	October 2022
Presentation on “Accumulation of heavy metals and polycyclic aromatic hydrocarbons in water, sediment and fish in Bolgoda Lake, Sri Lanka” - NARA Scientific Sessions 2022.	October 2022
Presentation on “Preliminary assessment of Zooplankton assemblage in Puttalam Lagoon, Sri Lanka”. - NARA, Scientific sessions	October 2022
Radio programme on “why sudden fish mortalities are occurred?”.	October, 2022
Presentation for Indo-Pacific Environmental Security Forum -2023”.	November 2022

Supervision of undergraduate students for industrial training

14 undergraduate students have been supervised for a training period of 03 months commencing from 12.02.2020 towards their fulfillment of undergraduate training. The students were studying in Ocean University of Sri Lanka and University of Kelaniya and training has been delivered on developing their knowledge and skills in the core areas of research planning, literature review, scientific data collection, sample collection and preservation, laboratory analysis, basic laboratory procedures, quality control and assurance, data interpretation and scientific writing.

Publications

Journal publications

1. Narangoda, S. R. C. N. K., Dangalle, C. D., Amarathunga, A. A. D.(2022). Selected Freshwater fish species for assessing the water quality of the lower catchment of the Kelani River, Sri Lanka”, *International journal of Environmental Monitoring and Assessment*.
2. Hettige, N.D., Hashim, R. B., Kutty, A. B. A., Ash'aari, Z. H. B. & Jamil, N.R.B. (2022). Using Benthic Macroinvertebrate Distribution and Water Quality as Organic Pollution Indicators for Fish Farming Areas in Rawang Sub-basin, Selangor River, Malaysia: A Correlation Analysis, *Journal of Fisheries and Environment*, 46(1), 180-197.
3. Hettige, N.D., Weerasekara, K.A.W.S., Amarathunga, A.A.D. and Chandrasiri, E.G.D.N. (2022). Dredging impact on water quality in Bomuruella Reservoir in Nuwara Eliya, Sri Lanka, *Ceylon Journal of Science*, 51(4), 131-139.

Abstracts

1. Narangoda, S. R. C. N. K., Dangalle, C. D., Amarathunga, A. A. D.(2022). “Assessment of heavy metal pollution in upper and lower catchment s of Kelani river basin Sri Lanka”. National Aquatic Resources Research & Development Agency (NARA) Scientific Session 2022, PP.57.
2. W.K. Suwandhahannadi, A.A.D.Amarathunga, K.A.W.S.Weerasekara, M.D.S.R.Maddumage, S.R.C.N.K. Narangoda, K.M.B.P. Kalaotuware, S.K. Pamarathne and P.H.Ginigaddarage (2022).Present status of pollution based on water quality in Kudawella andPuranawella fishery harbours, Southern coast of Sri

- Lanka, National Aquatic Resources Research & Development Agency (NARA) Scientific Session 2022, pp.59.
3. Amarathunga, A. A. D., Maddumage, M. D. S. R., Narangoda, S. R. C. N. K., Rupasinghe, D. D., Jayawardhana, J. K. P. C. and Pamarathna, S. K. S, (2022). Microplastic contamination on selected beaches in Sri Lanka coast line due to X Press Pearl ship disaster. National Aquatic Resources Research & Development Agency (NARA) Scientific Session 2022, pp.71.
 4. Hettige, N. D., Rohasliney, H., Ashaari, Z. H. B., Kutty, A. B.A., & Jamil, N. R. B. (2022). Assessment of physical health characteristics in selected Selangor Rivers in Malaysia, 7th International Conference for Women in Science Without Borders (WISWB2022), Faculty of Science, Universiti Putra Malaysia. Serdang, Selangor, Malaysia, pp.93.
 5. Hettige, N.D., Maddumage, M. D. S. R., and Wickramaarachchi W.D.N. 2022. Phytoplankton assemblage in Puttalam Lagoon, Sri Lanka, International Symposium on Agriculture and Environment (ISAE 2022), Faculty of Agriculture, University of Ruhuna, Sri Lanka ,pp.69.
 6. Hettige, N.D., Wickramaarachchi W.D.N. 2022. Diversity and Composition of Benthic Macroinvertebrates in Puttalam Lagoon, Sri Lanka, Proceedings of the 26th International Forestry and Environment Symposium 2022 of the Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka, pp.38.
 7. Hettige, N.D., Jayawardane, J.K.P.C, and Weerasekara, K.A.W.S. 2022. Benthic macroinvertebrates assemblages in the Mundel Lagoon, Sri Lanka, 9th Ruhuna International Science and Technology Conference -2022, Faculty of Science, University of Ruhuna, Sri Lanka, pp.91.
 8. Hettige, N.D., Maddumage, M. D. S. R., and Wickramaarachchi W.D.N. 2022. Preliminary assessment of Zooplankton assemblage in Puttalam Lagoon, Sri Lanka, NARA, Scientific sessions (Accepted), pp.69.
 9. Pamarathne, S.K.S, Weerasekara, K.A.W.S, Tirukeswaran, S, Mendis, B.R.C. 2022. Preliminary study on assessment of physicochemical characteristics of water in Deduru Oya Basin, Scientific Sessions, 2022, National Aquatic Resources Research and Development Agency (NARA). Pp.66.
 10. Thirukeswaran, S, Kalaotuwawe, K.M.B.P.P, Jayawardane, N.K.R.N, Pamaratne, S.K.S, Weerasekara, K.A.W.S, 2022, Beyond Evaluating the Water Quality of Nayarulagoon; a Way Forward to the Lagoon Ecosystem Restoration, *IEPSL 14th Annual General Meeting (AGM) and Associated Sessions*, Colombo, Sri Lanka.
 11. Jayawardhane, J.K.P.C and Weerasekara, K.A.W.S* (2022), Accumulation of heavy metals and polyaromatic hydrocarbons in water, sediment and fish in Bolgoda Lake, Sri Lanka, Scientific Sessions, 2022, National Aquatic Resources Research and Development Agency (NARA). pp.58.
 12. Chathurani, S.H.U., Jayasundara, J.M.N.M. and Premarathne, S.K.S. (2022), Assessment of physico-chemical parameters of water in Negombo lagoon during COVID-19 pandemic, Scientific Sessions, 2022, National Aquatic Resources Research and Development Agency (NARA). pp.58.

REPORTS, CONCEPT PAPERS AND NEWSPAPER ARTICLES

1. Concept paper on “Continuous oceanographic survey of the Indian Ocean with respect to all international maritime activities and important living and non living resources and pollution on July 2022.
2. Proposal/ Monitoring plan preparation for the Short term and Long-Term Impact Assessment due to X-Press Pearl Ship Burning Disaster of Colombo.
3. Report for Rapid Assessment of On-going Sea Cucumber Farming Practices and its Implication on Fisheries Livelihood’s at Kiranchi and Parititivu in Northern Province of Sri Lanka.
4. Newspaper article submitted for Oruwella newspaper on “Fuel Crisis and future of fishries industry in Sri Lanka” and article on Alien Invasive Species (AIS).

5.2 FISHING TECHNOLOGY DIVISION

Head of the Division: Dr. Nilanthi Priyadarshani

PROJECT No : 3.1

FEASIBILITY STUDY ON MODIFICATION OF EXISTING GILL NETS TO FULFILL IOTC RESOLUTION AND PROMOTE POLE AND LINE FOR SKIP JACK TUNA

Responsible Officers : Dr. W.N.C. Priyadarshani, Mr. H.M.T.C.Madhushankha,
Mr.W.A.K.Prabath, Mrs.K.H.K.Bandaranayake, Mr.S.Gunasekara and
Mr.K.P.G.L Sandaruwan

Estimated Budget : LKR 0.50 Million

Background

Indian Ocean is rich with high economically valued fish resources specially Skip Jack Tuna and it should be harvested properly. Gillnet is a popular fishing method used for catching tuna and tuna like fishes especially by small scale fisheries of coastal states of the Indian Ocean while now it is considered as destructive fishing gear because of its extremely high by catch. Marine mammals, seabirds, sea turtles, sharks and rays are all incidentally captured in gillnets. As such, Indian Ocean Tuna Commission (IOTC) introduced resolution (IOTC 19/01) of gillnets for High Seas in 2019 adhered by coastal states aiming to maintain stocks in perpetuity and high probability, with taking the sustainable yield and , rebuilding the Indian ocean yellow fin tuna stock in the IOTC area. The Sri Lanka also should implement that IOTC 19/01 by developing mechanism to maintain grift gill net submerged 2m depth from the surface as one option to mitigate the ecological impacts of gill nets. Meanwhile, those gill nets operate both high seas and within EEZ should be confined 2.5km with effect from 2022.

As per the request made by the MFAR, staff of Fishing Gear Technology (FTD), Marine Biology resource division (MBRD) and Socio-Economic Divisions (SED) of NARA conducted feasibility study on modifications of gill nets with above mentioned specifications while seeking possibility to promote Pole and Line fishery gain for Skip jack Tuna Fishery which was popular among fishermen 100 years ago. To use the Pole and Line fishery as alternative for gill net fishery, as selective fishing gear for target species and only fish of a certain size are caught by leaving juveniles to grow to spawning age and replenish the stock in the future. Small bait fish are thrown over the side of the boat to lure the tuna to the water surface and the fishermen get hooked them and fling them onto the ship's flat deck.

However, this fishery can be promoted based on studying the present status of fishery in terms of fish production, species composition, effort and bait requirement, gross income, operational cost and profit and then only gill net usage trend will be discouraged. Further, guidelines would be formulated for appropriate management strategies to ensure the biological and ecological sustainability, social acceptability and economic viability of the fishery.

Methodology.

The project activities were carried out under several steps as follows:

I. Stakeholder awareness meetings

Several awareness programs were held at Negombo, Beruwala, Mirissa, Hambanthota, Baticoloa and Kalmune area to make aware of the new IOTC resolution and identify possible issues arisen from that resolution implementation. The officials from Department of Fisheries and multiday boat owners/fishermen were participated for the programs and the relevant details i.e. net specifications,

boat specifications; socio economic data of the fishing industry of the relevant provinces were gathered during the meetings (Figure 1).



Figure 1. Awareness Programs held at Beruwela and Batticaloa

II. Net Modification and under water observation.

In some locations (Beruwela, Negambo, Mirissa and Kalmune), onboard existing gear operations of multiday boats were observed. In some of International Multiday (IMUL) boats with already available gill nets which could be adjustable up to 1-3 fathom (Buoy rope) was made gear adjustments and operated at 2m depths (Figure 2). Further, the submerged gill nets were examined and confirmed its exact depths through under water diving observations. Underwater photographs and video clips on gear operation and its actual behavior in under water were captured for further studies and information.

Information was collected from harbors on gear specifications of existing gill nets in province wise and district wise for Tuna and Tuna like fishery. Kalutara and Gampaha districts were observed in Western province while entire Galle, Matara and Hambantota districts were observed in Southern province. Ampara and Batticaloa districts were also observed in Eastern province.



Figure 2. Modifications of Gill net specification and underwater confirmation of Net deployment

III. Study the Potential of Pole and Line Gear for Skip Jack Tuna

The study was mainly focus on the collection and analysis of fishery related parameters, biological information and socioeconomic data of fishers in Pole and Line fishery industry. Here, the availability of free surface fish schools, distribution of bait fish and necessary gear/vessel upgrades for the future expansion of the fishery were determined through catch and effort data collection, length at maturity and hook size selectivity of skip Jack Tuna. The socioeconomic issues and the perception of stakeholders of the fishery on rules, regulations and available managing strategies related to the fishery were identified through analyzing the sustainability of the fishery in terms of ecological and economical perspectives, estimating profitability of the industry and evaluating the trend of fishery including pros and cons and thereby to determine provisions for the expansion of the fishery (Figure 3). All information collected would be used to provide management recommendations for the sustainability of the fishery.

Figure3. Pole and Line gear operation for Skip Jack Tuna

(<https://media.greenpeace.org/archive/Pole-and-Line-Fishermen-Catch-Tuna-27MZIFL0BXHZ.html>)



Results

1. Awareness programs and Gill net fishery information

Six awareness programs were conducted in Beruwala, Negombo, Mirissa, Hambantota, Batticaloa and Kalmunei. In addition field discussions also had with fishermen and boat owners at other harbors such as Galle and Valachchenai. However, Trincomalee, Puttalam and Jaffna coastal area were not covered during the study period due to limited budget.

Based on stakeholder meeting and site visits following information was gathered. In Beruwela North, the total fishing community consisted of 2270 people from 529 fishing families while only 570 were active fisherman. They are belongs to 16 Gramasewa divisions. Here, out of 137 of IMUL vessels, only 68 of those total vessels had VMS (Vessel Monitoring system) facilities while 60 of vessels were given deep sea operation permits (HS license). There were 77 of EEZ permit owners. In Negombo total of 498 IUML boats are operated.

In Galle district, there are 32601 people from 337 fishing families and only 11423 are active fishermen. There are 709 of IMUL boats. In Batticaloa District, there were 85005 fishing community while 26026 of them were active fishers coming from 23426 fishing families. Here, 462 of IMUL were operated during June, 2022 and only 5 of them were taken high seas license and no information found about VMS facilities. Fishing Population in Tangalle Fisheries District was 30424 in November 2022 from 8094 fisher families while only 9872 were active fishermen. There were 527 IMUL boats and 187 of Boats had VMS facilities which had High Seas Permits, but only 176 boats used Nets for

fishing. Three new IMUL boats were applied for registration. Fisher population in Matara district was 36810 from 9114 families and only 13726 were active fishermen. There were 1293 IMUL boats and only 20 of that total had permit for High Seas operation and 228 of boats for EEZ operation.

However, all fishermen or boat owners were not met since some of them were at sea for several weeks.

2. Field observation and adjustment/modification of gear specification

On board checking of multiday boats with existing gill nets were observed in Western, Southern and Eastern provinces and the findings are described below for each province.

A comparison of gill net specifications in three provinces are given in Table 01 and study sites are given in Figure 4.

The general diagram of gill nets with specification for tuna fishery is given in Figure 6, 8 and 10.

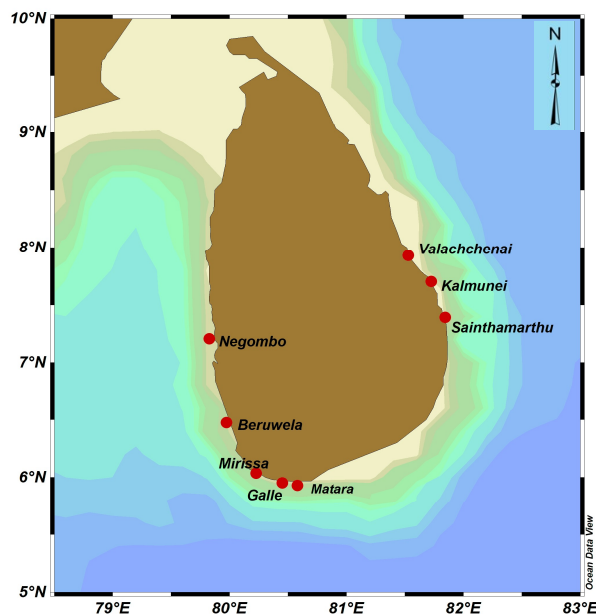


Figure 4. Map of the field observation and Data collection sites

a) Western Province (Kalutara , Gampaha districts)

According to the observation done at Western coasts (Negombo and Beruwela), Gill nets in most of the IMUL vessel had adjustable long buoy rope (Buoy line/rope) for 2 m depths (Figure 5 and Figure 6). Normally, Tuna gillnets in Negombo area have around 3 - 6 m (1 ½ - 3 fathoms) buoy rope and the length of the buoy rope can be adjusted according to the sea condition while Beruwela gill net buoy ropes could submerge around 2 m (1 fathom).

The mesh sizes of drift gill nets were varied from 5.00 inch to 6.00 inches with 18, 21, and 24 ply in both areas. Number of net pieces per boat was varied. Most of tuna gill net boats are used mechanical winch to haul the net. Therefore, they are keeping their gill net in more than 2m deep in water and sinking length changed according to the sea status. Underwater observation confirmed that head rope is lined at 2 m depth exactly and those specifications are already aligned with Gill net Fishery in Beruwela area. Thus, 2 m submersible Gill nets are already used and not necessary to introduce new specifications to their gill nets. Normal length of a single trip varied from one week to six weeks.



Figure 5. Multiday fishing fleets anchored at Western Province

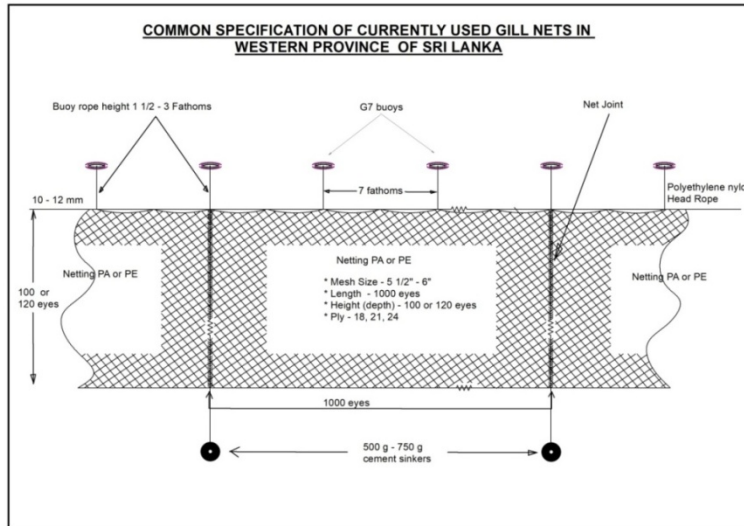


Figure 6. Gill Net Specification used in Western Province multiday boats

b) Southern Province (Galle, Matara, Hambantota districts)

According to the observation done at Southern coasts, the mesh sizes of drift gill nets of multiday boats were 6.00" inches with 18, 24 and 27 ply (Figure 7 and Figure 8). The Buoy rope is around 4 m (2 fathoms) which can be adjustable to 2 m submerged the net. Further, the Tuna gill net boats are used mechanical winch to haul the net and keep sinking the net at 2 m is possible. Number of net pieces per boat was varied although it has legally allowed 50 net pieces for a one boat (25 kutti). But, fishers are taking out extra 30 - 50 net pieces for a voyage, other than the allowed nets. Normal length of a single trip for fishing varied from one week to one and half of month.



Figure 7. Multiday Fishing fleet at Southern Province

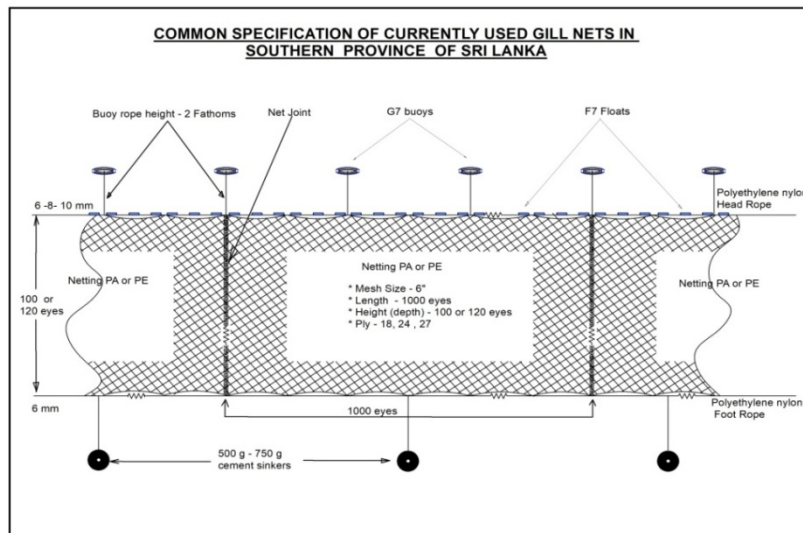


Figure 8. Gill net Specification used in Southern province Multiday Boats

c) Eastern Province (Batticaloa, Ampara districts)

Surface Gill net fishery was observed at Valachenai to Sainthamaruthu and submerged gill net fishery is not possible due to stony bottom in coastal waters. Thus, 2 m submersible gill nets cannot be operated in rocky areas and fishermen rarely go to high seas for fishing. They receive considerable harvest / production by fishing in coastal waters than deep sea. Because of the stony bottom, boats are anchored at near shore and use OFRP boats or Vallam to get in to multi day boats (Figure 9 and Figure 10).

According to the observation collected from Eastern coast; fishermen used drift gill nets which do not have buoy rope (Figure 9). Therefore, the gill net is always kept float on the sea surface and not sinking as the gill nets used in western coast. Mesh size was 5 inch to 6 inch. Ply was 24 and 27.

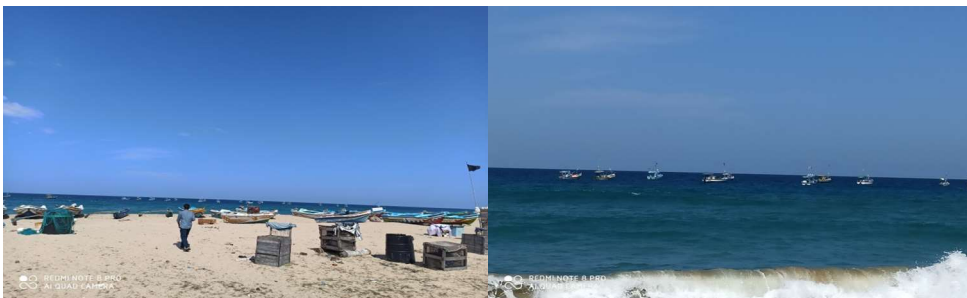


Figure 9. Multiday Fishing fleet at Poonachchimunai nearshore, Eastern Coast.

Duration of a single boat trip is 7 days (From Friday to Thursday). However, positive feedback was expressed on submerged gill net with some conditions in vessel upgrades and construct new fishery harbors among the area other than Valachchenai.

According to the discussion and interviews, fishermen of the eastern coast agreed to sink the net up to 2m depth with several conditions as follows,

- Fishermen are requesting fishery harbors for Saidamaduru and Batticaloa area. Valachchenai harbor is the only harbor in Batticaloa and Kalmunai area and fishermen have to travel long distance to reach the harbor. Currently fishermen in eastern coast especially in Poonochchimuneyi and Sainthamaruthu, keep anchor their
- boats in considerable depth away from the land and using OFRP boats or canoes they carry their harvest to the land.

- They do not have large enough boats to fix the winch and without winch fishermen unable to haul the gill nets from 2m depth using human power. Therefore, they are requesting funds to develop large boat to fix the winch.
- With those large boats with winch and fishery harbors, fishermen in Eastern coast like to sink the gill net up to 2 m depth as IOTC requirement.

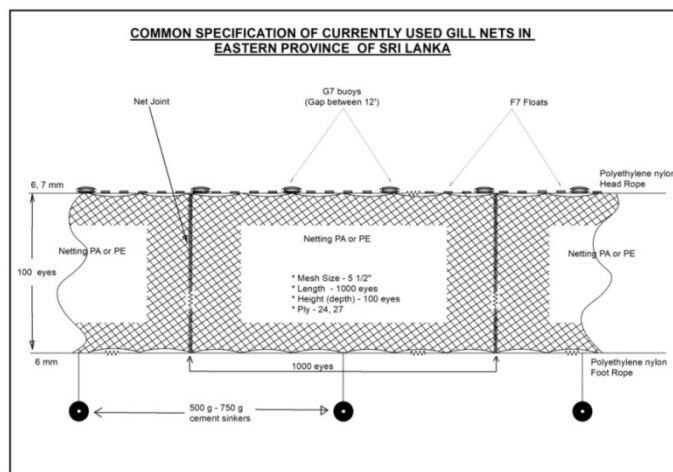


Figure 10. Gill net Specification used in Eastern Province Multiday Boats

Table 01. A comparison of Gill Net specifications among three provinces

Description	Western Province	Southern Province	Eastern Province
Whether use gill net (GN)	Yes	Yes	Yes
Nets are made by	Nylon	Nylon	Nylon
Length of the GN (eyes)	1000	1000	1000
Depth of the GN (eyes)	100 - 120	100 – 120	100
Eye size of the GN (inch)	5 ½" , 6"	6"	5 ½"
Ply of the GN	18, 21, 24	18 , 24, 27	27, 24
Top line of the GN (mm)	10, 12	10, 8, 6	7, 6
Bottom line of the GN (mm)	No bottom line	No bottom line	No bottom line
Nos of net pieces for a whole net (allowed)	50	50	50
G7 buoys	01 G7/7fathoms	110 – 120 buoys / a whole net	120 buoys / a whole net
Gap between two G7 buoys	07 fathoms		02 fathoms (12')
F7 floats	No	1900 – 2000 / a whole net	1900 floats/ a whole net
Gap between F7 floats	No		10'
Stone/ cement weights	2 stone / a net piece	1 stone/one net piece	1stone /1net piece
Buoy line length	1 ½ - 3 fathoms (9' – 18')	2 fathoms	No B/line (Surface)

3. Analysis of information on Pole and Line fishery for Skip Jack Tuna

- **Catch and effort**

The Pole and Line fishery in Sri Lanka is practiced in small scale and currently confined to two main landing sites Suduwella (Kottegoda) in Matara District in south coast and Sirimapura in Trincomalee District in east coast. Only seven (07) boats belonging to UN2B vessel type category (8.8-9.8 m inboard with insulated fish hold) are being operated for pole and line fishery in Suduwella while a total of 35 of UN2A vessel type category (8.8-9.8 m inboard without insulated fish hold) in Sirimapura. The fishing is practiced within 7-10 NM from the coast with 12 hours of true fishing time. In Suduwella, the average catch rate was 288 kg per boat while the peak catch of 600 kg per boat was recorded in March. In Trincomalee, the average catch rate was 111.6 kg per boat with a peak value of 350 kg per boat in May. However, fishing was not consistently observed even within the season due to multiple reasons such as poor catch rates, lack of free tuna schools, scarcity of bait and fuel crisis.

- **Target Species and the length frequencies**

The main target species of the Pole and Line fishery is Skipjack Tuna (*Katsuwonus pelamis*) which is around 96% of the total Pole and Line catch. In addition, neritic tuna species; Bullet Tuna (*Auxis rochei*), Frigate Tuna (*O. thazard*) and Kawakawa (*Euthynnus affinis*) also recorded as by catch of the gear.

The size range of Skipjack Tuna recorded during the study, ranged between 38 cm to 61 cm (FL) with a mode between 56 and 60 cm (Figure 7). This reveals that the Pole and Line fishery practicing in Sri Lanka mainly targets mature skipjack tuna.

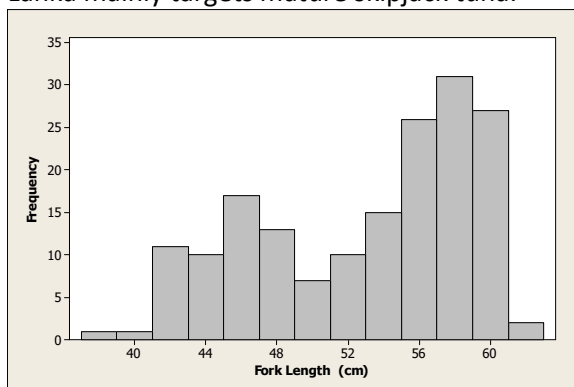


Figure 7. Length frequency distribution of Skipjack Tuna landings in Pole and Line fishery

- **Fishing season**

It was observed that the well-known fishing season of Skip Jack Tuna in Suduwella is from **December to April** while in Sirimapura fishing season falls from **March to June** which mainly corresponds to the monsoon impact in the two regions.

- **Bait requirement**

In Sri Lankan Pole and Line fishery, *Dipterygonotus balteatus* (mottled fusilier; Family: Caesionidae), red bait (Hingura) in common is the most preferred species (Sivasubramaniam, 1972) and during last two decades, lack of live bait availability was one of the main reasons for declining of the fishery (Amarasiri, 1991; DFAR, 1995). This bait fish normally is found at depths between 37 and 91 m (Carpenter et al, 2016) while the adults are mainly pelagic over the continental shelf comparatively distant from reefs. They prefer to form mixed species schools with other inshore small pelagic species such as **Sardines and Anchovies**. The juveniles are frequently reef associated (Bray, 2019), showed dense aggregations and can be caught at nightlights using small moxi nets and dip nets. However, in some countries bait fish catch are allowed at day time after sunrise and before sunset for bait fish sustainable management.

During the study, it was observed that the required *D. balteatus* per trip is approximately 100 kg. According to the Dr Fridtjof Nansen survey results in 2018, *D. balteatus* was recorded abundantly in

near shore waters (in 31 trawl stations out of 88 total fishing stations). The mottled fusilier *D. balteatus* was mainly distributed in South East and offshore waters of North West polygons (Rathnasooriya et al, 2019). The bait fish are collected using a kind of lift net in Southern province of Sri Lanka.

- **Skipjack tuna Distribution in Sri Lankan waters**

The catch of drift gill net operations (>300 kg per day) over the past years reflects that the target fish (Skipjack) are more than 99% schools are abundantly found beyond 10 NM fishing range where Pole and Line fishery is practiced.



Figure 8. Bait Fish (*Dipterygion notus balteatus* - mottled fusilier) with fishing gear for Pole & Line Fishery

Recommendations

To implement the IOTC regulation on Tuna gill net fishing nets, following are recommended

- Currently, fishermen are in Southern and west coast use a buoy rope which can adjust and possible to keep floating the gill net in 2m deep in the open ocean. Therefore, existing specifications of gill nets which are operating in prescribed area are not necessary to change according to the IOTC resolution.
- However, Tuna gill net operation in eastern coast, they do not have a buoy rope, hence they are not keep sink the gill net up to 2m. However, to implement the IOTC resolution, above discussed infrastructure facilities should be provided.
- Finally, we recommend, IOTC resolution can apply for the west and southern coast and cannot apply for the eastern coast, currently.

The expansion of Pole and Line fishery in Sri Lanka could only be practical subjected to the following preconditions.

- A suitable harvesting technique for live bait
- Vessel upgrade which can reach the free tuna fishing grounds located beyond 10 NM
- Technology skill development
- To establish bait management zone for sustainable bait management
- To need a valid fishing licence (such as sport or conservation) to catch your own live bait.

Constraints and future improvements

- Field observations were not made in North western, Northern and North Eastern Provinces due to limited funds for transportation, But MFAR has to be concerned it when implementing the IOTC (19/01) resolution.
- The requests made by fishermen in Eastern coastal area have to be considered for implementing the IOTC resolution. Fishermen are requesting fishery harbors for Saidamadura and Batticaloa

area. Valachchenaharbour is the only harbour in Batticaloa and Kalmunai area and fishermen have to travel long distance to reach the harbor. Currently fishermen in eastern coast especially in Poonochchimuneyi and Saindamaduru, they keep anchored their boats using OFRP boats /canoes and carry their harvest to the land.

- Fishermen in Eastern areas need large boats to fix the winch and without winch fishermen unable to haul the gill nets from 2 m depth using human power. Therefore, they are requesting funds to develop large boat to fix the winch.
- Seasonal Bait availability for Pole and Line Fishery has to be studied deeply.

5.3 NATIONAL HYDROGRAPHIC OFFICE

Head of the Division : Mr. S.R.C. Ranaweera

Overview of the Year

The prime objective of National Hydrographic Office (NHO) is to provide Hydrographic services to ensure safe and efficient navigation in Sri Lankan waters. This is a mandatory requirement of full filling the obligation of the International Convention for the Safety of Life at Sea (SOLAS). Accordingly charting areas are selected to ensure that hydrographic surveys are being carried out, as far as possible, adequate to the requirements of safe navigation where stakeholders and also being to prioritized. The other principal services are the provision of up dated and accurate bathymetric and topographic data for coastal zone management, environmental protection and maritime delimitation. The up to date hydrographic information coverage offers significant economic and commercial benefits through facilitating maritime trade and other marine activities.

It has been realized that hydrographic data is underpinning the blue economy activities, accordingly NHO has carried out new surveys for Nandikadal lagoon to develop a master plan. Here the hydrographic information perform a vital and valuable part of calculating carrying capacity to quantify the optimal economic and commercial benefit of each lagoon.

Following surveys and activities were conducted for the year 2022,

National Charting Program

3.1.1. Bathymetric data acquisition for Nautical Chart from Colombo to Negombo

3.1.2. Bathymetric data acquisition for Coastal Chart Little Basses reef to Pulmoddai Roads

3.1.3. Upgrading existing charts

3.2. Establishment of Database and online data processing unit for crowd sourced bathymetry parallel with the “Sea Bed 2030” global mapping project of General Bathymetric Chart of the Oceans (GEBCO)/ Nippon foundation

3.3 Surveys conducted for special requests

3.4 Contribution to other projects

Activities Undertaken

Table 1:1 Activities undertaken by NHO for year 2022

Program/Projects	No.	Activities	Officer Responsible	Period
1.0 National Charting Programme	1.1	Data Acquisition for Coastal Chart from Colombo to Negombo	S.R.C. Ranaweera Y.M.R.N. Kumari R.K.A. Ariyaratne	Jan- Dec
	1.2	Data Acquisition for Coastal Chart “Little Basses Reef to Pulmoddai Road”	W.A.A.P. Wijesundara K.A. Ranasinghe D.L.P. Hewage	
	1.3	Upgrading Existing Nautical Charts	L.S.C. Siriwardane R.M.D.I. Rathnayake	
	1.4	Data processing and Cartographic works	S.R.T.P. Singhabahu B.H.B. Jayamalie Darshana Wickramasinghe M.Malarathne	
2.0 Establishment of Database and online data processing unit	2.1	Survey by the fishing boats using fish finder	Y.M.R.Nilupa Kumari R.K.A.Ariyaratna R.M.D.I.Rathnayake,	Jan-Dec
	2.2	Crowd Sourced Bathymetry	Darshana Wickramasinghe	

for crowd sourced bathymetry parallel with the “Sea Bed 2030” global mapping project of General Bathymetric Chart of the Oceans (GEBCO)/ Nippon foundation	2.3	Create database Report writing and publication Mapping		
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Program/Projects	No.	Activities	Officer Responsible	Period
3.0 Surveys Conducted for Special Requests from Government and other Institutions	3.1	Bathymetric Survey at Approaches to Puttalam	S.R.C. Ranaweera	Jan- Dec
	3.2	Bathymetric Survey for CEB in Silawathura	Y.M.R.N. Kumari R.K.A Ariyaratne	
	3.3	Side scan Sonar Survey for MV X-Press pearl ship burning incident	W.A.A.P. Wijesundara K.A. Ranasinghe	
		Level Survey for the Dutch Canal	D.L.P. Hewage L.S.C. Siriwardane	
	3.4	Mapping for demarcation of areas in the sea cucumber export village in Northern province	R.M.D.I. Rathnayake S.R.T.P. Singahabahu B.H.B. Jayamalie Rajitha Harshana Darshana Wickramasinghe	
	3.5	Lagoon Survey at Arugambay Lagoon	M.Malarathne	

PROJECT NO : 1.1

DATA ACQUISITION FOR NAUTICAL CHART FROM COLOMBO TO NEGOMBO

Being an island nation located in a central position of the Indian Ocean, adopting a Blue Economy strategy is a mandatory for Sri Lanka. As we are the National Hydrographic Office of Sri Lanka improves safety at sea, increases the protection of the marine environment and advances national development leading for more efficient and safe maritime transport. The availability of the nautical charts have been promoting safety and security in navigation and peaceful and sustainable harness of ocean resources.

Further, the coastal stretch from East to West of Sri Lanka including Jaffna peninsula is covered with two British Admiralty charts named Colombo to Cape Comorin – BA 1587 and Trincomalee to Point Calimere BA-1584. Both of these charts are produced around 1970s with the scale of 1:300,000 and most of the sea areas are available as unsurvey area. The country aspires to become a maritime hub in the region, taking the advantage of its, the National Hydrographic Office of Sri Lanka is planned to produce a Nautical Chart from Colombo to Negombo with the Scale of 1: 100,000 based on the BA chart of 1587. The location of the chart is decided by considering the unique

geographical position, high accessibility to ocean resources from a lengthy coastline around the country, closeness to major sea lanes, a diverse range of coastal and marine ecosystems and a high potential for tourism and recreation industries.

NHO planned to conduct the bathymetric surveys to produce a nautical chart from Colombo to Negombo within this year. But, the Survey teams were allocated for the bathymetric survey projects based on the priority and the requirements of the national development projects.

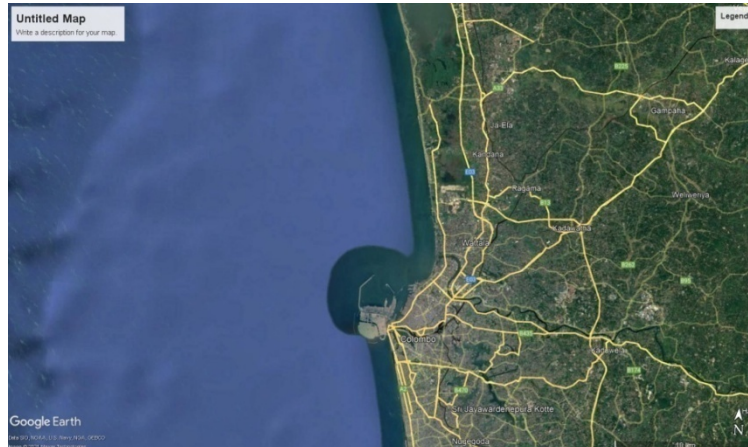


Figure 1:1 Area of the nautical chart from Colombo to Negombo in 2022

PROJECT NO : 1.2

DATA ACQUISITION FOR COASTAL CHART “LITTLE BASSES REEF TO PULMODDAI ROADS”.

According to the National Nautical Chart Index, the total coastal belt of Sri Lanka intended to cover with five small scale charts. Nautical Chart “Little Basses Reef to Pulmoddai Roads” is one of those. This covers 250 km long coastal stretch from South to East of the island. The total area intended to survey in two phases.

Due to the COVID-19 pandemic situation, the surveys couldn't carry out as planned within the year. Further, the survey team was utilized for the investigations of the Pearl X-press ship burning incident activities and the survey team was working with Side Scan Sonar to identify the debris. Furthermore, the surveys was carried out for the demarcation of areas in the sea cucumber export village in Northern Province.

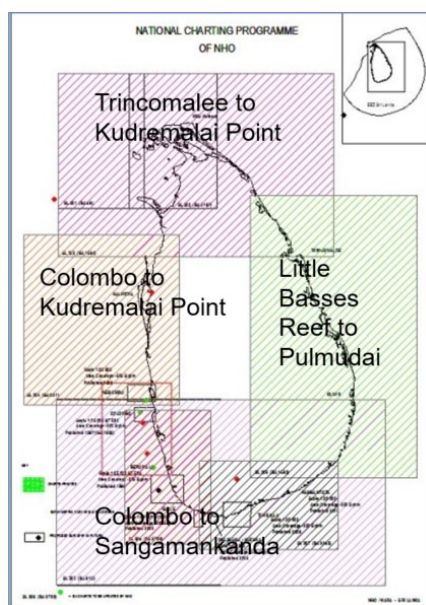


Figure 1:2 Nautical Charts covering the entire coastal belt

PROJECT No : 1.4

UPGRADING THE PUBLISHED NAUTICAL CHARTS

The published charts should be maintained to ensure the validity of existing data as the sea bed is subjected to change due to natural phenomena such as Tsunamis, storms or any other extreme weather condition or by other manmade hazard. Any changes of bathymetry are needed to be applied timely. Necessary communication links has been maintained with the relevant authorities, Harbor Master of Sri Lanka Port Authority and Director General of Merchant Shipping Secretariat.

PROJECT No :1.5

DATA PROCESSING AND CARTOGRAPHIC WORKS

- Data processing, mapping and cartographic work completed for the collected data for producing the Approaches to Nautical Chart of Puttalam harbour.
- Completed the Electronic Navigational Chart (ENC) of Puttalm area and sent to the United Kingdom Hydrographic Office which is one of the validation authority of the worldwide ENCs' as per the standards of International Hydrographic Office (IHO). The final version has submitted to UKHO after the completion as per the validation instructions of UKHO.

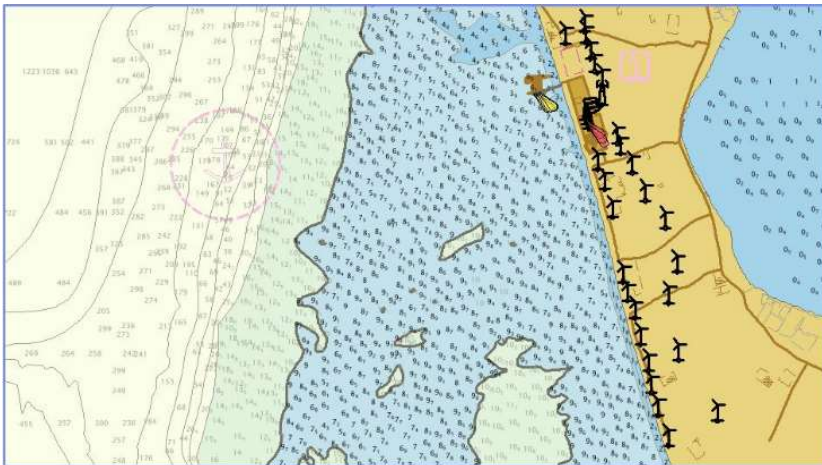


Figure 1:3 ENC at Puttalam Harbour

PROJECT No: 2.0

ESTABLISHMENT OF DATABASE AND ONLINE DATA PROCESSING UNIT FOR CROWD SOURCED BATHYMETRY PARALLEL WITH THE “SEA BED 2030” GLOBAL MAPPING PROJECT OF GENERAL BATHYMETRIC CHART OF THE OCEANS (GEBCO)/ NIPPON FOUNDATION

Bathymetric coverage of the sea around our country is very little and need to be done vast area and it needs years and years to fulfil this with the systematic bathymetric surveys. The world contest is very similar and hence the GEBCO Nippon Foundation has started a project called Seabed 2030 and member states of International Hydrographic Organization been invited to collaborate this project covering their own seas from the bathymetry.

The objective of this project is to map the Indian Ocean using crowd sources bathymetry and maintain and updating the data base and disseminate data for marine management, spatial planning and research in marine geology, ecology and oceanography. This will be a continuation project until 2030.

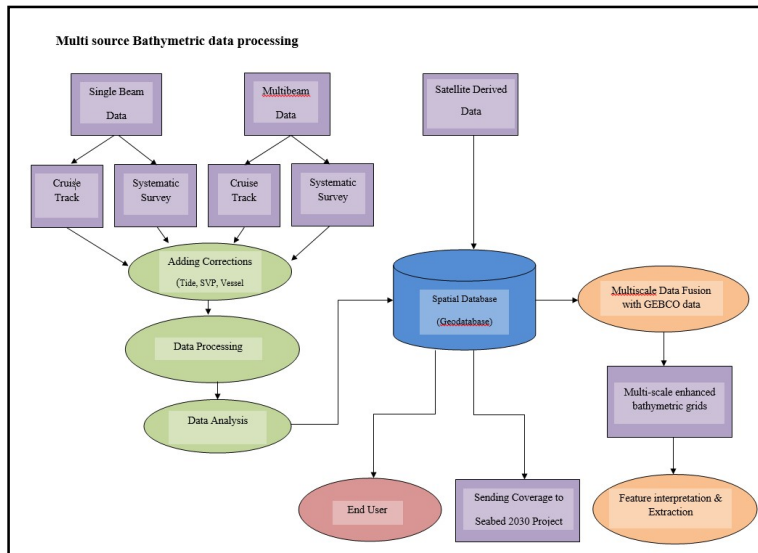


Figure 3.1: Working procedure

Because of the COVID 19 pandemic situation purchasing was delayed of necessary items of infrastructure facilities to establish Unit and the networking system as planned for this year. The spatial database interface was generated using ArcGIS platform and model of the surface was created. Crowd sourced bathymetry from the Fridgetof Nanson Survey, Zhen He project, RV “Samuddrika” cruise track data and the bathymetric data from systematic surveys of NHO, bathymetric data from the admiralty charts were associated to the database. The overall progress of the project is 37% for the year 2021.

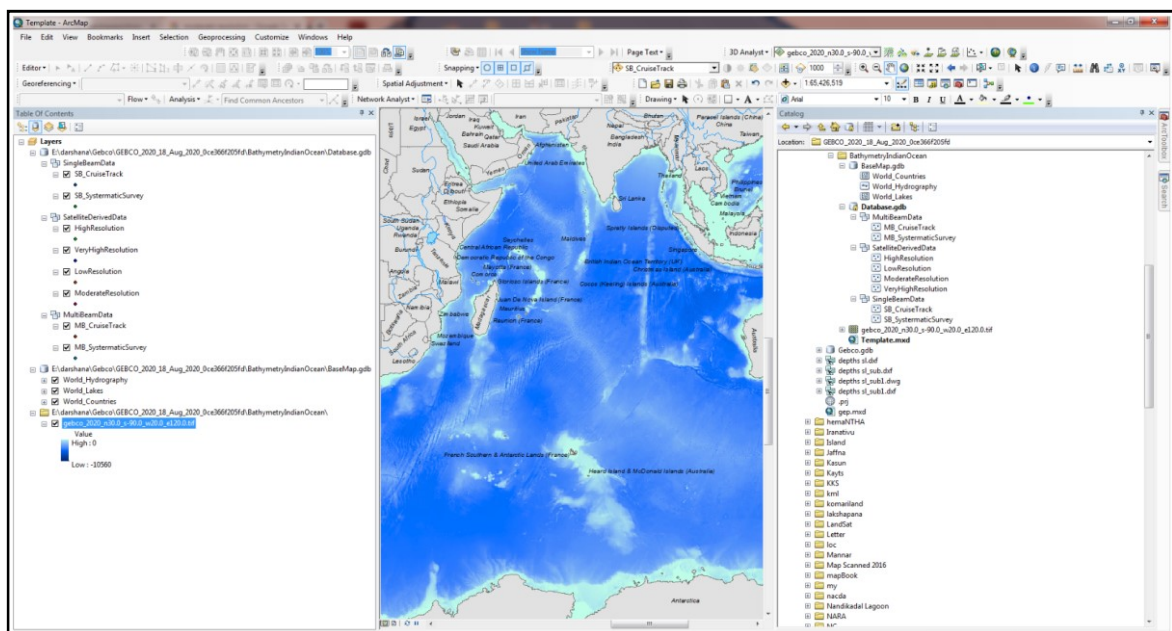


Figure 3.2: Spatial Database Interface

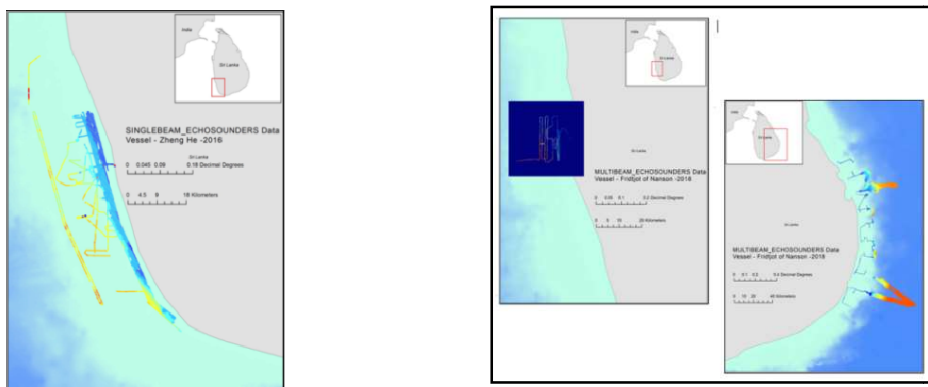


Figure 3.4: Bathymetry from the Fridgehof Nanson Survey

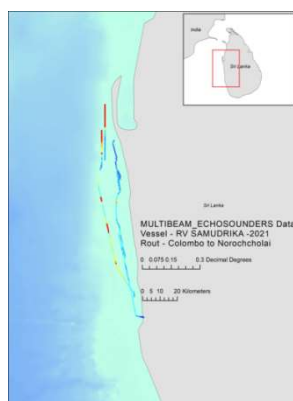


Figure 3.5: Bathymetry from RV "Samuddrika" Cruise

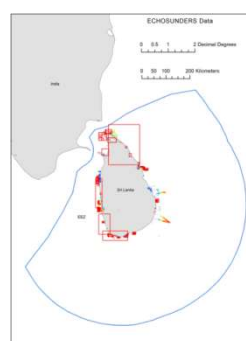


Figure 3.6: Bathymetry from NHO Nautical Charts



Figure 3.3 Bathymetry from Admiralty charts

PROJECT No : 3.0

SURVEYS CONDUCTED FOR SPECIAL REQUESTS FROM GOVERNMENT AND OTHER INSTITUTIONS

PROJECT 3.1: NAUTICAL CHART FOR APPROACHES TO PUTTALM

Energy produced from coal fired plants is cheaper and more affordable than other energy sources. Economic benefits gained by operating the Norochcholai power plant are vital for the development of Sri Lankan power sector and have a significant positive effect on the national economy. As we are the National Hydrographic Office of Sri Lanka improves safety at sea, increases the protection of the marine environment and advances national development leading for more efficient and safe

maritime transport. In 2011, the nautical chart of “Approaches to Norochcholai” was produced by identifying the recommended barge channel for the coal transportation upto power plant.

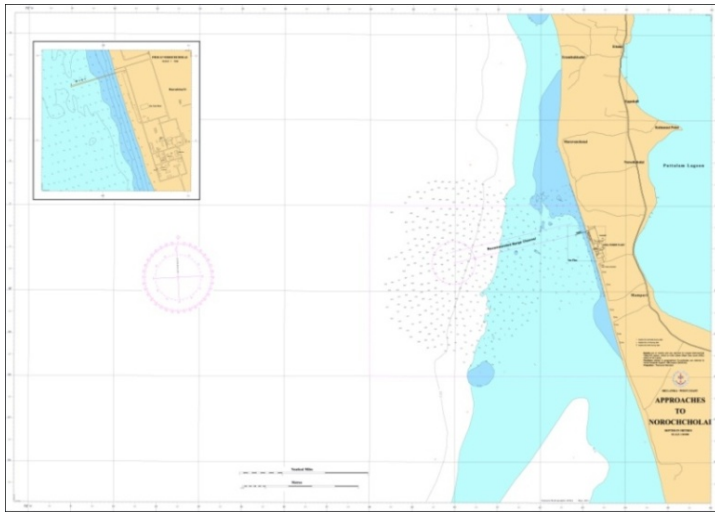


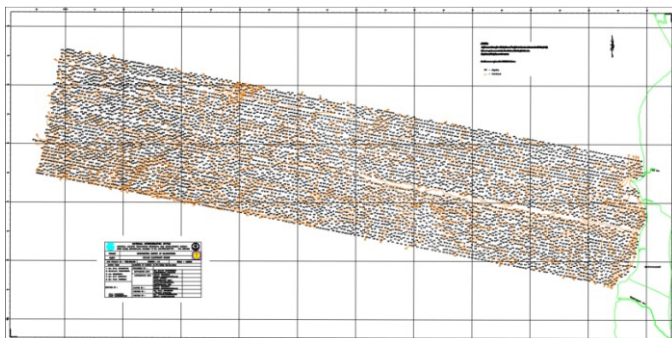
Figure 3. 1: Nautical chart Approaches to Norochcholai

Then, the harbor master and the Ceylon Shipping Co-operation emphasized the importance of having the Nautical chart of Norochcholai by considering the contribution for the national economy of the country. Therefore, the National Hydrographic Office provided the priority for collecting bathymetric data for the Nautical Chart of Norochcholai as an urgent basis and utilized RV. Sammudrika and a small survey boat. The nautical chart of Norochcholai will be published in few stages. At the initial stage, nautical chart of Puttalam harbor is produced including the harbor limits of Puttalam harbor as its gazette. As the second stage data collected within this period using RV. Sammudrika to produce the nautical chart of Approaches to Puttalam and data processing and the mapping is ongoing.

PROJECT 3.2 : BATHYMETRIC SURVEY FOR CEB IN SILAWATHURA

Ceylon Electricity Board (CEB) has been developing wind power plant at Mullikula area and they have been requested from National Hydrographic Office (NHO) of National Aquatic Resources Research & Development Agency (NARA) to conduct bathymetric survey from Marichchakadu to Silawathura to identify the channel to transport long/blades and heavy wind turbine components and to identify the suitable location for a pier for equipment unloading along the coastal strip. CEB has been revealed from the initial investigation that at least 5m draft is required to facilitate the barge transportation.

Survey area comprised from Marichchakadu to Silawathura 4.5km long coastal stretch and 19 km to the Seaward.



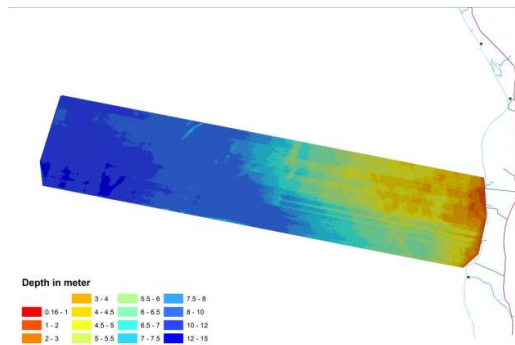


Figure 3.2: Final bathymetric maps of the study area

PROJECT NO : 3.3

SIDE SCAN SONAR SURVEY FOR MV X-PRESS PEARL SHIP BURNING INCIDENT

The ship MV X-Press pearl sank about 9.5 nautical miles from the Colombo harbour and was carrying a consignment of hazardous chemicals, raw materials for cosmetics and aluminum processing by-products and 300 tonnes of bunker oil. With the sinking of the ship, the release of the chemical is a serious risk to the ocean and the coastal ecosystem. The areas under direct impact are the western coast harbors from where there is offshore fishing, near shore fishing and lagoon fishing and thousands of fisherman have lost their livelihoods.

Further, Sri Lanka is situated strategically at the crossroads of major shipping routes to South Asia, the Far East and the continents of Europe and America, making the country a convenient port of call for shipping lines. Therefore, the side scan sonar was carried out by covering the coastal stretch from Colombo to Panadura area to search the debris based on the incident to facilitate for the safe navigation. Mapped out the scattered debris spread and has identified more than 300 target locations from where the debris will be removed.

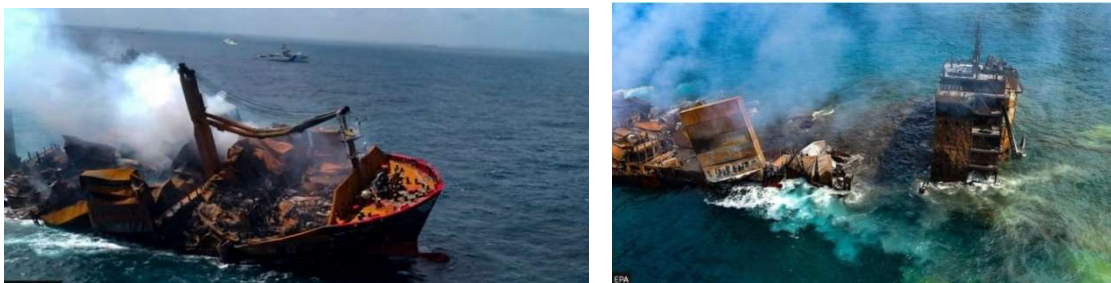


Figure 3.3: MV X-Press Pearl ship burning

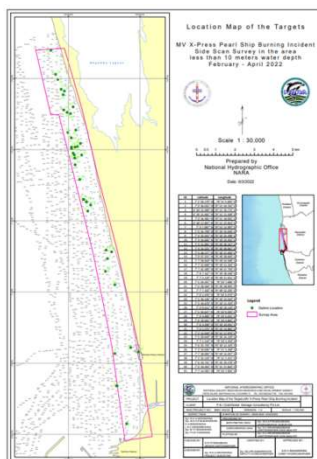


Figure 3.4: Scattered debris and identified target locations map

PROJECT No : 3.4

LEVEL SURVEY FOR THE DUTCH CANAL

In Puttalam district, the water from the Dutch canal is used for the prawn culture in Puttalam and Mundalama lagoon. Because of the deposited sand in Dutch canal the dredging is required to remove them and NAQDA, the client of the project is requested to do the cross sections and LS section survey.



Figure 3.5: Field Work at Dutch Canal

PROJECT No : 3.5

MAPPING FOR DEMARCATION OF AREAS IN THE SEA CUCUMBER EXPORT VILLAGE IN NORTHERN PROVINCE

To encourage the sustainable agriculture and fishery ventures, the Jaffna district is selected for establishing the dedicated buffer zone for sea cucumber farming for overseas market. The National Aquaculture Development Authority (NAQDA) is awarded this project to demarcate the sea plots for sea cucumber farms. Surveys were carried out to demarcate of plots for sea cucumber export village in Northern Province.

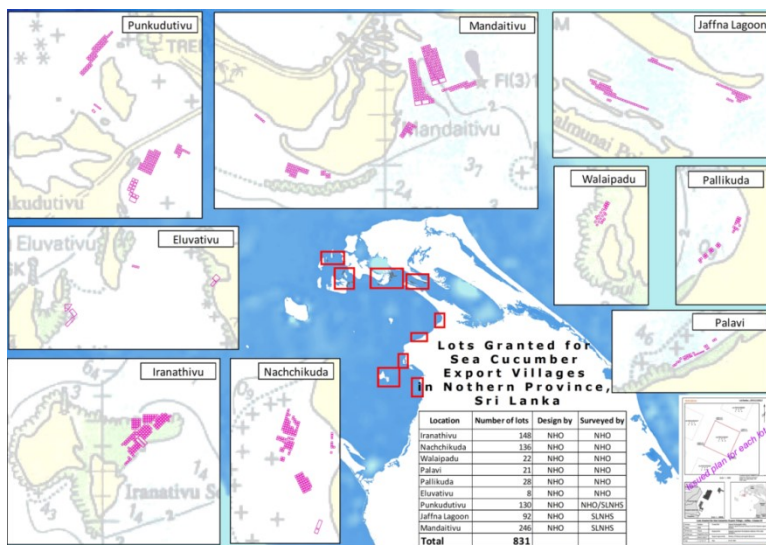


Figure 3.6: Maps of the Sea Cucumber export village in Northern Province

PROJECT No : 5.6

LAGOON SURVEY AT ARUGAMBAY LAGOON

As per the requirements of the inland fisher men to increase the catchment of the fishing, bathymetric and RTK survey is doing for dredging purpose to increment of the lagoon area and volume capacity of the entire lagoon.

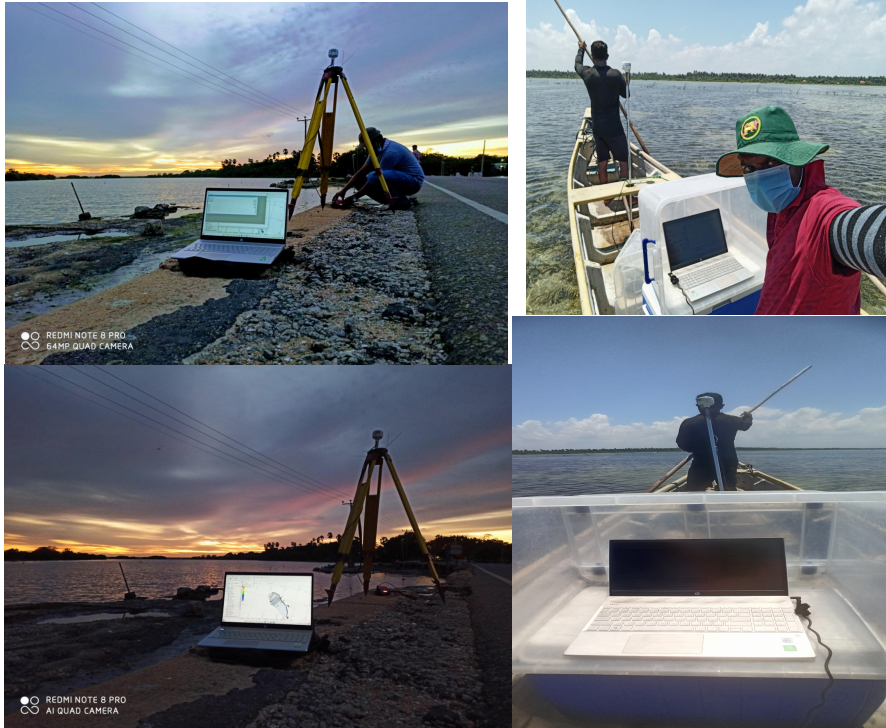


Figure 3.7: Field Survey at Arugam Bay

Publications / Maps

1. Electronic Navigational Chart of Puttalam

Training / Awareness Programs conducted:

1. Routine Awareness Program in Hydrographic Surveying and Chart Production for the undergraduates and School children
2. Industrial training programmes for the; Faculty of Geomatics, Sabaragamuwa University of Sri Lanka for fulfil the requirement of FIG/IHO/ICA Category B (Hydrography)
Sir John Kothalawala Defense University

Foreign / Local Training and International Commitments

1. FIG/IHO/ICA Cat A Course at University of New Hampshire under the Nippon Foundation/ GEBCO Training programme



Figure 7.1 : Group Photograph

2. North Indian Ocean Hydrographic Commission- Remote virtual meeting, 22-25 August, 2022, Bali, Indonesia.
3. Proficiency in Fire Prevention and Fire Fighting course at Mahapola Training Institute, Port Authority of Sri Lanka
4. Proficiency in Personal Survival Techniques Course at Mahapola Training Institute, Port Authority of Sri Lanka

Consultancy Surveys Conducted for Special Requests

Project	Contract Amount (Rs)
Nautical Chart for Approaches to Puttalm	Rs.13,364,650.00
Bathymetric Survey at Silawatura for CEB.	Rs.8,060,175.00
Side Scan Sonar Survey for MV X-Press pearl Ship Burning Incident	Rs.29,054,700.00
Total	Rs.50,479,525.00

5.4 INLAND AQUATIC RESOURCES AND AQUACULTURE DIVISION

Head of the Division : Dr. P.P.M Heenatigala

Project no.	Project title	Total Allocation LKR Mn	Responsible officers
1	Development of aquaculture and health management to enhance fish production in Sri Lanka.	2.00	M. G. I. S. Parakrama A.D.W.R ajapaksha P. A. D. Ajith Kumara R. Weerasingha A.M.A.N.Adikari A. S. L. E. Corea P. Mythily, ChathurangaPrdeep LakshikaJayasekara HarshaneeDeepakumari P. P. M Heenatigala
2	Enhancement of export oriented aquaculture industry in Sri Lanka through development Ornamental fish, Aquatic plants and sea weed culture technology.	1.00	RamaniShiranth SarathJayanatha T. Nuwansi S. Sugshwari HarshaneeDeepakumari P.Mythily
TOTAL (LKR/Mn.)		3.00	

Summary

Inland Aquatic Resources and Aquaculture Division (IARAD) conducted 02 research and development/ Inland Aquatic monitoring projects in 2022, consisted with 11 research components. Study conducted targeting to improve the production efficiency of Asianseabass (*Latescalcarifer*) aquaculture in lagoon waters of Sri Lanka revealed that olein palm oil could be used as a substitute for the fish oil when formulating sea bass fingerling diets. A study on application of Biofloc technology (BFT) to enhance the aquaculture in Sri Lanka has been identified that molasses as the most suitable carbon source that could be used for the BFT systems when rearing *Cyprinus rubrofuscus* post-larvae. Similar study conducted with *Oreochromis niloticus* advanced fingerlings reported higher growth performances with fermented biofloc system which consists of *bacillus sp.* Culture trials conducted to develop commercial scale pearl oyster industry in Sri Lanka has identified that the Trincomalee / Cod Bay area as a suitable site for pearl oyster culture in the East coast, Sri Lanka with high survival rate of 96.75%.

A disease survey conducted in ornamental fish farms has identified that, Trichodina infection as the most common parasitic infection among ornamental fish farms in Kaluthara and Gampaha districts. Disease monitoring work carried out in shrimp culture facilities in Western and North Western provinces reported WSSV disease was in the vannamei shrimp culture systems.

Study conducted to strengthen the export oriented endemic ornamental fish industry revealed that, still tank system is an easy, low-cost breeding technology which could be applied for mass production of *Devvariopathirana*. Breeding trials conducted with barb fish using L-Ascorbic acid shown that it could be successfully applied to condition the breeding tank water, to reduce their hatching time and increase hatching rate and fish survival rate. Further, a study conducted with Oranda goldfish confirmed that use of ovulin double dose (0.7mg/kg) for female Oranda fish and single dose for male Oranda fish could be used to breed oranda goldfish successfully.

Studies conducted to develop in - vitro propagation techniques for aquatic plants reported that shoot generation of *Aponogeton* could be successfully induced with 2mg/L BAP:0.5 mg/L IBA and *Aponogeton* shoot multiplication could be induced with 3mg/L IBA:3 mg/L IBA. Similar study conducted with *Nymphaea* reported that, combination of 2mg/L BAP:1mg/L TDZ: 0.5mg/L IBA:0.5mg/L kinetin successfully induced callus generation of *Nymphaea*.

Study conducted to find out the growth performances of aquatic plants cultured in different aquaponic recirculation systems identified commercial prawn diet as a suitable feed to co-cultivate Guppy and *Bacopa* plants cultured in simple floating raft aquaponic system.

Potential to produce organic fertilizer using seaweeds available in Sri Lanka has been evaluated and confirmed the possibility to utilize seaweed extracts as a natural fertilizer additives and growth promoter for some commercial crops.

PROJECT No:1.1

DEVELOPMENT OF AQUACULTURE AND HEALTH MANAGEMENT TO ENHANCE FISH PRODUCTION IN SRI LANKA.

Responsible Officer/s : Dr.A.D.W.Rajapaksha, Dr.M. G. I. S. Parakrama, Mr.P. A. D. Ajith Kumara, Mr.R. Weerasingha, Mrs.A.S.L.E. Corea, Mrs.M.A.N.Adikari, Mrs.P. Mythily, Mr. Chathuranga Prdeep, Mrs.Lakshika Jayasekara, Mrs.Harshane Deepakumari

Duration : 1 year (started 2021)

Location/s : Around Sri Lanka

Total Allocation : LKR 2.0 million

COMPONENT 1: Community mobilization for improving the production efficiency of asian seabass (*Latescalcarifer*) aquaculture in lagoon waters of Sri Lanka.

Officer/s Responsible : R. Weerasingha, P. A. D. Ajith Kumara, A. Maheepala,

Introduction:

Sea bass farming is a slow-growing business in Sri Lanka due to a lack of suitable manufactured commercial feeds and mortalities. Small-scale sea bass farmers in the country use trash fish to feed their fish. Relying on the trash fish supply is no longer sustainable if we want to expand sea bass aquaculture locally. Besides, trash fish remain among edible food commodities in some areas. Present import restrictions have affected feed prices and led to unnecessary rises. Feeding trash fish may cause the spreading of diseases and low survival, ultimately, farmers evacuate from the business due to poor economic return.

Fish oil is one of the most expensive feed ingredients in the feed industry. As it is replaceable with other cheap oil sources, alternative plant oil sources are tested in fish diets on and off. Palm oil contained low content of HUFAs compared to fish oil. However, olein palm oil contains a low saturated fatty acid level compared to crude palm oil. Moreover, palm oil is a rich source of carotenoids and vitamin E. Therefore, we examined the effect of olein palm oil as a fish oil replacer in sea bass diets.

Objectives:

To determine the effects of palm oil as a fish oil replacer in juvenile seabass diets

Materials and methods

Experimental site

The experiment was carried out at NARA Regional Research Center, Kalpitiya for ten weeks.

Experimental diets

Two diets were prepared separately to contain 4% fish oil (+basal diet, T1) and 4% olein palm oil (+basal diet, T2). Each diet contained 40% crude protein.

*Due to transport and labour allocation issues last year, the initiation of the trial took place beyond the planned time. Fingerlings were not allocated in cages according to the early decided stocking density due to high mortalities (fuel shortage affected delaying fish sorting and grading).

Feeding trial

Two cages consisting of 30 fingerlings per each were fed with two diets separately. Initial sampling and intermittent sampling were conducted. Feeding was done three times a day. Cage cleaning was done once a week (Figure 1). Initial sampling was done on 10th August 2022 (Figure 2). The second sampling was conducted on 26th September 2022. Final sampling was conducted on 28th October 2022 (Figure 3).

Sample collection and analysis

Weight and length data were collected. Weight gain, total length gain and specific growth rate were calculated.

Statistical analysis

Calculated data were analysed by analysis of variance (ANOVA) using SAS 9.4 programme at 0.05 level of significance. If there were any significant difference, data were subjected to Tukeys' test to compare means at 0.05 significance.



Figure 1: Cleaning of cages



Figure 2: Initial sampling



Figure 3: Final sampling

During the feeding trial, fish were fed up to the satiation level. Weight gain, total length gain and specific growth rate of fish fed palm oil contained diet was high compared to fish fed fish oil contained diet (Table 1). Mourente & Bell (2006) studied to replace fish oil with rapeseed oil, linseed oil and palm oil in European sea bass diets. They replaced 15% fish oil with palm oil without affecting growth.

Table 3: Growth performances of *Latescalcarifer* after 10 weeks

Samplings	Diets	
	T1	T2
Initial weight (g)	11.69 ± 0.68	13.74 ± 0.76
Final weight (g)	32.87±4.27 ^b	56.73±8.38 ^a
Weight gain (%)	181.14±36.49 ^b	312.93±61.00 ^a
Initial length (cm)	9.63 ± 0.31	9.27 ± 0.19
Final length (cm)	13.96±0.60 ^b	17.00±0.69 ^a
Length gain (%)	44.88±6.24 ^b	83.45±7.46 ^a
Specific growth rate (SGR)	1.25±0.18 ^b	1.75±0.17 ^a

***Whole body proximate, whole body fatty acid analysis, and gut, gill and liver histology are in progress.**

By the intermediate sampling data which is after 46 days revealed that the fish passed early fingerling stage showed no significant difference after feeding either fish oil or olein palm oil (Table 2).

Table 2: Intermediate growth and length of Sea bass after 46 days

	T1	T2
Weight	40.56±2.12	46.33±4.52
Total length	13.47±0.36	14.39±0.69

Conclusion

Fish oil in sea bass fingerling diets can effectively replace with olein palm oil. However, all data must be completed and compiled to come to a final conclusion.

References

Mourente, G., & Bell, J. G. (2006). Partial replacement of dietary fish oil with blends of vegetable oils (rapeseed, linseed and palm oils) in diets for European sea bass (*Dicentrarchus labrax* L.) over a long term growth study: Effects on muscle and liver fatty acid composition and e. Comparative Biochemistry and Physiology - B Biochemistry and Molecular Biology, 145(3–4), 389–399. <https://doi.org/10.1016/j.cbpb.2006.08.012>

COMPONENT 2: A preliminary study on cultivating local *Artemia* spp. as a collaborative project with PalatupanaSaltern, Lanka Salt Limited, Hambantota.

Responsible officer : R. Weerasingha, Mythily Panchalingam

Introduction:

The larval rearing of cultured species in Sri Lanka fully depends on live food. Among live food, *Artemia* spp. is one of the main and widely accepted live food sources. According to statistics from Sri Lanka Customs, Sri Lanka annually imports around 20,000 kg of *Artemia* cysts, accounting for 90% of the national requirement. It negatively impacts the economy of the country.

In Sri Lanka, *Artemia* spp. naturally inhabits Hambantota, Palavi and Puttalam salterns (Sunderam&Royan, 1984). They reported that salt-producing high saline sites in Palavi and

Hambantota show the potential for producing *Artemia* cysts. Studies have focused on improving *Artemia* farming in salt ponds through different culture systems, such as static Vs. flow-through systems & integrated culture systems, and one-cycle Vs. multi-cycle systems; feeding protocols; feed types and fertilization procedures (Hoa&Sorgeloos, 2015). However, with the climatic changes and other conditions in Sri Lanka, the production performances of *Artemia* could vary. Unexpected rains that cause prolonged low salinity and high water temperature on sunny days are the main constraints faced by local *Artemia* farmers.

The knowledge on feeding *Artemia* is not much developed among *Artemia* farmers. In general, stocked *Artemia* in the saltwater of 80 g/L is fed by green water pumped from a fertilization pond, sometimes conducting extra feeding with rice bran, fish meal, or formulated feed, as needed. However, maintaining good green water stock is also challenging for new *Artemia* farmers due to the high cost of inorganic fertilizers. So they seek optimum conditions and proper feeding protocols to maximize their cyst production.

Objectives:

- Identification of suitable growing media for adult *Artemiaspp*
- Observing suitable culture conditions for locally available *Artemiaspp*

Materials and Methods:

First, we met the field officer and the chairman of Lanka slattern limited, Palatupana, Hambanthota. Pond construction had been started. Further construction works had not been completed from the Lanka slattern side due to a lack of enough fund allocations. Therefore, the project was not conducted.

Meanwhile, a few field visits were arranged for meeting small-scale salt farmers in *Artemia* village, Puttalam.



Figure 1, 2 and 3: Partially constructed three ponds at Hambanthota



Figure 4 and 5: Naturally collected *Artemia* cysts

Figure 6: A constructed earthen pond to maximize natural *Artemia* cyst production



Figure 7 and 8: A demonstration of the status of the *Artemia* production in *Artemia* village



Figure 9: Slattern ponds that alternatively produce *Artemia* cysts



Figure10: Meeting *Artemia* farmers at Palavi with Export development board

COMPONENT 3:Application of Biofloc technology to enhance the aquaculture of Sri Lanka

Responsible officers : Amitha Adikari, Prajani Heenatigala

Introduction

In a world where more than 800 million people continue suffering from chronic malnourishment and where the global population is expected to grow by another 2 billion to reach 9.6 billion people by 2050, it is important to meet the huge challenge of feeding our planet while safeguarding its natural resources for future generations. In this context, aquaculture plays a key role in eliminating hunger, promoting health, reducing poverty, as well as generating jobs and economic opportunities.

On the other hand, global aquaculture has yet to face some serious challenges. For instance, aquaculture has been accused of being an unsustainable activity, because of the effluents discharged to the environment which contain an excess of organic matter, nitrogenous compounds, toxic metabolites, and elevated rates of chemical and biochemical oxygen demands. Other serious accusations include the competition for land and water, there is a need of a growing system with minimum or zero water exchange within the same culture tanks.

Thus, strategies aimed to overcome these challenges are required. In this regard, the modification of physicochemical variables of the culture system to favor the proliferation of particular biotic communities has been adopted not only to improve the recirculation of nutrients but also to use the biomass of such biotic communities as a direct food source for cultured organisms. Biofloc technology (BFT) has been identified as a solution to these problems. BFT is a technique of enhancing the water quality by the addition of extra carbon to the aquaculture system. Its promises to solve some of the above challenges and revolutionize aquaculture.

Experiment 1: Use of different carbon sources for the biofloc system during the early nursery stage of *Cyprinus rubrofuscus*.

Methodology

Location:

The study was conducted in the Aquaculture Research Center (ARC) of the National Aquatic Resources Research and Development Agency (NARA).

Experimental fish:

Fourteen days old *Cyprinus rubrofuscus* with a mean weight of 0.007 ± 0.004 g and mean length of 0.5 ± 0.2 cm were stocked in 18 rectangular fiberglass tanks with the dimension of 2m x 1.5m x 1.5m³. Experimental fish were stocked at 400 larvae per m² and continuous aeration was supplied throughout the culture period. Fish were fed twice daily using commercially prepared fish feed containing 42% crude protein. The culture period was 45 days and water exchange was not carried out throughout the culture period.

Preparation of experimental tanks:

Two weeks prior to the start of the experiments tanks were filled with conditioned water. Except for the control 5 ml, mother biofloc culture was introduced to each tank, and tanks were aerated vigorously to facilitate microbial growth and floc formation.

Source of Carbon:

Five treatments with three replicates were allocated randomly which consist of 100% molasses (MO), 100% rice bran (RB), 100% wheat flour (WF), 50% molasses + 50% rice bran (MR₅₀), and 50% molasses + 50% wheat flour (MW₅₀) that act as carbon sources to produce biofloc, while control treatment was maintained without the addition of carbon sources.

Maintenance of C: N ratio:

At the initial stage until floc formation C: N ratio was maintained 15:1 and at the maintenance phase, it was maintained at a 9:1 ratio. All the calculation was done according to Avnimelech (1999).

Organic carbon sources:

The formation of biofloc was begun with quantities of organic carbon sources proposed by Avnimelech (1999) and Ebeling et al. (2006), whereas a 15.1 C/N ratio was used until total ammoniacal nitrogen (TNN) concentration reached 1.0mg/l to stimulate the growth of heterotrophic bacteria. After TNN reached 1.0mg/l the C/N ratio was maintained as a 6:1 ratio to maintain the bacterial biomass of the bio floc(Avnimelech1999)

Water quality parameters:

After stocking, the main variables of the water quality were monitored daily. Temperature and dissolved oxygen by means of a digital meter (model 55; YSI), and pH with a digital pH meter (pH-10; Denver Instruments). Total ammonium nitrogen (TAN) by the salicylate method (8155), nitrite by the diazotization method (8507), and nitrate by the reduction and diazotization method (8171); these measurements were carried out weekly.

Results

Growth performances:

Compared to the control, the final body weight of MO, WF, and MORB was significantly high, and the highest average final body weight (0.18 ± 0.1 g) was recorded in WF treatment. MO, WF and MORB showed significantly higher avg. final body length compared to control.

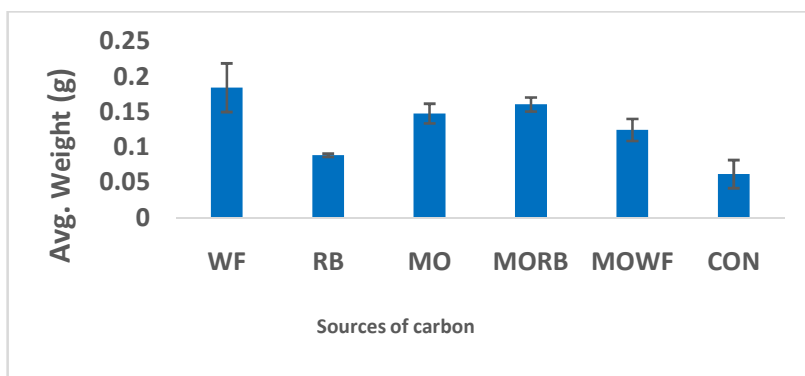


Figure 1: Final average body weight of fish

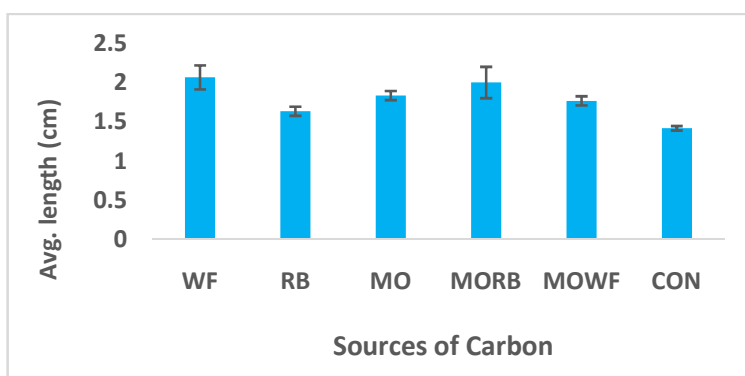


Figure 2: Final average body length of fish

The highest Weight gain percentage was recorded for WF treatment and the highest SGR percentage and survival rate were recorded for MO treatment.

Water quality and floc performances:

The temperature, pH, and dissolved oxygen concentration among the treatments ranged between 27.2- 29.5 °C, 6.9-7.4, and 9.2-8.4 mg/l respectively. Total ammonia nitrogen (TAN) levels were maintained at less than 1.0 mg/l throughout the experiment except for WF treatment.

Conclusion:

MO-based BFT system is more suitable to rear *Cyprinus rubrofuscus* post-larvae compared to the other carbon sources.

Experiment 2: Efficiency of non-fermented and fermented inoculants for biofloc culture of tilapia (*Oreochromis niloticus*) advanced fingerling stage

Objective:

Explore the possible contribution of biofloc technology application to tilapia advanced fingerling production in Sri Lanka

Specific Objectives:

- Evaluation of non-fermented and fermented biofloc inoculant for maintaining suitable water quality for tilapia advanced -fingerling culture.
- To evaluate most suitable inoculation method which gives good performance in tilapia advanced fingerling culture
- Evaluation of effect of BFT on health status of fish.

Materials and methods

Arrangement of experiment tanks and fish stocking.

The rectangular 12 fiberglass reinforced plastic (FRP) tanks were arranged in aquaculture research Centre (ARC) giving indoor condition and total culture period was eight weeks. FRP tanks with a capacity of 800 L were used and constant aeration systems were maintained for 24 hours.

Tilapia fingerling were acclimatized for 1 week prior to the experiment. In the tanks with the bioflocs, water were not be exchanged during the experiment period. However, the water was added to maintain the water capacity due to evaporation loss. Aeration was provided throughout the experiment. Commercial feed (Prima tropical fish feed, contained crude protein = 42%, crude protein = 10%, crude fibre = 4%) was provided daily in each tank at 5% of the total body mass. Daily feed rations were split into two equal amounts and given to all the tanks two times a day at 1000 am and 1500 pm.

Preparation of biofloc culture media

Biofloc is formed using wheat flour (WF), molasses and 50:50 mixtures of WFMOL by maintaining a C/N ratio at 20.

Water quality parameters and biometric indices

Water quality parameters and biometric parameters were measured as per the table below.

Water quality evaluation were done based on T, pH, DO, TAN, NO₂⁻, NO₃⁻, Volume of water used (to change water). Growth performance of tilapia were examined using Body weight, body length and survival rate.

Genotypic identification of bioflocculant-producing bacteria with 16S r- DNA sequencing

The high potential of bioflocculant-producing bacteria was further confirmed by genotypic identification through 16S rDNA sequencing. The boiling method was used to extract bacterial DNA. It was conducted as per the manufacturer's protocol. DNA is quantified using Nanodrop. All samples were measured in triplicates and the A260/A280 ratio. The quality of extracted DNA was checked through gel electrophoresis. In this study, PCR involved a single set of primers that targets a specific gene that was used to detect an organism. Extracted genomic DNA from individual isolated bacterial strains was subjected to PCR amplification of 16SrDNA using universal PCR primers, 8F and 1492R to amplify the 16S rDNA gene [31]. The sequences of primers used were; 8 Forward "5'-AGA GTT TGA TCC TGG CTC AG-3' " and 1492 Reverse "5'- ACG GCT ACC TTG TTA CGA CTT-3' ". All PCR reagents used for the amplification of bacteria followed recommended reaction volumes and final concentrations provided by the manufacturer. All PCR products were verified by agarose gel electrophoresis and visualized in the gel documentation chamber. Only DNA samples with a single band and clear PCR product shown on agarose gel were selected to be sequenced. The amplified PCR products were sent to the 1st Base Laboratory, Macrogen in Korea

Isolation and screening of bioflocculant bacteria from bioflocculant in each treatment

Samples of bioflocs have been transferred into Imhoff cone for 24 hours to allow the biofloc to calm down. The settled biofloc samples have been amassed by using siphoning out excess water. Biofloc that settled down in Imhoff cone turned into centrifuged at 6000 rpm for three mins to gain focused biofloc pellet. Isolation of bacteria from biofloc was executed via unfold plate technique of biofloc pellet at the surface of marine agar. Biofloc from each pond changed into plated in 2 replicates. Plates had been incubated at 30°C for in a single day. Isolate bacteria and prepare stock cultures to further studies.

Total Viable Count of Bacteria in BFT

A study was carried out to evaluate the total count of bacteria which is in both fermented and non-fermented culture systems in the experiment to evaluate the number of total bacteria involved and gain of the bacterial community in the biofloc with comparison. When determining the colony forming units per 1ml, Take 1ml from each replicate and dilute in serial dilution. And thereafter take 1ml from each selected dilution factor and plated it from the pour plate method to evaluate the total count. After 24hrs, count the colonies using the colony counter

Morphological observation and phenotypic characterization of biofloculant-producing bacteria

Morphological characteristics of biofloculant-generating bacteria were accomplished with the aid of microscopic observations and the use of the Gram staining approach. Phenotypic identification became absolutely achieved according to Bergey's guide of Systematic Bacteriology to decide the taxonomy of isolated biofloculant-generating bacteria because it provided descriptions and photographs of species and assessments to differentiate amongst genera and species. In this study, most of the phenotypic characteristics of the isolates were similar to those indicated by Bergey's Manual of Systematic Bacteriology. Based on biochemical characterization, biofloculant-producing bacteria are going to identify in ongoing process to get results.

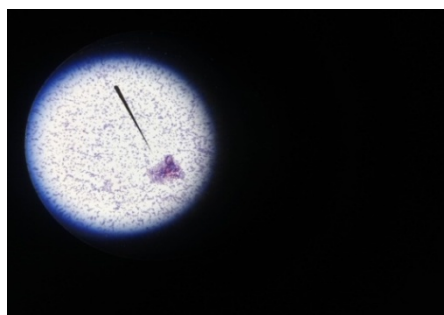
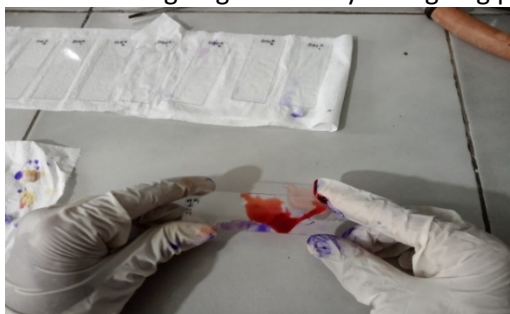


Figure 3. Gram staining of biofloculant bacteria sample

Determination of the flocculating activity of biofloculant-producing bacteria

All identified biofloculant-producing bacteria were cultured in enrichment medium (The enrichment medium (per litre): 10.0 g of glucose, 0.5 g of urea, 0.2 g of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 5.0 g of K_2HPO_4 , 2.0 g of peptone, 0.2 g of KH_2PO_4 and 0.5 g of yeast extract in distilled water). Inoculum was prepared by incubating in a Shaking water bath, with 200 rpm at 30°C for 3 days. The resultant culture broth was centrifuged using a centrifuge at 8,000 rpm for 30 minutes at 4°C . The cell-free supernatants were used as produced biofloculant to determine the flocculating activity of the bacteria. The flocculating activity was measured using a modified Kaolin clay suspension method. Five gram of kaolin clay was suspended in 1 l of deionized water for preparation of 5.0 g/l of kaolin clay suspension. Kaolin clay suspension was adjusted to pH 7. For flocculating activity, 240 ml of kaolin clay suspension and 10 ml of biofloculant solution (cell-free supernatant) were added into 250 ml beaker. By using homogenizer, the flocculating activity was started with rapid mixing at 230 rpm for 2 minutes, followed by slow mixing for 1 minute at a speed of 80 rpm. The stirring speed was reduced to 20 rpm and stirring was continued for 30 minutes. The stirring apparatus was stopped and the samples in the beakers were allowed to settle for 30 minutes. The optical density (OD) of the clarifying solution was measured with a Spectrophotometer at 550 nm. A control experiment was prepared using the same method but the biofloculant solution was replaced by deionized water. The flocculating activity was calculated as follows;

Flocculating activity: $[(B-A)/B] \times 100\%$

Where A and B were absorbance at 550 nm for sample and reference respectively.

Results

The results of the study revealed that the fermented inoculant (FI) treatment showed higher final body weight and higher final body length compared to Non-fermented inoculant (NFI) treatment. FI showed higher weight gain compared to FI. FI showed a higher specific growth rate compared to NFI but the Feed conversion ratio of different treatments were no significant difference among treatments ($p>0.05$). NFI showed highest mortality and lowest survival rate compared to other treatments.

Table 1: Water quality parameters among different carbon sources

	Carbon source				
Parameters	CON	FI	NFI	MB	SE
pH	6.17 ^a	6.77 ^c	6.40 ^b	6.23 ^a	0.04
DO (mg L ⁻¹)	8.45 ^a	7.85 ^b	8.03 ^c	7.78 ^b	0.04
Temperature °C	27.11	27.14	27.16	27.12	0.02
TAN (mg L ⁻¹)	1.72 ^a	0.45 ^c	2.91 ^b	1.31 ^a	0.18
NO ₂ ⁻ (mg L ⁻¹)	0.51	0.44	0.61	0.78	0.15
FV (mL L ⁻¹)	0.10 ^a	7.44 ^b	0.36 ^a	5.74 ^b	1.5
TSS (mg/L)	18.12 ^a	143.26 ^b	66.00 ^{ab}	175.26 ^b	38

Total Viable Count of Bacteria in BFT

In culture water, total count of bacteria during the experiment. Initial (0th day) total bacteria count was shown in the table, in Fermented, non-fermented and clear water system respectively. Subsequently, total count of bacteria was increased in fermented treatment than non-fermented and clear water treatments.

Table 2. Total count of bacteria (CFU/ml)

	Replicates	Initial CFU/ml	Final CFU/ml	Gain of
Fermented	T2R1	144×10 ³	17×10 ⁵	
	T2R2	64×10 ³	12×10 ⁶	
	T2R3	196×10 ³	11×10 ⁵	
Non-fermented	T3R1	24×10 ³	1×10 ⁷	
	T3R2	54×10 ³	26×10 ⁴	
	T3R3	15×10 ⁴	58×10 ⁴	
Control	C1	45×10 ¹	4×10 ⁴	
	C2	1×10 ³	77×10 ³	
	C3	45×10 ¹	72×10 ³	

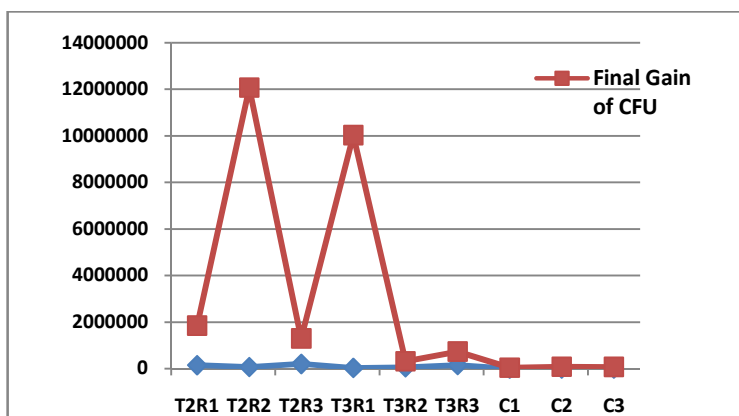


Figure 4. Comparison between final and initial total bacteria count

Morphological observation and phenotypic characterization of biofloculant producing bacteria

In this study isolated bacteria species are unsuccessfully identified bacteria because results are pending yet. Those isolated bacteria most can identify as similar to bacterial genera known as bacillus for now. In this study, most of the phenotypic characteristics of the isolates were similar to those indicated by Bergey's Manual of Systematic Bacteriology. Based on biochemical characterization, biofloculant producing bacteria are going to identify in ongoing process to get results.

Table 3. Phenotypic characterization of freshwater biofloculant producing bacteria isolated from biofloc

	Gram Staining	Pigmentation	Shape	Catalase	Oxidase	Starch Hydrolysis
Unknown 1	+	White	Rod	+	-	+
Unknown 2	-	White	Cocci	-	-	-
Unknown 3	+	White	Rod	+	-	+
Unknown 4	-	White	Rod	+	+	+
Unknown 5	+	White	Rod	+	+	+
Unknown 6	+	White	Rod	+	-	+
Unknown 7	-	White	Rod	+	-	+
Unknown 8	-	White	Rod	+	+	+
Unknown 9	+	White	Cocci	+	-	-
Unknown 10	+	White	Cocci	+	-	-
Unknown 11	+	White	Cocci	+	+	-
Unknown 12	-	White	Cocci	-	+	-
Unknown 13	-	White	Cocci	-	-	-
Unknown 14	+	white	Rod	+	-	+

Conclusions

Fermented inoculants with *bacillus sp* shows higher performances in biofloc system in *Oreochromis niloticus* advanced fingerling stage

COMPONENT 4: Development of commercial scale pearl oyster industry in Sri Lanka

Responsible officer : A.M.C. Pradeep Kumara

Introduction

High demand with esteemed price made pearl as queens of the jewel. Historical sources indicates that economy of several countries bordering the Indian and Pacific Oceans and some countries along the Eastern Atlantic Ocean was particularly dependent on pearl fishing prior to the twentieth century. In Sri Lanka, particularly The Gulf of Mannar was well known for most abundant sources of

natural pearls in the world. The underwater pearl banks that stretch from Mannar Island south to the coastal town of Chilaw are located in depths ranging from five to ten meters. Sri Lankan pearls enjoyed a wide international popularity, but at the beginning of the 20th century, the pearl fishing industry was declined due to the number of reasons mainly by climate change and others such as sand silting up the beds, attacks by predacious fish and other enemies, overfishing, overcrowding of beds by the oysters and disease.

For pearl culture, culture sites should be naturally sheltered against strong waves, winds and current during monsoon period. Bay areas are the most preferable area for pearl mariculture practices and it help for operate the system all year round.

Objectives

- Identify a suitable location for pearl oyster culture practices on the East Coast.
- Develop and establish suitable techniques in spat collection and rearing of matured pearl oyster species.
- Morphometric and Genetic identification of collected pearl oyster species from Gulf of Mannar.

Activities carried out

- Monitoring the Growth performance, survival and mortality of the previously (2021) collected pearl oysters to Trincomalee/Cod Bay sea area
- Develop spat collecting materials and spat attachments and maintaining matured oysters prior for nucleation
- Analyze environmental parameters to identify optimal conditions for pearl oysters
- Identify pearl oyster species in genus level before pearl nucleation

Results

According to the water quality parameters and environmental parameters, Trincomalee / Cod Bay area selected as for the experimental pearl oyster culture site in the East coast, Sri Lanka.

Stocked 8,000 of Pearl oyster species on 2021 at Cod Bay sea area in Trincomalee and monitored the Survival rate, Spat fall and environmental parameters on year 2022.

Survival rate of Pearl oysters in Cod Bay culture site in 2022 - 96.75%

Number of spatfall- 2575

Number of pearl oyster rafts prepared in 2021 in East coast – 06

Number of spat collectors maintained – 120

Table 01: Average size of pearl oysters stocked in Cod Bay sea area

Average length (mm)	54.5 ± 3.5
Average Width (mm)	43.85 ± 0.15
Average Height (mm)	10.7 ± 3.3
Average body weight (g)	21.93 ± 0.57

- Morphometric and Genetic analysis were done to analyze Pearl oyster Samples and identified the species as *Pinctadafucata* -The Akoya pearl oyster with a genetic lineage specific to the Indian Ocean.



Figure1: Prepared Pearl oyster muscle samples for genetic identification

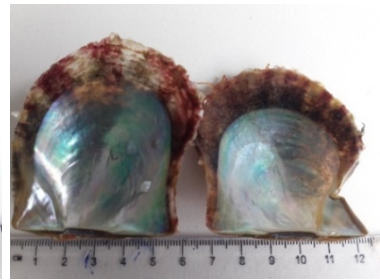
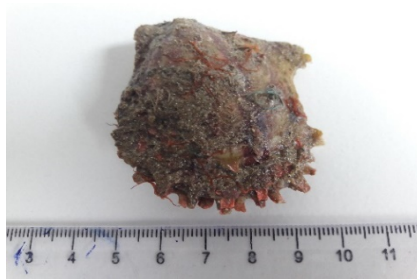


Figure 02, 03: Pearl oyster samples for morphometric identification

Output:

- Introduce non-traditional aquaculture to fisher communities.
- Diversification of cultured aquatic organism species in mariculture industry in Sri Lanka
- Initiate pearl oyster farming in selected culture ground with suitable culture techniques.

Outcome:

- Development of suitable raft, pearl oyster culture structures and spat attachment materials
- To check the identified secondary culture grounds against experimental pearl oyster raft culture
- Receiving of expertise knowledge regarding technical and scientific issues in pearl oyster culture.

Constraints

- Due to economic crisis hard to achieve regular monitoring studies monthly.
- Due to lack of labor force there some delays in achieving Targets

Component 5: Promoting oyster (*Crassostrea madrasensis*) and Green mussel (*Perna viridis*) in the coastal regions of North and East.

Officers Responsible: A.S.L.E. Corea

Introduction

Mollusc culture is an established aquaculture process in many countries. In Sri Lanka it is not a common aquaculture practice specially as molluscs are not favoured as a food item within the country. However they are consumed in areas where they are found naturally. And it is also utilized in the tourism trade as many hotels use them in their menus. Therefore this is a novel aquaculture practice that could increase the income of coastal fishing families

Possibility of introducing edible oyster culture as a community based project for Trincomalee district was commenced in 2021. Since the funds were restricted the project was limited to Trincomalee in the Eastern province and to study the possibility of breeding oysters in the area to support culture activities. Studies on growth and survival of oysters *Crassostrea madrasensis* was carried out in Trincomalee during the '90s. However it was not introduced as a commercial venture as spat were not readily available in the area and transport of spat from other areas for commercial culture was not feasible. The present study selected a location where growth had not been studied previously, but since the lagoon area consisted of a cove it would be easy to develop spat as well as collect them, because drifting of spat with currents would be minimal in this area.

A feasibility study on green mussel culture in Mannar was planned with establishing breeding colonies to produce spat. However due to lack of funds this part was not commenced

Goal and objectives

Main goal is to Increase the commercial bivalve culture among fisher communities by achieving the following objectives

- To identify suitable culture sites and select communities to take up oyster culture
- To introduce culture methodology to selected community participants through training workshops
- To study the breeding of oyster in selected sites and the spat availability for culture purposes
- To collect necessary spat from nearby areas for culture activities
- To provide necessary material and technical knowledge

Justification /Rationale

A feasibility study on oyster culture will be carried out in Trincomalee in selected sites as it has been proved that oyster culture can be carried out in Trincomalee. Sites would be selected to promote community based culture activities, so that it would benefit small fisher communities. Easy access to spat will be studied by establishing a breeding colony of oysters that would provide spat for the culture activities in the area

Activities planned

- To establish 2 community based oyster culture projects in Mannar
- To establish a community based oyster & green mussel culture in Trincomalee
- To find out the potential of green mussel culture in Mannar
- To study the breeding potential of oysters in Trincomalee

Methodology

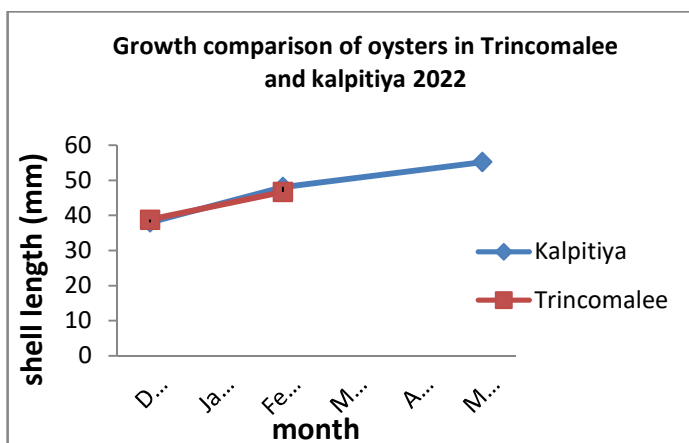
Oysters transported from Kalpitiya were to be grown in Trincomalee and their breeding was to be monitored. Suitable communities to be selected to carry out Green mussel and oyster culture to be selected. Transferring of spat collection technology for already available green mussel culture and to provide technological inputs were anticipated.

Results

Due to the fuel crisis and financial restrictions, selected sites could be visited only twice. (February and May) during the field visit in May it was found that all rafts containing mollusk grow baskets had been stolen and the mollusk baskets were deposited at the bottom of the lagoon. About 50% animals had died due to sediment accumulation in the cages

NARA management decided to stop the project at this point due to financial restrictions.

The results obtained up to the time of stopping the project showed satisfactory growth compared to the growth observed in Kalpitiya.



The growth could have been similar to kalpitiya at this site if, culture activities were continued. Breeding could not be studied as the project was stopped before the reproduction season.

During the first field trip only growth and survival were observed. No spat were observed. However since this was a non-breeding season spat were not expected. The only activity carried out during next field trip was to restore the culture basket, clean the oysters and remove dead animals and build a temporary rack to hang the baskets. The site was not visited thereafter as the management decided to stop the project and DG informed this verbally.

Conclusion

No conclusion could be reached as the activities were stopped in the middle of the project. Only one field visit was carried out to study the growth survival and breeding, but this was during the non-breeding season. Thereafter the next field activity was devoted for restoring the live animals. Subsequently the project was ended by NARA management.

COMPONENT 6: Investigate the disease conditions of cultured Ornamental Fish and Shrimp in Sri Lanka

(a). Investigate the disease conditions of Cultured Ornamental Fish in Kalutara and Gampaha District in Sri Lanka.

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

Specific Objectives:

- Investigate the new pathogens encountered in ornamental fish and understand the pathogenicity, therapeutic and control measures.
- Study the seasonality of the pathogens inhabiting in fish species.
- Understand the environmental conditions related to prevailing disease outbreaks.
- Aware the farmers to identify disease conditions and to apply control measures. .

Physical activities carried out.

- Survey on recently encountered disease condition, susceptible species in ornamental Industry.
- Selected Ten ornamental farms in Kalutara and Gampaha district.(with coordination of NAQDA)
- Visited each farm once in three month and collected samples from infected fish species.
- Water samples collected from each pond containing infected fish.(Dissolve Oxygen, Ph, Ammonia, Nitrite, Nitrate, Temperature measured.)
- Fish samples analyses for parasite and bacteria according to the clinical symptoms.

- Histopathological samples were collected for understand the pathological damage of the fish.
- Bacteria cultured and identify for species level (conventional methods) & tested the pathogenicity under laboratory conditions.
- Antibiotic susceptibility tested with commercially available antibiotics.



Selected Ornamental fish farm and Sample collection

Results

In Kalutara district Hadapangoda area was focused for the study as the fish mortality recorded in 2021. Five farms were selected for the study. Three field visits were conducted due to fuel crisis and limited financial allocations. Total 57 guppy fish were collected throughout the experimental period. Main parasites which were encountered in Kalutara is *Trichodina*.

Three farms have been used disinfectants (KMnO_4 , Cl_2 etc) when taking samples. Therefore we couldn't see the parasite in those farms during the sampling period.

In Gampaha district 89 fish were collected and contain guppy, Sward tail and Angels.

District	No. of farms	No. of field Visit	No. of fish sampled
Kalutara	05	03 (Feb., June, Sep.)	Guppy, 14, 20, 23 (57)
Gampaha	04	03 (March, Aug., Oct.)	Guppy, Swardtail, Angel 42, 25, 22 (89)

Average Water Quality of selected farms in two District.

Kalutara District:

Farm No.	DO (mg/l)	PH	Tem (C ⁰)	NH ₃ (mg/l)	NO ₂ ⁻ (mg/l)	NO ₃ (mg/l)
1	3.45	6.96	26.7	0.42	0.368	0.884
2	3.8	6.97	27.0	0.425	0.193	0.918
3	8.8	7.04	27.1	0.98	0.15	0.488
4	5.0	6.94	27.9	0.11	0.746	0.636
5	3.2	6.9	27.1	0.11	0.305	0.110

Gampaha District:

Farm No.	DO (mg/l)	PH	Tem (C ⁰)	NH ₃ (mg/l)	NO ₂ ⁻ (mg/l)	NO ₃ (mg/l)
1	3.6	6.82	28.1	0.11	0.039	2.23
2	6.0	6.97	27.6	0.44	0.034	1.1
3	4.8	22.12	27.3	ND	0.025	1.35
4	8.13	7.04	27.65	0.21	0.068	1.23



- Farm no.4 recorded high infection with *Trichodina* in all 3 samples .Higher levels of NO₃wererecorded all farms in Gampaha.
- Farmers were aware with the therapeutic usage of 2g/ l salt is effective for totally eradicating *Tricodina* ,*Gyrodactylus*(Skin Flukes),*Dactylogyrus* (Gill flukes were rarely encountered.
- Experiment was conducted for investigating the immunity development of Guppy by supplementing the feed with Garlic.

Conclusions

- *Trichodina*, is the common parasites in two districts.

Outputs

- Isolated bacteria for guppy and Angels are non pathogenic.
- External parasites are not prominent in aquarium fish.

Constraints:

- Unable to continue the project work due to fuel shortage, lack of chemical an insufficient allocation.
- 2.Histopathological samples couldn't process due to lack of instruments.

(b) Disease monitoring, prevention, and monitoring water quality conditions for health management in the shrimp aquaculture industry in Sri Lanka

Officer Responsible: P.Mythily, L. Jayasekara, P.P.M.Heenatigala

Introduction

In recent years, the shrimp culture sector has grown enormously. It indicated that 14,415 mt of the total production of which *Litopenaeusvannamei* contributed 75% in 2021.*L. Vannamei*was introduced to Sri Lanka for the first time in 2018 using SPF brooders that were imported. However, it is still unknown how this species will affect our cultural system. Numerous diseases commonly afflicted cultivated shrimp throughout the world, and these disease-causing organisms are to blame for high mortality rates and significant financial losses for this business. On a regional and global scale, the

emergence and rapid spread of serious diseases of penaeid shrimps have been primarily caused by poor industry practices, such as the careless trans-boundary movement of brood stock, poor better management practices, and poor disease surveillance programs.

A shrimp disease surveillance system is required for pathogen control, early infection identification, routine disease status monitoring, and quick response in the control of pathogens. In addition, surveillance can identify emerging and re-emerging diseases in shrimp aquaculture. Prevention of diseases in aquaculture is required, as cures are hard to achieve and intervention after the onset of a disease is often difficult and costly. Even optimally managed ponds cannot completely prevent disease outbreaks, but early detection of disease is an important aspect of effective biosecurity.

The main viral diseases reported in Sri Lanka were white spot syndrome virus (WSSV), *Monodonbaculovirus* (MBV), and yellowhead disease (YHD) in *Penaeus monodon* cultures (Munasinghe et al., 2010). Recently, some studies reported the occurrence of IHHNV and WSSV infections in *P. vannamei* cultures in Sri Lanka (Jayasekera and Heenatigala, 2021). Similarly, in 2022, the first report of *Enterocytozoon hepatopenaei* (EHP) infection in *P. vannamei* shrimp culture was recorded. Therefore, close monitoring of *P. vannamei* farming in Sri Lanka is an urgent requirement for disease prevention and management in the culture system (Ananda et al., 2022).

Main objectives:

Disease monitoring, prevention and health management in *L. vannamei* culture

Objective/s

- Monitoring/ identify the disease outbreaks in *L. vannamei* culture systems.
- Identify the suitable preventive and control measures to minimize the virus disease outbreaks in shrimp aquaculture.
- Minimize losses from disease outbreaks through early disease diagnosis.
- Recommend suitable control measures and corrective actions for the disease identified
- Develop of database on disease outbreaks in shrimp aquaculture

Methodology

- Samples were collected representing all 5 shrimp culturing zones and background data collected with the help of pre developed questionnaire.
- DNA was extracted using extraction buffer of IQ 2000 test kit
- PCR was performed with Test kit IQ 2000.
- Identification of disease positive shrimps.



Figure 1 & 2 : Field data collection



Figure 3: Analyzing samples

Diseases monitored under the disease monitoring programme

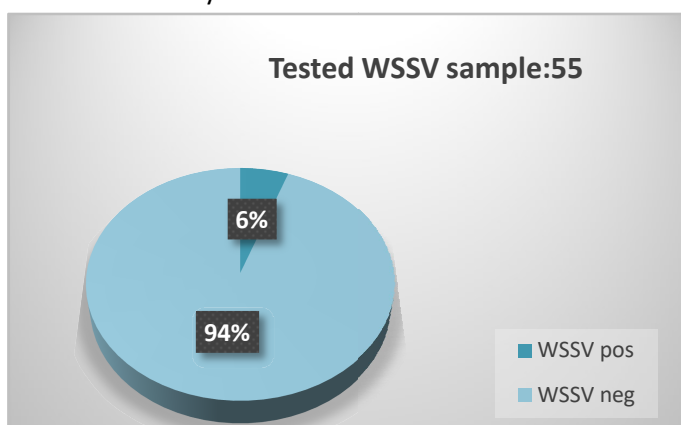
- White spot disease (WSSV)
- Infectious Hypodermal and Haematopoietic Necrosis disease (IHHNV)

- Acute Hepatopancreatic Necrosis Disease (AHPND)
- Necrotizing hepatopancreatitis (NHPB)

Results

- 29 farms were monitored randomly with 55 samples from different shrimp subzones including Katakaduwa, Koththanathiv, Mangalaeliya, Kakkapalliya, Thoduwawa, Iranawila, Bangadeniya/Kumbulukuliya, Arachchikattuwa, Mandamanthivu/Madurankuliya, Ambakandawila, Kusala, Kudaverankatuwa, verankattuwa, Bagahavetiya, Manalthive, Karamba, Pularthivayal, Kuduiruppuwa areas covering all 5 zones.
- Stocking densities of the selected grow out ponds were ranged from 40-250, varied with the grade of the farm. Most of the “C” grade farm stocked in 40/m²

Prevalence analysis on WSSV with current data



Total num of farms visited: 29

Total num of sample analyzed: 55

Total num of positive sample: 03

- Out of the 48 samples tested for each virus, findings indicated, 6 % of the farm's presence for WSSV with the detected level of infection as indicated in system's instruction manual
- The samples that tested positive for WSSV were collected from the area of Madurankuliya

Other disease test results

- Samples tested for IHNV show negative results in randomized collected samples
- The samples tested for AHPND / NHPB show negative results in randomized tested sample

Output

- Generating disease incidence data sheets based on regular monitoring of shrimp farms periodically.
- Identification of emerging diseases in the industry alongside existing diseases

Outcome

Generating data map including disease data sheets (emerging/existing), water resources, the way disease spreads (including all sources of input, and management strategies), the level of BMP adopted by different sub-zones, etc for better disease management strategies.

Conclusions

With the data available for this year, the annual incidence of white spot syndrome virus (WSSV) is 6%.

Recommendations

- Continue to collect data on existing diseases in our shrimp industry every year and generate their prevalence data sheets

- Expansion of PCR diagnosis of shrimp diseases further for the diseases by using commercial diagnostic kits (Taura syndrome (TSV), Yellow head disease (YHV), Necrotizing Hepatopancreatitis (NHP), Acute Hepatopancreatic Necrosis disease (AHNDP), EHP(EnterocytozoonHepatopenaei))
- Expansion of bacteriological studies in the culture system (identify the bacteria species, counts, etc.)
- Identify the BMP followed and create a management strategy at zone levels to minimize the disease incidence and spread

Constraints

- Due to the economic crisis, regular field inspections were hindered
- Lack of human resources to monitor water quality conditions in Effluent and Estuarine Water source in the Shrimp Farming area in Northwestern province,

Progress (Project 1.2) : Financial : 100% Physical Progress : 94%

PROJECT NO : 1.2

ENHANCEMENT OF EXPORT ORIENTED AQUACULTURE INDUSTRY IN SRI LANKA THROUGH DEVELOPMENT ORNAMENTAL FISH, AQUATIC PLANTS AND SEA WEED CULTURE TECHNOLOGY.

Officer/s Responsible : Mrs.Ramani Shirantha, Mr.Sarath Jayanatha, Mrs.T. Nuwansi,Mrs. S.Sugeehwari, Mrs.Harshanee Deepa kumari, Ms.P. Mythily
 Duration : 1 year (started 2021)
 Location/s : Around Sri Lanka
 Total Allocation : LKR 1.0 million

COMPONENT 1: Science & Technology Application to Strengthen Export Oriented Endemic Ornamental Fish Industry and Conservation of Threatened Fishes

Responsible Officer (s) : Ramani Shirantha

Introduction:

NARA as a national body has to maintain a collection of rare endemic fishes for education/awareness purposes and also needs to develop conservation strategy with advanced breeding technology for supplying of quality brooders for export oriented fish industry. Thus the project was focused to supply quality brooders through technology development of the selected export demanded endemic fishes. As per request made by the Ornamental Fish Export Association of Sri Lanka, captive breeding of the fish species given below was continued but the production numbers is very low. This may possibly due to the poor quality of brooders.

Objectives:

- To supply quality brooders of seven endemic fishes for ornamental fish breeders/exporters
- To improve captive breeding technology of *Malpuluttakretsiri*

Activities carried out:

1. Breeding technology development for Devariopathirana

In August 2021, about 20 sub-adults >4.5 cm in total length were collected from “*RadaDola*” stream at Rakwana. They were then reared in glass tanks (45 cm x90 cm) and were fed with ox-heart twice a day for nearly six months at NARA. In February 2022, sexing was done and were introduced at 1:2 (male to female) ratio to a rounded cement breeding tank (90 cm in diameter) with three layers of aquatic plants at 60 cm water depth. The fish stocking density was 15 individuals/tank. Some water

quality parameters were also measured biweekly. The tank was observed every other day for presence of eggs, fry, fingerlings but no water-exchange or air supply was done over a three month period. Once breeding trial was success, the fry were captured, number was counted, length& weight of each were obtained and released back to the tank.

The fecundity was assessed as; no of fry/5 (total no. of females) whereas the fry survival was assessed as; initial no. of fry/no of fingerling after two months.

Results:

The offspring of *D. pathirana* can be sized up to 3.0 cm TL with 0.28 g average body weight in a three months period if fed with chopped ox-heart twice day. It was found that *D. pathirana* has 80 average fecundity and it is a serial spawner that shades the eggs in several batches within a single spawning cycle. This species reported a low larval survival (55%) but with five pairs, a total of 225 fish production can be obtained in six months period. Thus, the technology developed can be considered as an easy, low-cost, simple and rapid compared to already known breeding methods.

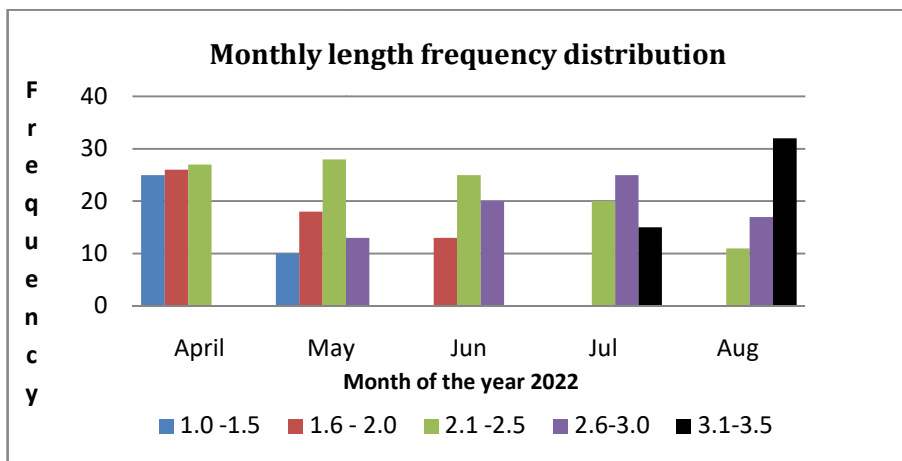


Figure 1: monthly length weight frequency distribution of *Devariopathirana*



Fry of *D. pathirana*



Weight recording of *D. pathirana*



Collecting of fingerlings *D. pathirana* to take measurements.



Three months aged *D. pathirana*
(3.0 cm length & 2.8 g body weight)

Figure 2: Some photo illustrations of the *Devariopathirana* breeding experiment

2. Breeding of other endemic ornamental species

Only one field visit was made to Deraniyagala area to collect gravid *Garraceylonensis*. They were sexed, reared separately in cement tanks. After four months period four pairs were selected and introduced to a specific breeding tank of gravel substrate and water recirculation system. They were given a single dose of ovaprim hormone (0.05mg/g per body weight). Just after injection male fish started to chase female but breeding was not induced properly. The experiment trails are still going on with reduced hardness in the water.

3. Breeding technology development for *Malpuluttakretsiri*

This experiment was initiated using totally covered (30 cm × 20 cm) cement tanks of 20 cm water depth which tanks were kept at the indoor aquarium at NARA. The length of brooders were varied from 4.2 (female) -5.2 (male) cm. Each pair was introduced to separate tanks. Cool water shock was given in every morning and evening in order to induced them for spawning. After 5-6 days they showed courtship behavior, built bubble nets but none of them shed their eggs. The experiment designed changed and next step will be trailed out. Breeding of other endemic fish species for which species captive breeding technology has been developed during the past years were continued.

Infra-facility development

One 10'×10' fish breeding cement tank was renovated.

The following fish species were collected and now rear at NARA.

Fish species	No of pairs at NARA
<i>Garraceylonensis</i>	5
<i>Pethianigrofaciata</i>	10
<i>Pethiareval</i>	15
<i>Pethiabandula</i>	12
<i>Pethiacumingii</i>	15
<i>Puntiustitteya</i>	20
<i>Malpuluttakretseri</i>	5
<i>Belontiasignata</i>	20
<i>Devariopathirana</i>	25
<i>Rasboroidesvaterifloris/R. palidus</i>	15

10 different species of rare endemic fishes were displayed at the exhibition conducted by the National Zoological Gardens from 23 to 31 December 2022.

Major Findings and outputs

An easy low-cost breeding technology for mass production of *Devariopathirana* using a still tank system.

Constraints

Lack of sufficient enough fish stocking tanks.

COMPONENT 2:Development of breeding technology on high value exotic ornamental fish species.

Responsible Officer(s) : N.P.Harshani Deepakumari

Introduction

Aquarium keeping is one of the most popular of hobbies with millions of enthusiasts worldwide. Together all countries of the European Union and United State have the largest market for ornamental fish. The vast majority of ornamental fishes in the aquarium trade are from freshwater origin and farm-raised (Leal et al. 2015). Most of the ornamental fish is sourced from developing countries in the tropical and sub-tropical regions (Andrew C.2006).

As a result of advancements in breeding, transport and aquarium technology, more and more species are being added every year. The ornamental fish industry in Sri Lanka has a long history, which began with small-scale and has now developed into a thriving export industry which provides significant income and employments to many people. Sri Lanka as a country has highest export potential in exporting ornamental fishes to the world (Wijesekara R.G.S and Yakupitiyage A. 2001). Guppy, Neon tetra, Platy, Swordtails, Molly, Angels, Goldfish, Zebra danio, and Discus are the main ornamental fish species dominating the Sri Lankan export market. Out of these species, 60% of the total exports consist of Guppy, Swordtail, Platy, and Molly (EDB). But there are high demand for the new varieties of ornamental fish hence development of new varieties and breeding of them in the country is paramount.

But the breeding of exotic ornamental fish species is difficult under local conditions and development of induce breeding technology is paramount. (Kithsiri, Rupika and Siriwardena, 2006). Induce of breeding of fish can be done in two methods including captive breeding using hormones and manipulating environmental conditions (Induced Reproduction in Fish | Minnesota Sea Grant, 2020).

Objectives

- Develop breeding technologies for high value exotic ornamental fish varieties (collaborate with NAQDA)

Activities carried out (Methodology)

This project was planned to conduct as a collaborative project with National Aquaculture Development Authority (NAQDA). NAQDA was the responsible party to import brooders of high value ornamental fish that are having suitable characters. NARA was planned to purchased certain varieties of imported brooders and develop technology. But unfortunately NAQDA didn't import brooders. Therefore NARA decided to purchase fish that were decided to import from local market according to the availability.

1. Development of method to increase the hatching rate and larval survival of barb fish (*Barbusconchonus*)

This experiment was started in 2021 and finalized in 2022 with several breeding trials. *Barbusconchonus* eggs were conditioned with several doses of L-Ascorbic acid as 0, 250, 500, 750, 1000, 1250mg/l. Each treatment was conducted with three replicates. Hatching time, hatching rate and larval survival rate were determined for each treatment.

2. Development of induce breeding method for Thai oranda goldfish (*Carrasiusauratus*) using double dose of hormone.

Thai Oranda goldfish (*Carrasiusauratus*) were purchased from local market and breeding technology was developed. Purchased brooders were conditioned with high protein diets until sexually matured. Breeding trial was conducted using double doses of commercially available hormone, ovulin as 0.0, 0.5, 0.7 and 1.0ml/kg for female and single dose for male. The second dose of hormone for female given after 2hrs of first dose and male were injected after 1hr of second dose of female. Each dose was given in three replicates.

3. Development of diet to increase fecundity and larval survival rate for green cobra guppy (*Poecillia reticulata*)

This experiment is going on. Guppy fish diets were prepared using different doses of L-Ascorbic acid as 0, 100, 200, 300, 400mg/kg. Four weeks old green cobra guppy fish were used for the experiment

and they were fed with prepared diet until reproduction. Maturation period, fecundity, larval survival rate, growth performance of guppy will be determined.

Results:

1. Development of method to increase the hatching rate and larval survival of barb fish(*Barbus conchoni*)

When barbfish eggs were conditioned with 1000mg/l L-Ascorbic acid hatching time was reduced to 48hrs. Hatching rate was significantly different between treatments and best hatching rate (81%) was observed when eggs were conditioned with 1000mg/l L-Ascorbic acid. Survival rate of hatchlings were also increased up to 83% with the use of 1000mg/l L-Ascorbic acid.

2. Development of induce breeding method for Thai oranda goldfish (*Carrasius auratus*) using double dose of hormone.

Fecundity and hatching rate were significantly different among the treatments and best fecundity was observed when using double dose of 0.7ml/kg for female and single dose for male as (1016 $\pm$ 45 eggs). Latency period was 6hrs and hatching rate of eggs was recorded as 83.97%. According to the results thaioranda goldfish can successfully induce for breeding using double dose of 0.7ml/kg for female and single dose for male.



Figure 1: Selection of sexually matured brooders, administration of hormone, breeding behaviors and hatchlings

3. Development of diet to increase fecundity and larval survival rate for green cobra guppy (*Poecillia reticulata*)

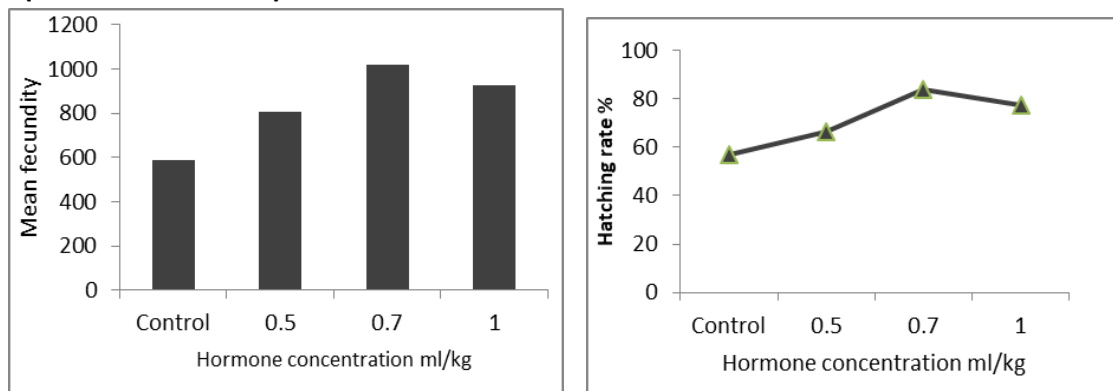


Figure 2: mean fecundity and hatching rate

This experiment is on-going. Diet preparation was finished and feeding is going on. Still fish were not start to reproduce. Growth performances were determined up to date. There is a significant difference between treatments for growth performances.



Figure 3: Feed preparation and trial

Conclusions:

L-Ascorbic acid can successfully use to conditioned the breeding tank water to reduce the hatching time and increase the hatching rate and survival rate for barbfish. Oranda golfish can successfully breed using 0.7mg/kg double dose of ovulin for female and single dose of male.

Recommendations:

1000mg/l L-Ascorbic acid can use to incubate *barbusconchoni* eggs.

For Thai oranda goldfish 0.7ml/kg ovulin double dose for female and single dose for male can use to induce the breeding.

Outputs & outcomes:

Transfer knowledge to society through training programs.

Constraints:

- High value exotic fish species were not imported by NAQDA due to economic crisis and therefore this project was conducted only using the species available in the local market.
- Sudden water quality changes (sudden drop of hardness of water) affected the maturation of goldfish during August, September and October months. Hence conditioning water up to required water quality level took time and affected to the sexual maturation of gold fish.
- The limitation of reporting to work during fuel crisis period also affected to the continuation of trials.
- Success of the experiment is completely depend on the sexual maturity of the fish and it's out of human control.

COMPONENT 3: Development of *in - vitro* propagation protocols for high demand aquatic plant species.

Responsible Officer(s) : D.M.S. Sugeeshwari

Introduction:

As this ornamental aquatic plant industry, has focused to the export market, it is very much importance to get large number of plant production. This could be achieved by using micro propagation techniques. Hence the National Aquatic Resources research and development agency, plant tissue culture laboratory has undertaken various research to develop protocol for the selected aquatic plants and conducting mass production of aquatic plants to the plant house of the NARA.

Aponogeton is genus of aquatic plants which belongs to the family Aponogetonaceae. There are six species occurring in Sri Lanka and except *A. crispus* other species are in IUCN Red list. But there is a huge demand for these species for world market. (Amarawansa T.W.G.J.C *et al*, 2015) These species are popular as aquarium decoration plants as well as for medicinal plant for novel drug discovery. (Case study by C.N. Wijerathna *et al*, 2018) according to the case study done by C.S.Wijerathna, most of the people have tried to do the illegal exports for United State and Singapore. Because of this illegal export, Sri Lanka was unable to receive the right value for these plants.

Hence micro propagation of these plants will help for the mass production and to take the license for the export.

There are many varieties of water lilies in the market. These varieties having a high demand and most of the varieties are high cost value. *Nymphaea "Midnight"* is a type of high valued water lily which cannot be propagating vegetative. Hence, aquatic plant growers have made request for the development of micro propagation technique for this species. One plant cost Rs. 3000.00 in the market and due to this matter; they are unable to achieve the market requirement. Therefore, it is important to develop the protocol for the micro propagation of this species.

Objectives:

Main objective is to develop protocol for micropropagation technique for the *Aponogeton* Species and *Nymphaea "Midnight"*

- To Identification of specific medium composition for shoot initiation and shoot multiplication of *Aponogeton* Species and *Nymphaea "Midnight"*.
- To Identification of specific medium composition for rooting of *Aponogeton* Species.

Activities carried out (Methodology)

Results

1. Development of complete Micro propagation protocol for *Aponogeton* species

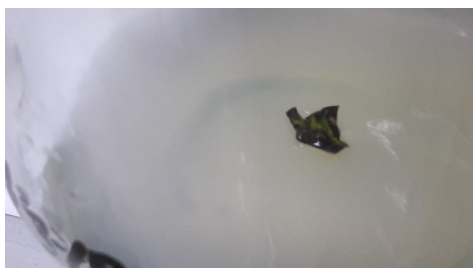
Seeds has elected as explants. After the sterilization ex plants were cultured in Liquid Murashige and Skoog Medium with Plant Growth Promoters. Generated shoots were cultured in liquid MS medium with different concentrations of Cytokinin (BAP 0-4 mg/L) with 0.5mg/L IBA (Indole Butyric Acid). Then generated callus culture for shooting with liquid MS medium with different concentrations of Cytokinin (BAP 0-4 mg/L) with 0-4 mg/L IBA (Indole Butyric Acid).



Shoots *Aponogeton*

2. Development of sterilization protocol for *Nymphaea "Midnight"*

Selected ex plant was leaf. After ex plant sterilization, ex plants were cultured in Murashige and Skoog medium with different concentration of BAP:TDZ:IBA: Kinetine. After developing the callus, do the culture for shoot formation with different concentration of BAP:IBA.



Callus from *Nymphaea "Midnight"*

3. Production of *Cryptocorynewendtii* plants for ornamental sector
 .sale plants were produced and send to the plant house for 1000Arround



Cryptocorynewendtii Production

Conclusions:

Aponogeton shoot could be generated using 2mg/L BAP:0.5 mg/L IBA. Shoot multiplication was higher in 3mg/L IBA:3 mg/L IBA.

Nymphaea callus generated in the combination of 2mg/L BAP:1mg/L TDZ:0.5mg/L IBA:0.5mg/L kinetin .

Outputs

- Providing best protocol for micro propagation of Aponogeton Species, better growth of the aquatic plant culture industry.

Outcomes:

- Large scale propagation technologies for selected ornamental plants.

Constraints:

- Effect for continuous research performance from the situation with fuel crisis

COMPONENT 4 : Study the effect of different hydroponic culture techniques for the growth performances of aquatic plants in aquaponic recirculation systems

Responsible Officer: Dr. K.K.T.Nuwansi

International demand for aquatic plants has shown a steady increase in the past few years and Europe considered as the strongest market for aquatic plants but, currently a growth in demand has been experienced in the US market with the increasing number of species, varieties and quality. The major attractive species, *Cryptocoryne*, *Anubias*, *Echinodorus*, *Aponogeton*, *Hygrophyla*, *Bacopa*, *Myriophyllum*, *Lagenandra* having high demand and play a vital role among exports. Ornamental fish and plant industry is a fast developing industry in Sri Lanka and it is one of the good source of foreign exchange earnings to the country. To fulfill the current demand in this sector it is needed to find efficient culture systems with minimum impact to the environment.

The recent expansion of freshwater aquaculture may require a large quantity of fresh water. The limited availability of freshwater resources has forced the rethinking of wise use of freshwater in the aquaculture sector to concern the water productivity. Aquaponics is a technology that integrated agri-aquaculture systems discipline which seeks the combination of fish and plant culture technologies to confer advantages and conserve water and nutrients and other biological and economic resources. It is already cultivated the aquatic plants in hydroponically and less attempts taken in aquaponics. Thus it would be beneficial to find out the possibilities of cultivating aquatic macrophytes for a low cost and environmentally friendly manner. So it is better to produce aquatic macrophytes aquaponically as the local and international demand for aquatic plants has shown a

steady increase during past several years. In this experiment *Bacopa* and *Anubias* grown hydroponically which is a highly productive method of growing plants without using soil and can compete well even in the export market for higher price due to absence with soil borne pathogens. First experiment was design to study the influence of different types of commercially available diets on the growth performances of guppy with *Bacopa* plant in an aquaponicsystem. The three basic hydroponic culture methods were evaluated in the second experiment namely floating raft method, nutrient film technique (NFT) and gravel bed system cultivated with *Anubias* and *Bacopa* plants. Among these techniques, systems like nutrient film technique further minimizes the space used to cultivate and it can be modified as a vertical farming system which further increase the production in a unit area. Thus, in this study attempt was taken to find out which hydroponic system is most suitable for the cultivation of selected aquatic plants.

Objectives:

- To study the effect of culture techniques for the growth performance of Aquatic plants
- To study the effect of culture techniques for the growth performances of the ornamental fish sp. that cultivated aquaponically with the plant
- To find out the best culture technique for the growth of *Anubias* and *Bacopa* spp.

Methodology

(Study area, Field sampling, data collection and analysis)

Experiment carried out in NARA Head office Aquaculture research center and Aquatic plant poly-tunnel.

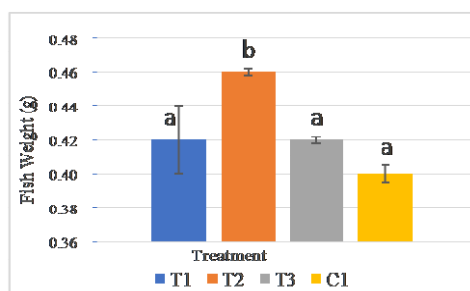
Under this topic two experiments were carried out in this year and in the first one is to study the influence of different types of commercially available diets on the growth performances of guppy (*Poecilia reticulata*) with an aquatic plant (*Bacopa monnieri*) in an aquaponic system

Treatments:

Treatments		No of replicates
T1	Commercial fish feed	3
T2	Commercial Prawn feed	3
T3	1:1 combination of T1 and T2	3
C1	Commercial fish feed	3

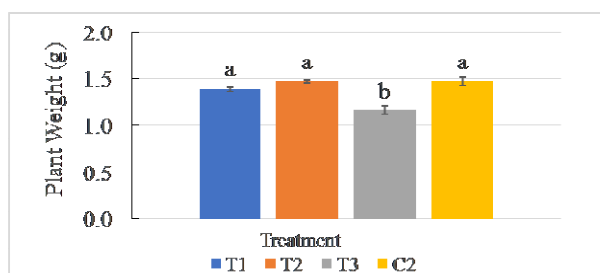
Other than this C2 was designed to compare the plant growth consists with only hydroponic component

Result :



Mean weight of fish in different treatments

Treatment	Mean weight (mean $\pm$ SE) (g) of fish				
	Initial	15 th day	30 th day	45 th day	60 th day
T1	0.22 $\pm$ 0.02 ^a	0.233 $\pm$ 0.006 ^a	0.304 $\pm$ 0.0135 ^a	0.399 $\pm$ 0.010 ^a	0.42 $\pm$ 0.02 ^a
T2	0.20 $\pm$ 0.03 ^a	0.253 $\pm$ 0.005 ^b	0.348 $\pm$ 0.006 ^b	0.414 $\pm$ 0.007 ^b	0.46 $\pm$ 0.002 ^b
T3	0.21 $\pm$ 0.03 ^a	0.259 $\pm$ 0.002 ^b	0.354 $\pm$ 0.018 ^b	0.395 $\pm$ 0.004 ^a	0.42 $\pm$ 0.002 ^a
C1	0.20 $\pm$ 0.02 ^a	0.244 $\pm$ 0.002 ^a	0.306 $\pm$ 0.001 ^a	0.384 $\pm$ 0.004 ^a	0.40 $\pm$ 0.005 ^a



Mean plant weight in different treatments at the end of 60th day

Treatment	Mean weight of plant (g)				
	Initial	15 th day	30 th day	45 th day	60 th day
T1	0.27 $\pm$ 0.07 ^a	0.71 $\pm$ 0.02 ^a	0.84 $\pm$ 0.06 ^a	1.15 $\pm$ 0.10 ^a	1.39 $\pm$ 0.02 ^b
T2	0.26 $\pm$ 0.01 ^a	0.75 $\pm$ 0.03 ^a	0.84 $\pm$ 0.02 ^a	1.14 $\pm$ 0.09 ^a	1.47 $\pm$ 0.02 ^b
T3	0.25 $\pm$ 0.04 ^a	0.65 $\pm$ 0.09 ^a	0.86 $\pm$ 0.02 ^a	1.00 $\pm$ 0.08 ^a	1.16 $\pm$ 0.04 ^a
C2	0.21 $\pm$ 0.01 ^a	0.62 $\pm$ 0.06 ^a	0.82 $\pm$ 0.03 ^a	1.14 $\pm$ 0.10 ^a	1.47 $\pm$ 0.04 ^b

Treatment	Feed Conversion Ratio(FCR)	Feed Efficiency Ratio(FER)	Protein Efficiency Ratio(PER)
T1	1.46 $\pm$ 0.15 ^{ab}	0.69 $\pm$ 0.06 ^a	1.92 $\pm$ 0.18 ^a
T2	1.21 $\pm$ 0.01 ^a	0.83 $\pm$ 0.01 ^b	2.01 $\pm$ 0.02 ^a
T3	1.43 $\pm$ 0.02 ^{ab}	0.69 $\pm$ 0.01 ^a	1.85 $\pm$ 0.02 ^a
C1	1.62 $\pm$ 0.05 ^b	0.62 $\pm$ 0.02 ^a	1.70 $\pm$ 0.05 ^a

Conclusion:

According to the fish growth parameters as well as the plant growth parameters T2 diet could be taken as the best diet among the selected three diets in this experiment. Thus, commercial prawn diet could be recommended to co-cultivate Guppy and Lunuwila plant in simple floating raft aquaponic system.

2nd Experiment

Constructing and modification of the system-



These are the three basic methods used in this experiment.

Treatments –

Treatments	No of replicates
Deep water culture technique	3
Media based system	3
Nutrient film technique	3

Apart from these 3 treatments 2 controls were designed to compare plant growth and fish growth.

Whereas C1- Only consist with fish tank component.

C2- Only consist with hydroponic component (floating raft system)

The system modified according to the above figure and water allowed to circulate with the help of submersible pump system and periodically on by cyclic timer attached to it. .

- Time duration: 4 months
- Selected plant species: *Anubiasbarteri* var. *nana* (petite) and *Bacopamonniari*
- Stocking density of the plants: 20 plants per unit
- Size of the plant: Anubias- 5g-10g
- Bacopa- 8cm in length
- Selected fish species: *Cyprinus carpio* var. *koi*
- Stocking density: 2 fish per liter
- Substrate for net pots: coconut husks

Parameters measured (fortnightly sampling)

- Plant growth parameters
 - weight of the plant (at the end)
 - leaf length
 - leaf width
- Fish growth parameters
 - Weight of the fish
 - Length of the fish

According to the above growth parameters the best system was selected.

Results:



According to the obtained results, *Bacopa* actively grown in all the three systems. But NFT technique seem to be more efficient to co- cultivate *Bacopa*, *Anubias* and Koi carp.

Outcomes

Supply good quality aquaponically produce aquatic plant production to the local and foreign market

Outputs

Development of the culture techniques for better and sustainable aquaculture practices in Sri Lanka.

Recommendations

It is further recommended to study other aquatic plants also with different ornamental fish varieties to broaden the production capacity.

Constraints:

Due to the economic crisis smooth running of the experiment observed in 3rd and 4th quarter of the year.

COMPONENT 5: Assessment of available seaweeds resources and identify their potential for organic fertilizer and its effect on the growth of commercial crops in Sri Lanka. (Join with faculty of Agriculture, University of Ruhuna)

Responsible Officer : Sarath Jayanatha

Introduction

The marine seaweeds are important sources for develop fertilizer and can be used to meet the demand of organic fertilizer requirement in Sri Lanka. According previous studies, existing following species could be used for the development process of fertilizer. The potential species are mainly, *Sargassum* sp, *Gracilariasalicornia*, *Gracilariaverucosa*, *Kappaphycusallverazii* and *Ulva* sp.

Seaweed contains essential minerals such as Ca, K, Mg, P, S, N, Cu, Mn, Bo and other organic components. According to analysis of fertilizer produced from seaweed contains constituents' organic and inorganic components which increase the nutrient uptake and help in the assimilation of carbohydrates and protein contents advantages for plants growth. Also is noticeable that seaweed fertilizers increased the resistibility against disease and reduced the chance of insect attack and increase the water holding capacity of the soil (Wahab, 1991). Seaweed extracts contain major and minor nutrients, amino acids, vitamins, cytokinins, auxin like growth promoting substances and have been reported to stimulate the growth and yield of plants, develop tolerance to environmental stress, enhance antioxidant properties and increase nutrient uptake from soil (Turan and Kose, 2004 and natural plant growth substances like auxins, gibberlins and cytokinins (Jameson, 1998). The liquids extract obtained recently to use as spray for following crops, grasses, cereals, flowers and vegetables. Acutely seaweed can be used for fertilizer to avoid excessive

fertilizer application and improve minerals absorptions. The extracts derived from seaweed are biodegradable, non-toxic, non-polluting and non-hazardous to human animal, and bird (Dhargalkar and Pereira, 2005).

Materials and methods

Collection of samples.

The seaweeds *Sargassum* sp and *Ulva* sp were collected from Weligama- Koggala in south costa. Sample rinse with seawater to removed unwanted particles and epiphytes attached on surfaces and transported to laboratory. To remove the salt seaweeds washed with thoroughly using tap water and finally with distilled water. Finally, all samples were kept in dry air to reduce water content up to 15%.

Based on filed study, *Sargassum* sp, *Ulva* sp were selected from Koggala to Weligama coast.

1. Preparation of foliar spray

Following species used for preparation of extraction. Rinse these seaweed materials for remove salt and unwanted materials. Grinded seaweed materials were used for preparation of foliar spray. Dried seaweed powder mixed with distilled water 150g/L kept 4 days to extract nutrients into water and filtrate used as concentrated spray.

Experimental trails for crops.

Trials for *Capsicum* sp (MI-ii) to evaluate growth increments and yield using both foliar sprayer.

Trial was carried out in experimental pots with MI 2 species (*Capsicum* sp) and recommended fertilizer and combination of both seaweed foliar sprayers. The following growth parameters are taking to quantify their impact test the relative proportion of the variation due to treatment effect against the variations due to combination.

Treatment combination for *Capsicum* sp trials in pot experiment.

Treatments	Combination
T1	no chemical or algae-control
T2	chemical fertilizer
T3	<i>Sargassum</i> sp + Fertilizer
T4	<i>Sargassum</i> sp
T5	<i>Ulva</i> sp + Fertilizer
T6	<i>Ulva</i> sp

Trials for Tea plants *Sargassum* sp and *Ulva* sp foliar spray

The impact from the two selected seaweed extract on yield of tea plant was tested in filed. T1 to T3 with four (T1R1, T1R2, T1R3 and T1R4) replicates in each were tested after acclimation of three weeks with both seaweed extract. T1-T3 plots were design area of 10m² with buffer zone to avoid effect on each other's. After three weeks period of acclimation, leave weight were collected in separately from T1-T3.

Leaves cabbage experimental trial (exported verities)

This trial also conducted in experimental pots in a selected location that they arrange from T1 to T6 with three replicates in each treatments. Experimental plants were selected (15 days) and grown 3 plants in each pot. After two week period of acclimation fertilizer combination were tested as below.

Treatments	Status
T1-Control	Trial completed
T2-Fertilizer	
T3-Fertilizer+ <i>Sargassum</i> sp	

T4-Sargassum only	
T5-Ulva+fertli	
T6-Ulva only	

Following measurements were taken every week during the experiment, such as height of trees, no of leaves during the growth and final weight of each replicates were recorded.

Statistical Analysis

Data were analyzed using analysis of variance (ANOVA) following randomized block design. Differences were considered significant at 5% level of probability. The p-value corresponding to the F-statistics of one-way ANOVA is lower than 0.05, suggesting that the one or more treatments are significantly different. The Tukey HSD test was conducted to find out between which groups have significant difference. These post-hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

Results:

Results section for *Capsicum sp.*

The highest mean yield recorded in treatment no T5 (101.5g) followed by treatment T3. Also, least mean weight value of 18.75g recorded in treatments no. 4. T4, which was conducted only *Sargassum sp* extraction.

Length variations of pods in different treatments *Capsicum sp.*

According to above figures for mean length variation of pods in *Capsicum sp.*, shows the highest value of length recorded from T3 (5.54cm) followed by T2 (5.52cm) and the lowest value was recorded in T6 (5.09cm). T2-recommended fertilizer for growth of Cabbage and T3 is combination of foliar sprayer from *Sargassum sp* and T6 is combination of foliar spray from *Ulva sp*. The highest yield of 1616.18g was recorded from T5 followed by T3 (1575.75g).

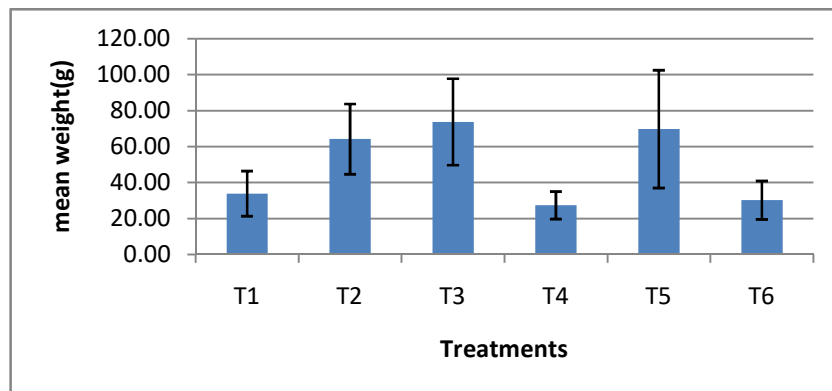


Fig:4. Mean weight of *Capsicum sp* yield distribution graph.

The data are the means $\pm$ SDs. The bars (i.e., the means) with different letters are significantly different within the different parts of plants and different fertilizer treatments ($P < 0.05$).

The mean weight of yield was tested whether there is significantly different between each groups; T3 shows the highest value of 73.77g followed by T5 (69.75g) and the lowest values of 27.39g was recorded from T4. T3 has combination of *Sargassum sp* and fertilizer, T5 has combination of *Ulva sp* and recommended fertilizer mixture and T4 combination of *Sargassum sp* only. Therefore, results reveal that, the extracted foliar sprayer from *Sargassum sp* shows positive effect on growth compared to *Ulva sp*.

The p-value corresponding to the F-statistics of one-way ANOVA is lower than 0.05, suggesting that the one or more treatments are significantly different. The Tukey HSD test was conducted.

These post –hoc tests would likely identify which of the pairs of treatments are significantly different from each other.

The Tukey HSD test results based on Post Hoc analysis,

Treatments pair	Tukey HSD Q statistic	TukeyHSD p-value	Tukey HSD inference
T1 vs T2	3.7447	0.1168783	insignificant
T1 vs T3	4.9273	0.0174858	* p<0.05
T1 vs T4	0.8003	0.8999947	insignificant
T1 vs T5	4.4300	0.0406213	* p<0.05
T1 vs T6	0.4488	0.8999947	Insignificant
T2vs T3	1.1826	0.8999947	Insignificant
T2 vs T4	4.5450	0.0335918	* p<0.05
T2 vs T5	0.6852	0.8999947	Insignificant
T2 vs T6	4.1935	0.0594026	Insignificant
T3 vs T4	5.7276	0.0041007	** p<0.01
T3 vs T5	0.4974	0.8999947	Insignificant
T3 vs T6	5.3761	0.0078405	** p<0.01
T4 vs T5	5.2303	0.0102137	* p<0.05
T4 vs T6	0.3515	0.8999947	Insignificant
T5 vs T6	4.8788	0.0190264	* p<0.05

Fig: 5. The Tukey HSD results for treatments pairs

(T3-Sargassum sp+ recommended fertilizer and T4-Sargassum sp only).

Fig:5 shown in there are significant different between following groups, Post hoc comparison using Turkey HSD test indicated that the mean yield of T1(control) significantly different from T3(*Sargassum* sp and fertilizer combination). T1 significantly different from T5(*Ulvasp* with fertilizer), T2(fertilizer) significantly different from T4(only *Sargassum* sp), T3(*Sargassum* sp with fertilizer) significantly different from T4(*Sargassum* sp), T3 significantly different from T6(*Ulvasp* only), T4 significantly different from T5(*Ulvasp* with fertilizer), T5 from T6 also significantly different (p<0.05).

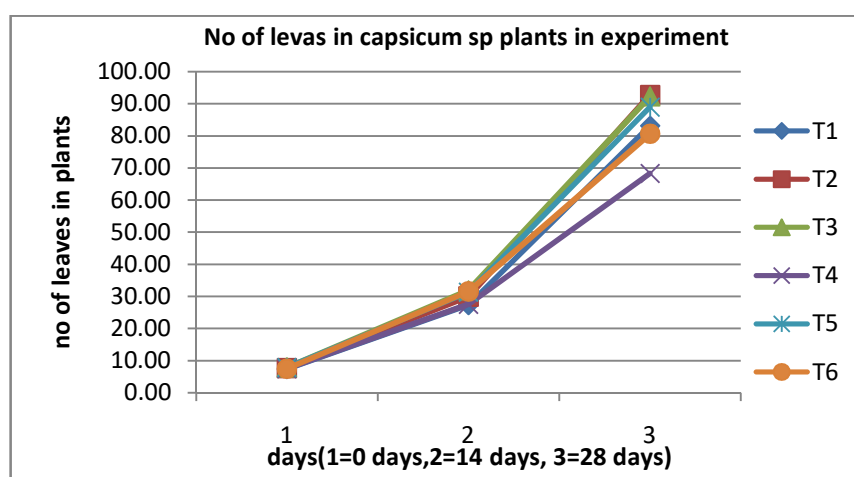


Fig 6. Changes number of leaves in Capsicum sp during the first 28 days (T1 to T6, P>0.05)

Height of trees and number of pods were considered during the first 28 days in Capsicum sp; there were highest number of leaves (92.67) recorded treatments number T2 followed by T3.

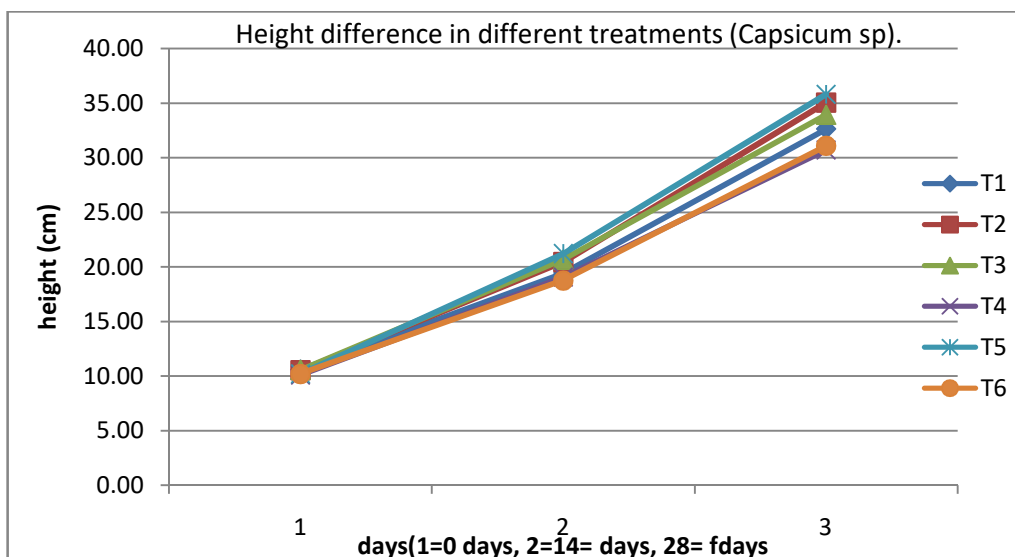


Fig:7: height variation during the growth of *Capsicum* sp in first 28 days.(T1-T6)

The height also varies among the treatment; which shown T5 has highest height followed by T2 during the first growth of trees.

Consequences, ANOVA results reveals that there were no significantly different in different treatments from both height of trees and no of leaves in experiments ($p > 0.05$).

These result suggested that the combination of *Sargassum* sp has highest impact rather than *Ulva* sp for growth performance of the selected plants.

Results section in Tea plants experiments.

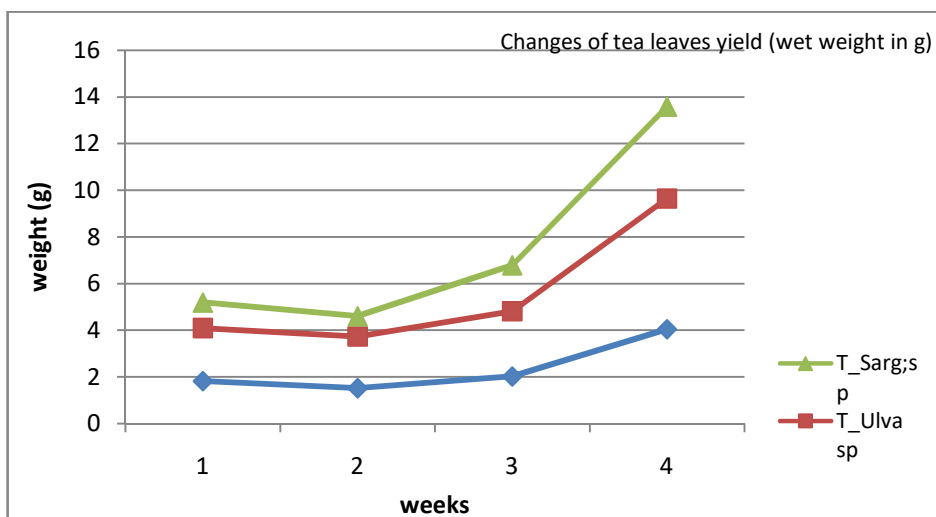


Fig :6Changes of leaves yiled from tea plants (T1(control), T2 Ulvasp, T3 Sargassum sp.($p=0.688$

Recommendation

Seaweed extracts can be used as a natural fertilizer additives and growth promoter for crops.

The level of tendency also high when compared with other combination against drastic environmental conditions. studyhas reported *Sargassum* sp (brown) seaweed are valuable as manure, since they contain some of the soluble alginates(polyuronides) which serves as soil conditioners ad alginate acids which accelerates the decomposition of the organic matter by bacteria. Also remarkable water retaining capacity reported from *Sargassum* manure.



Figure 1: initial stage of MI (II) experiment pots

Experimental site for tea plant in Panatiyana area



Capsicum sp experiments trials for growth performance study



Levaes Cabbage experiment



Progress (Project 1.2) : Financial : 100%

Physical Progress : 91%

Publication

Research papers /Conference Proceedings

Full papers

1. Weerasingha, R., Kamarudin, M.S.*, Karim, M. M. A. & Ismail, M. F. S. (2022). Replacing fish oil with crude palm oil in the diet of larval hybrid lemon fin barb (*Barbonymus gonionotus*♀ x *Hypsibarbus wetmorei*♂). Aquaculture Reports, 24, 101121.
2. Weerasingha, R., Kamarudin, M.S.*, Karim, M. M. A. & Ismail, M. F. S. (2022). Effects of selected dietary plant oils on survival, growth, fatty acid profile, and enzyme activity of a tropical hybrid carp (*Barbonymus gonionotus*♀ x *Hypsibarbus wetmorei*♂) larvae. Aquaculture Reports, 24, 101181.

ABSTRACTS

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2. N.P.H.D.K Nainanayake, Effect of environmental conditioning using different aquatic plants on fecundity and hatching performance of *Barbus conchoni* (rosy barb),NARA scientific session, Colombo, 2022
3. K.K.T.Nuwansi, S.M.H.A. Bandara, K. Jeyavananand D.M.S. Sugeeshwari (2022). Effect of different types of diets on the growth performances of Guppy with *Bacopa monnieri* plant in a combined system. NARA Scientific Session, NARA Auditorium, Colombo. Abs. 23p
4. Sugeeshwari D.M.S, W.A.K.D.Madurangika, K.K.T.Nuwansi (2022), Protocol development for the sterilization technique and germination process for *Aponogeton natans* seeds. NARA Scientific session 2022. P 14.
5. A.D.W.R. Rajapakshe, J.P.T. Madushani, H. Rupika and D. Satheesh 2022 Effect of garlic supplemented diet on growth performances, survival and disease resistance against *Aeromonas hydrophila* in guppy (*Poecilia reticulata*). NARA Scientific Session, NARA Auditorium, Colombo. Abs. 19p
6. A.M.C.P. Kumara, C.B. Medagedara and V. Pahalawattaarchchi 2022 An experimental culture trial to investigate growth performance of Pearl oyster, *Pinctada fucata* at sea cucumber farms in Palk Bay, Northern Province, Sri Lanka NARA Scientific Session, NARA Auditorium, Colombo. Abs. 20p
7. P.Mythily.,2022. Assessment of soil and water characteristics of the Tubificids worm's natural habitat in the Central province, Sri Lanka. In abstract of annual scientific session of The National Aquatic Resources Research and Development Agency (NARA), Colombo, Sri Lanka 2022,P.75
8. B.M.L.P. Jayasekera&,P.P.M. Heenatigala (2022).Presence of White spot syndrome virus and Infectious Hypodermal and Haematopoietic Necrosis virus in *Litopenaeus vannamei* shrimp aquaculture in North Western Province, Sri Lanka. Proceedings of the Annual Scientific Session2022: National Aquatic Resources Research and Development Agency, Colombo -15, Sri Lanka: pp.27.

9. A.M.A.N. Adikari, P.P.M. Heenatigala, A.D.W. Rajapakshe, K.L.W.T. Maduka and S.B.K. Dunusinghe (2022). Use of different carbon sources for the biofloc system during the early nursery stage of *Cyprinus rubrofasciatus*. Proceedings of the Annual Scientific Session 2022: National Aquatic Resources Research and Development Agency, Colombo -15, Sri Lanka: pp.14.
10. Weerasingha, R., Kamarudin, M. S. B., Abd Karim, M. M. B. and Ismail, M. F. S. (2022). Effects of different dietary lipid levels for hybrid lemon fin barb (*Barbonymus gonionotus* ♀ × *Hypsibarbus wetmorei* ♂) larvae. In: Proceedings of the International Scientific sessions of National Aquatic Resources Research and Development Agency (NARA) 2022. 21st October 2022. Auditorium of National Aquatic Resource Research and Development Agency, Colombo 15, pp. 12: NARA.
11. Weerasingha, R., Kamarudin, M. S. B., Abd Karim, M. M. B. and Ismail, M. F. S. (2022). Crude palm oil as a fish oil replacer in the diets of hybrid lemon fin barb (*Barbonymus gonionotus* ♀ × *Hypsibarbus wetmorei* ♂) larvae. In: M. Bahmani (Eds.), 6th International Congress of Fisheries and Aquatic Research. 16th to 17th November 2022. Tehran: ICFAR.

Training (virtual) / Workshops / Meetings participated:

1. Study tour in Australia under DFAT KILE Project- A scoping study to develop a plan for sustainable marine aquaculture in Sri Lanka
2. Geographic information systems (GIS), Dept. Geography, University of Colombo (60hrs).
3. The “Introductory Course on ISO 14001:2015 Environmental Management System” conducted by University of Peradeniya.
4. Mariculture Technology for developing countries sponsored by the Ministry of Commerce and organized by Fujian institute of Oceanography from April 7th, 2022 to April 27th, 2022 in Xiamen, the Peoples Republic of China
5. Fish disease prevention & control and quality & safety control for Developing Countries" (Nov.9- Dec 8 2022) organized by Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences and Sponsored by the Ministry of Commerce of the People’s Republic of China
6. Fish seed production and feed development for developing countries, 10 October-8 November, Virtual courses on fisheries and aquaculture by FFRC – China.
7. Seminar on Internet of Things Application and Digital Aquaculture for Developing Countries (18 August-7 September), Virtual courses on fisheries and aquaculture by FFRC – China.
8. Training Course on Tilapia Breeding and High-yield Farming Techniques for Developing Countries. **Virtual courses on fisheries and aquaculture by FFRC – China.**
9. Inception Meeting of GCP/ GLO/ 086 /ROK “Smart and Sustainable Aquaculture through Effective Biosecurity and Digital Technology”, a global project funded by the government of the Republic of Korea. From 11-12 November 2022.
10. The inception workshop on technical assistance in sea cucumber aquaculture and processing, restocking and management of depleted wild resources. 21st October 2022. Earls Court, Cinnamon Lakeside, Colombo 2.
11. Workshop on Climate impacts on aquaculture and fisheries, 27th-28th June 2022 at Movenpick hotel, Kollupitiya.
12. Workshop on climate finance, 23rd-24th November 2022 at Movenpick hotel, Kollupitiya.
13. Training Workshop on “Appreciation & Understanding of EMP Implementation and Environment & Social Safeguard Perspectives of the Moragolla Hydropower Project”, 28-29 December 2022, Habarana.
14. Attended to the Workshop on Concept Note Development on Climate Change Adaptation Project in Fishery Sector for Green Climate Fund, organized by FAO, Movenpick Hotel, Colombo.

Reports submitted

1. Reports of X-press Pearl Ship Fire Incident – bio monitoring of the coastal and shore ecosystems along the beach from Chilaw to Kerawalapitiya.

2. Report on the Patanangala fish landing site in Yala National Park submitted to Department of Wildlife Conservation.
3. Report on "Suitability of fish cage culture in Boldoda Lake- A rapid assessment "

Extension work:

1. Represented as a committee member - Wildlife Sector Research Committee, Department of Wildlife Conservation.
2. Represented as a committee member - Concept Note to Study Temperature Tolerant Marine Species in the Indian Ocean, Indian Ocean Rim Association (IORA).
3. Represented as a committee member - National Steering Committee on NDCs in Fishery Sector, Climate Change Secretariat and Ministry of Environment.
4. Production of *Crypocoryne wendtii* plants for ornamental sector
5. Artemia testing services provided for the outsiders and issuing reports for Artemia hatching rate.
6. Consultancy services for farmers on their request.
7. Breeding and selling of ornamental fish species and live feed in the NARA head office.
8. Supervision of community based project of Ornamental Aquatic plants conduction in Colombo, Gampaha and Kaluthara District.

Student's supervision:

Guide 3 B. Sc undergraduates for their researches under the following topics.

1. Development of bioencapsulated oral vaccine against *Aeromonas hydrophila* infections in Koi carp (*Cyprinus carpio*).
2. *In Vitro* Study of antibacterial effects of selected plant extracts against bacterial pathogens of fish and shrimp.
3. Development of sustainable Aquafeeds by replacing fish meal with insect meal for Clara (*Crala carla*).
4. Effect of garlic supplemented diet on growth performances, survival and disease resistance against *Aeromonas hydrophila* in guppy (*Poecilia reticulata*).
5. Immunostimulatory Effect of Coriander seeds (*Coriandrum sativum*), Heen bovitia (*Osbeckia octandra*) and Hathawariya leef (*Asparagus racemosus*) and disease resistant against *Aeromonas hydrophila* in Koi Carp.
6. Effect of dilatory supplementation of Butterfly pea on the colour enhancement of fighter fish.
7. One day practical Training program for Open University students.
8. Intern training for University of Ruhuna, Jaffna and Ocean University students.
9. Supervision of final year research students from South Eastern University and University of Colombo to complete their research successfully
10. Industrial training given for university students (n= 15)

5.5 MARINE BIOLOGICAL RESOURCES DIVISION

Head of the Division : Dr. Sisira Haputhantri/ Dr. R.P.P.K. Jayasinghe

OVERVIEW OF THE YEAR 2022 (MBRD)

Research Staff : The Marine Biological Resources Division (MBRD) consists of 12 Scientists, 1 Development Officer, 5 Research Assistants, 5 Field Research Assistants, 1 Management Assistant, 1 Lab Attendant and 1 Helper.

The MBRD is the major division carrying out research towards the management, development and conservation of marine living resources. The research programme carried out by MBRD includes,

- Management-oriented research projects on small and large pelagic fishery resources.
- Development-oriented research projects assessing the viability of under exploited and unexploited marine resources.
- Conservation of coral reefs and threatened marine fauna.
- Species identification and population studies using molecular methods.

Two major treasury-funded research projects were carried out by MBRD in 2022. Apart from treasury funded projects, MBRD carried out several external funded/consultancy projects. MBRD attended to several activities in advisory and consultative capacities. More importantly, MBRD responded to a number of requests made by the Ministry of Fisheries (MoF) and the Department of Fisheries and Aquatic Resources (DFAR) by providing recommendations to resolve problems on the exploitation of marine fishery resources.

On court orders, a number of fish samples were analysed by MBRD to determine whether the fish samples submitted had been killed by using explosives or not. The MBRD staff also appeared at several Magistrates' Courts, in order to provide expert evidence regarding dynamite cases handled by the Sri Lanka Police and DFAR.

In 2022, a large number of marine samples including fish and other aquatic organisms were received from various stakeholders notably Magistrates' Courts, DFAR, Department of Wildlife Conservation (DWLC), Department of National Zoological Gardens and the fishing industry for identification. In addition, MBRD issued 307 reports on the identification of shark fin/skin samples in year 2022. The identification of shark fin/skin sample were mostly based on morphological characters. When morphological identification failed, organisms were identified using molecular methods.

The staff of the division was very interactive with the fishing community throughout the island and also supported the private sector by attending to requests made by them. The division provided facilities and guidance to university students in undertaking industrial training and final year research projects/postgraduate projects and to school pupils to carry out their research projects. In addition, the division conducted lectures and awareness programmes especially for Sri Lanka Coast Guards, Sri Lanka Navy and the fishing community.

The research staff of MBRD was actively engaged in updating the large pelagic and small pelagic fishery databases, analysing the fish landing statistics, providing national statistics on large pelagic fish production and preparing research papers on trends and prospects of marine fisheries in Sri Lanka. Several reports were also prepared and submitted to the DFAR for settling fishing disputes, advising on resource utilization and fisheries management.

Treasury funded projects carried out by MBRD in 2022:

No	Project Title	Budget (Rs. Millions)	Ongoing	New
2.1	Monitoring and assessment of small pelagic fishery resources	1.5	Ongoing	
2.2	Monitoring and assessment of large pelagic fishery resources	1.5	Ongoing	

PROJECT NO 2.1:

MONITORING AND ASSESSMENT OF SMALL PELAGIC FISHERY RESOURCES

Coastal fisheries in Sri Lanka primarily target small pelagic species but also other species including large pelagic and demersal fish. The small pelagic group represents over seventy marine species found in Sri Lankan waters. However, the key target species groups in the fishery are sardines, herrings, anchovies and mackerels. Unsustainable fishing practices exist in the coastal fishery such as fishing effort increase, night fishing during spawning season(s) and extensive catching of immature fish.

Small pelagic fish species form an important part of the animal protein requirements of Sri Lankans while contributing around 30% to the marine fish production of the country. The small-scale artisanal fishermen operated with small-meshed gillnets and outboard engine Fiber Reinforced Plastic (OFRP) boats mostly target small pelagic fish species. Surrounding nets are also used in some districts. In addition, the beach seine, a traditional fishing gear operating seasonally in Sri Lanka, also catches a considerable quantity of small pelagics. However, at present, there remains a doubt regarding the potentiality of coping with the unprecedented challenge of rapidly growing food demands under unsustainable fishing practices and deteriorating environmental conditions with limited small pelagic resources.

The Marine Biological Resources Division (MBRD) of NARA monitored small pelagic fish landings over a number of years with the aim of assessing the status of the fishery and resources with the key objective of ensuring the long-term sustainability of the resources. MBRD continued the port sampling data collection program at major and minor coastal fish landing sites in Sri Lanka in 2022 despite the COVID-19 pandemic situation and fuel crisis etc. Also, enumerators of the Department of Fisheries and Aquatic Resources (DFAR) engaged in the same data collection programme.

Under the project, a scientific investigation of three common small pelagic species, Big eye scad (*Selar crumenophthalmus*) and Indian mackerel (*Rastrelliger kanagurta*), and Shorthead anchovy (*Encrasicholina heteroloba*) in the west coast of Sri Lanka was carried out.

The historical fisheries data collected since 2001 was made use of for assessing the stock status of a key small pelagic stock on the west coast. Accordingly, the catch per unit effort (CPUE) of spotted sardinella (*Amblygaster sirm*) in the small-meshed gillnet fishery operated with OFRP boats on the west coast was standardized by Generalized Linear Models (GLM) using the Delta-log normal approach. A data-poor stock assessment method, the stochastic length-based spawning potential ratio (LBSPR) was used to assess the same stock in the west coast.

There is a seasonal trend in *A. sirm* non-zero catch rates (Figure 1). The lowest catch rates in the small mesh gillnet fishery were observed during the 1st quarter of the year whereas the highest catch rates were observed during the 3rd and 4th quarters of the year. Moreover, a considerable variation in the catch rates between districts can be observed but, catch rates between Negombo and Chilaw were quite similar. Moreover, catch rates apparently depend on total fishing time, fishing depth and the number of net pieces used in the fishery per single fishing operation.

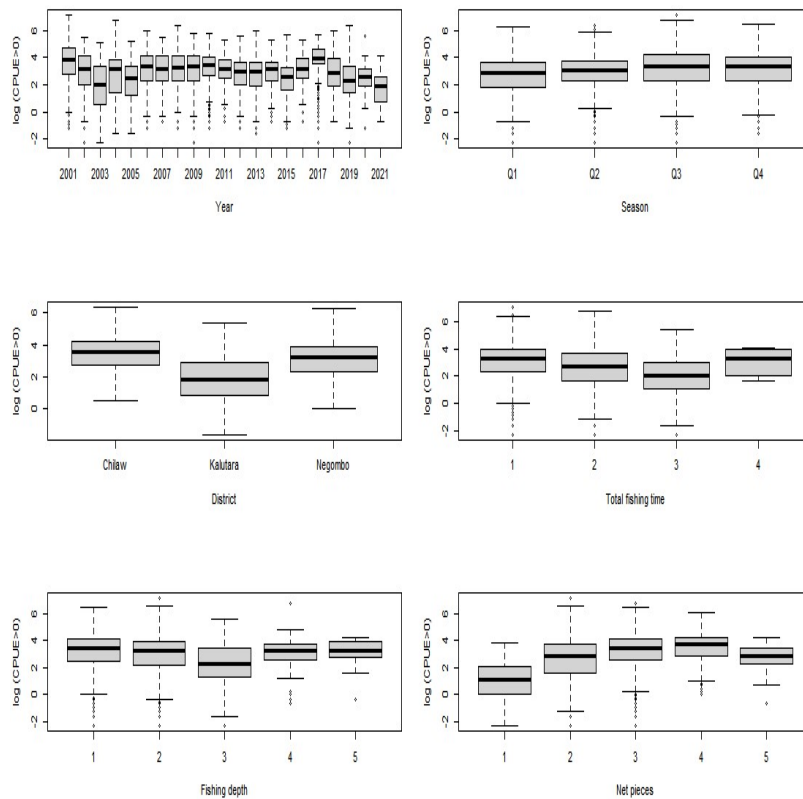


Figure 1. Box plot of non-zero CPUE of *A. sirm* in the west coast small mesh gillnet fishery, Sri Lanka in log scale with respect to parameters (a) Year (2001, 2002, ..., 2021), (b) Season (1: January – March; 2: April -June, 3; July – September; 4: October - December), (c) District (Kalutara; Negombo; Chilaw), (d) Total fishing time (h) (1: ≤ 6 ; 2: $6 >$ and ≤ 12 ; 3: $12 >$ and ≤ 18 ; 4: > 18), (e) Fishing depth (m) (1: $1 <$ and ≥ 20 ; 2: ≥ 20 and ≤ 40 ; 3: > 40 and ≤ 60 ; 4: > 60 and ≤ 80 ; 5: ≥ 80) and (f) Number of net panels (1: 1 -10; 2: 11-20; 3: 21-30; 4: 31-40; 5: 41-50).

The standardized CPUE indices were obtained using the results of Bernoulli-based and Gaussian-based GLM models (Figure 2). The highest standardized CPUE index was reported in 2017 (Figure 3).

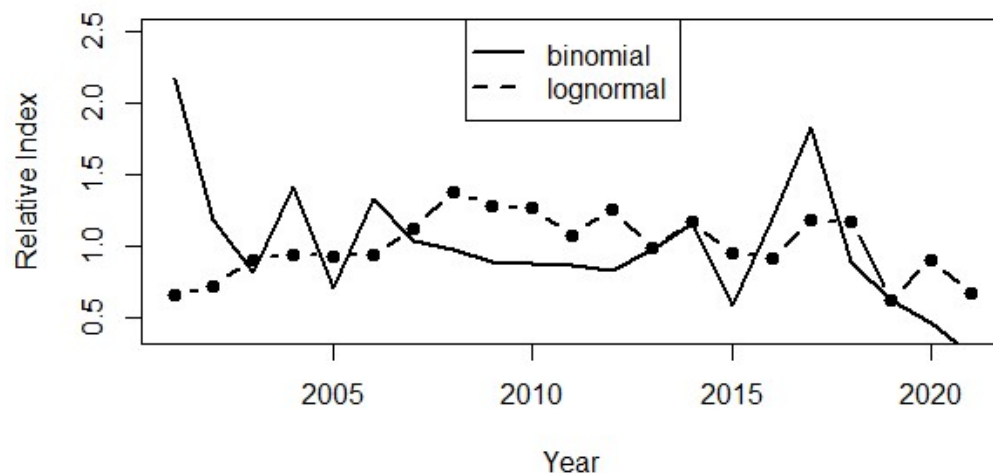


Figure 2. Estimated relative indices of *A. sirm* in the west coast small mesh gillnet fishery, Sri Lanka using Bernoulli-based and Gaussian-based GLM models: 2001 – 2021

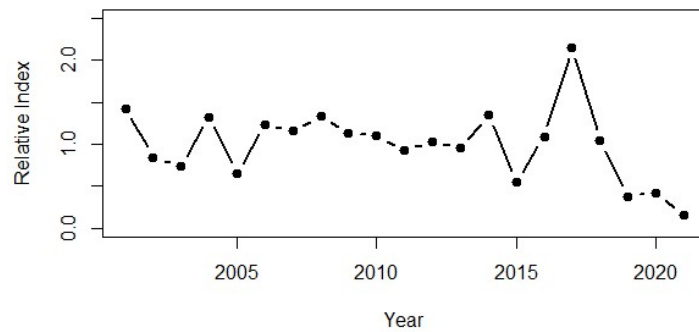


Figure 3. Standardized catch per unit effort (CPUE) of *A. sirm* in the west coast small mesh gillnet fishery, Sri Lanka using the delta-lognormal method: 2001 – 2021. Values were scaled by dividing their means.

There is a seasonal trend in *S. gibbosa* non-zero catch rates. In general, the average catch rates were higher during the 2nd quarter of the year. Moreover, a considerable variation in the catch rates between districts was observed but, the catch rates between Negombo and Chilaw were quite similar. Moreover, catch rates apparently depend on factors such as total fishing time, fishing depth and the number of net pieces used in the fishery per fishing operation. In general, catch rates were higher for the vessels operated in the shallow depths with respect to the vessels operated in the deeper waters. Fishermen are still able to maintain a healthy catch rate via conducting fishing operations with an increased number of net pieces.

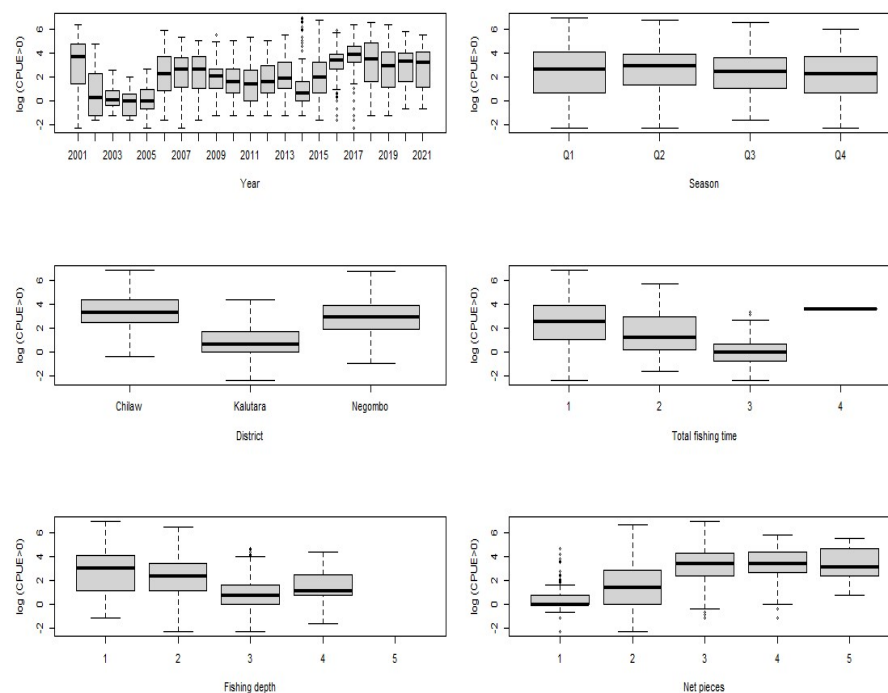


Figure 4. Box plot of non-zero CPUE of *S. gibbosa* in the west coast small mesh gillnet fishery, Sri Lanka in log scale with respect to parameters (a) Year (2001, 2002, ..., 2021), (b) Season (1: January – March; 2: April -June, 3: July – September; 4: October - December), (c) District (Kalutara; Negombo; Chilaw), (d) Total fishing time (h) (1: ≤ 6 ; 2: $6 < \text{and} \leq 12$; 3: $12 < \text{and} \leq 18$; 4: > 18), (e) Fishing depth (m) (1: $1 < \text{and} \leq 20$; 2: $\geq 20 \text{ and} \leq 40$; 3: $> 40 \text{ and} \leq 60$; 4: $> 60 \text{ and} \leq 80$; 5: ≥ 80) and (f) Number of net panels (1: 1-10; 2: 11-20; 3: 21-30; 4: 31-40; 5: 41-50).

Among different years considered under the study for the spotted sardinella assessment conducted using stochastic LBSPR, the respective stock remained relatively in a healthy state in 2005, 2006,

2008 and 2009 compared to other years (Figure 5). The worst case in which median SPR has reached the limit reference point was reported in 2020. This suggests that the stock is no longer sustainable at the current exploitation level and strong management measures are needed at this critical stage to rebuild the spotted sardinella stock on the west coast. However, as per the stock status in 2021, this stock is likely recovering (Figure 5). The probable reason for this recovery trend could be the low fishing pressure due to the COVID-19 pandemic and the X-Press Pearl ship disaster which occurred on 20th May 2021.

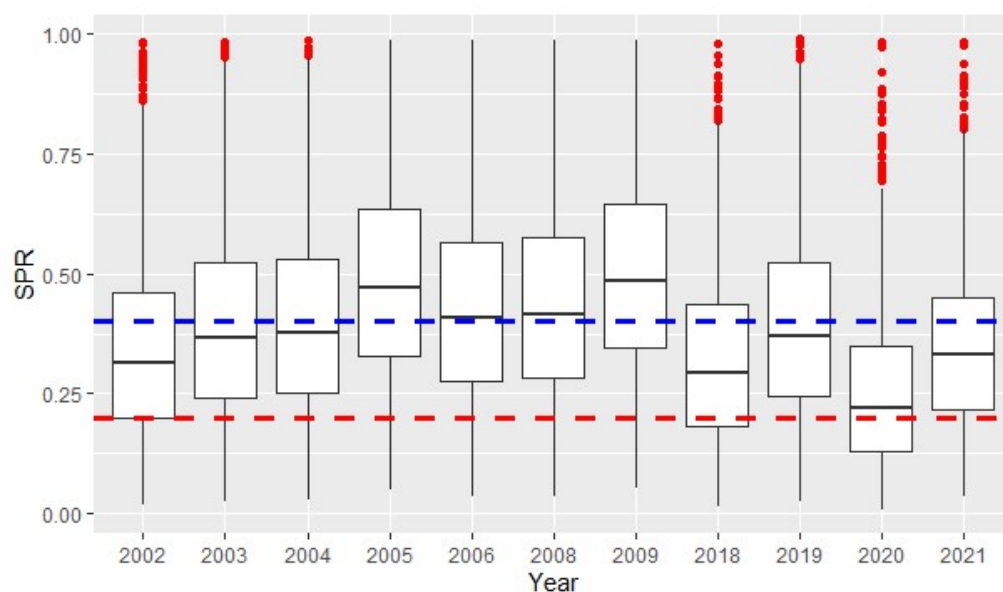


Figure 5. Box plots for summarizing the results of stochastic LBSPR assessment of spotted sardinella in the west coast, Sri Lanka (2000-2021)

The following results for the biological study were obtained using the collected samples.

Table 1. A summary of the values of biological parameters obtained for Indian Mackerel, Big eye scads and Shorthead anchovy

Species	sex	Sex ratio (M:F)	N	Length range (cm)		Weight range (g)		A	b	r	K
				Min	Max	Min	Max				
<i>Rastrelliger kanagurta</i>	Grouped	1:1	153	16.5	27.5	24.32	245.5	0.03	2.68	.9674	1.1648
<i>Selar crumenophthalmus</i>	Grouped	1:1	123	11.5	23	21	173.43	0.02	2.8	0.9437	1.2503
<i>Encrasicholina heteroloba</i>	Grouped	1.3:1	868	4.6	9.6	0.67	6.02	0.024	2.68	0.68	0.89

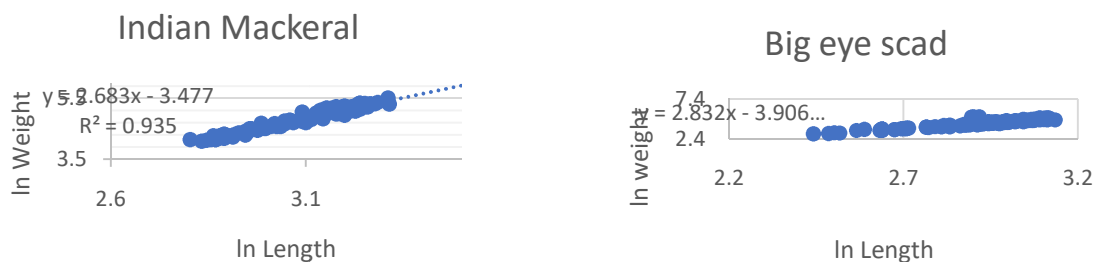


Figure 6. The length-weight relationships of the Indian mackerel and Big eye scads in the West coast of Sri Lanka

According to the results, both Indian mackerel and big eye scads show a strong positive correlation between length and weight. Also, the growth of both species was negative allometric ($b < 3$). The sex ratio of both fish species was 1:1.

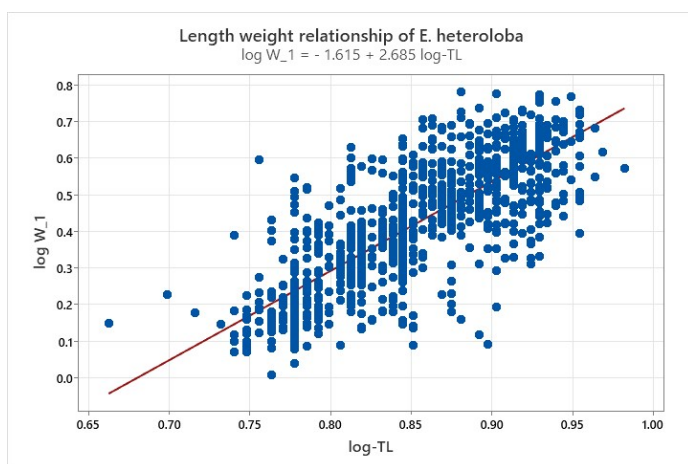


Figure 7. Length weight relationship of *E. heteroloba*

PROJECT No: 2.2

ASSESSMENT AND MONITORING OF LARGE PELAGIC FISHERY RESOURCES VIA PORT SAMPLING

Large Pelagic Fishery

Port sampling and fisheries statistics

Large Pelagic Port sampling is a collaborative fisheries data collection programme implemented by the Marine Biological Resources Division (MBRD) of NARA, Department of Fisheries and Aquatic Resources (DFAR) and Statistics Unit of Ministry of Fisheries (MoF) 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 and the project has been conducted continuously with an objective of obtaining catch and effort data and biological data of large pelagic fish, in particular tuna and tuna-like fish. Data are stored in a database (PELAGOS) maintained by MBRD.

IOTC data submission and attending working party meetings organized by IOTC

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 each year. This is a collaborative attempt

of the Statistics Unit of MoF, DFAR and the MBRD of NARA. We were able to submit the production estimations of 2021 as per the required formats adhering to the deadline. The total production of tuna and tuna like species of Sri Lanka in year 2021 was 87546 t with more than 80% contributions from the EEZ. According to species wise catch records in 2021 skipjack followed by yellow fin has provided the highest contribution while sword fish also has a significant contribution to the large pelagic production. Among the range of gear operated, the highest proportion of catch was harvested by longline followed by gill net in both high seas and within EEZ.

The data submitted to IOTC needs to comply with the resolutions 15/02 implemented by the IOTC. In the submission, catch and effort data, length-frequency data, information on discards and vessel information are provided in detail as per the requirements of the resolutions. As a result of complying with the resolutions, Sri Lanka was able to achieve a 76% compliance rate in 2021.

The key priority areas to be concerned about in the future prospects of the fishery are:

- How to comply with the IOTC catch reduction resolution of Yellowfin tuna in upcoming years
- Management directives on BET catch level
- To increase the length data to comply with resolution 15/02
- Year-round study on sea birds associated with the large pelagic fisheries
- Stock assessments of the species, namely, *Istiophorus platypterus* (Thalapatha), *Makaira nigricans* (Nil Koppa) and *Scomberomorus commerson* (Ahin Thora) revealed that those stocks are overfished or subject to overfishing in the Indian Ocean, hence future management endeavors should be more focused towards those species.
- More consideration should be given for the shark family Carcharhinidae as they are listed under appendix II of CITES.

Overall, it can be concluded that potentialities in the expansion of large pelagic fishery is currently limited with the present regional level management and conservation measures based on stock status of most of the species in the Indian Ocean. However, the expansion potentialities could still be pragmatic for skip jack tuna and sword fish fisheries.

The study on pole and line fishery targeting skip jack tuna in Sri Lanka was carried out with an objective to investigate the possibility to expand the fishery. However, the findings revealed that the expansion of pole and line fishery in Sri Lanka could only be practical with a suitable harvesting technique for live bait, vessel upgrade which can reach the distance of free tuna fishing grounds and technical skill development.

OTHER PROJECTS CARRIED OUT EXCEPT THE TWO MAIN ONGOING PROJECTS

1. SRI LANKA - NORWAY BILATERAL PROJECT

1.1 WORK PACKAGE 1 (WP1)- STRENGTHENING MARINE FISHERIES DATA COLLECTION IN SRI LANKA

Sri Lanka consists of productive seas with good fishery resources as a coastal nation. Thousands of families depend on the fishery industry directly or indirectly. Hence, it is vital to collect fisheries landing data systematically and continuously in order to monitor the resource exploitation and to provide recommendations to ensure the sustainability of fishery resources.

The first phase of the Sri Lanka – Norway bilateral project was launched in 2017 with the aim of fulfilling the above need with several other needs relevant to the marine fisheries sector, and the second phase of the project is now in progress. Accordingly, Work Package 1 (WP1) of the project was initiated with the aim of improving the fisheries data collection system for marine fisheries in Sri Lanka to provide reliable statistical landing data covering the entire country for sustainable management of the marine fisheries. Three local partners are responsible for the implementation of

this work package: MBRD of NARA, Department of Fisheries and Aquatic Resources (DFAR) and the Statistics Unit (SU) of the Ministry of Fisheries (MoF). The Norwegian experts provide technical support for strengthening the marine fisheries data collection in Sri Lanka.

Enumerators attached to the MBRD and DFAR collect fisheries data using tablet software. They collect fish landing data with biological data according to a monthly field schedule prepared based on an annual sampling program. The program contained 22 fisheries harbours divided into large-scale high and large-scale low and 946 landing sites, divided into three strata high, medium and low. The port sampling program was conducted in 2022 despite the COVID 19 outbreak and fuel crisis covering the entire coast in Sri Lanka but, it could not be performed for several months due to these reasons. The data were stored in a data server located in DFAR.

Data analysis workshop

Several online and physical data analysis workshops were carried out by the Norwegian team members from the Institute of Marine Research (IMR) and the Directorate of fisheries. The first phase of the workshop was completed in 2021. In 2022, the first workshop was conducted on the 21st and 23rd of September 2022 via the Microsoft Teams online platform. Scientists of the Marine Biological Resources Division of NARA, officials of the DFAR and the Statistics Unit of the Ministry of fisheries participated in the workshop.

The second workshop was conducted physically from 21st to 24th November 2022 at Amagi Aria Hotel, Negombo. The following topics were included in the workshop:

- Developing data quality and monitoring reports in R programming
 - Sampling plan compliance
 - Fleet details
 - Vessel
 - Gear
 - Catch
 - Biological info and length measurements

- Upscaling and catch estimation

The workshop was conducted by Norwegian team members from the Institute of Marine Research (IMR) and the Directorate of fisheries. The 15 officers from the Department of Fisheries and Aquatic Resources, the Statistical unit of the Ministry of Fisheries, and Scientists attached to the Marine Biological Resources Division of NARA actively participated in the workshop.



Fig.2. Conducting the data analysis workshop for the Sri Lankan team and the discussions held at NARA after the workshop between the Norwegian team members and the Sri Lankan team members.

The Field visit to the fish landing site

The field visit was carried out with the Norwegian team members at the Poruthota fish landing site on 25th of November, 2022. At the field visit, the practicalities and issues including a few issues in data entering into the tabulated software were identified. One of the key issues in data reporting was to determine the actual number of active fishing boats on the sampling day operated at major landing sites.

Introducing measuring boards for obtaining reliable fish length data

The Norwegian team introduced a photo-based system for obtaining fish length data at the sampling sites to enhance the efficiency and reliability of the fish length data. Ten measuring boards were provided by Norway to be used for taking the length measurements. In December 2022, the inventor of the method, the Norway project coordinator visited Sri Lanka to demonstrate and test the method. He demonstrated this photo-based method and software used to the staff members of MBRD at the MBRD Biology Laboratory and visited the Poruthota fish landing site, with the scientists of MBRD. This method is due to be introduced to the enumerators in 2023.



Fig.3. a) Explaining the photo-based method at the MBRD laboratory b) Testing the method at a fish landing site c) Photo of the measuring board with fish

Discussions between the collaborators

Regular meetings among the members of NARA, the Statistical Unit of MoF, DFAR, and the Norway team were held online. In addition, physical meetings were held at NARA and DFAR in November 2022. The following matters were taken into consideration:

- Preparation of a data policy: rules, responsibilities, and Memorandum of Understanding
- Data management team(s)
- Monitoring sampling compliance and quality
- Addressing sampling improvements
- Correction of data
- Estimation and upscaling procedures
- Distribution of statistics and reports
- Revision sampling design

Main challenges

- Due to fuel and economic crises, enumerators could not be employed during the holidays.
- Technical errors occur in the tabulated software. Some vital data could not be entered into the software due to the generated bugs. The support of the software developer (private company) was not available to fix these issues due to financial constraints.
- The technical errors of the provided tab have occurred due to the reduction of battery power.
- There is a necessity to train the enumerators on time. Physical and onsite training are essential to enhance the data quality, which is the basement of the data collection. However, the unavailability of getting funds for conducting workshops and field programmes prevent such trainings.

The continuous discussions between the Norway and Sri Lanka teams were performed to sharpen the project outcomes and to overcome issues. Suggestions for modifications of the software and sampling program were also made for 2022.

1.2 NORWAY SRI LANKA BILATERAL PROJECT - WORK PACKAGE 2 (WP2)

The bilateral project between Norway and Sri Lanka was started in 2017, with the aim of improving the management of the marine fish resources of Sri Lanka. The Norway government provides technical support for this project. The project support is given for improving the technical knowledge of fisheries' independent stock assessment methods. The following are the activities carried out by MBRD during 2023. This project has two components work packages 1 and 2. Under work package 2 one online training course and two physical training courses were held. The online training course was held from 9th to 13th May 2022. During the training, pelagic biomass estimation methods and analysis by using Stox and R software were discussed. These biomass estimation data will be used to prepare management recommendations for the sustainable utilization of fishery resources. The first and second physical training was held at the NARA head office in March and November 2022 for the acoustic stock assessment method. The resource person was Mr. Totland Atle, the Ecosystem Acoustic specialist. During the program, the 2021 Kalpitiya shrimp trawl survey report was finalized, followed by data analysis and hands-on training for data analysis using R software. During the second physical training by the same resource person, a new EK 60 echosounder was introduced. Training on mounting, calibration, and data recording with EK 60 echosounder was received. A data repository was prepared for acoustic data storage and easier access among the team. In June 2023, writing commenced for two manuscripts with the help of Dr. Padmini Dalpadado, a Senior Scientist from IMR Norway. The data collected during the Bay of Bengal ecosystem survey in 2018 will be used for these manuscripts. The main purpose is to enhance scientific writing and publication skills among MBRD scientists.

X – PRESS PEARL ENVIRONMENTAL IMPACT ASSESSMENT

Demersal fishery

Biological sample and data collection on the fisheries aspects on demersal fish from fish landing sites in Negombo was initiated in October 2022 and continued till end of December 2022 on a monthly basis. In the field, data on fisheries aspects such as demersal species composition, weight etc were collected. Information on fishing gear, depth, duration etc. was collected by interviewing the fishers. Biological samples of three demersal fish species; *Lutjanus fulvivflamma*, *Lethrinus lentjan* and *Scolopsis bimaculata* were collected for the laboratory analysis. Furthermore, gut content analysis was conducted for the three demersal fish species. Gut samples of three specimens of each fish species were submitted monthly to the ESD for micro plastic analysis. The average CPUE for the demersal fish and slipper lobsters (*Scammarctus batei*) was estimated at 15kg/boat/day and 8 kg/boat/day respectively. Bottom set gill net and bottom set long line were the main fishing methods used for capturing demersal fish and shell fish species. Gut content analysis of *Scolopsis bimaculata* exhibited a highly specific dietary pattern which mainly fed on krill. Even though *Lutjanus fulvivflamma* and *Lethrinus lentjan* exhibited more generalist dietary patterns which had fed on different food items such as shrimps, crabs and fish. The sample and data collection will be carried out in 2023 on a monthly basis. At the end of the year, it will be able to conclude on the stock status of *Scolopsis bimaculata*, *Lutjanus fulvivflamma* and *Lethrinus lentjan* in the coastal waters off Negombo. Furthermore, size at maturity and spawning seasons of these demersal fish species will be determined.

EXTERNALLY FUNDED PROJECTS/ CONSULTANCY PROJECTS CARRIED OUT IN 2022

- Continuous monitoring of the study which is carried out to assess the environmental impacts to marine resources due to Lakvijaya power plant was started from September 2022 for a one year period.

Study on the Environmental Impacts to Marine Resources due to Lakvijaya Power Plant- This is a one year project and project activities were started from September 2022. Marine Biological Resources Division is responsible for investigating the impacts to marine biota including zooplankton, Ichthyoplankton, benthic macro-invertebrates. Fishery independent surveys and dependent surveys were carried out to investigate the possible impacts to commercially important fish species. In addition, underwater surveys were conducted in the sea adjacent to the power plant and nearby coral reef habitats to assess the possible impacts.

OTHER ACTIVITIES UNDERTAKEN BY MBRD

1. MBRD research staff actively engaged in the environmental impact assessment of X-Press Pearl ship disaster. Accordingly, MBRD conducted studies/ surveys aiming to investigate the effect of the incidence on demersal fish populations and chemical contaminations for the marine biological resources and marine environment.
2. External Supervision of a BSc final year research project and thesis of a student from the University of Ruhuna (Ms. M.H.H. Wathsala Jayalath).
3. Provided Industrial Training on Biotechnology for 2 students of the University of Ruhuna and 5 students from the Ocean University.
4. Identified 8 shark fin samples sent by fish exporters using molecular methods.
5. Identified 2 stranded whale samples by using molecular methods.
6. Identified 3 mussel samples and 3 aquatic worm samples for IARAD by using molecular techniques.
7. Identified 5 turtles, 3 dolphins and a fish species of a fish kill associated with the X-Press Pearl ship disaster using molecular methods.

WORKSHOPS/MEETINGS ATTENDED

1. Indian Ocean Tuna Commission (IOTC) Twenty fifth Scientific Committee meeting, Victoria, Seychelles, 3-9 December 2022.
2. Indian Ocean Tuna Commission (IOTC) 20th working party on Billfish, virtual, 12-15 September 2022.
3. Workshop on Climate adaptation and financing for fisheries, 23-24 November, 2022, Colombo, Sri Lanka
4. Workshop on Climate adaptation Planning, 28-29 June 2022, Colombo, Sri Lanka
5. Inception workshop on Responsible use of fisheries and aquaculture resources for sustainable development, funded by Government of Norway, organized by Ministry of Fisheries in collaboration with FAO, 24th May, 2022, Colombo, Sri Lanka
6. Participated at a five day residential workshop on implementation of Port State Measures to prevent, deter and eliminate IUU fishing in Sri Lanka in 2022, Negombo, Sri Lanka
7. Seminar on Fishery Development and Management for the Silk Road Countries conducted by Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences (FFRC), virtual, from 6th -26th July 2022.
8. The 18th Session of the IOTC Working Party on Ecosystem and By-catch, virtual, 05 – 09 September, 2022.
9. The 19th Session of the IOTC Working Party on Data collection and Statistics, virtual, 11th November – 02nd December, 2022.
10. Workshop on Data analysis using R- under the WP 1- Norway Sri Lanka Bilateral Project, 21-24 November 2022 at Amagi Aria Hotel, Negombo

11. FAO Workshop on Fisheries data collection and statistics (Global) held on 8th November 2022 via online.
12. FAO Workshop on Fisheries data collection and statistics (Asia and Pacific) held on 26th and 27th July 2022 via online.
13. IORA core group meeting on fisheries management on 15th November 2022 via online.
14. EAF-Nansen Programme Forum in Dakar, Senegal, 18-20 October 2022.

PUBLICATIONS

Full papers

1. S.S.K. Haputhanthri, K.H.K. Bandaranayake, M.I.G. Rathnasuriya, K.G.S. Nirbadha, S.J.W.W.M.M.P. Weerasekera, A.A.S.H. Athukoorala, R.A.M. Jayathilaka, H.A.C.C. Perera and C. Creech. 2022. Reproductive biology and feeding ecology of the blue swimming crab (*Portunus pelagicus*) in Northern Coastal Waters, Sri Lanka. Tropical Life Sciences Research 33(2): 155 -178. <https://doi.org/10.21315/tlsr2022.33.2.8>
2. U.S.P.K. Liyanage, R.P.P.K. Jayasinghe, J-O Krakstad, and K. Arulanathan. 2022.
3. Distribution and Abundance of the Blue Whale (*Balaenoptera musculus indica*) off Sri Lanka during the Southwest Monsoon 2018. Journal of Marine Science and Engineering 10 (11):1626. doi10.3390/jmse10111626
4. N.N. Wijayawardene, D-Q Dai, P.K. Jayasinghe, S.S. Gunasekara , Y. Nagano, S. Tibpromma, N. Suwannarach and N. Boonyuen Ecological and Oceanographic Perspectives in Future Marine Fungal Taxonomy. 2022. Journal of Fungi 8(11): 1141; [doi.10.3390/jof8111141](https://doi.org/10.3390/jof8111141)
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REPORTS

1. Management of the Jaffna trawl fishery to maintain sustainable fishery resource utilization. Submitted to the Ministry of Fisheries.
2. K.H.K. Bandaranayake, Manuja Promodaya and Chaminda Karunaratne. 2022. Ja Kotu Survey In Madu Ganga River. The report submitted to the Ministry of Fisheries.
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6. D.G.T.C. Balawardhana and S.S.K. Haputhantri, 2022. Sea urchin fishery development in the west coast of Sri Lanka. The report submitted to the Department of Fisheries and Aquatic Resources.
7. Species identification of dried shark fins, skin, jaws, ray gills and fresh shark meat samples produced by the exporters to get the export permit.
8. Recommendations were given to DFAR for formulating regulation for Black sea urchin (*Stomopneustes variolaris*) harvest in west coast of Sri Lanka.

REVIEWED PAPERS / EDITORIAL BOARDS

1. Dr. S.S.K. Haputhantri reviewed two papers submitted to Fishing for Life 2022: South and South-East Asian Conference on Small Scale Fisheries and Aquaculture held on 19th and 20th September 2022 at Ocean University of Sri Lanka.
2. Dr. S.S.K. Haputhantri reviewed a scientific paper submitted to the Sri Lanka Journal of Aquatic Sciences (SLJAS) for possible publication.
3. Dr. S.S.K. Haputhantri reviewed a scientific paper submitted to the Journal of the Marine Biological Association of the United Kingdom for possible publication.
4. Dr. R.P.P.K. Jayasinghe reviewed papers submitted to Frontiers in Marine Science.
5. Dr. R.P.P.K. Jayasinghe reviewed papers submitted to Ocean and Coastal Management.
6. Dr. D.R. Herath reviewed a scientific paper submitted to the Journal of the Marine Biological Association of the United Kingdom for possible publication.

7. Dr. R.P.P.K. Jayasinghe reviewed abstracts submitted to the Annual Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources (SLAFAR) 2022
8. Dr. D.R. Herath and Dr. R.P.P.K. Jayasinghe served as editorial members of the Proceedings of the NARA Annual Sessions 2022.

REPRESENTATION OF MBRD SCIENTISTS AT NATIONAL COMMITTEES/ NATIONAL SERVICES

1. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD has been acting as a member of the Steering Committee for Fishery Improvement Project (FIP) for Sri Lanka longline tuna and billfish fishery since 2017.
2. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD acts as a member in the Steering Committee for Fishery Improvement Project (FIP) for Sri Lanka Blue Swimming Crab fishery.
3. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD acts as a member in the implementation committee for National Plan of Action (NPOA) for conservation and management of sharks in Sri Lanka.
4. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD acts as a member in the implementation committee for National Plan of Action (NPOA) to prevent, deter and eliminate Illegal, Unreported and Unregulated (IUU) Fishing.
5. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD acts as the Focal Point of Work Package 1 (assistance to upgrade existing NARA's port sampling programs on coastal fisheries data collection and improve fisheries statistics) of "Sri Lanka – Norway Bilateral project" to improve the management of fish resources of Sri Lanka.
6. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD acts as the NARA Focal Point of French Development Agency (AFD) funding Fisheries Harbours Project.
7. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD serves in the committee formed by the Ministry of Fisheries with the aim of developing the local canned fish industry in Sri Lanka.
8. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD served in the committee formed by the DFAR to formulate "Ring Net Fishing Management Regulations" for regulating the ring net fishing operations in Sri Lanka.
9. Dr. S.S.K. Haputhantri, Principal Scientist of MBRD served in the committee formed by the DFAR to formulate a regulation in order to manage the crab fishery in Sri Lanka.
10. As per an invitation of the Chairman/NARA, Dr. S.S.K. Haputhantri chaired the session on Marine and Coastal Fisheries at the NARA Annual Scientific Sessions 2022 held as a virtual conference on 21st October, 2022.
11. Ms. G.K.A.W. Fernando, Scientist of MBRD act as a member of the Blue Carbon Ecosystems Task Force appointed by the Secretary, Ministry of Environment, Sri Lanka since 2022
12. Dr. R.P.P.K. Jayasinghe, Principal Scientist servers as the Coordinator for "Sri Lanka – Norway Bilateral project" to improve the management of fish resources of Sri Lanka.
13. Dr. R.P.P.K. Jayasinghe, Principal Scientist serves as a member of the National Expert Committee on Biological Diversity (NECBD) coordinated through the Biodiversity Secretariat, Ministry of Mahaweli Development and Environment.
14. Dr. R.P.P.K. Jayasinghe, Principal Scientist serves as the Sri Lankan Focal Pont for the EAF-Nansen Programme of the FAO.
15. Dr. R.P.P.K. Jayasinghe, Principal Scientist acts as the IORA Focal Point for Sri Lanka for Core Group on Fisheries Management (CGFM)
16. Dr. D.R. Herath, Senior Scientist of MBRD acts as a member of the National Committee on Fisheries and Aquatic Resources Sector (NCFARS) of the Sri Lanka Council for Agricultural Research Policy (SLCARP).

5.6 NATIONAL INSTITUTE OF OCEANOGRAPHY AND MARINE SCIENCES

Head of the Division : Dr. K. Arulanathan

Oceanography Division is responsible for planning and conducting coastal and offshore oceanographic studies around Sri Lanka. In this regard oceanographic and marine geological scientists conduct research in the fields of physical, chemical, biological oceanography. The Division has been conducting research on coastal and deep ocean research having long term archival of oceanographic datasets such as tides, currents and waves. The division provides its scientific and technological services to a wider range of applications such as coastal constructions, living and non-living resource exploitation, and energy harnessing including environmental impact assessments (EIA).

Progress of Research Projects

Oceanography Division has conducted eight major projects and several consultancy services during the year 2022. Following are the major projects conducted by the division during 2022.

	Projects	Responsible Officer/s
6.1	Tuna Fishing Ground Advisory and Fisheries Information Service	Sudheera Gunasekara, K.B.S.S.J Ekanayaka, N.G.L.N.Uthpala
6.2	Maintenance of sea level station	K.W.Indika
6.3	Offshore sand investigations in continental shelf of South-western coast	Dileka Samaranayaka, Damith Perera Ruchira Jayathilake
6.4	Seasonal variability of ocean (boundary) current and other parameters around Sri Lanka	K.B.S.S.J Ekanayaka K. Arulanathan Ashoke Weerakoon N.G.L.N.Uthpala Dr WNC Priyadarshani
6.5	Hydrology and water circulation of Lankapatuna Lagoon	Damith Perera K.B.S.S.J Ekanayaka Ruchira Jayathilake

PROJECT NO : 6.1

POTENTIAL FISHING GROUND FORECASTING (TUNA FISHING GROUND ADVISORY AND FISHERIES INFORMATION SERVICE)

Officer responsible : S.S. Gunasekara
Total Fund Allocation : 0.30 million LKR
Duration : Continues Project

Introduction

The fishery has a long tradition in Sri Lanka and contributed 1.1 % of GDP in 2019 (CBSL., 2019). The marine fishery is the dominant fisheries sector in Sri Lanka, contributing 82.1% to the country's total fish production (Ministry of Fisheries., 2020). Offshore tuna fishery has a significant contribution to the economy as tuna contributes 49.5% of total fish exports of 299 million US\$ in 2019 (Ministry of Fisheries., 2020).

Expansion of coastal fisheries has limited prospects as coastal resources are heavily utilized presently. A comparison of DrFridtjof Nansen's surveys (1978-1980) with the survey results in 2018

shows that the decline in total catch rates was oblivious in all the coastal regions, incredibly profound along the West coast (Krakstad et al. 2018). Sustainable development of the fisheries sector needs to be focused on the offshore fisheries sector. It can be expanded fishing area and can be improved by incorporating technology to minimize post-harvesting losses. Offshore fishing was introduced several decades ago. Fishers use their traditional knowledge and information from other fishing vessels to find fishing grounds. Satellite remote sensing is a proven tool for finding potential fishing areas and significantly reducing the search time. The National Fisheries and Aquaculture policy section emphasizes "Strengthen the fisheries forecasting system for fishers to obtain information on locations for productive fishing" Section 4.1.17 (Ministry of Fisheries, 2018).

At present, fishers use traditional knowledge and information from other vessels to reach the fishing grounds. Nevertheless, fishing masters used to rely on word-of-mouth from other fishing vessels to locate fishing grounds. Since the fishery role is opportunistic, a non-random distribution of fishing vessels highly concentrated in an area indicates an abundance of target fish. Like skipjack tuna, fishers tend to remain in warmer waters where masters seek opportunities to cast their nets. Therefore, this kind of fishery is not economically inefficient and post-harvest loss is high. Potential fishing areas are places in the waters where a high abundance of fish and suitable for fishing operations. Understanding the oceanographic factors that affect fish distribution is important to find out the possible fishing grounds. It is possible to use near-real-time oceanographic information from satellite remote sensing to predict potential fishing grounds.

Fishery forecasting involves understanding the oceanic processes and interactions of physical, biological, and chemical parameters. Remote sensing data can provide a significant part of the information needed to assess and improve the potential fishing grounds and assist judicious exploration, conservation and management of marine resources. Timely forecasting of potential fishing grounds information can help an optimizing the scheduling of fishing operations. Fish tend to aggregate in ocean areas that exhibit conditions favoured by specific fish species. Relevant oceanographic conditions, such as sea surface temperature, ocean colour (productivity), upwelling, thermal fronts gyres and eddies favouring the fish school, can be monitored and measured by remote sensing sensors. Several countries use potential fishing zone prediction technology to increase fishing efficiency. Nara started the development of tuna fishing ground prediction in 2005 and implemented it operationally from 2008 to the present. Since 2016, the fishing ground forecast provided three times a week.

Main objective

To enhance the economic and time efficiency of offshore/high seas fishery by providing information on potential tuna fishing ground advisory to multi-day fishing vessels

Specific Objective/s

To provide potential fishing zone advisories for tuna multi-day fishing vessels of Sri Lanka

Methodology

Sea surface temperature, sea surface height and sea surface chlorophyll data obtained from satellite remote sensing, fisheries catch information, and global ocean physical models are used to obtain preferable areas for yellowfin tuna (Figure1). This information is disseminated to fishers via email, telephone, radio and WhatsApp. Fishers are expected to use advisories to improve their fishing operation.

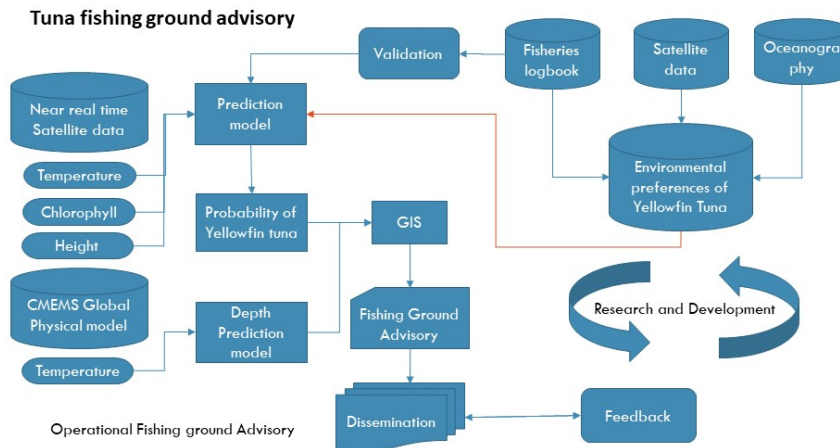


Figure.1 Flowchart of the Methodology

Activities proposed to be completed during the period

- Generating fishing ground advisory maps
- Fishery data collection: VMS data fisheries data
- Model development
- Validation of results
- Disseminate information by telephone, radio, email and web to the users
- Awareness programs for fishermen, vessel owners and other stakeholders

Results:

Activities carried out:

Timely forecasting of potential fishing grounds information can help an optimizing the scheduling of fishing operations.

Even under COVID-19 restrictions, fuel shortages, curfews, technical failures, and limited research staff, 133 yellowfin tuna fishing ground advisories (target 134) were produced three times a week and disseminated to high sea fishermen via email, telephone, Facebook and WhatsApp (Fig. 2).

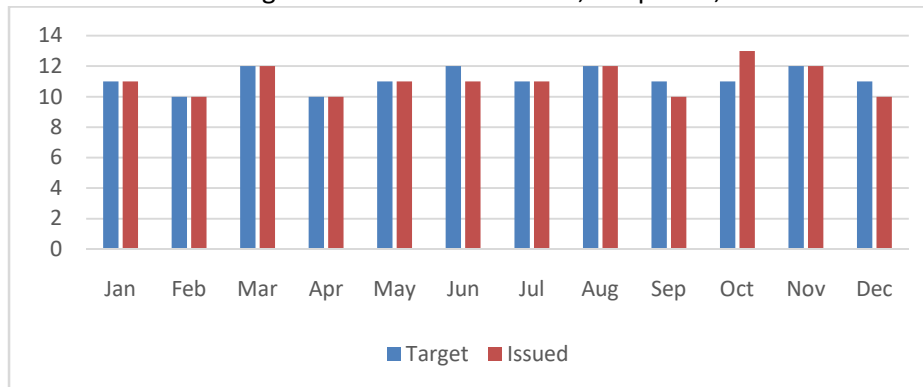


Figure 2: Fishing ground advisories issued in 2022

Awareness of Skippers and owners of multi-day fishing boats about potential fishing ground forecasts of Nara will be a crucial factor in the project's success. Therefore, awareness programs should conduct frequently. Awareness programs and fisheries data collection were conducted in Negambo, Dikowita, Beruwala, Ambalangoda, Hikkaduwa, Galle, Mirissa, Devinuwara, Suduwella, Nilwella, Kudawella and Tangalle, Valachenai, Trincomalee, Chilaw, Kalpitiya, Myliddy and Point Pedro fisheries harbours. Several awareness programs were cancelled due to limited fund availability (Fig. 3).

Awareness materials (Leaflets and banners) were designed, and 1000 leaflets and 23 banners were printed with funds from the Ministry of fisheries livelihood development project: Improve the awareness of satellite technology for locating fishing grounds (V5506). SSB radio was reinstalled to establish direct communication with multi-day vessels. In-situ data collection using temperature-depth recorders (TDR) was unable to conduct. However, TDR sensors were able to procure with funds from the Ministry of fisheries development project 01 in December 2021.

The number of email subscribers has been increased up to 380. Fishing ground advisories were started to disseminate via WhatsApp, and 400 vessel owners and DFAR officers have received the advisories. Projects Facebook page (www.facebook.com/tuna.forecast) and Department of fisheries registered skippers Facebook group (ඩිවර දෙපාර්තමේන්තුවේ ලියාපදිංචි නියමු එකතුව, <https://www.facebook.com/groups/1007014279736528>) were used to disseminate advisories effectively. Dialog Sayuru project also disseminate fishing ground advisories via TV screens at 8 fisheries harbours and through their Facebook page (<https://www.facebook.com/sayuru.lk>) which has 42000 likes.

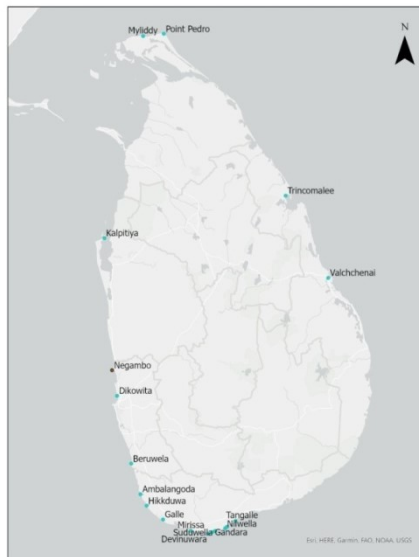


Figure 3: Map of fisheries harbours awareness programs conducted during 2022

Potential fishing ground forecast for skipjack tuna gillnet fishery

Skipjack tuna (*Katsuwonus pelamis*) is one of the most important fish species in the Sri Lankan gillnet fishery. Skipjack tuna inhabits the epipelagic zone (shallower than ~100 m) and is associated with warm water (>28–29 °C) (Druon et al. 2017). Understanding the oceanographic factors that affect fish distribution is essential to finding out the possible fishing grounds.

The objectives of this study were to investigate the connection of skipjack tuna fishing grounds with environmental factors in the northern Indian ocean using fishery logbook data and oceanographic parameters. Skipjack tuna catches from the gillnet fishery of Sri Lanka (–2 S to 12 N, 75 E to 90 E) from the 2016–2019 period were matched with sea surface temperature (SST), sea surface salinity (SSS), chlorophyll-a and other relevant oceanographic parameters from satellites and in-situ data from Copernicus Marine Environment Monitoring Service (CMEMS) during the study period using statistical modelling (Generalized Additive Model). The one-variable model using SSS and SST had the highest explained deviance (6.08% and 4.9%).

A multi-criteria model was developed to predict potential fishing grounds using SST and SSS data from the product GLOBAL ANALYSIS FORECAST PHY 001 024 provided by the CMEMS. The model provides a 5-day fishing ground forecast. Models were developed using the R statistical program

language (version 4.0.3) and ArcGIS Pro 2.9.3. The prediction model results were validated with fishermen's feedback, logbook and vessel monitoring system data.

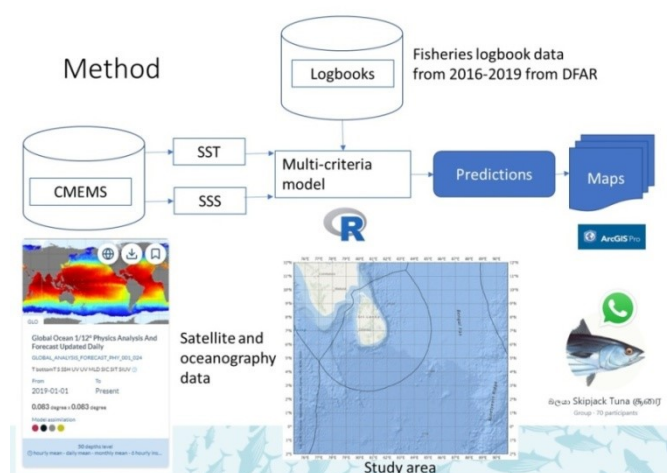


Fig 4. Flow chart of the method used for Skipjack tuna 5-day fishing ground forecast

NARA has released an experimental forecast of skipjack tuna fishing grounds for multi-day vessels using gillnets. This provides a map showing the areas where the skipjack tuna for the next five (5) days from the date the forecast is issued. Satellite, oceanographic, and fisheries data are used to create this forecast. The forecast maps will issue three days per week (Monday, Wednesday, and Friday). the forecast maps are issued for sea areas between -2 South to 12 North latitudes and 75 East to 90 East longitudes. This service was initiated on 02nd May 2022. During 2022, 83 potential fishing ground advisories for skipjack tuna are produced three times a week and disseminated to fishers via WhatsApp. The forecast results were partially validated with fisheries logbook data and VMS data of vessels from the Valachchenai fisheries harbour.

Outputs & outcomes

- The impact of the project will be the improved high sea fishery of Sri Lanka.

Outputs

- Improved the predictability of potential fishing grounds
 - The model was updated for the latest satellite and oceanographic modal data sources
- Potential fishing ground forecast for skipjack tuna gillnet fishery
- Increasing the number of recipients
 - The number of email recipients was increased up to 380
 - WhatsApp 400 recipients
 - Facebook page 1100 followers
- Increase the awareness on the usage of fishing ground advisories

Outcome

Improve the efficiency of the tuna multi-day fishery of Sri Lanka. Due to the fuel crisis, fishermen are more dependent on potential fishing ground advisories.

Conclusions

Even under COVID-19 restrictions, curfews, technical failures, and limited research staff, 133 yellowfin fishing ground advisories (target 144) and 83 potential fishing ground advisories for skipjack tuna were produced three times a week and disseminated to high sea fishermen via email, telephone and WhatsApp.

Recommendations

Potential fishing ground forecasting is a dynamic process of analyzing fisheries, satellite and oceanographic data and fine-tuning prediction models by updating data sources. There are no scientific fishing programs for tuna and tuna-like species, in-situ oceanographic data collection and adequate fisheries logbook data collection program. The validation of predictions and improvement of the tuna environmental preferences rely on the Department of Fisheries logbook data which has low accuracy and low quality. It is crucial to improve the quality of fisheries logbook data. These are essential to enhance the prediction model and provide reliable advisories.

At present, Nara provides potential fishing ground forecasts for yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*). However, there is a possibility to develop advisories for bigeye tuna (*Thunnus obesus*) and billfishes. Incorporating the physical ocean model will provide future predictions, and fishers will be able to plan the cruise before leaving the port. Improving the accuracy of hooking depth of longline will be able to introduce deep longline fishing methods, which are successfully used by other fishing nations.

Awareness programs are used to aware fishers, vessel owners and relevant government officials about the tuna potential fishing ground prediction and use of that information for offshore tuna fishery. Nara has a limited capacity to conduct awareness and disseminate information to users. SSB radio can be used to provide information directly to fishers in the sea and get real-time feedback. Developing a mechanism to send area-specific potential fishing ground advisories to fishing vessels via VMS system will improve the dissemination and management of high sea fishery resources.

Constraints

- Two scientists allocated for the project have been left Nara, and no replacements were done. A new forecasting model for bigeye tuna and billfishes was planned during 2022, and were unable to complete the activity due to the unavailability of the required staff. It is crucial to allocate the necessary staff and support of supporting divisions to achieve the targets.
- Validating the forecast with logbook data was partially completed due to the unavailability of the required staff.
- Hardware failures of satellites and data delays caused interruption of the advisories. Therefore, the development of methods to get alternative satellite data is recommended.

Financial Allocation (Rs) 0.3 million : Financial progress (%) Physical Progress (%) 153

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5. Ministry of Fisheries., 2018. National Fisheries and Aquaculture Policy. Ministry of Fisheries.
6. Ministry of Fisheries., 2020. Fisheries Statistics 2020. Ministry of Fisheries.

PROJECT No : 6.2

MAINTENANCE OF SEA-LEVEL MONITORING NETWORK AROUND SRI LANKA

Officer responsible	: K.W. Indika
Total Fund Allocation	: 0.33 million LKR
Duration	: Continues Project
Locations	: Trincomalee, Colombo, Mirissa, Kirinda, Point Pedro

Introduction:

The SDG goal of UN 'Climate Action' is to reveal the necessity of urgent action against climate change via anthropogenic activities. Sea level variability and change are manifestations of climate variability and changes by the circumstances of natural and manmade. Continues sea level monitoring, recording and reporting are important for the study of threatening coastal life and limiting coastal land as an Island state country with the higher potential of ocean-based disaster.

According to the record of the Intergovernmental Panel on Climate Change (IPCC) the Global Mean Sea Level Rising (GMSLR) rate during 1901-1990 was 1.5 (1.3 to 1.7) mm per year while during 1993-2010 was 3.2 (2.8 to 3.6) mm per year with greater rate since the end of 19th century. The latest measurement of the annual average global sea level trend is 3.4 mm/yr., the steric height increased by 1.2 mm/yr., Ocean mass increased by 2 mm/yr., according to the climate change research Centre of NASA in December 2022. Rising sea levels are caused by the absorption of atmospheric temperature, expanding volume of oceanic water, and addition of excess water to the ocean by melting of glaciers and ice sheets with reducing of solid water storage on land. The stored more than 90% of excess energy is associated with anthropogenic climate change as the leading contributor to the global thermo-steric sea level rise (J. Climate (2015)). Historical records of the earth's surface temperature show 2010 -2019 are the warmest decade ever recorded as a finding of NASA. As shown by the latest report of the United Nations IPCC paints a very sobering picture of the challenges we face at the end of this sanctuary in 1.1m due to sea level rise.

Main objective:

- Continuous data collection and maintenance of existing sea level monitoring stations
- Installation of instruments to the Point Pedro Stations
- Installation of instruments to the Kirinda Stations
- Development of the existing "Sea Level" web portal under the NARA web page.

Specific Objectives

- Quantification of sea level trend around Sri Lanka
- Determination of monsoon response around Sri Lanka
- Quality controlling and archiving of sea level time series data.
- Issuing monthly sea level related destructive event report to the DMC.
- Installation of data transmission to the Colombo head office from Point Pedro and Kirinda.
- Leveling of Colombo and Point Pedro sea level monitoring stations.

Methodology

The methodology of the study conducted based on data acquisition from the automated sea level monitoring network around the country.

Study area

The study area is all the shoreline of the country. The present sea level monitoring network consisted of five stations at Trincomalee, Point Pedro, Colombo, Mirissa, and Kirinda. Site selection and land

clearance were completed for the proposed new tide station at Dondra fishery harbor but procurement processes for construction were incomplete due to not recovering bids. The main reason is not compatible with the engineering estimate with the practical estimate of the financial inflation of the Country.

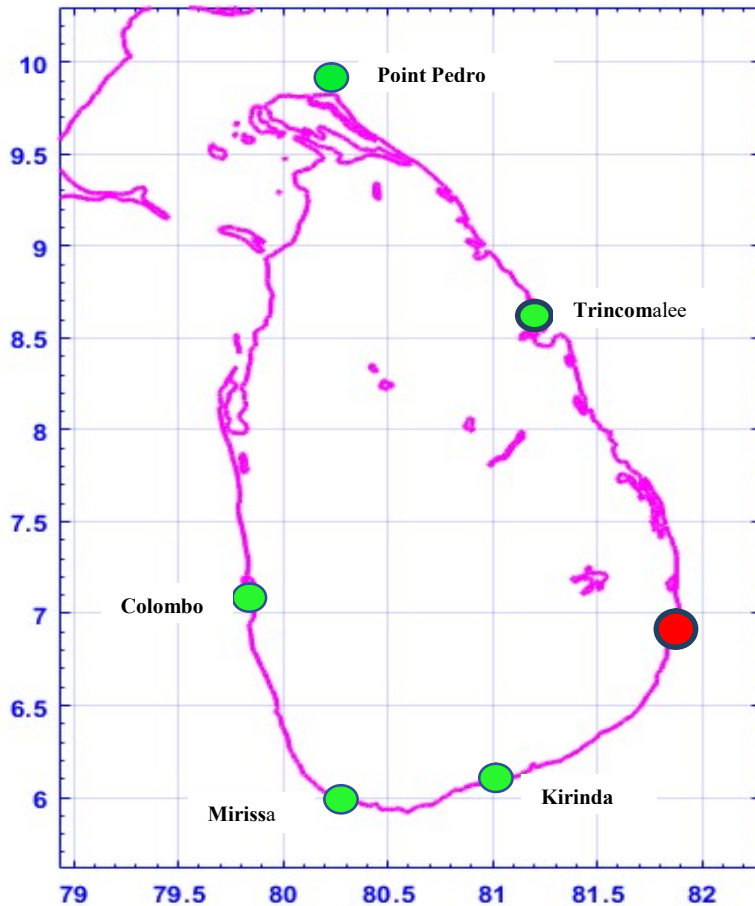


Figure 01: Sea level monitoring network around the country

The green color indicates the present existing network of sea level monitoring, and the red colour shows the proposed sea-level station in the Pottuvil.

Table 01: Description of the sea level stations and data collection.

	Location	Status	Parameters	Transmission	Collaboration
01	Trincomalee	Functioning	Water height : Radar and Hydrostatics pressure sensor	Satellite : communication	University of , Hawaii , IOC
02	Point Pedro	Functioning	Water height : Radar and Hydrostatics pressure sensor	General Packet Radio Service (GPRS) : local communication via Mobitel	First Institute of Oceanography (FIO), China
03	Colombo	Functioning	Water height : Radar and Hydrostatics pressure sensor	Satellite : communication	University of Hawaii, IOC

04	Mirissa	Functioning	Hydrological and meteorological :Wind, rain fall, water temperature, tide, pressure, Humidit	General Packet Radio Service (GPRS) : local communication via Mobitel	First Institute of Oceanography (FIO) , China
05	Dondra	Completed land clearance.	Water height : Radar and Hydrostatics pressure sensor	General Packet Radio Service (GPRS) : local communication	South China Institute of Oceanography (SIO) , China
06	Kirinda	functioning	Water height : Radar and Hydrostatics pressure sensor	Data Transmission USB	Hawaii University, Hawaii, IOC
07	Pottuvil	Completed Site selection and land clearance	Hydrological and meteorological parameters	GPRS	FIO

Mechanism of the data collection

The methodology consisted of data acquisition, temporary saving, and transmission to the data server at the head office. The received data to the server need to be completed following the main steps in order before using the data product development, downloading, processing, quality controlling, and analyzing.

The data process and analysis were conducted by using Matlab R2018a, Panoply, and Microsoft excel. The long-term sea level variation was derived using ECMWE reanalyzed data using Panoply software. The tidal range was calculated according to the equations of Understanding of Tide by NOAA (Hicks. 2006). The parameters we use to collect under the main two categories. They are meteorological parameters such as wind speed and direction, atmospheric pressure, atmospheric temperature, humidity, and precipitation, and hydrological parameters such as water temperature and sea level height. The data acquisition, temporary saving, and transition conduct automatically by pre-defined time intervals via satellite and General Packet Radio Service (GPRS). The Mirissa data transmit every minute to the NARA data server at the head office via the local communication network (Mobitel). The satellite data transmission conducts every 15 minutes via the Metosat to the server of the University of Hawaii and update on the web page of the Global sea level monitoring facility of the Intergovernmental Oceanographic Commission (IOC) with a delay of a few minutes.

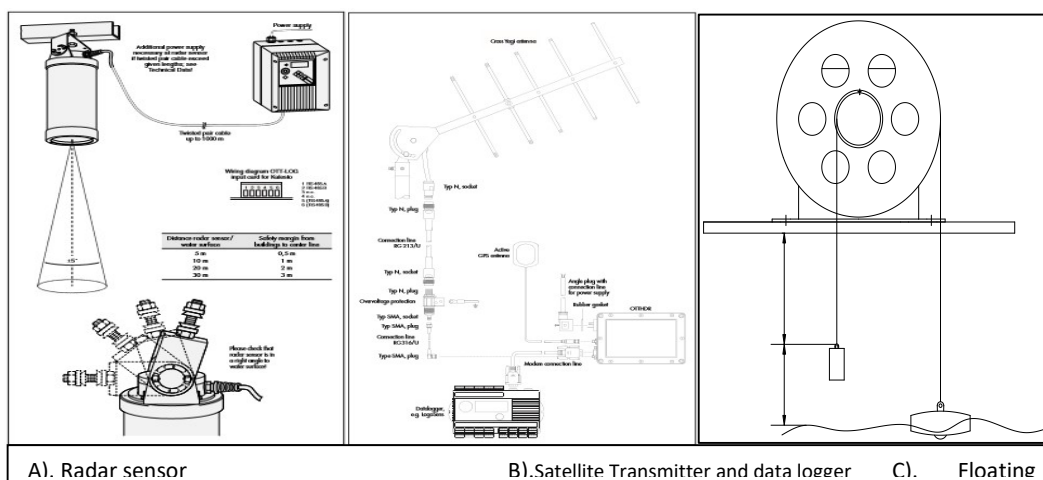


Figure 02: Schematic diagram of Kalisto radar sensor, Satellite antenna and floating tide gauge.

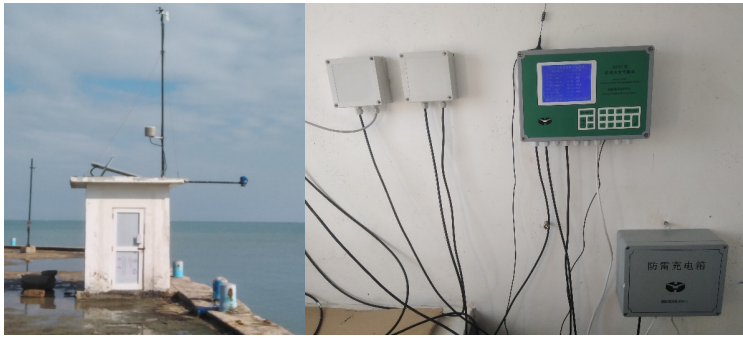


Figure 03: Sensors and transmitters of a sea level measuring station.

Sea level monitoring station and data transmission modems installed at Point Pedro's new sea level Monitoring station. The instrument cost approximately more than 10 million. The instrument was obtained under the donation of the First Institute of Oceanography, China. The collated data save automatically to a data logger and transmit by pre-defined time intervals via satellite and General Packet Radio Service (GPRS).

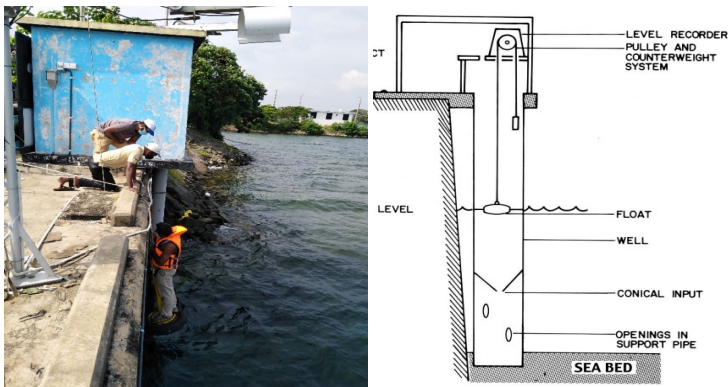


Figure 04: Sea level measuring station at Trincomalee.

Its shows the tide well established along the jetty wall to direct to the bottom of the sea from the tide house. The floater was established on the water surface inside the tide well. It gives a noise-filtered environment to measure sea level signals due to the creation of an undisturbed environment inside the well.

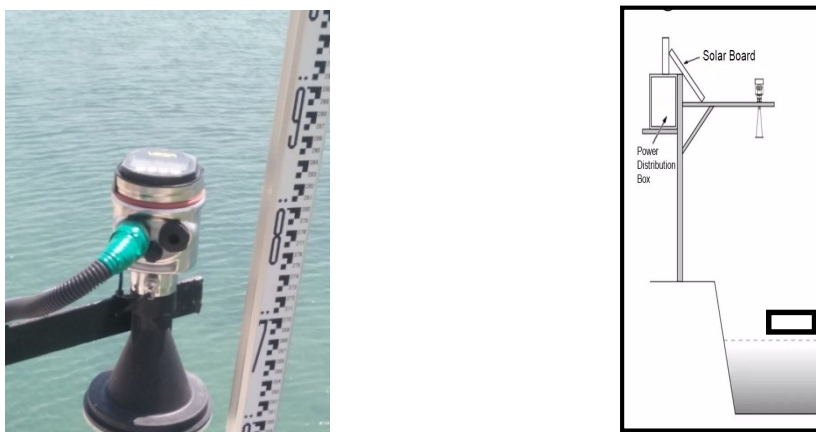


Figure 05: Acquisition of water level using radar sensor installed at Point Pedro fisheriesharbor.

The first figure shows the actual installation of the radar sensor to direct sea surface mean while the leveling process also was done, the second image is the schematic diagram of the sea level measuring using the radar sensor. When the radar antenna emits microwave pulses, it has a certain emission angle. There should be no obstructions in the area radiated from the antenna to the medium surface and the area of radiated microwave beam.

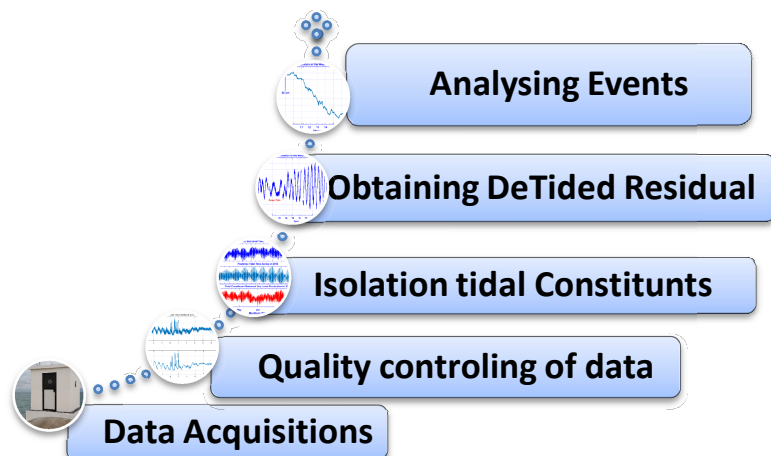


Figure 06: Flow chart shows the basic steps of the data handling from acquisition to analyzing.

The quality controlled data were used to obtain de-tided residual sea level signals and analyze the events such as storm surges, meteotsunami, and Tsunami. The analysis was conducted using Harmonic analyzing functions developed by Matlab software, high-frequency detection functions, and moving averages, analyzing of energy density spectrum, and filling of missing time column functions.

Activities conducted during period of project

- Updated Quantification of Sea level rise around Sri Lanka
- Analyzed seasonal sea level signals.
- Study of extreme sea level events (Storm Surge, meteotsunami, El Niña, La Niña)
- Data downloading, preparation & quality controlling
- Data Product development and published on the NARA web page.
- Installed sensors to Point Pedro's new station
- Installed data transmission system to Point Pedro station to receive data to the head office
- Repaired damaged radar sensor by a fisheries boat at Point Pedro fishery Haber.
- Maintenance conducted in the functioning state of Trincomalee sea level monitoring station
- Instruments installed Kirinda sea level monitoring station
- Issued monthly sea level-related destructive event reports (12) to the Disaster Management Center (DMC).
- Leveled sea level stations of Point Pedro, Colombo
- Trained 03 university students (Undergraduate)
- Repaired damaged door at Mirissa sea level Monitoring station
- Published 5 publications using sea-level data

New Sea level monitoring stations

The new functioning two stations were added to the existing sea level monitoring network. The Kirinda station was renovated last year and installed a radar sensor in April 2022. The point Pedro station construction was completed 2021 and the installation of instruments and transitions of data to the Colombo head office started in April 2022.



Figure 07: Sea level Monitoring stations at Kirinda and Point Pedro

Results obtained

The sea level variation was studied around Sri Lanka using the Mirissa, Colombo, Trincomalee, Point Pedro and Kirinda tide gauge observations by the segmented time period of a solar day, fortnight, monthly, seasonal, and long-term. The results were compared with the western coast, southern coast, and eastern coast of Sri Lanka. The Stellate data was used from European Centre for Medium-Range Weather Forecasts (ECMWE) re-analyzed data. The tidal-related calculation was done according to the methodology of Understanding of Tide by NOAA (Hicks. 2006).

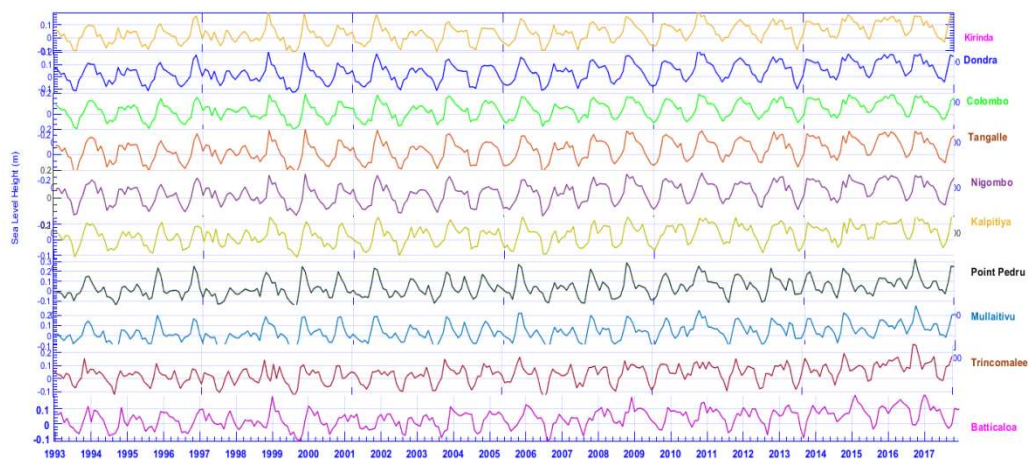


Figure 08: Annual Average Sea Level Trend around Sri Lanka

The graphs are in ordering Tangalle, Batticaloa, Negambo, Kirinda, Point Pedro, and Colombo. The green lines are fitting linear trend of monthly average sea level trend. The blue lines are monthly average sea level variations.

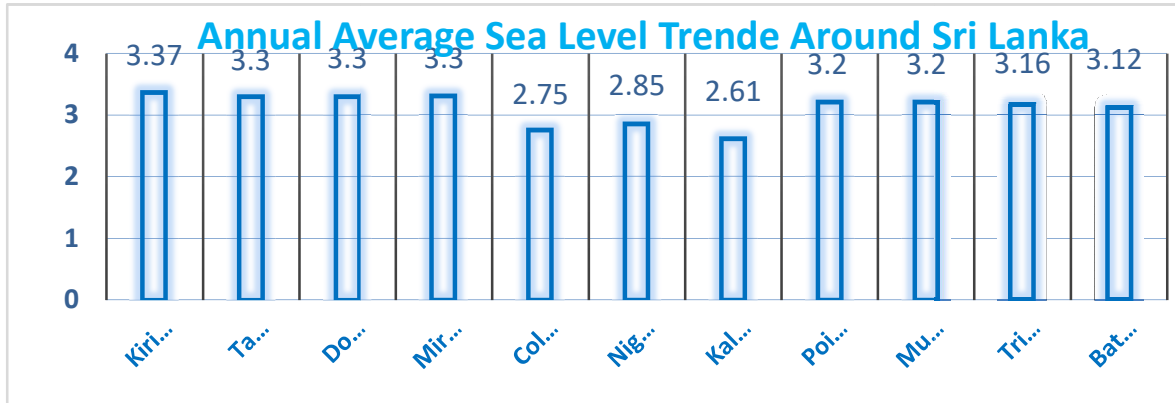


Figure 09: Annual Average Sea Level Trend around Sri Lanka

Number	Station Name	Location		Trend (mm)
		Latitude	Longitude	
01	Kirinda	6.120656	81.410025	3.37
02	Tangalle	5.883324	80.885746	3.30
03	Dondra	5.8015	80.447795	3.30
04	Mirissa	6.906914	79.577978	3.30
05	Colombo	6.906914	79.577978	2.75
06	Nigambao	7.17539	79.567343	2.85
07	Kalpitiya	8.22462	79.528431	2.61
08	Point Pedru	9.97030	79.528431	3.20
09	Mulathive	9.29190	79.528431	3.20
10	Trincomalee	8.61110	79.528431	3.16
11	Batticaloa	7.73979	79.528431	3.12

Table 02: The location of sea level observation collected from satellite and annual average sea level trend according to the 25 years of sea level data.

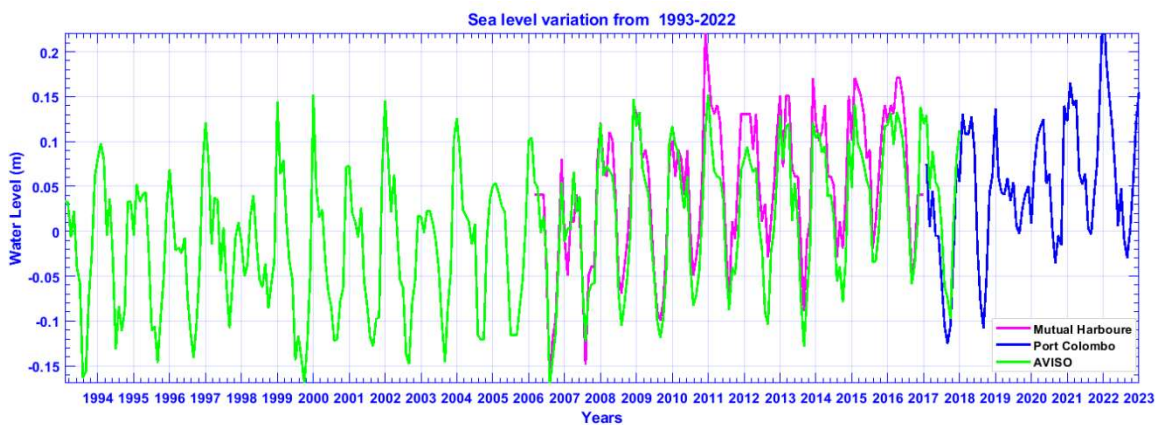


Figure 10: Comparison of satellite derived sea level variation and Colombo tide gauge observation in the same axis.

- A). Green line is the monthly average sea level variation during 25 years from the 1992-2018.
- B). Green line is the monthly averaged tide gauge observations from 2006 to 2017.
- C). Blue line is monthly average tide gauge observation from 2017-2022

Calculation of Mean Sea Level (MSL)

The mean sea level determination is a long-term process. The local mean sea level calculates by collecting water level measurements over a period of 19 years (a Metonic cycle) at various locations and then averaging all of the measurements. Whether establishing the NARA sea level monitoring station in 2004 we haven't continued data to the same datum. NARA had to relocate to the Colombo port authority due to the Colombo, Mutual fisheries harbor development.

Table 03: Calculation of Mean Sea Level (MSL)

Year	Months												MSL
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2017	1.0834	1.0489	1.0911	1.0438	1.0584	1.0057	0.9632	0.9421	0.966	1.0496	1.1594	1.1238	1.0446
2018	1.1209	1.0982	1.0986	1.1181	1.0807	0.9703	0.9108	0.882	0.9381	1.0328	1.0528	1.1272	1.0359
2019	1.0512	1.034	1.031	1.0499	1.0236	1.0453	0.9965	0.9873	1.0156	1.032	1.0406	0.9986	1.0255
2020	1.0626	1.0943	1.1062	1.1151	1.043	1.0545	0.9938	0.9548	0.9855	0.9749	1.1304	1.1125	1.0523
2021	1.1557	1.1303	1.1363	1.0542	1.043	1.0545	0.9938	0.9869	1.0314	1.0669	1.1547	1.2605	1.0890
2022	1.1825	1.1423	1.1083	1.0585	0.9963	1.0382	0.9819	0.9607	0.9907	1.0425	1.1108	1.1459	1.0632
	1.1094	1.0913	1.0953	1.0733	1.0408	1.0281	0.9733	0.9523	0.9879	1.0331	1.1081	1.1281	1.0517

Identification of extreme events

During the year 2022, two destructive extreme weather events were recorded. One from the southern coast due to ASANI and second is northern coast due to the tropical cyclones MONDOUS-22 originated in the Bay of Bengal.

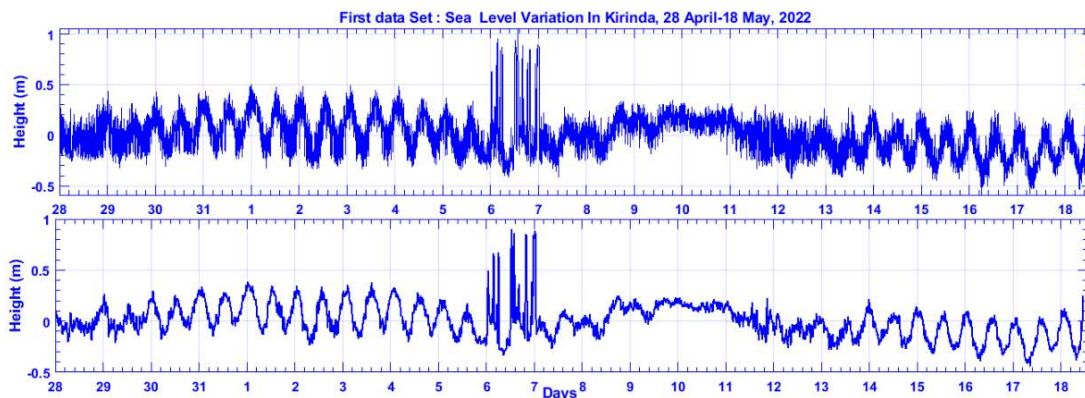


Figure 11: Sea level variation in Kirinda sea level monitoring station during Cyclone ASANI.

A). First graph is observed sea level variation during 6th and 7th May 2022.

B). Second graph is the smoothed line filtering noises by moving average

The graph shows first data set collected from Kirinda station. This grape indicate storm surge condition with more than 50 cm of sea level fluctuation due to the impact of a typical cyclone ASANI in the Bay of Bengal during 7th and 8th May, 2022.

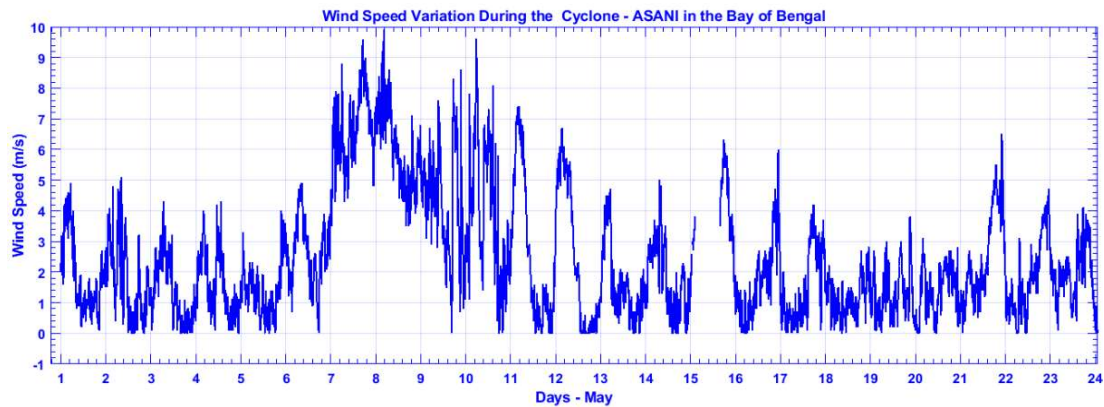


Figure 12: Wind Speed variation in the Southern Coast during the Cyclone ASANI. The maximum wind speed during the ASANI was 10 m/s at the Mirissa observation station.

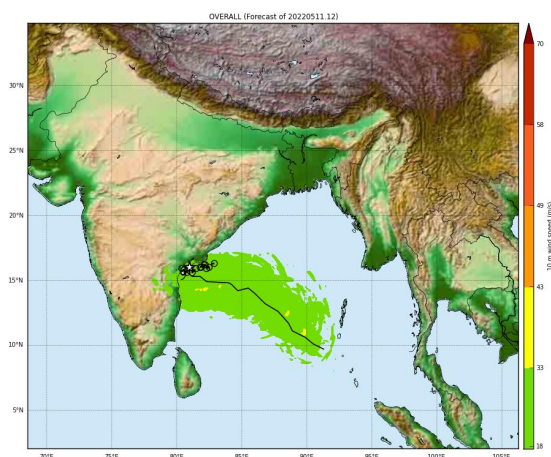


Figure 13: The map shows the track of ASANI tropical cyclone.

The reason of the abnormal sea level signal is the impact of tropical cyclone ASANI formed over the southern Bay of Bengal on 7th the May and moved north-west toward central eastern India. On 10 May at 0.00 UTC, Its center was located approximately 260 Km south-east of Kakindada City, with maximum wind of 120 Km/h (Ref: Moderate resolution Imagine Spectro-radiometer, MODIS). Extreme Weather condition in Sri Lanka.

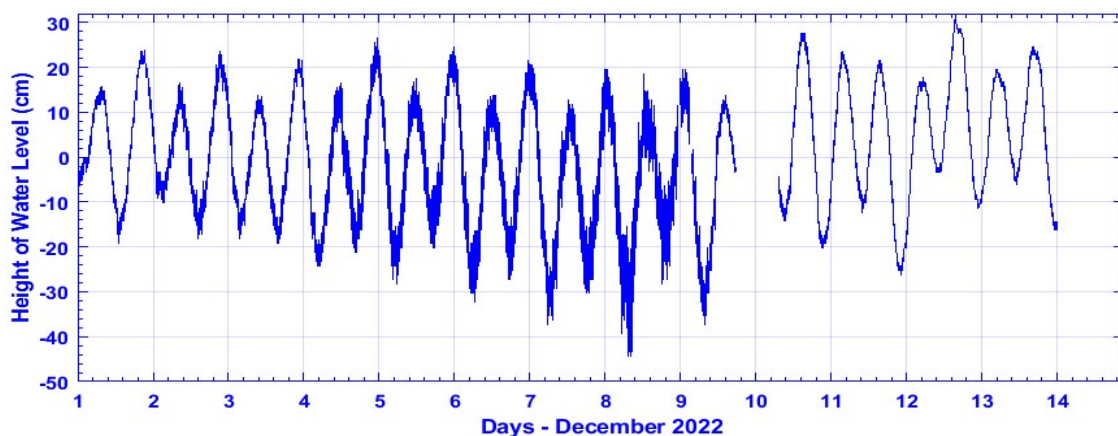


Figure 14: Abnormal sea level fluctuation during the cyclone Mondous 22. The graph shows destructive sea level condition in the north coast of Sri Lanka recorded by the newly established Point Pedro Sea level monitoring station from 7th to 8th December 2022. The storm surge height was 75cm at Point Pedro in the northern coast of Sri Lanka.

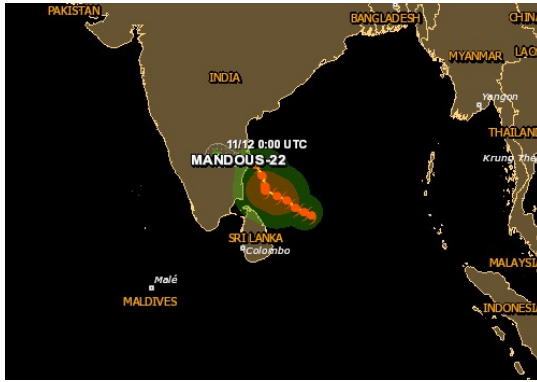
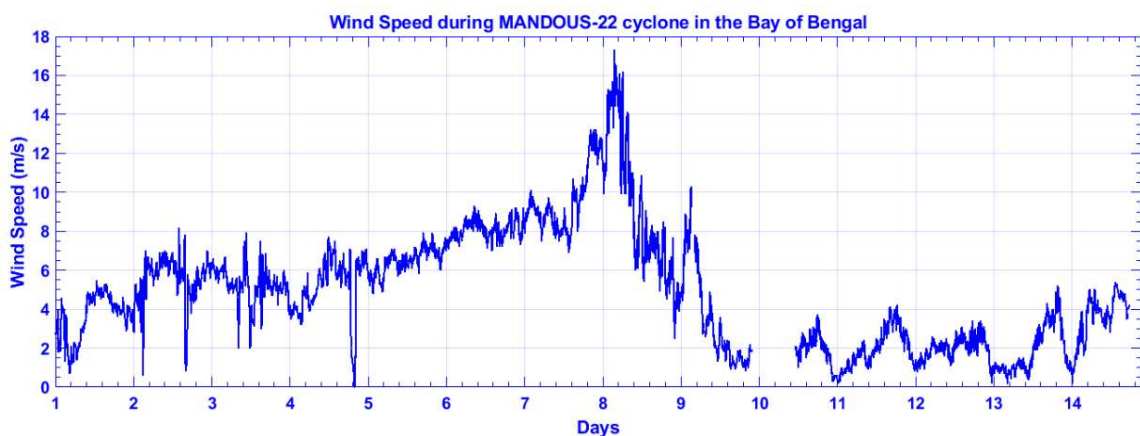


Figure 15: The overall track of the MANDOUS-22 cyclone in the Bay of Bengal (Ref: Indian
Figure 16: Wind Speed variation in the Southern Coast during the Cyclone Mondous 22.

Table 04: Description of Available data

	Station	Parameter	Period of data available
01	Mirissa	Wind speed and Direction	2017-2022
		Sea Level	2017-2022
		Atmospheric Temperature	2018-2022
		Atmospheric Pressure	2017-2022
		Water Temperature	2017-2020
		Rainfall	2017-2022
02	Colombo	Sea level height	From 2005 to 2016 and from 2017 to 2022 (Relocated)
03	Trincomalee	Sea level height	2017-2022
04	Hambanthota	Sea level height	2009,2010 (Only few month available)
05	Kirinda	Sea level height	2008-2011 (No continues data available), 2022 only one month.
06	Point Pedro	Sea Level height	2019 few month, 2022 few month
		Wind speed and Direction	From June 2022
		Atmospheric Pressure	From June 2022
		Atmospheric Temperature	From June 2022 (few month)



MeteorologicalDepartment) The tropical cyclone MANDOUS -22 formed over the southern Bay of Bengal on 8th the December 2022.

The maximum wind speed during the Mondous 22 was 17 m/s at the Point Pedro. The Mondous 22 cyclone brought bad impact to health and environment by polluted air particle, fisheries industries, dairy industry, in addition to the heavy rain and wind

The table shows the available data and their periods. There are missing data for every parameter of the data due to the malfunction of the instrument and the breakdown (power cut) of the power supply. The Mirissa station is working by the main power supply and external battery backup. The power system of the Mirissa converted to solar power in 2022. Trincomalee, Colombo, Kirinda, and Point Pedro Stations are working on solar power systems. The maintenance process of Kirinda not was abled as required because of the fuel availability, cost, and fund shortage with the financial inflation of the country.

Description of trained university students

Most of undergraduate and master students are select NARA to complete their internship as well as the research thesis. Following students were directed by the universities and they were completed their academic requirements using sea level and meteorological data including the mentoring.

Table 05: Trained undergraduate students

Name	University	Tropic of the research
Miss. W.M.S.W. Weerakoon , NO: 715392913	Department of Electrical & Computer Sciences, Open University of Sri Lanka,	Feasibility study for an offshore wind plant in Sri Lanka.
Miss. VarshaniBrabakaran	Department of Oceanography and Marine Geology, Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Sri Lanka	Determination of potential wind energy using Weibull distribution in Mirissa, Southern coast of Sri Lanka,
Mr. ThavarasaVinithSteeban	Department of Oceanography and Marine Geology, Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Sri Lanka	Assessment of Indian Ocean Dipole (IOD) Influence on Rainfall and Temperature in the southern coast of Sri Lanka.
Mr.D. A. R.Daranagama	Department of Civil Engineering, Faculty of Engineering, University of Peradeniya.	Evaluate the impact of precipitation pattern and Spatial distribution over Compound Flooding.
Mr. V. D.Athuraliya (PD/E/WE/2020/01)	Master in Environmental and Water, Department of Civil Engineering, Faculty of Engineering, University of Peradeniya.	Modelling Dynamic Behaviour of Salinity Intrusion in Kalani River.
Mr. Chinthaka	General Sir John Kotelawala Defence University located at Ratmalana.	Analysing of tidal signal.

Dissemination data and data product

The metadata and data product have published through the NARA main web page under the “Sea Level” portal. The interest community can be requested the data according to their requirement based on the row data or as technical report. We have provided technical reports and row data for the several coastal development works such as waste water management system, harbor developments, researches, student, and bathymetric surveys.

The “Sea Level” web page consisted a contact form for a person who interest can be sent a message with an email address via the contact form, then we can be provided relevant data or information as their requirements. Further web portal includes monthly sea level graphs generated using processed data based on availability of data in sea level stations around the country.

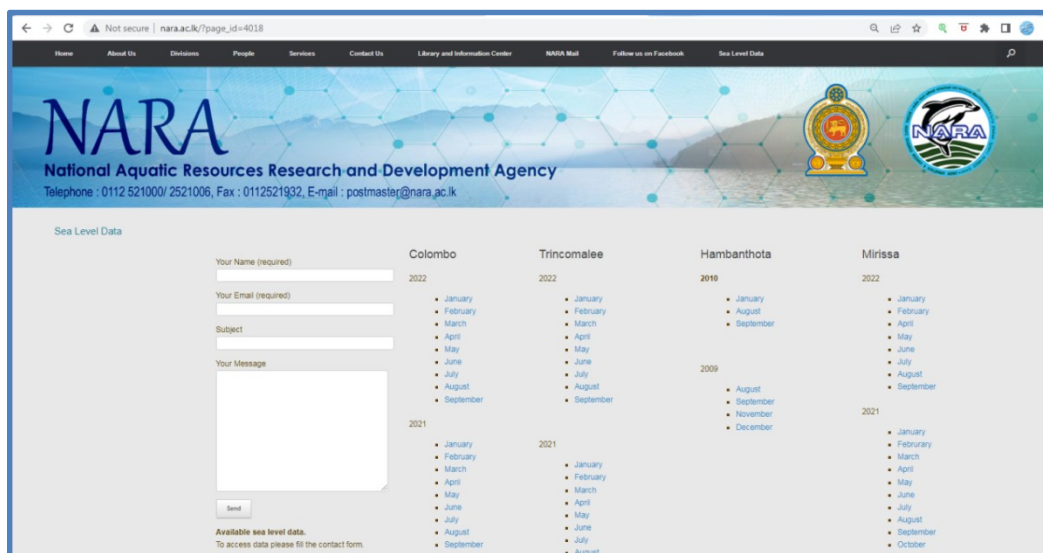


Figure 17: Sea level web portal interconnected with NARA web page

NARA has provided facilitate and directed approximately 80 users through the contact form of the web page. Total number 593 of mails received through contact form increasing the number of users of NARA webpage. The monitoring and evaluation division of the NARA contributes for the updating and developing of Sea Level web portal.

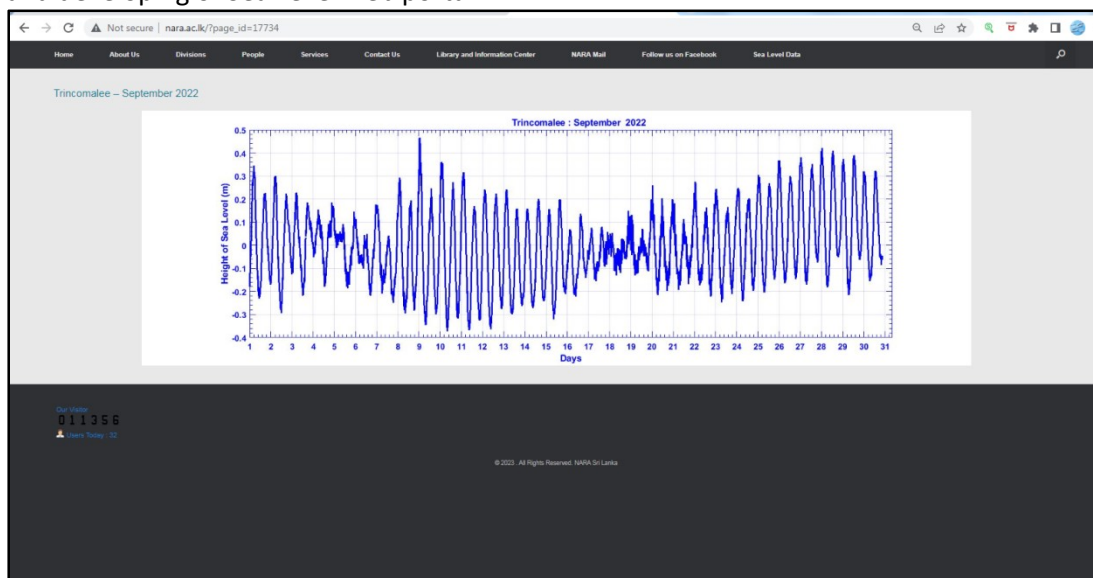


Figure 18: Monthly sea level Product Available in the NARA web page

Publications done during this year findings

1. Feasibility study for an offshore wind plant in Sri Lanka, Annual Research Conference, International Conference on fisheries and Aquaculture, Colombo, Sri Lanka, 2022.
2. Determination of potential wind energy using Weibull distribution in Mirissa, Southern coast of Sri Lanka, Annual Research Conference, National Aquatics Resources Research Development Agency, Sri Lanka, 2022.
3. Assessment of Indian Ocean Dipole (IOD) Influence on Rainfall and Temperature in the southern coast of Sri Lanka, Annual Research Conference, National Aquatics Resources Research Development Agency, Sri Lanka, 2022.
4. Study of Sea Level variation in the East coast of Sri Lanka, Annual Research Conference, National Aquatics Resources Research Development Agency, Sri Lanka, 2022.

5. Study of hydrodynamics of Lankapatuna coastal lagoon in East coast of Sri Lanka. Annual Research Conference, National Aquatics Resources Research Development Agency, Sri Lanka, 2022.

Technical report issued Sea level related destructive event

1. 12 reports were issued using sea level records around Sri Lanka to the Disaster Management Center (DMC). The report will be used as scientific evidence for the compensation process of the coastal communities and assets affected by the ocean-based distractive event by DMC.



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State Ministry of National Security and Disaster Management

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 தொலைபேசி எண் 07
 Vidyā Mawatha, Colombo 07.

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 Vidyā Mawatha, Colombo 07.

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 தொலைபேசி எண் 07
 Vidyā Mawatha, Colombo 07.

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 எனது எண்
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DMC/Miti/Desinventar
 correspondence/ 2021

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**Sea Level Observations
November 2022**

**National Aquatic Resources Research and Development Agency (NARA),
Crow Island, Mattakkuliya
Colombo 15**

Prepared by:

K.W. Indika - Research Scientist
National Institute of Ocean and Marine Sciences (NIOMS)

Sea level observation including tidal and extreme events are as following during the month of November 2022.

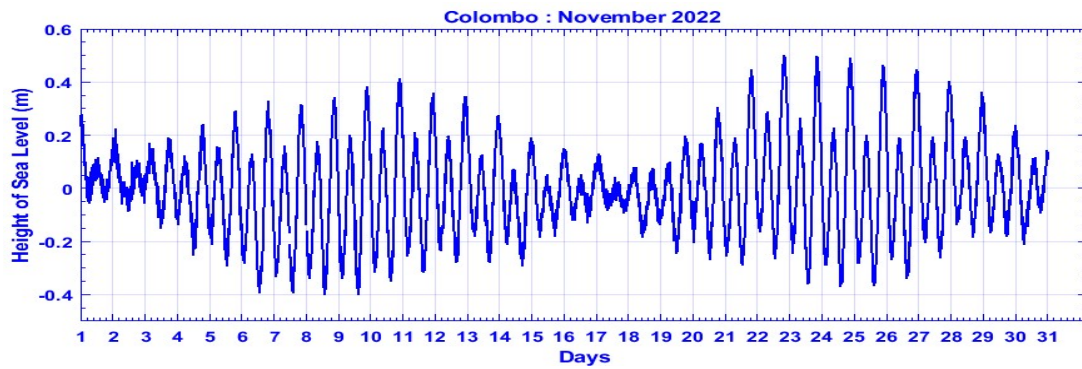


Figure 01: Sea level in SLPA station, Colombo

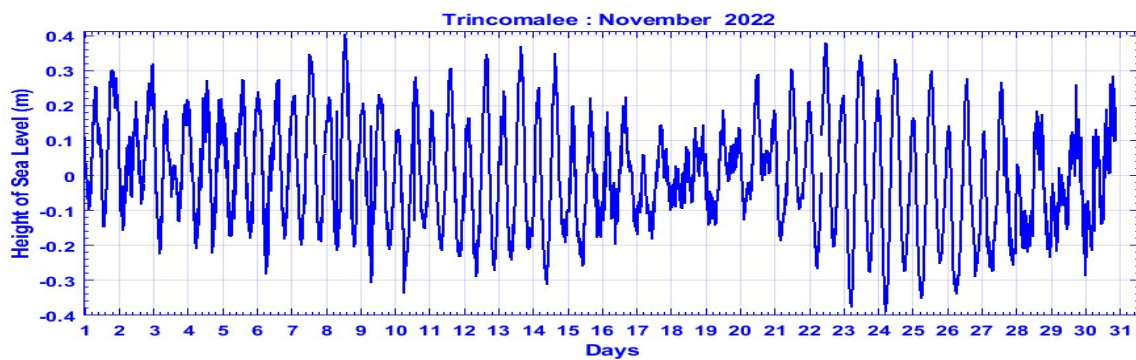


Figure 02: Sea level in Cod Bay, Trincomalee station

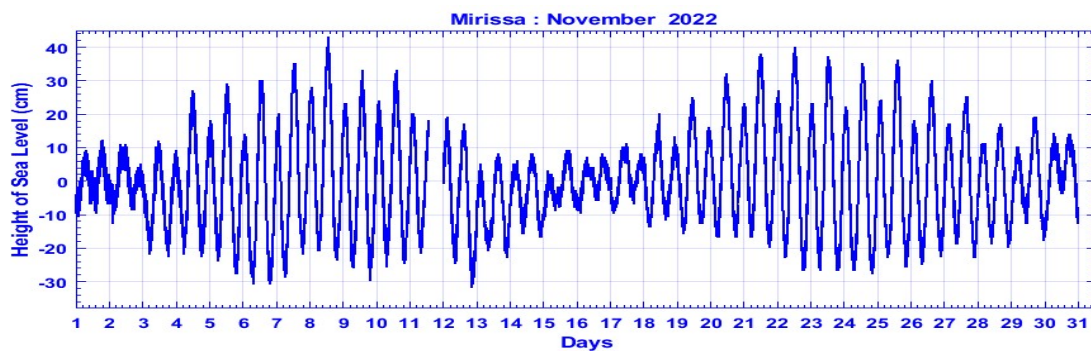


Figure 03: Sea level in Mirissa Station, Matara

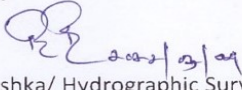
According to the observations no destructive events were recorded during the month of November 2022.

Leveling information of Colombo

The leveling process conducted by the National Hydrographic Office of NARA.

Leveling information of Point Pedro Sea Level Station

Benchmark Details

TO : Head/ NIOMS
THRO' : Head/ NHO 
FROM : B.Y.T. Dhanushka/ Hydrographic Surveyor
DATE : 28th January 2022
SUBJECT: **LEVELLING FOR NEW TIDE GAUGE AT COLOMBO PORT AUTHORITY- 2022**

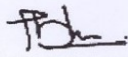
This is to inform you that Benchmark, "BM NARA" which was established on the SLPA pier in 2017 has been connected to the Fundamental Bench Mark (FBM) 52-FBM-UB-COLOMBO at Ibbagewatta, and the following values have been re-derived with respect to the Mean Sea Level (MSL)

Derived values as follows,

BM No.	Description	Elevation (m)	Remarks
BM-Tide (SLPA)	Bolt on Concrete	1.484	Near Old Tide Gauge
BM NARA	Brass Bolt	1.572	On SLPA Pier at near New Tide Gauge
SW2 (Bolt 2)	Bolt	0.314	Bolt at Switch Pole
SW1 (Bolt 1)	Bolt	0.305	Bolt at Switch Pole
RAD (Sensor 1)	Bottom level of the Sensor	3.358	Fix to the Tide House
RA2 (Sensor 2)	Bottom level of the Sensor	3.361	Fix to the Tide House
A	Top of Switch Pole	1.543	Near Tide Gauge

Level Datum : Mean Sea Level (MSL)
Level Book : LB 2015/01

Sketches are annexed for your reference


.....

B. Y. T. Dhanushka,
Hydrographic Surveyor/ NHO

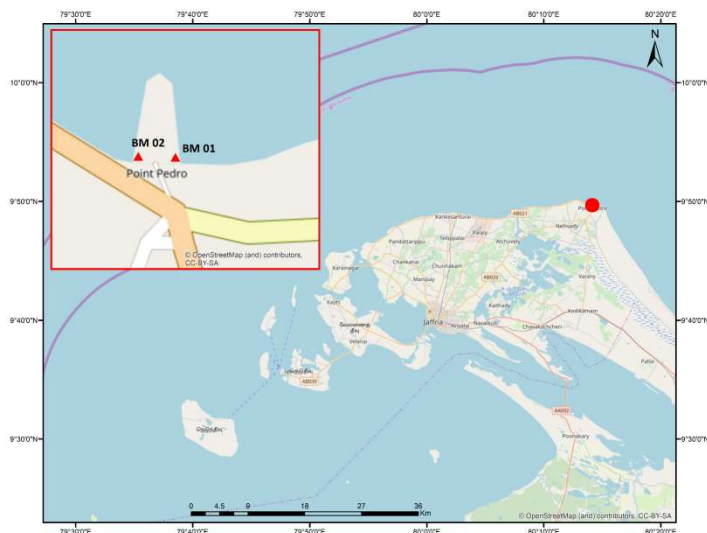


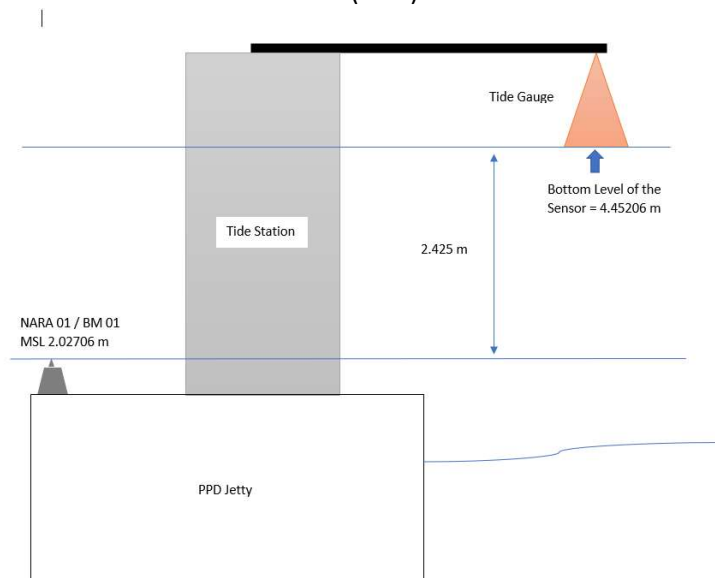
Figure: The map shows the exact location of the Point Pedro Sea level station and the jetty

“BM 01/NARA 01 and BM 02/NARA 02” which was established on the Point Pedro Jetty have been connected to the Survey Department BM 06 (Geodetic Point ID: 91SL-420-006), and the following values have been re-checked and calculated to the Mean Sea Level on the site by the National Hydrographic Office (NHO).

Table 06: Derived and Calculated Values as follows,

BM No.	Description	Elevation (m)	Remarks
BM 06	Survey Department BM	3.70066	Near the Temple
BM 01/NARA 01	NHO BM	2.02706	On the Jetty
BM 02/NARA 02	NHO BM	2.57346	On the Jetty
Bottom Level of the Sensor	Tide Gauge Sensor	4.45206	On the Building

Level Datum: Mean Sea Level (MSL)



PPD Tide Gauge Diagram

Figure : Schamatic diagram show the jetty, tide station and the radar sensore and the height relations.

Key Performance Index (KPI)

Key Performance Index (KPI)		Progress
1	Number of Functioning sea level stations	5 of 5
2	Number of new sea level stations added to the existing sea level network	2 of 2
3	Number of report issued related ocean based destructive events. (DMC)	12 of 12
4	Number of data product generated (Graphs)	12 of 12 Monthly
5	Number of data product uploaded to the NARA web site	12 of 12
6	Number of Publication using sea level observation	05
7	Number of applications using this data.	06 University Students for graduate Research

Conclusions

- The sea level rising trend was unequally positive around Sri Lanka
- The annual trend in the east coast is ~3 mm/year, west coast ~2.9m/ year, Southern coast ~3.2 m/ year, Northern coast ~2.9m/ year
- Sea level rising rate around Sri Lanka is a little lower than the global sea level trend (Global 3.4mm Ref: NASA).
- Seasonal variation is 18-22 cm per year.
- The maximum seasonal sea-level variation was recorded from November to December, while the minimum was from August to September on the east coast.

Recommendations

- Concern of policy planers and manages of coastal development
- Awareness of people living along the coastal belt
- Protection of highly vulnerable coastal Infrastructures (harbour, port cities, water breaks, sand bars, Jetties, railway track, road, piers)
- Protection of highly sensitive lowland coastal habitats
- Continues monitoring, recording and further studies are required

Output

- Establishing of Sea level and meteorological observations network around the Sri Lanka
- Long term archive of sea level data and information
- Estimation of annual sea level rise around Sri Lanka.
- Identification of extreme sea level event real time and near real time (Strom Surge, Meteo
- tsunami,
- El Niña, La Niña)
- Data to re-establish Mean Sea Level (MSL).
- Strengthening the national disaster management system of the country. For ocean based disaster prevention, mitigation and management.
- Dissemination quality-controlled data and data product through the NARA web page
- Establishment of sea level data base for research and national developments.
- Conservation of historical data for the research and national development

Outcome

- Quantification of long term sea level rise around Sri Lanka
- Providing information's regarding ocean based destructive event to prevention, mitigation and management to the DMC (Monthly Report).
- Maps and graphs for highly vulnerable coastal area by the sea level rise.
- Minimizing the damages from ocean based destructive events

- Prevention and mitigation of coastal low lying land and communities in ocean based destructive events.
- Preparedness for the future climate change impact. (sea level rise)
- Recommendations for the policy planners of coastal development, land use management and disaster managers
- Commercial benefits for the construction of coastal infrastructures (water breaks, sand bars, coastal cities, harbors, waste management, river mouth management, saltwater intrusion)

Beneficiaries

- Policy planners for coastal land used planning, coastal resource management, Construction
- Disaster managers of Ocean based disaster prevent, mitigate and manage.
- Researchers and Scientists who interest Oceanic dynamic and climate change.
- General public

Constraints

The estimated fuel cost in 2021 was not sufficient for conducting field activities in 2022. The maintenance process of Kirinda and Point Pedro was not able as required because of the fuel availability, cost, and fund shortage with the financial inflation of the country. The maintenance and the repairing works of radar sensor damage by the fishing boat not able to conduct as required time..Therefore some field work was reduced and some were conducted jointly with other projects.

Project No : 6.3

Offshore sand investigations in continental shelf of southwestern coast

Component 01 : Geological and geophysical investigations in continental shelf of Southwestern coast of Sri Lanka

Officer responsible : T.B.D.T Samaranayake , H.A.S.D Perera
Duration : 31 January 2022 to 31 December 2022

Introduction

Due to rapid development in construction industry since 2009 the demand for the construction materials including sand has grown up enormously resulting shortage of the supply. The crisis led to illicit sand mining in major river banks which arise many environmental issues.

Therefore there is an urgent need for an alternative for river sand. Offshore sand consider as a promising alternative for river sand (Ratnayake and Chaminda,2014). More on, offshore sand can be used for beach nourishment and land reclamation. As the demand for the sand increases more sand reserves should be identified to fulfill the demand. In addition, many government organizations such as Sri Lanka Land Reclamation and Development Corporation (SLLRDC), Department of Coast Conservation and Coastal Resources Management (CCD) have raised the importance of exploration of new sites for offshore sand extraction.

The project aims to study a site of Southwestern coastal stretches for construction sand and mineral sand. The site was selected based on comprehensive literature survey. Since the extraction process in deep ocean is not economically feasible, this study intended to study the construction.

Objectives

- To prospect the construction and mineral sand resources selected sites
- To study the possibility to utilize offshore sand in selected sites for an alternative for river sand
- To map the continental shelf in terms of Geology and Geophysics

Methodology (Study area, Field sampling, data collection and analysis)

The study consisted of two major components ;Sedimentological study and Sub bottom profiling survey. The data and sample collection planned in following months based on the monsoon .

Sediment Sampling

Fifty samples was collected from pre -determined locations, using the Van-Veen grab sampler

Sub bottom profiling

The sub bottom profiler “Innomar SES-2000” Sediment parametric echo sounder was used to differentiate strata and data was used to measure the layer thickness and sand volume in the proposed sites.

Sample and data analysis

Laboratory analysis for sediment samples

- Sieve analysis

Granulometric analysis was done to study the sand size distribution in the area.

- Chloride content and shell content

Chloride and shell content directly affects to the reinforcement of the concrete as they react with several chemical compounds. Therefore it is crucial to study them before recommending dredged sand as an alternative to river sand.

Standard laboratory procedures were employed.

- Heavy mineral content

Heavy minerals was concentrated by employing gravity method and the concentrate was observed under microscope and the approximate abundance was calculated.

Data analysis

ISE 1.2 software was employed to process sub bottom survey data

Results: Activities carried out:

Literature survey was carried out through -out the year and was completed as proposed. Two sites from southwestern offshore area (Ambalangoda and Balapitiya) were selected and following activities were conducted (Table 01). The area proposed from offshore ,Balapitiya could not completed due to unfavorable weather conditions and unpredicted rise of fuel cost.

Table 01 : Activities carried out

Activity	Progress	
	Ambalangoda	Balapitiya
Grab samples	Completed	Completed
Sub bottom survey	Completed	Unfinished
Sample analysis	Completed	Completed
Data Processing	Completed	NA
Data analysis	Completed	Completed

Outputs & outcomes

Grab samples

Grain size and distribution characterization

All the parameters related to grain size were calculated based on Falk and Ward (1957) classifications.

Ambalangoda

Total of 30 samples, the mean grain size of the samples varied from 0.08 to 0.88 mm while the D50 of the samples varied from 0.07 to 0.92 mm. Both the mean grain size and the D50 of the samples were in the recommended range defined by engineering standards. However, in some locations the sediment grain size was too fine to be used for construction purpose. All the samples are in the range of poorly to moderately sorted range

Balapitiya

Despite of five samples all the other samples were composed of excess amount of shell fragments and coral particles. The mean grain size of sediment samples varied from 0.8 mm.

Shell and coral percentage

The shell and coral percentage for the size (mm)>10 was less than 5% at Ambalangoda area. However, the excess shell and coral fragment amount could be observed in the samples collected from Balapitiya area.

Chloride percentage

The chloride percentage was 2.4 %, 3.1% by the weight of the sand at Ambalangoda area. The chloride percentage in the Balapitiya area was not tested, as the site is not suitable for sand mining. The Chloride percentage in the Ambalangoda area is also larger than the recommended range.

Heavy Mineral content

The heavy mineral content was tested only for Ambalangoda area. After the panning only small amount (0.03%-0.1%) was found and therefore, further processing was not performed.

Sub bottom profiling

The total surveyed area of the off-Ambalangoda is 45km² and the average thickness of the sediment varied from 0.2m-2.0m while the total estimated sand volume is 22.5Mm³.

Conclusions

Off-Ambalangoda area was suitable area for sand mining considering the sand reservation and the grain size. However, a detailed survey should be carried out as there sub surface of the area composed of continuous small patches of rocks. Off-Balapitiya area was not suitable for sand mining due to fine sediment and excess amount of coral and shell fragments

Constraints

Unfavorable weather conditions

Unexpected rise of fuel cost

Component 2**Beach profile, Sediment characteristics and wave action on sandy beaches of Western coast of Sri Lanka.**

This study involved a thorough investigation of beach sediment samples on the swash zone and berm crest along the western coast of Sri Lanka. The variability of grain-size distributions, beach profiles, and their connection to wave dissipation will be assessed to fully grasp the implications.

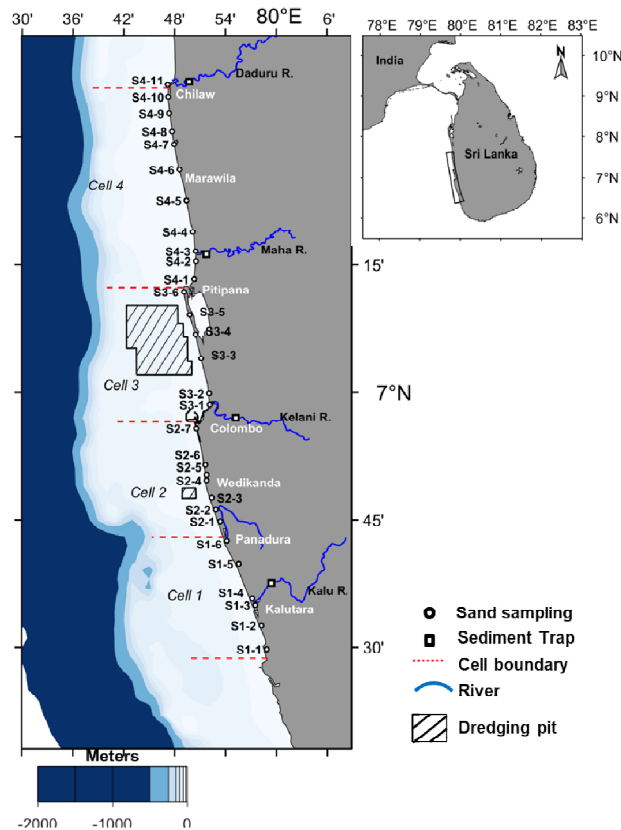


Figure 1:- Overview of the study area indicating the four defined coastal cells, sample locations, rivers and offshore sand mining sites (hatching area).

The variability of grain-size distributions.

180 beach samples were collected during three surveys conducted in October 2021 (summer profile), March 2022 (winter profile) and October 2022 (summer profile) between Beruwela and Chilaw (Figure 1-1). S-1-1 indicates cell 1 and position 1, and S-4-11 indicates cell 4 and location 11. Samples were taken from Beruwela (S-1-1) to Chilaw (S-4-11).

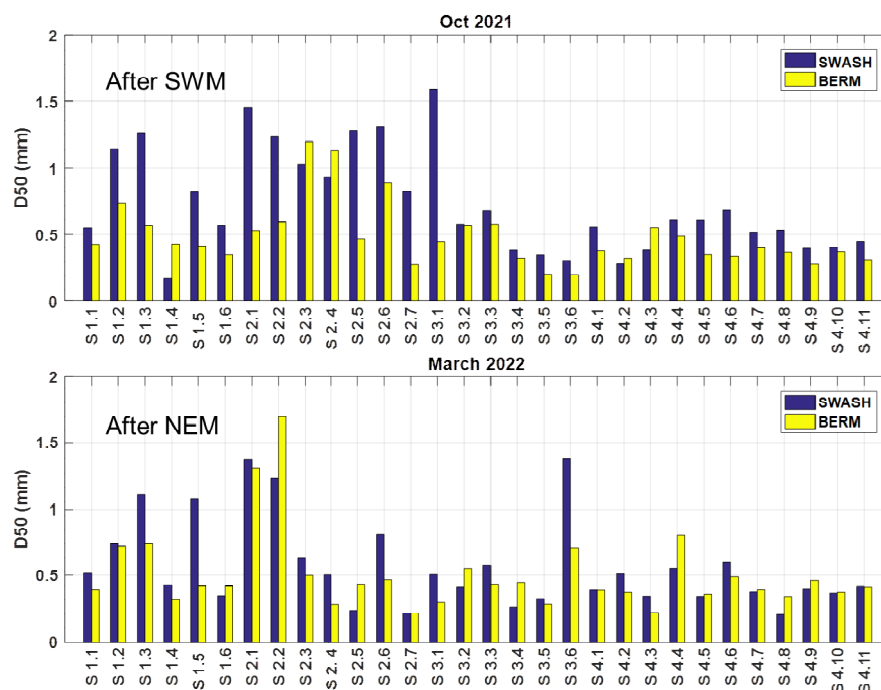


Figure1:- Comparison of median grain sizes (D50) of Swash beach and berm crest along Beruwela to Chilaw after SWM and after NEM in 2021-2022.

In most of the samples, the swash D50 values are coarser than the corresponding berm crest values, as shown in figure 1-2. It is obvious that D50 values in the swash zone should be higher as the finer sand is washed away from higher waves. In a later section, we'll discuss the effects of near-shore wave conditions on sand beaches. In addition, we observed that the swash zones along the transects at Calido Beach (S-1-4), Agulana (S-2-3), Ratmalana (S-2-4), and MahaOya (S-4-3) are finer than the apparent dry beach. These transects therefore have a higher risk of erosion.

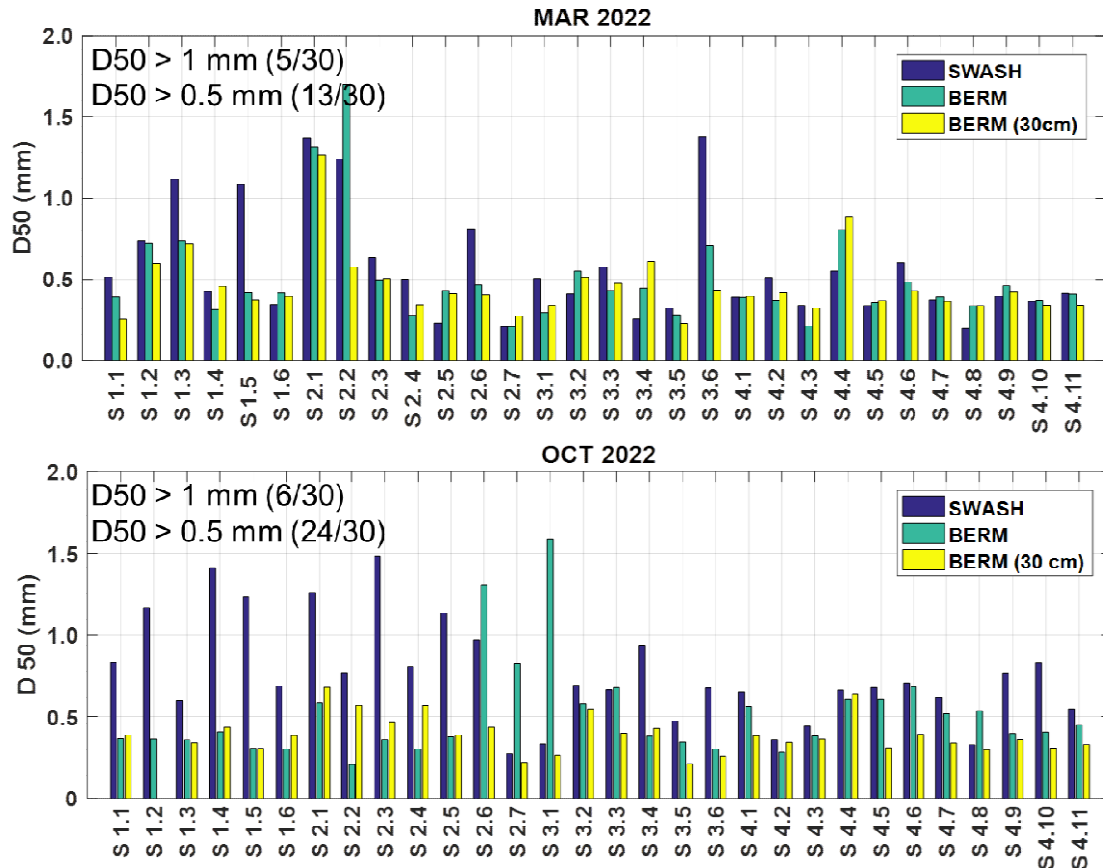


Figure1-3: Comparison of median grain sizes (D50) of Swash beach, berm crest and berm core (30 cm) along Beruwela to Chilaw after SWM and after NEM in 2022.

Along with swash and berm crest samples, the same sampling sites in March and October of 2022 also collected 30 cm deep core samples at the berm. In March, only 20% of D50 readings were more than 0.5 mm, but in October, we observed that 80% of them were coarser than 0.5 mm (Figure 1-3).

Except for transects at Kalu River (Calido beach) and Kelani River (Mattakuliya beach), all the other berm crests are finer than the swash beach. Generally, fine particles are washed away by stormy conditions. Therefore the Swash and near shore sand are often coarser than the dry visible beach. In our studies, this feature is clearly visible.

Spatial variation of wave energy and D50 along Sri Lanka's western coast.

The study contrasts the median grain size values (D50) of beach samples and near-shore wave power. The corresponding wave power (KW/m) at 15 meter depth was determined using SWAN based wave transformation model.

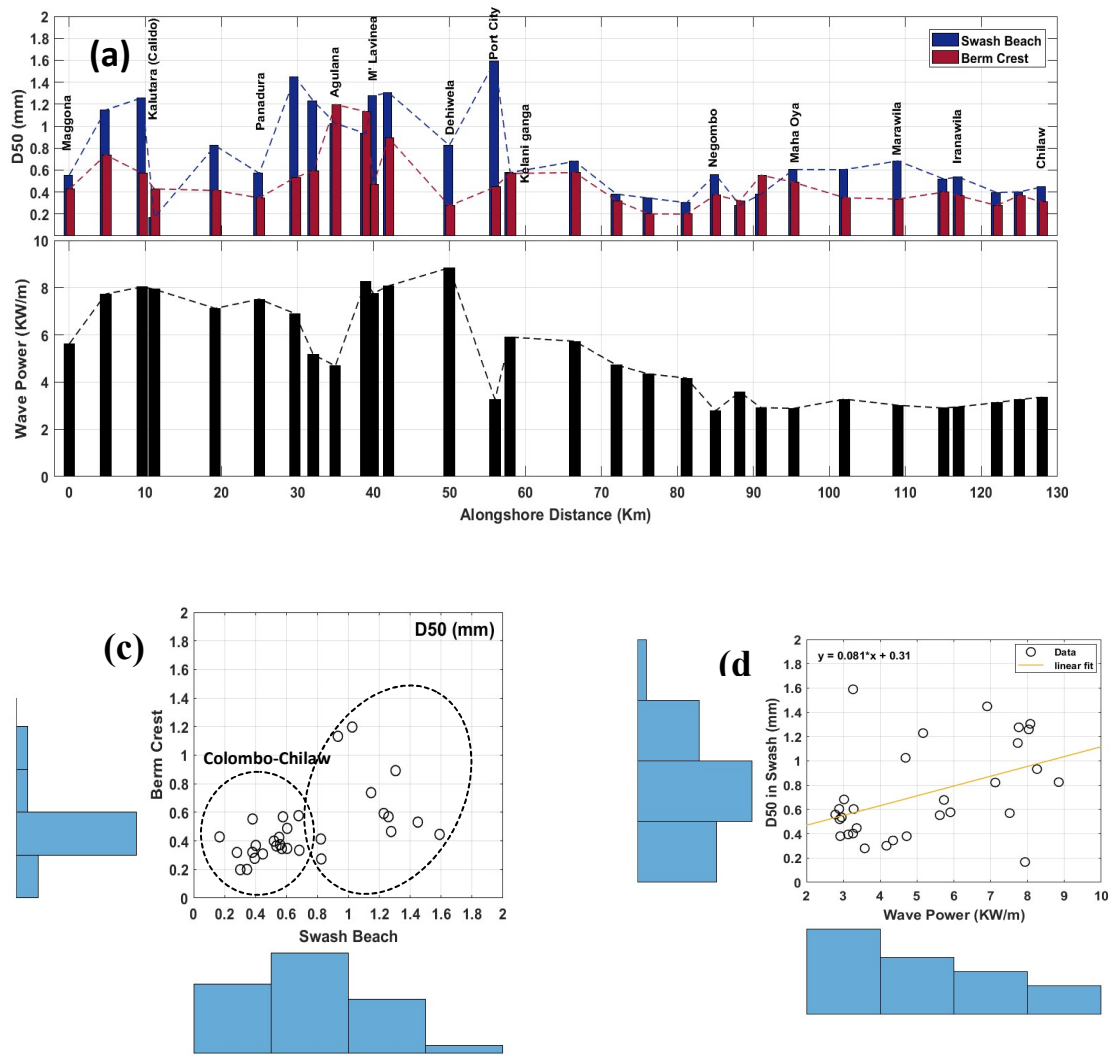


Figure1:- Comparison of median grain sizes (D50) of Swash beach and berm crest (a) Wave power calculated at 15 m water depth of sampled transect (b) correlation graph of D50 values of Berm crest and Swash beach (c) and correlation graph of D50 value of Swash beach and wave energy in winter profile.

This characteristic has been discovered to be connected to the spatial variation of wave energy along Sri Lanka's western coast. The results of this spatial-temporal variation in sediment distribution on beaches can therefore be applied to initiatives such as sand nourishment and beach front & coastal development.

According to our sieving analysis, Swash and berm samples collected in after SWM, have median grain sizes ranging from 0.6 to 1.0 mm and 0.2 to 0.6 mm, respectively. In addition, we noticed a considerable difference in D50 values in the coastal segments Beruwela-Colombo and Colombo-Chilaw, where we detected that sand is coarser in south Colombo than in north Colombo (fig 1-2). This feature is strongly correlate with the spatial variance of wave energy in the western coast of Sri Lanka. Coastal segments of Beruwela-Colombo and Colombo-Chilaw, have median grain sizes ranging from 0.8 to 1.6 mm (coarse-very coarse) and 0.2 to 0.8 mm (medium-coarse), respectively. It is generally accepted that the nourishing sand should be approximately equal to or coarser than that of the native beach.

Beruwela-Colombo has the greatest average wave heights of the entire studied zone, as this sector is exposed to all wave directions. Except for the coastline stretch between Panadura and Agulana, the wave strength in this area ranges from 6 to 8 KW/m. Colombo-Negombo section is sheltered against the southern wave directions by a 2 km long breakwater arm of the Colombo port, which would increase the wave shadow, extending it northwards. As a result, wave conditions in this area (likely up to Uswatakeiyawa) would calm down. The average wave energy in Uswatakeiyawa is 6 KW/m, gradually decreased to 3 KW/m up to Negombo. The typical wave energy in the Negombo-Chilaw region is rather modest, averaging around 3 KW/m.

The littoral cutoff diameter (LCD) on Sri Lanka's western coast is calculated using data from sieving analysis. GLOGOCZOWSKI and WILDE (1971) and HICKS and INMAN (1987) were the first to recognize the notion of LCD along the wave-dominated California coast. The LCD is a grain size threshold below which no significant amount of sand will stay on a particular beach (HICKS, 1985). Sediment finer than the LCD supplied to a beach will likely be easily entrained, suspended, and deposited offshore as a permanent loss to the beach system (EITREIM et al., 2002).

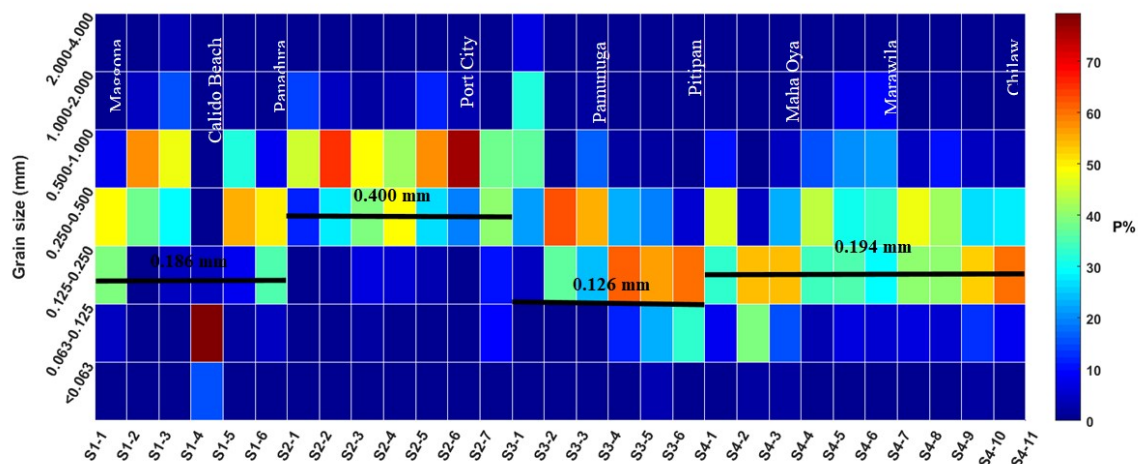
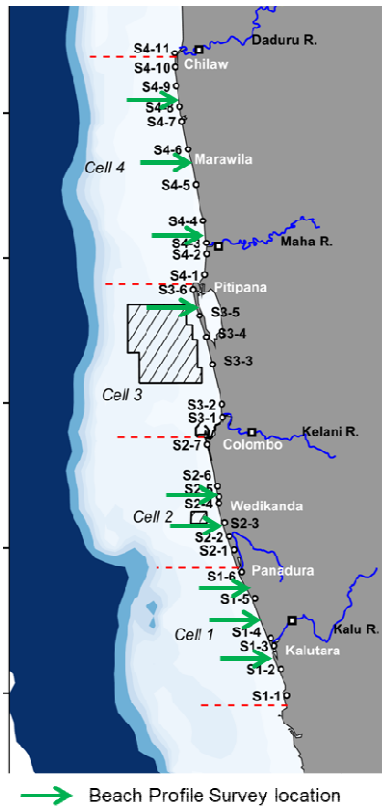


Figure 1-5: Map of spatial variance of grain size passing along the coastal stretch between Beruwela to Chilaw, black line represent the LCD value for given coastal cell.

The LCD values are calculated for four coastal littoral cell using the method of HICKS (1985). The LCD is determine by taking the average D10 value(the grain size for which 90% of a sample is coarser and 10% is finer based on sieve analysis) of four defined littoral cells and then subtracting one standard deviation from that number to arrive at an LCD. The map of spatial variance the LCD values are shown in figure 1-5.

Beach profile survey

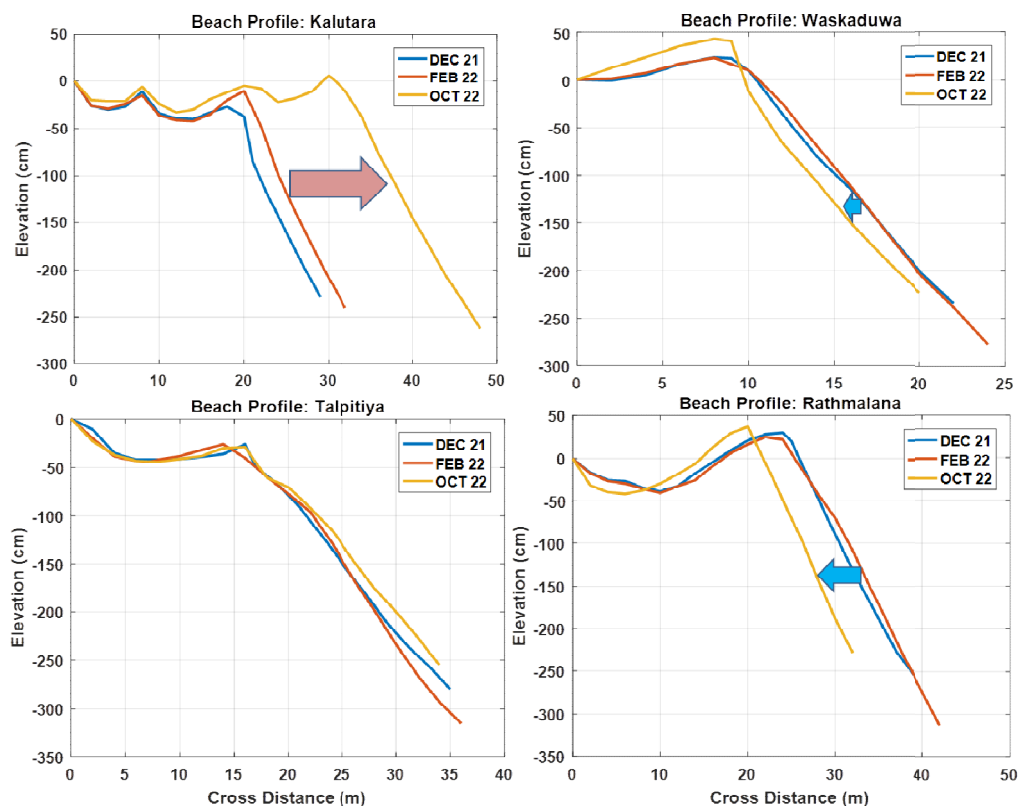
Beach profiles which provide useful information for coastal monitoring studies and management processes were conducted using the “Emery method”. Emery presented a simple method of beach profiling based on the use of two rods, marked off in a given unit (feet or centimeters), whose alignment and reading of the intersection with the horizon would allow for the determination of differences in level along the beach profile (Emery, 1961).



Survey completed : Dec 2021, Feb 2022, and Oct 2022
Profiles :

Cell 01	1. Kalutara South 2. Waskaduwa 3. Talpitiya
Cell 02	4. Rathmalana 5. M' Lavinra
Cell 03	6. Pitipana
Cell 04	7. Maha Oya 8. Marawila 9. Ambakadawila

Nine beach transects were surveyed in three times between December 2021 to October 2022. The results of the profiling survey are given in the figure 1-6.



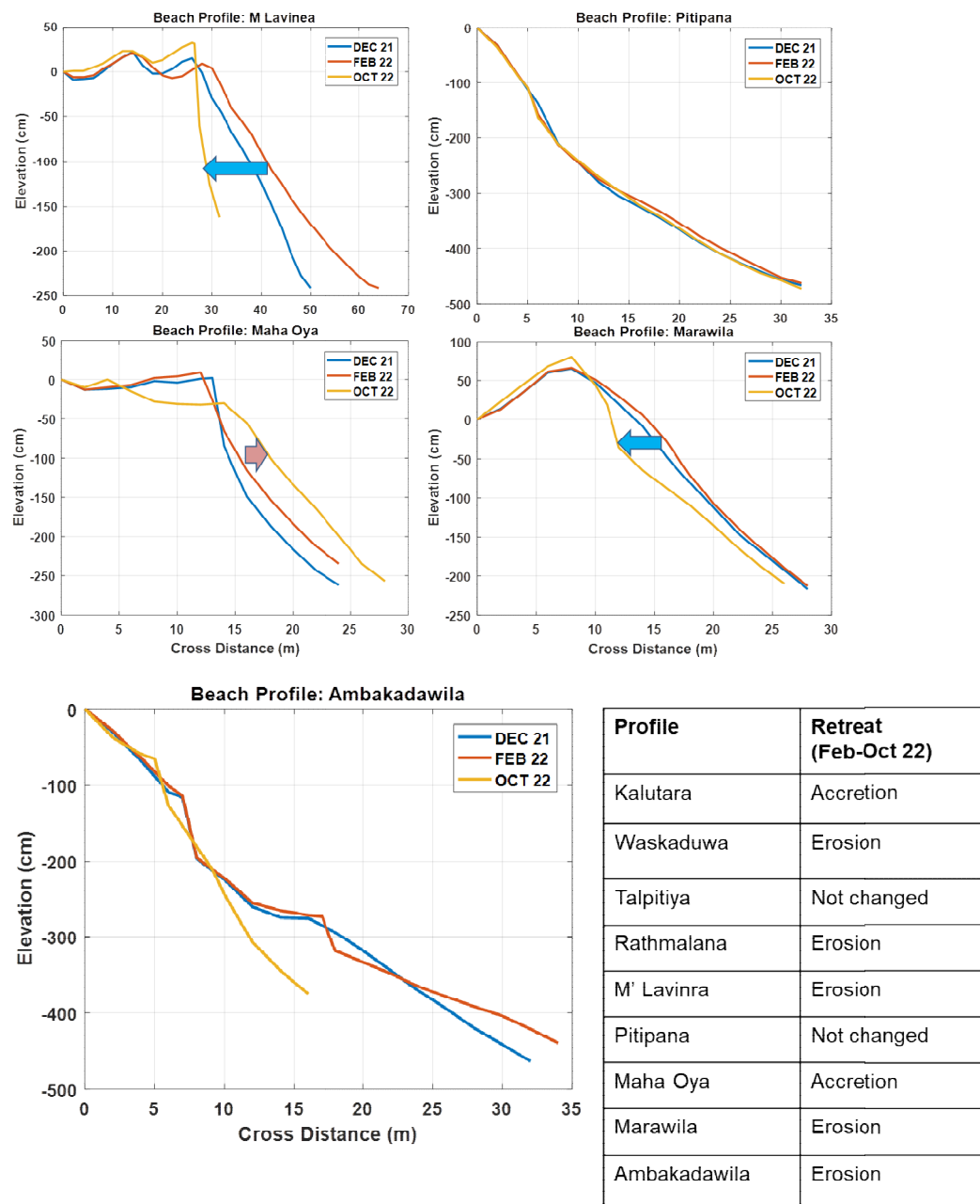


Figure 1-6: Cross-shore variation of beach profiles

Normally, storm conditions on Sri Lanka's western coast cause beach profiles to erode between February and October. However, during the North East monsoon, calm wave conditions cause beach profiles to build up. But because the estuaries and lagoons discharge sediment at different times, this can be changed there.

Assessing the river sediment load (MahaOya River)

Rivers have a significant role in the coastal sediment budget as the primary sources of natural sediment. Further, it is essential to comprehend the minimum grain size threshold, also known as the littoral cutoff diameter (LCD), in order to determine the actual contribution of river sediment load to the littoral beach. MahaOya River located on a severely eroding coastline between Negombo and Chilaw on the western coast of Sri Lanka was focus in this study. Here, we collected forty-four beach samples from the swash zone and berm crest during two sediment sampling surveys in March and October 2022. Concurrently, a streamer-type sediment trap was placed at 2 km upper streams

of MahaOya River to capture the bottom to 1.5 meters river sediment load (Figure 1-7). Sediment samples were sieved by mechanical sieving method in the classic Wentworth grain size scale (63-2000 μm).

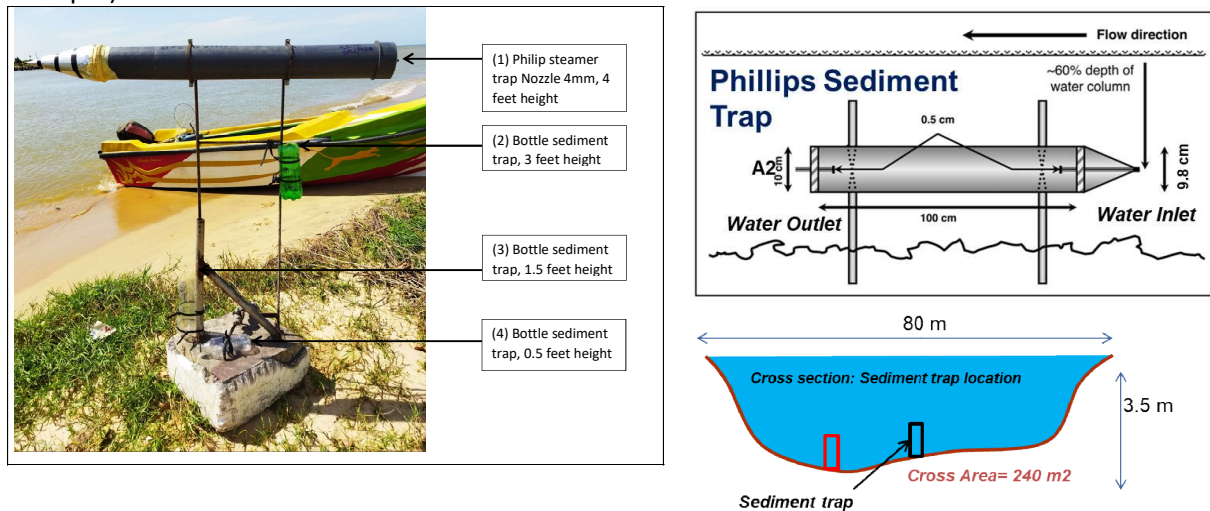


Figure1-7: A close up picture of Phillips type sediment trap installed and cross section of the Maha Oya River.

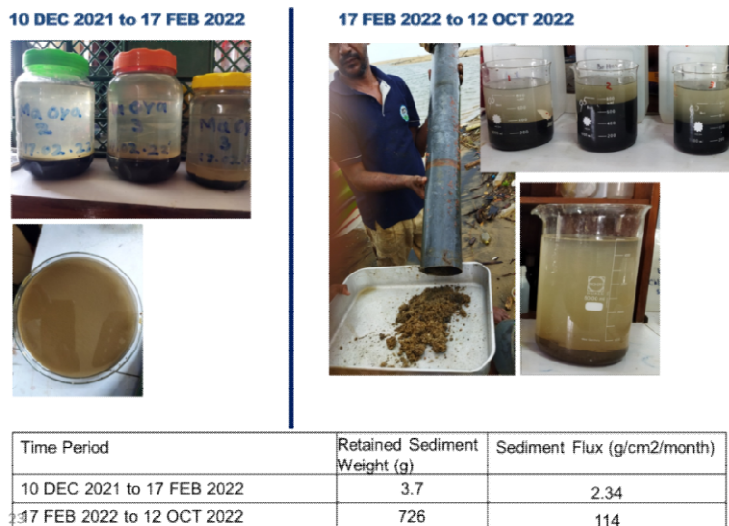


Figure1-8: The sediment recovered from sediment trap installed at Maha Oya and sieving results obtained.

Assuming constant sediment flux via the cross section of River,	
Total sediment via 4 mm nozzle	= 875.6 g/year
Nozzle area	= $1.256 \times 10^{-5} \text{ m}^2$
Sediment flux via 1 m^2 area	= 697133.3 kg/year/ m^2
Total Sediment load via the cross section of River	= 16731210 kg/year
1 m^3 of dry sand	= 1 650 kg
Total River Sediment for Maha Oya	= $10\,140 \text{ m}^3$ /Year

According to the literature, the sand discharge through the Maha Oya was reduced from 0.15 mcm/year in 1984 to 0.05 mcm/year in 2001 due to river sand mining (Ratnayakage, 2020; Wickramaarachchi, 2010). Our calculations show that in 2022, this number will be further decreased to 0.01 mcm/ year.

It is evident that there is a major shortage of river sand input into the western coast as a result of extensive river sand mining that has led to catastrophic erosion in the adjacent coastal cells.

Project No: 6.4

Seasonal Variability of Ocean (boundary) Current and other parameters around Sri Lanka

Component 02:

Responsible Officer/s : Dr. K.Arulananthan, Dr. W.N.C.Priyadarshani, Mr. R.M.R.M Jayathilake, Mr. W.R.W.M.A.P. Weerakoon, Mr., Ms. N.G. L. NadeeUthpala, and Mr. K.B.S.S.J. Ekanayaka

Allocated budget (SLR) : 0.45 million LKR

Background

Sri Lanka is sandwiched between Arabian Sea on its western side and the Bay of Bengal on its eastern side, with contrasting water mass experiences bi-annually reversing monsoon currents. The boundary currents, East Indian Coastal Currents (EICC) and West Indian Coastal Currents (WICC) and southwest monsoon current hugging the coast traverse via the southern tip of Sri Lanka, plays an important role in transfer and distribution of heat and water along with biomass, nutrients, sediment, pollutants, etc. in the Northern Indian Ocean. Understanding sub-seasonal mechanisms in the context of monsoonal dynamics and large-scale upper ocean variability is vital for the fisheries resource management, prediction of eventual fate of pollutants and sediments, assessing the impact of ocean-based disasters and climate change impact on ocean.

Due to a lack of on-board and mooring data collection, continuous data on ocean currents, attributable to dynamics and coastal oceanographic phenomena is scarce in Sri Lankan maritime waters. As such, it was intended set up a mechanism to gather seasonal oceanographic data by hull mounted ADCP on R/V Samuddrika and data collection from a moored ADCP at Mirissa coastal water during 2020 to study the temporal dynamics of South Sri Lanka coastal current (SSLCC).

Moreover, the Sri Lankan offshore waters transporting water with different properties through reversing ocean currents driven by monsoon winds. 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. During the SW monsoon, increased chlorophyll concentrations ($> 5 \text{ mg m}^{-3}$) was recorded around Sri Lanka, particularly along the southern coast (Vinayachandran et al., 2004), which appears to be a major upwelling region and lasting these elevated chlorophyll concentrations for more than four months. Thus, bio-chemical mixing would result alterations in all marine ecosystems and having long-term studies are crucial to address both natural and manmade issues on marine environment.

Moreover, plastics and polythene litter accumulation with non-degradable micro plastics on either beach sand or surface waters have become a problem worldwide, and research on plastic and polythene litter is carried out as an emerging trend in Sri Lanka too, but several gaps had to be filled in further. Here, to study plastic and polythene pollution in the submersible layers and assess the distribution patterns of those pollutants in the ocean pertaining to ocean current patterns, and the moment of different water masses was targeted. Further, ship accidents and marine debris release from cargo ship demand continuous monitoring of the waters around Sri Lanka, in order to assess the long-term impact of contaminants on the natural environment.

Specific Objectives

- To re-establishing capacity for recommencement of ship-based ocean current observation by ADCP and understanding spatial and temporal variabilities of Sri Lanka coastal current (SLCC) in Western and Eastern coastal waters
- To study seasonal variability of selected biological, physical, and chemical ocean parameters such as nutrients, chlorophyll, pH, phytoplankton and zooplankton.

- Monsoonal influence on the dispersion of microplastics and marine debris in sub-Surface marine waters around Sri Lanka.

Methodology

Three sampling occasions were carried out and the location map is given in Figure 1.

i. Hull mounted ADCP operation and Data analysis of moored ADCP at Mirissa

ADCP (Acoustic Doppler Current meter) was mounted at R/V Samudrika and four transects were carried out from Colombo to Kalpitiya, Western Coast during Northeast monsoon (7-10, February 2022). Data extraction and filtration the Mirissa mooring was completed for each month from January to April, 2022. Horizontal velocities plots and Feather plots were completed for all monitored depths.

In addition to re-analysis data, a continuous and long-timescale monitoring, the data collected from a moored ADCP at Mirissa coastal water during 2020 was used in this study for the studying the temporal dynamics of South Sri Lanka coastal current (SSLCC). The sub surface mooring system was consisted with main float including Acoustic Doppler Current Metter (ADCP), SBE - 375m CTD set, KVLAR cable 250m, Floating ball 2 sets, 55750 & 55751 ORE-PORT acoustic releaser two sets and deck unit, Iron chain 10m and Nylon Cable 10m and gravity anchor with 800kg.



Figure 1. The location of the deployment ($5^{\circ}51.582'N$, $80^{\circ}24.601'E$), 10km off Mirissa coast.

ii. Seasonal variability of Physico-chemical parameters

Here, three sampling occasions were carried out as follows;

a) Cruise in western coast during North East Monsoon (NEM)

Water sampling and in situ data collection were done in 15 locations at 3 depths (Total 45 samples) from Colombo to Kalpitiya (Figure 2a) using R/V Samudrika. The distance between two points of transects was 0.1 Degree (11.1 km). In situ data was collected for Temperature, Salinity and pH using CTD (Sea Bird 9 plus) and water samples were analyzed for nutrients (Nitrate-N, Nitrite-N, Phosphate-P and Silicate-Si), Chlorophyll *a*, Total Suspended Solids (TSS) and Plankton (Zooplankton and Phytoplankton).

b) Water sampling at Kalpitiya Lagoon and adjacent waters

In situ data and water samples from 9 locations (Figure 2b) were collected and analyzed for Nutrients, pH, Salinity, Temperature, and Chlorophyll *a*, Total Dissolved Solids (TDS) during 31 August- 02 September, 2022.

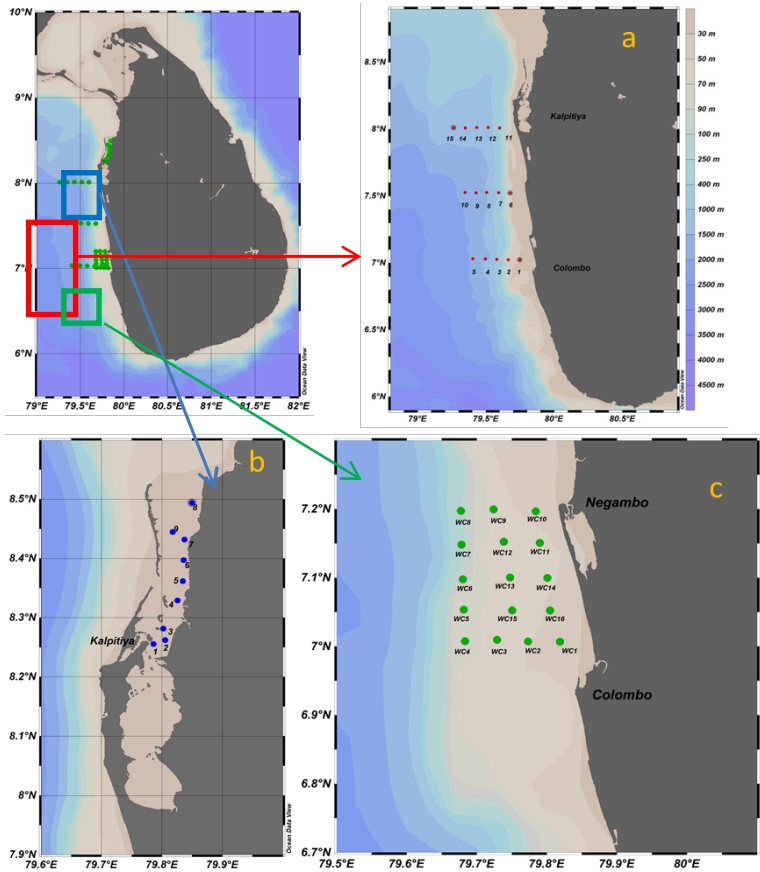


Figure 2. Map of the sampling locations: a. Colombo to Kalpitiya, b. Kalpitiya Lagoon and c. Colombo to Negombo

c) Cruise from Colombo to Negombo during North East Monsoon

Water sampling and in situ data collection were done in 16 locations at 3 depths (Total 48 samples) from Colombo to Negombo (Figure 2c) using R/V Samuddrika. In situ data was collected for Temperature, Salinity and pH using CTD (Sea Bird 9 plus) and Water samples were analyzed for nutrients (Nitrate-N, Nitrite-N, Phosphate-P and Silicate-Si), Chlorophyll a, Total Suspended Solids (TSS) and Plankton (Zooplankton and Phytoplankton). The area covered the M/V Xpress Pearl ship damaged vicinity too.

Results

ADCP Operation and Data Analysis

The sub surface mooring system was consisted of main float including Acoustic Doppler Current Metter (ADCP), SBE - 375m CTD set, KVLAR cable 250 m, Floating ball 2 sets, 55750 & 55751 ORE-PORT acoustic releaser two sets and deck unit, Iron chain 10m and Nylon Cable 10m and gravity anchor with 800kg.

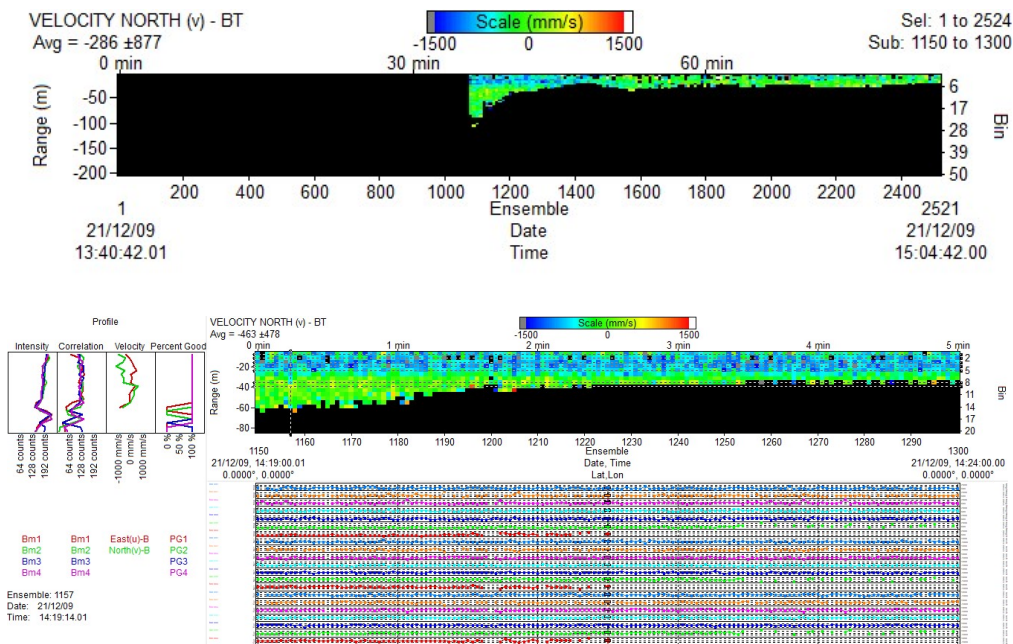


Figure 1.1 ADCP data measurement off Mirissa.

As the transitional passage between Bay of Bengal and Arabian Sea, southern coastal region of Sri Lanka shows a highly dynamic nature in terms of seasonal and monsoonal variability. Therefore, it is important to understanding about variability of regional coastal current in order to predict and identifying the extreme bio-chemical changes and pollutant distribution.

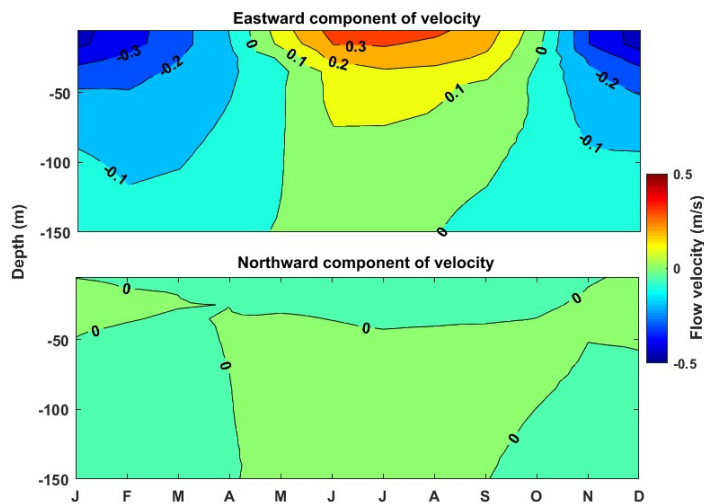


Figure 1.2: The climatologically monthly a) Eastward component of velocity b) Northward component of velocity off Mirissa derived since 1992 to 2017 from ECCO2. Negative (positive) values indicate westward (eastward) for zonal velocity and southward (northward) for meridional velocity. The seasonal variation variation of zonal velocities (East-West) was analyzed in order to understand the zonal velocity fluctuation in the domain. Figure 1.2 shows the climatological monthly mean of the Eastward component of the velocity and Northward component of velocity at 10 km off Misissa for the period between 1992 and 2017. An East-west component of the velocity varies between -30 cm/s and 30 cm/s while North-South component of the velocity varies -10 cm/s and 10cm/s. However, seasonal variability of zonal velocity current conveys to directions, eastward and westward. This current was following the edge of the continental shelf having approximately 100 km wide, and later developed into an approximately 200 km-wide current as it turned westward south of Sri Lanka.

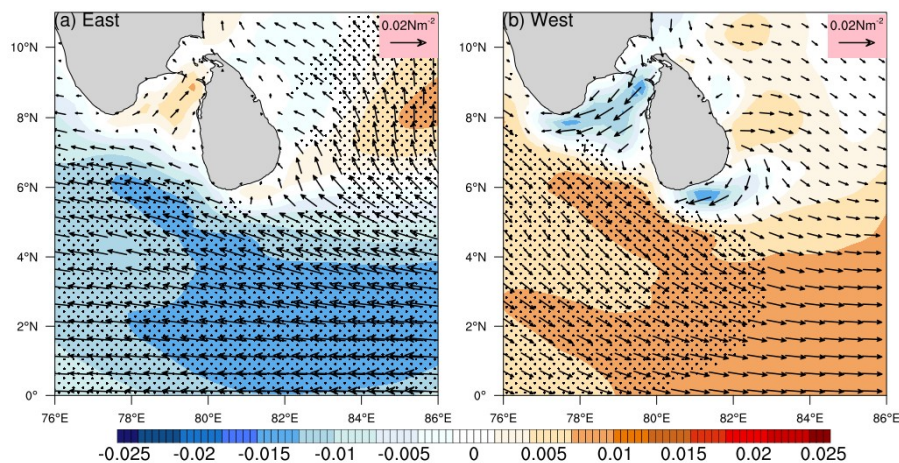


Figure 1.3. Composite wind stress vectors anomalies superimposed with anomaly magnitude (shading; in ms^{-1}) and 90% significance level (stippling) during JJA: (a) eastward case and (b) westward case. (Wickramage&Jayathilaka, 2020)

Figure 1.3 displays the composite wind stress anomaly fields for the months of June through August. The findings suggest a considerable variation in the southwesterly wind stress during the two cases south of latitude 5.5. Wind stress across the area decreases in the eastward case, whereas it increases in the westward case.

One limitation of this research is that only one year's length of velocity observation data was employed. In order to advance our understanding of the SSLCC fluctuation, we will carry out the sensitivity experiment and continue collecting velocity observations throughout Sri Lanka's southern coast during the summer.

Changes in Physico-chemical parameters in Western coastal waters Water Quality changes from Colombo to Kalpitiya Coastal area

Spatial variation of Nutrients in surface waters

During the tail end of NEM of 2021 (7-10 February, 2022), both Nitrate-N ($>0.333\mu\text{g/L}$) and Nitrite-N ($>0.635\mu\text{g/L}$) amounts were higher in Colombo and area compared to Kalpitiya (Norochcholai, North western part) area (Figure 2). The values of Nitrate-N and Nitrite-N varied between $0.118\mu\text{g/L}$ to $0.451\mu\text{g/L}$ and $0.127\mu\text{g/L}$ to $1.181\mu\text{g/L}$ in surface waters respectively. The possible reason to observe higher values of Nitrogen constituents could be related to land based fresh water runoff from Kelani River and some debris degradation which generated from Damaged M/V Xpress Pearl ship. Average values of Nitrate-N and Nitrite-N for three transects (Colombo, Chilaw and Kalpitiya) in the surface waters were $3.666\mu\text{g/L}$, $0.176\mu\text{g/L}$ and $0.179\mu\text{g/L}$ for Nitrate-N and $0.990\mu\text{g/L}$, $0.381\mu\text{g/L}$ and $0.365\mu\text{g/L}$ were for Nitrite-N respectively (Table 1).

Phosphate-P concentrations of the study area ranged from $1.315\mu\text{g/L}$ to $7.745\mu\text{g/L}$, while higher values ($3.558\mu\text{g/L}$ to $7.745\mu\text{g/L}$) were observed in middle of the survey area close to Chilaw (Figure 2) and the average value of the transect was $5.412\mu\text{g/L}$ (Table 1). The higher Phosphate values could be resulted from agrochemical runoff from Daduru Oya water flux. Silicate-Si values varied from 3.962 to 8.673 and the maximum value was recorded at the middle area (location 9) of the Chilaw area which could be related to water turbulence behavior in that area during the monsoon. However, averages value of three transects were almost same. Higher values ($> 6.822\mu\text{g/L}$) of $\text{SiO}_2\text{-Si}$ were also noted at Location 1 and 15.

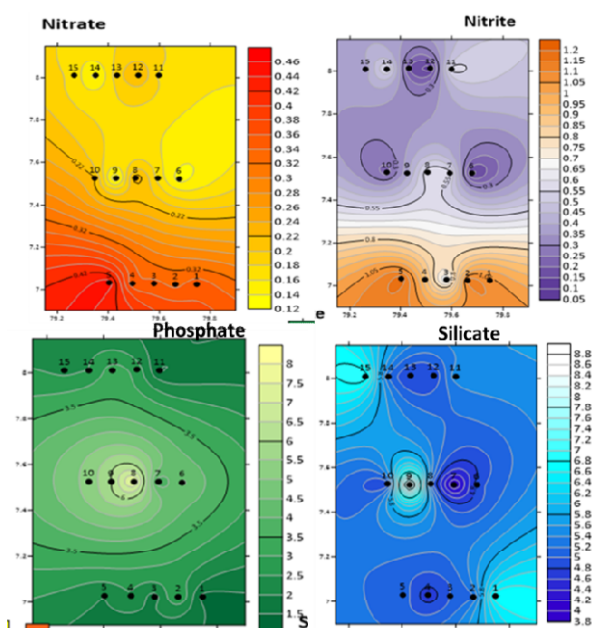


Figure 2. Nutrients and pH variation in surface waters

Spatial variation of Nutrients in 5m and 10m waters

Nitrate-N ($>0.328\mu\text{g/L}$) and Nitrite-N ($>0.370\mu\text{g/L}$) amounts in 5m depths were higher in Colombo transect compared to Chilaw ($0.127\text{--}0.203\mu\text{g/L}$ and $0.203\text{--}0.894\mu\text{g/L}$) and Kalpitiya area ($0.131\text{--}0.193\mu\text{g/L}$ and $0.127\text{--}0.226\mu\text{g/L}$) (Figure 3). The values of Nitrate-N and Nitrite-N varied between $0.118\mu\text{g/L}$ to $0.451\mu\text{g/L}$ and $0.127\mu\text{g/L}$ to $1.181\mu\text{g/L}$ in surface waters respectively. Both average concentration of Nitrate-N and Nitrite-N at 10m depths were varied between $0.125\text{--}0.386\mu\text{g/L}$ and $0.112\text{--}1.082\mu\text{g/L}$ (Figure 4) while their average values were higher in Colombo area compared to other two areas ($0.364\mu\text{g/L}$ and $0.718\mu\text{g/L}$) respectively. The possible reason to observe higher values of Nitrogen constituents could be related to land based fresh water runoff from Kelani River and some debris degradation which generated from Damaged M/V Xpress Pearl ship.

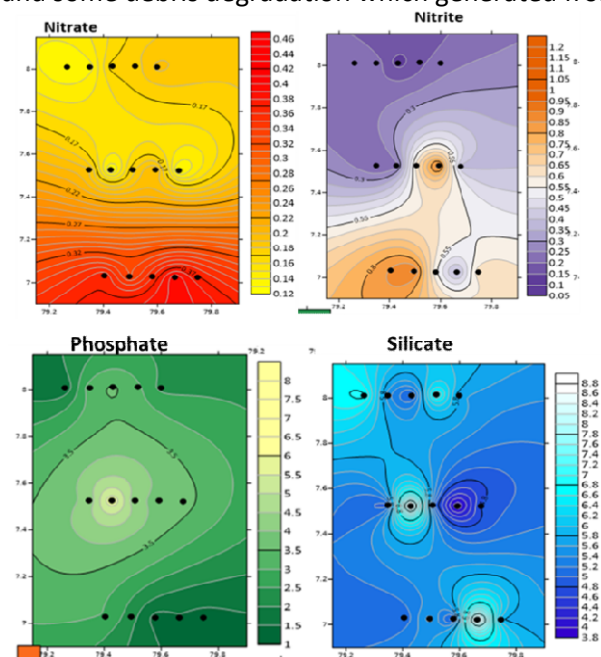


Figure 3. Nutrients variation in 5m depths

Vertical variation of Nutrients in three transects

With the comparison of three layers (0m, 5m and 10m), all the nutrients except Silicate-Si had not observed any remarkable difference in each locations (Table 01). Silicate-Si had similar values in three depths in all locations (5.000 µg/L) which indicated that land based run off or soil erosion is quite similar in all locations. Further, it is explained that water mixing is higher in all areas but specific to the location.

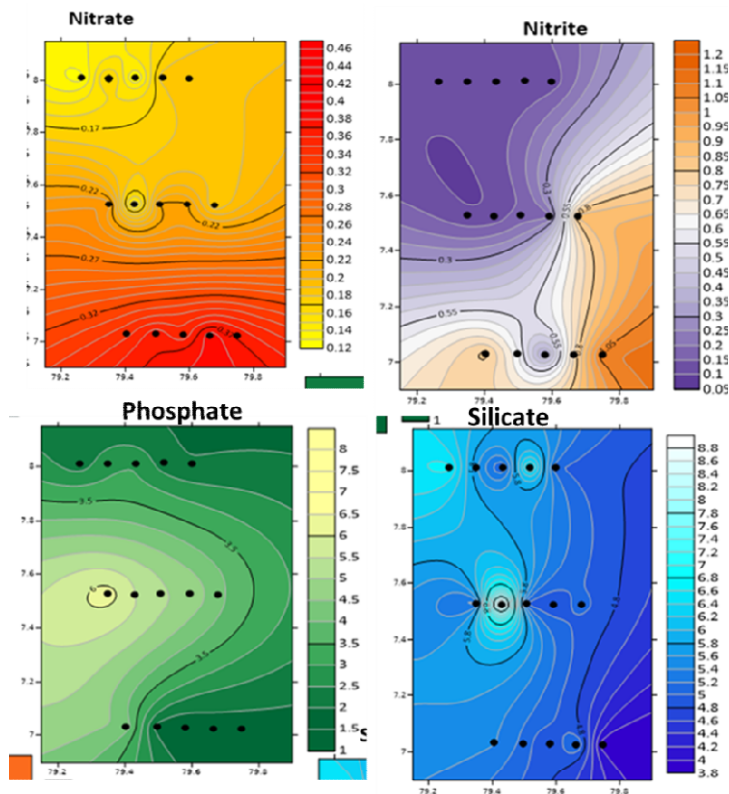


Figure 4. Nutrients variation in 10m depths

Table 1. Average concentration of nutrients in three depths of three transects

Surface					
Location	NO ₃	NO ₂	PO ₄	SiO ₃	pH spectro
Colombo	0.366	0.990	2.139	5.352	7.9971
Chilaw	0.176	0.381	5.412	5.487	7.8652
Kalpitiya	0.179	0.365	2.482	5.453	7.9076
5M					
Colombo	0.365	0.669	1.854	6.037	7.9780
Chilaw	0.165	0.469	4.366	5.487	7.9954
Kalpitiya	0.162	0.199	2.781	5.958	8.0155
10M					
Colombo	0.364	0.718	2.246	4.881	7.9806
Chilaw	0.199	0.292	5.173	5.801	7.9833
Kalpitiya	0.161	0.118	2.452	5.812	8.0347

Spatial and vertical variation of pH

The results of the pH of the surface waters during February, 2022 from Colombo to Kalpitiya showed that the values were varied from 7.581 to 8.011 (Figure 5). All values were below the standard marine pH levels (8.200). In general, pH values were decreasing from Colombo towards Kalpitiya area and the lowest value was recorded near in the middle of the transect (Location 9), Chilaw similar to the highest value of Silicate-Si. Low pH values could be due to the degradation of concentrated debris brought from by DaduruOya and Kala Oya river basin run off during North East monsoon. Average pH value of all transects was below 8.000 (Table 01) which indicating that considerable acidification process is going in surface waters, 5m and 10m depths in all transects except at Kalpitiya subsurface waters (5m and 10m). There is no distinct difference in pH values vertically, but the ecosystems could be impacted since minute change in pH would alter the biogeochemical cycles considerably.

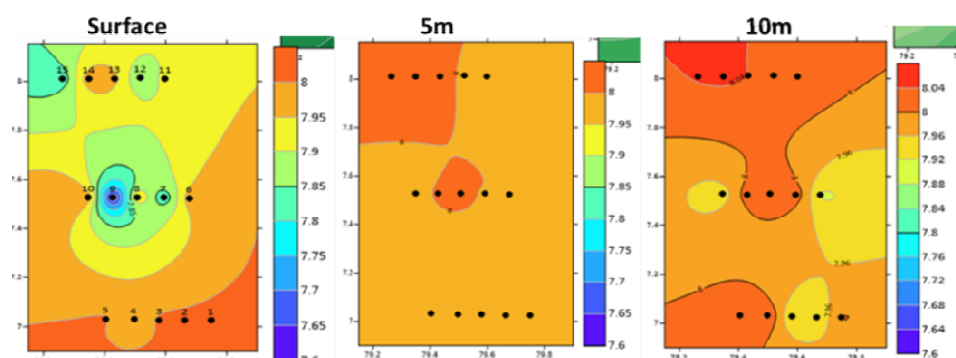


Figure 5. Spatial variation of pH at surface, 5m and 10m depths

Spatial and vertical variation of Total Suspended Solids

Total Suspended solids (TSS) in Colombo area varied from 4.00-22.80 mg/L while average value remained as 10.68 mg/L (Table 02). In general, average concentrations are considerably low in 5m and 10m depths except WC4 and WC5 locations. The observed unusual values could be related to the ship movement of the area. The highest average TSS values were recorded in Chilaw area while Kalpitiya area had low values except WC15 located far away from the land. High load of fresh water inputs from land could be reason for high TSS values in Chilaw area during the study period.

Table 2. TSS variation at surface (0m), 5m and 10m depths in Colombo (brown), Chilaw (Blue) and Kalpitiya (black) transects

Location		Total Suspended solids (mg/L)		
		0m	5m	10m
WC-1	Colombo	11.80	2.00	6.40
WC-2		4.00	8.00	9.40
WC-3		6.40	4.20	5.20
WC-4		22.80	27.80	4.80
WC-5		8.40	5.20	20.00
average		10.68	9.44	9.16
WC-6	Chilaw	12.00	13.80	9.00
WC-7		11.80	9.20	12.80
WC-8		20.40	7.60	15.00
WC-9		8.80	8.80	21.60
WC-10		22.20	6.40	8.20
average		15.04	9.16	13.32
WC-11	Kalpitiya	4.20	1.60	2.80

WC-12		2.80	6.00	2.00
WC-13		4.20	4.40	6.40
WC-14		9.60	6.40	2.80
WC-15		14.20	18.60	55.60
average		7.00	7.40	13.92

Chlorophyll a and Plankton changes

Chlorophyll a variation

The chlorophyll a (Chl-a) concentration of western coast varied from 1.44 - 19.88 µg/L in surface waters while it was fluctuated between 1.89 – 8.22 µg/L at 5m depths (Figure 5). Chl-a concentration of 10m depths changed from 0.64 – 10.50 µg/L. The highest value was recorded in kalpitiya area distant from the land indicating high primary production associated with coral community. Average values of all there depths were above 6.36 µg/L in Kalpitiya area during the peak monsoon season of the area.

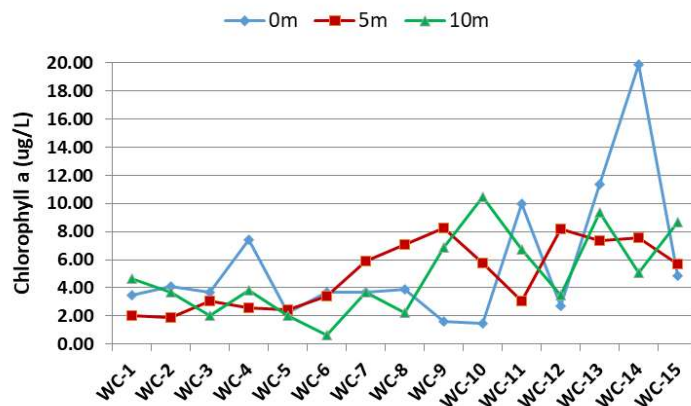


Figure 5. Chlorophyll a concentration at three layers (0m, 5m and 10m) in Colombo (WC1-WC5), Chilaw (WC6-WC10) and Kalpitiya (WC11-WC15)

Location	Phytoplankton		Zooplankton	
	Abundance (number / m3)	Number of species	Abundance (No/m3)	Number of Species
1	0	0	164	4
2	0	0	377	8
3	6070	5	239	6
4	2533	5	1522	7
5	3566	4	1736	7
6	1687	2	2302	9
7	0	0	2114	8
8	3156	3	1686	8
9	0	0	1082	6
10	0	0	2189	7
11	10036	4	2038	9
12	0	0	2164	6
13	17829	1	3435	9
14	0	0	3271	7
15	0	0	2126	7

Phytoplankton abundance and diversity

Phytoplankton abundance varied from 0 -17829 numbers/m³ while no any micro-phytoplankton (> 20µm) were observed in eight locations (Table 3). The highest average abundance (5573/m³) was recorded in Kalpitiya transect although only phytoplankton were notice in two sites. The least abundance (969/m³) was recorded in Chilaw transect. In general, phytoplankton abundance in all three transects are considerably very low compared to previous values recorded in July, 2021. Number of species also very less and it was varied 0-5 which further confirmed decline of phytoplankton diversity and distribution in western coast during the study season.

Zooplankton abundance and Diversity

Zooplankton abundance varied from 164 - 3435 numbers/m³ while the highest and lowest values were recorded at location 13 and location 01 respectively, (Table 03). With the comparison of three transects, the highest average abundance (2607/m³) was also recorded in Kalpitiya similar to phytoplankton abundance and the least values was observed in Colombo transect. The number of species varied 4 - 9 while the highest number was recorded location 6, 11 and 13 while least number also recorded in Colombo area. Although there was a positive interrelationship with abundance of phytoplankton and Zooplankton, in some locations, only zooplankton was detected without phytoplankton. This phenomena could be a result of Zooplankton grazing on phytoplankton or the phytoplankton should be lower in size of detective level (<20µm) or both reasons since Chlorophyll *a* was measured in all locations, although phytoplankton was not observed (Figure 6).

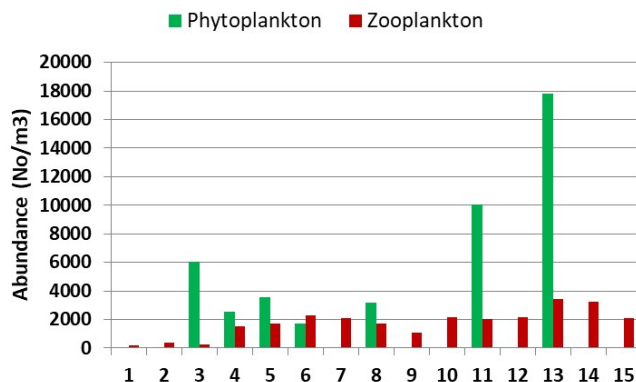


Figure 6. Phytoplankton and Zooplankton fluctuations among locations during February, 2022 (North-East monsoon)

Physico-chemical changes in Puttalam Lagoon

Puttalam Lagoon is hyper-saline estuary covering 327km² area and fed by Kala Oya and MiOya with 2.2m³/s and 8.1m³/s of water flux respectively. The lagoon is connected to Mundallake from its south side by a channel and water remains brackish to saline due to daily dynamics. Consequently the physico-chemical properties also alter and biological status and the ecology of the system also change accordingly. Thus, tidal mud flats, sand dunes, sea grass beds, coral reef and other ecosystems and their wide range of services could be altered time to time, hence affect on lagoon inhabitants/ associated faunal species and wellbeing of the community.

Temperature and Salinity

During end of South West monsoon, temperature of the lagoon varied 27.70°C to 27.90 °C while salinity remained 34.70 – 35.50 psu indicating that lagoon water fully covered and flushed with sea water (Figure 7). Low salinity with warm temperatures in southern side was related to fresh water inputs and its movement towards south during the study period.

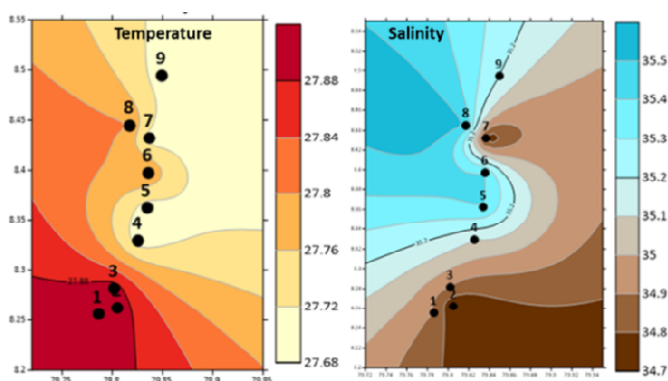


Figure 7. Temperature and salinity variation in Puttalam Lagoon during September, 2022

Nutrient fluctuations

According to the current results, high Nitrogen concentration was noticed in northern side of the lagoon which could be related to nutrient rich sea water intrusion. Nitrate-N and Nitrite-N concentrations varied from 0.017-0.365 and 0.870-1.280 $\mu\text{g/L}$ respectively. However, maximum phosphate (10.885 $\mu\text{g/L}$) was recorded in the middle of the lagoon which could be a result of eroded sediment movement from Kala Oya or boat movement at the time of sampling. Further, high concentration of silicate-Si ($> 26.00 \mu\text{g/L}$) was observed in southern side of sampling area indicating that land based sediment inputs feed from Kalpitiya area and expected high phytoplankton activity in the area. but, biological properties were not done during this period, detailed monitoring of water properties are needed for further interpretation.

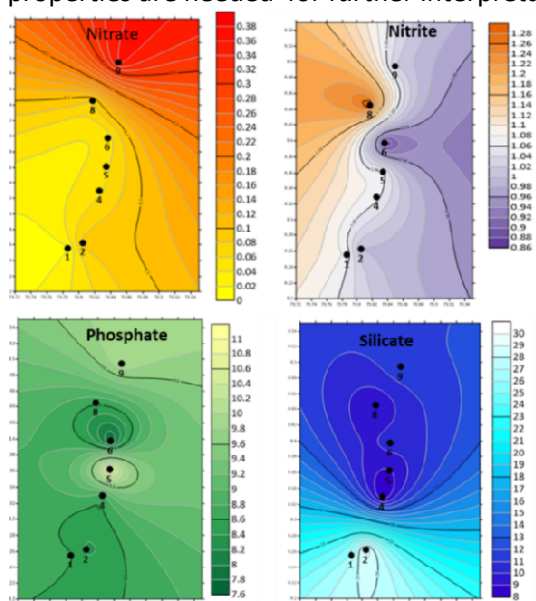


Figure 8. Nutrient variation in Puttalam lagoon in September, 2022

Physico-Chemical changes in Colombo to Negombo area during North East Monsoon

Spatial and vertical variation of pH

pH of the surface area changed from 7.614 to 8.048 while considerably low value (7.644) were recorded about 15 km away from the coast (location 7) associated with Negombo lagoon water movement and Xpress Pearl Shipwreck vicinity. Location 1 and 16 associated with Kelani river discharge also had quite low pH (< 7.929) in surface waters. However, lowest pH was recorded in location 15 (7.651) at 5m depths close south to Xpress Pearl shipwreck vicinity and Kelani river movements towards North. In 10m depths, the lowest pH was detected near to location 3 (7.145) which could be directly resulted due to Kelani river inputs.

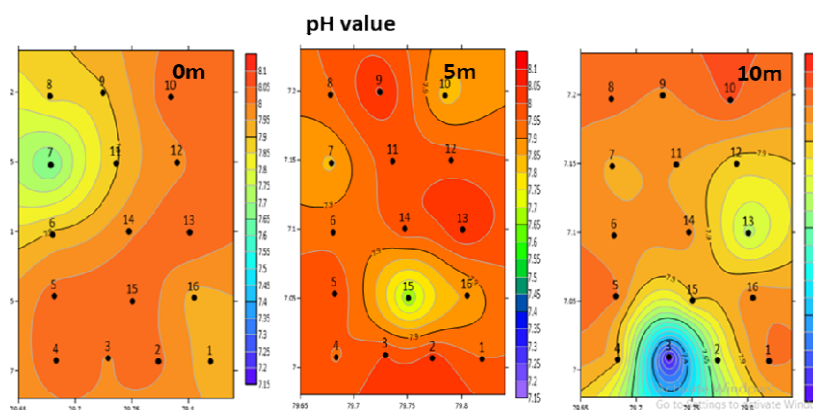


Figure 9 pH variations in three depths (0m, 5m and 10m) from Colombo to Negombo in December, 2022

Spatial and vertical variation of Chlorophyll a

Chlorophyll a (Chl-a) concentration of the surface area was distinctly varied from 1.444 -11.369 $\mu\text{g/L}$. The highest and the lowest concentrations were observed at location 15 and 12 respectively (Figure 10). The highest values could be related to Xpress pearl ship generated high nutrients and other organic debris.

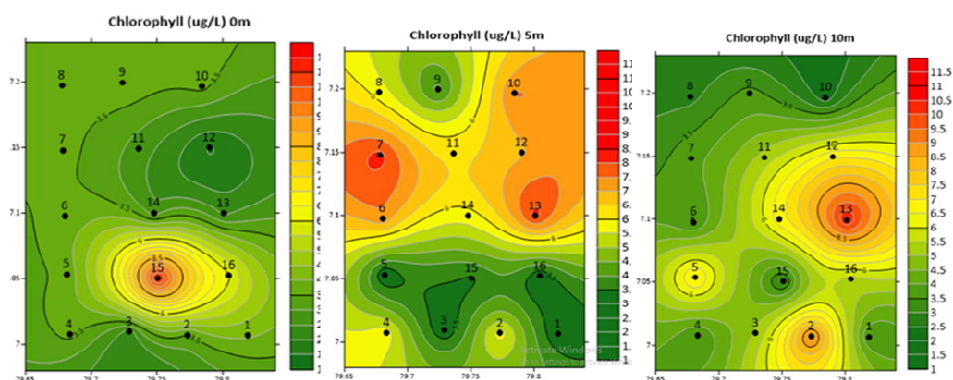


Figure 10. Chlorophyll a variations in three depths (0m, 5m and 10m) from Negombo to Colombo during December, 2022

Chl-a at 5m depths varied from 3.074 to 8.170 $\mu\text{g/L}$ while minimum and maximum values were recorded at location 1, 16 and 13 respectively. The highest values close to location 13 should be related to coastal water currents with concentrated phytoplankton guilds towards land with Xpress Pearl shipwreck associated nutrient inputs. Chl-a at 10m depths varied 2.204 to 10.498 $\mu\text{g/L}$ and the least and highest values were recorded at location 10 and 13 respectively. The maximum value is coupled with the high concentration at 5m depths.

Spatial and vertical variation of nutrients

Nitrate-N and Nitrite-N of the Negombo-Colombo study area varied from 0.248 - 0.564 $\mu\text{g/L}$ and 0.112 - 0.718 $\mu\text{g/L}$ while maximum values were observed in location 13 and 15 respectively. The observed high values could be associated with shipwreck generated debris. Phosphate-P of the area changed from 0.119 - 4.605 $\mu\text{g/L}$ and maximum concentration was noticed near to location 4 and 12 and possible reason has to be examined further. Silicate-Si concentration fluctuated between 3.793 - 8.785 $\mu\text{g/L}$ while the highest value recorded at location 16. The potential increase in silicate-Si would be resulted due to bottom mixing associated with reef system.

Constraints and Improvement

The study was planned to conduct in two legs: one in North east Monsoon and South west Monsoon. However, limited fund provided restricted the two cruises into one and detail study was unable to carry out. Thus, comprehensive study in four seasons is recommended to carry out so as to interpret coastal status through physico-chemical characteristics and ocean current study.

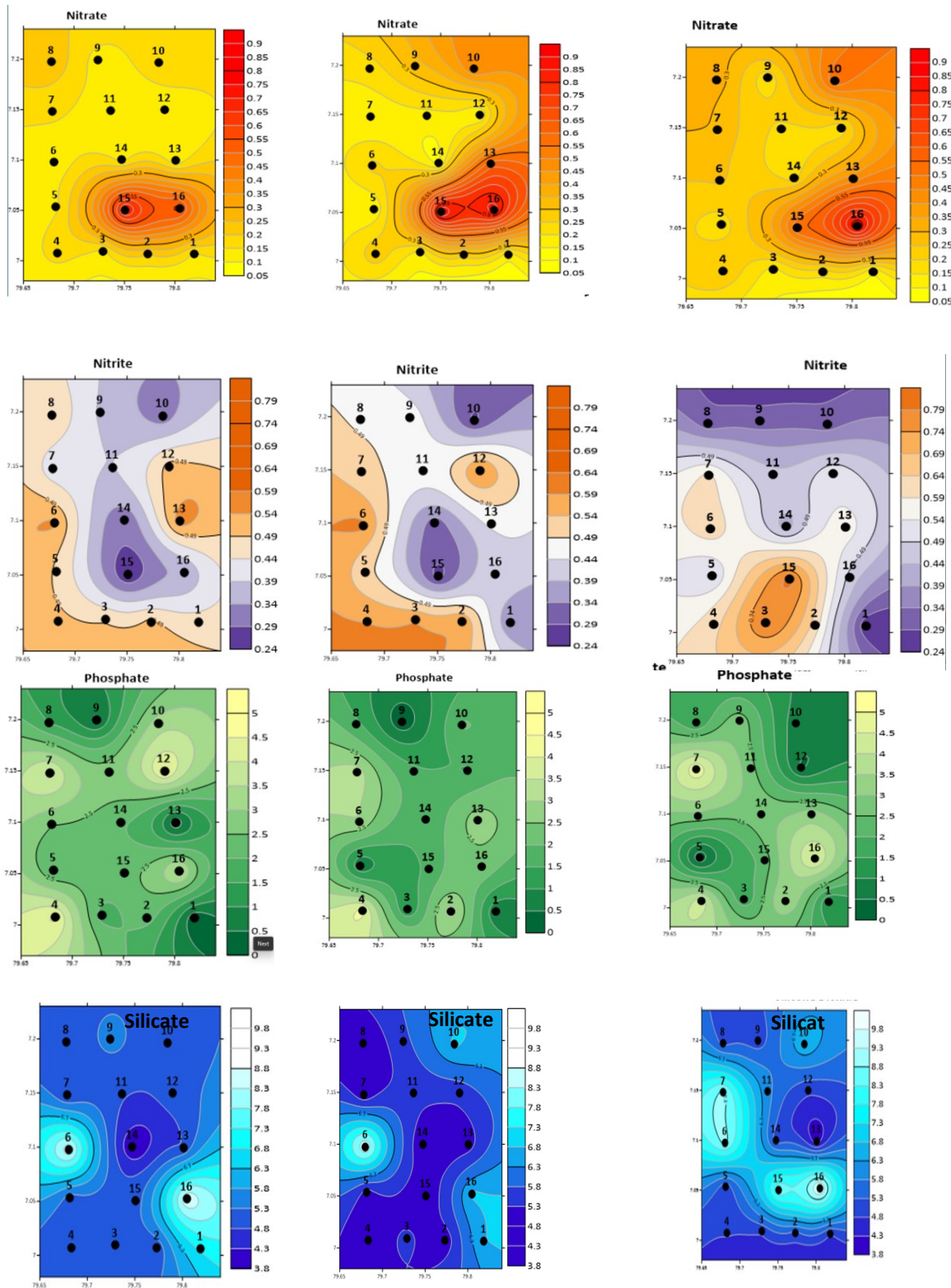


Figure 11. Nutrient variation in three layers from Colombo to Negombo area

Component – 2

MONSOONAL INFLUENCE OF THE DISPERSION OF MICROPLASTICS AND MARINE DEBRIS IN SUBSURFACE MARINE WATERS AROUND SRI LANKA.

Officer Responsible : Ashoke Weerakoon

Duration : 31 January 2022 to 31 December 2022

Microplastic pollution is an emerging environmental problem, particularly in the marine environment, and nations are concerned about this issue due to the potential health and environmental issues these pollutants could cause. In this study, an attempt has been made to investigate the vertical distribution of microplastics present in coastal waters around Sri Lanka. Sampling was conducted at 16 selected locations, vertically to a depth of 20 m with an interval of 5 m, based on the depth of the location. Fourier transform infrared (FTIR) spectroscopy was used to identify polymer categories, chemical composition, and the sources of pollution of microplastics (size range: 0.3 – 5 mm) excluding plastic nurdles. The study assessed the effect of monsoon weather, extreme weather, and water depth as important factors on the dispersion of microplastics in subsurface waters of the West coast of Sri Lanka.

Introduction

Over the past decade, plastic debris, as a major marine and coastal litter have become an emerging issue all over the world (Masura et al., 2015). Plastics and polythene have been used over the last six decades without proper recycling but with a dramatic increase in production (Avio et al., 2016), resulting the majority of those waste ending-up into the oceans (Derraik, 2002). 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, i.e., particles smaller than 5.0 mm in size (Arthur et al., 2008) 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.

Importance of the Study

Plastics and polythene have become a problem worldwide, and is a critical research need. Although research on plastic and polythene litter have been carried out as an emerging trend in Sri Lanka, the field of study has several gaps to be filled in. Firstly, although research studies have been conducted on the abundance on microplastics, all studies are limited to a very limited period of time. This results in a lack of time-series data, and the lack of projectability of trends. Secondly, all research studies conducted so far have been focusing on the litter accumulated on either beach sand or surface waters. In fact, no studies have looked at microplastics in subsurface waters. According to the FAO and IMR protocol reviews, observing surface waters for microplastics is insufficient, since plastics are made of a wide variety of polymers that consists of different physical and chemical properties. These properties determine the fate, and the ultimate destination that plastics would reside. Furthermore, plastic particles are subjected to different changes, once they are released to the natural environment. One major reason to causing this change is the monsoon weather. Although numerous studies have been done on the effect of monsoon driven passive movement of microplastics, there are no such studies conducted in Sri Lanka. Conducting such a study, is important to understand the influence of monsoon weather on vertical and horizontal movement of marine litter, and the potential effects on different marine ecosystems, and the biota exists in different layers of the water column. Consequently, there is an increased interest and a need for a study to understand the level of plastic and polythene pollution in the environments below the sea surface.

Furthermore, a study is needed to assess the distribution patterns of those pollutants in the ocean pertaining to ocean current patterns, and the moment of different water masses.

On the other hand, marine pollution due to collapsing shipping liners has been increased over the time, where the recent incidence; the collapsed X-press pearl ship has caused an immense level of pollution, especially by non-degradable waste including microplastics. This incident demands continuous assessment of the waters around Sri Lanka, in order to assess the long-term impact of contaminants on the natural environment. Therefore, this study will focus on (i) qualitative and quantitative assessment of plastic and polythene content in subsurface sea water, (ii) assessment of distribution patterns pertaining to seasonal variations, (iii) identifying potential sources of pollution, (iv) assessing physical and chemical characteristics, and (v) assessment of aging and weathering of plastic and polythene debris found in sea water, with a special emphasis on microplastics and marine debris released by the recently collapsed cargo ship.

Objectives

- To identify and trace microplastics and marine debris released by the collapsed ship, and identify their existence in the water column, and their distribution around the Island.
- To assess the physical and chemical characteristics and thereby to assess the aging and weathering of plastic and polythene debris in subsurface water (deep sea) water.
- To study distribution patterns of plastic/ polythene debris with regard to monsoonal effects and seasonal variations.
- To conduct an in-depth analysis on sources of pollution, and chemical composition of plastic/ polythene debris in sea water.
- To construct a time series data set of the pollution level through continuous monitoring.
- To develop more effective analytical methods and protocols through experimentation and research collaboration.

Material and Methods

Study Area

During the initial phase; Project Phase – I (2021–2022), two coastal stretches; (i) the Western coast, and (ii) the Eastern coast were surveyed, with plans to expand the project to study other coastlines in the next stages. In order to study the off-shore waters in the aforesaid locations, two major sites, each containing a certain transects of 15–20 km were selected for sampling in the Western and the Southern coasts. This selection of sites was done based on the preliminary findings from the early stage. The selection of sampling stations was done pertaining to geographical, seasonal and ecological significance of potential sampling sites (Table 1). In 2022, coastal waters parallel to land from Colombo to Negombo were selected as the major study site for the assessment of microplastics, where data from assessments conducted from Trincomalee was used to make comparisons between the two coastlines.

Table 1. Sampling locations and their importance			
Coastal stretch	Sampling location	Importance	Study period
Western coast	Colombo to Negombo	Major ocean currents, seasonal weather	2021, 2022
Eastern coast	Trincomalee	Major ocean currents, seasonal weather	2021 and earlier

Collection of Samples

In the study component conducted in the West coast, sampling was done from 16 5 sampling stations from five transects. Surface (sea water) sampling, and CTD profiling were employed on a quarterly and seasonal basis. Water samples were collected from pre-defined depths using the Rosette sampler and the Ratner water sampler. Surveys were carried out majorly on R/V Samudrika, the official national research vessel of NARA, where supplementary surveys were conducted on small boats or multi-day boats (hired), depending on the availability and the functionality of equipment,

and the research vessel. Known volumes of water samples were collected using a manta trawl net (mesh size = 330 μm), a submersible water pump, and a Ratner sampler depending on the location characteristics, requirement, and the weather condition.

In this study, satellite imagery and a high spatial resolution in-situ data will be used to investigate different ocean processes, where these data will be used to assess the relationships with horizontal and vertical movement of microplastics with monsoon-driven changes. For instance, meteorological data off the southern coast and East coasts of Sri Lanka together with field data will be collected on-board R/V Samudrika, and other research cruises conducted around Sri Lanka, will be used as inputs to analyze the dispersion of microplastics. Furthermore, the effect of other oceanographic parameters will also be considered in the study. For example, suspended material such as sediment, chlorophyll, etc. in the surface waters around Sri Lanka will be used as a passive tracer to reveal flow patterns using satellite imagery. Field data including wind speed and wind direction will be collected from coastal meteorological stations located in the southern and eastern coasts. Furthermore, meteorological data from ECMWF-ERA interim data will also be used for the model purposes and comparison of data. The MODIS satellite imagery system will be used to access data on the ocean color and SST, which will indirectly be important for the study.

Preparation and Analysis of Samples, and Data

Samples were analyzed for both quantitative and qualitative parameters. The microplastic particles found in water samples at different depths in the water column were categorized based on their (1) Shape, (2) Color and (3) Size. Standard laboratory methods (suggested by NOAA) will be used for all laboratory procedures. Furthermore, a particle size analysis was done based on estimations of the number of particles from subsampling. Polymer identification was conducted using Fourier transform infrared spectroscopy (FTIR; ALUMOS II (Bruker, UK)), in which spectra (32 scans) were collected in reflectance mode in the range 4000–500 cm^{-1} , and resolutions of 4 cm^{-1} (Atugoda et al., 2020). The verification of polymers was performed based on the percentage match against a standard polymer library, where only matches above 60 % were selected as positive responses (Leistenschneider et al., 2021). Both descriptive and inferential statistical techniques will be employed in the study. Software packages: SPSS, PSPP, ODV, and MATLAB will be used to analyze, illustrate and interpret data.

Results and Discussion

Occurrence of Microplastics

In view of moving average, the occurrence levels of microplastics ranged approximately from 2 PCM to 350 PCM (Fig. 1) during the assessment period. The highest occurrence level was recorded during the Southwest monsoon, in which elevated occurrence levels have been found from all depth levels from 0 m to 15 m. In contrast, the lowest occurrence levels were found during the Northeast monsoon. However, in the assessments conducted in the last two years, elevated levels of microplastics from coastal waters in the East have been found (i) during the Northeast monsoon period, and (ii) when the Sri Lankan dome is active, while unprecedented presence of microplastics have been found during the cyclone season. Besides, relatively higher concentrations of microplastics and marine debris were observed from stations in coastal waters that can be attributed to the turbulent waters with resuspension of bottom sediments, especially in locations where the bottom depth is comparatively low.

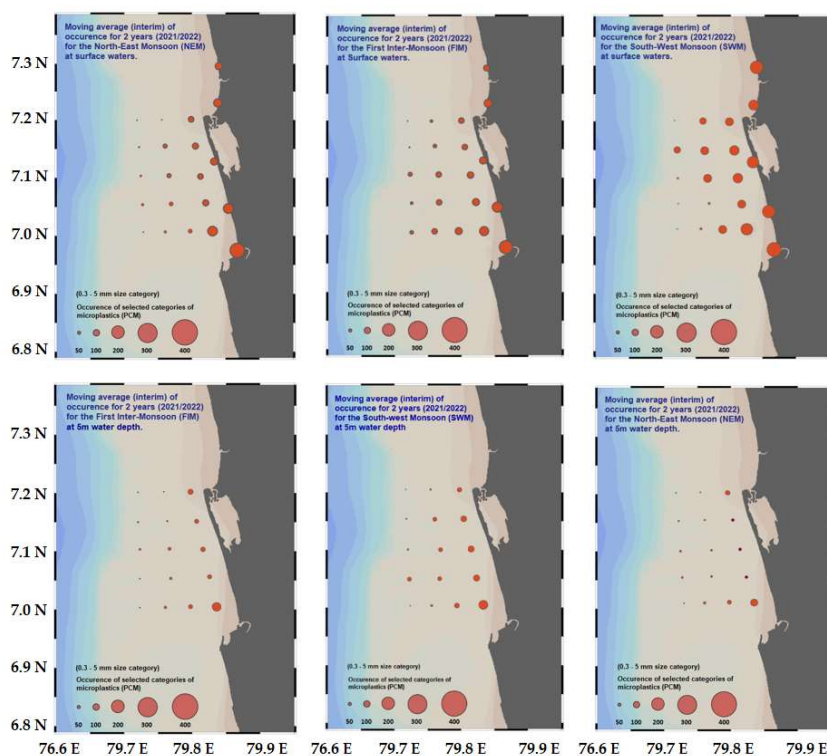


Fig. 1. The occurrence levels of microplastics in coastal waters of the West coast, based on the moving average calculated for the surveys conducted in two years (2021 to 2022) in main monsoon seasons.

The overall results from the two-year comparisons reveal that the occurrence levels of microplastics in nearshore waters were different to that of off-shore waters due to a number of reasons of which depth of the water column is an important factor. During the Southwest monsoon, the occurrence levels of microplastics and marine debris in subsurface waters are elevated compared to that in all other seasons, while particles that are denser than sea water were found from the surface layer (i.e., from 0-5 m). As a result of vertical mixing in a dwarf water column located in close proximity to the coast, the highly dense particles can be found from the surface waters, thus, this movement could be observed as strange. However, during the Northeast monsoon, a slight stratification can be observed in calm seas, where more lite microplastics particles could be observed from the surface waters on the Western coast. However, this condition is fairer to the locations with reasonable water depth. Additionally, during the first and the second inter-monsoon periods, the average occurrence levels of microplastics were low compared to the other seasons, provided that no extreme weather event prevailed.

Furthermore, the vertical distribution of debris particles turns out to depend on their occurrence levels or the concentrations in the surface layer. In places where ample vertical mixing is present, the concentrations of debris thought-out the water column remains extreme. However, at places where surface currents and longshore currents are active, the occurrences of debris in the surface layer have been affected as they were transported away by those forces. As a result, the occurrence levels of microplastics in the shorter water column could be low. However, still the pollution levels of the surface layer could be higher as they are located in close proximity to the coast, which is by default the single but the largest host of pollutants. Thus, the findings reveal that the vertical mixing affects the number, mass, and size distribution of buoyant plastics captured by surface nets, and other standard equipment for at-sea plastic pollution sampling. This is in line with the findings from Hidalgo-Ruz et al. (2012), about the impact of vertical mixing on the sampling methods and equipment used in microplastics assessments.

Effect of Extreme Weather on Subsurface Microplastics

On top of monsoon weather as a key determinant of vertical movement of microplastics, the extreme weather conditions appear to have a considerable influence on the dispersion of marine pollutants (Jayathilaka et al., 2022). The extreme weather systems ranging from depressions to cyclones could influence both the horizontal and vertical distribution of microplastics in the ocean environment. For instance, the cyclones: “Yass” in May, 2021, and “Mandous” in December, 2022, had an influenced the elevated occurrence of microplastics in the water column. On the 22nd of May, 2021, a depression in the Northern Bay of Bengal intensified into a cyclone named “Yass”, influenced the distribution of microplastics including nurdles from a collapsed ship: “MV X-Press Pearl” in the nearshore waters off the West coast on 25th May 2021, with strong landward winds (>12 m/s) and exceptional wave heights (>3 m) during 26th and 28th May 2021 (Jayathilaka et al., 2022). Most investigations have considered a movement in a near-surface layer a few meters deep and have found a drift of between 1.5 % and 4.1 % of wind speed (Chang et al., 2012, Schumann et al., 2019; Wu, 1983). Furthermore, the effect of an underlying, large-scale ocean current is included as a scalar add-on. In this case, the Western Sri Lankan Coastal Current has contributed to the movement of drifting nurdles. Advection of spills on the sea surface is generally defined, in its simplest form, by surface current associated with wave-induced current, tidal current, and by the wind-driven current. As the wind-driven current was strong (>12 m/s) during the storm (Jayathilake et al., 2022), the pellets were dispersed nearly parallel to the wind direction (Churchill and Csanady, 1983, Wu, 1983, Perrie et al., 2003).

The average occurrence of microplastics in the west coast during 2021 and 2022 has been increased to a great extent compared to 2020. This very likely caused by the pollution of the study site by the collapsed cargo vessel: “X-Press Pearl” during the Southwest monsoon, and the extreme weather prevailed during the end May, 2021. During this period, there were strong onshore winds (> 10 ms⁻¹) and swell waves (height ~2 m), associating the onset of the Southwest monsoon with the currents flowing to the south along the West coast of Sri Lanka across the study area. Elevated occurrence levels of microplastics and other debris have been found from both the surface and subsurface waters, besides the consequent coastal pollution.

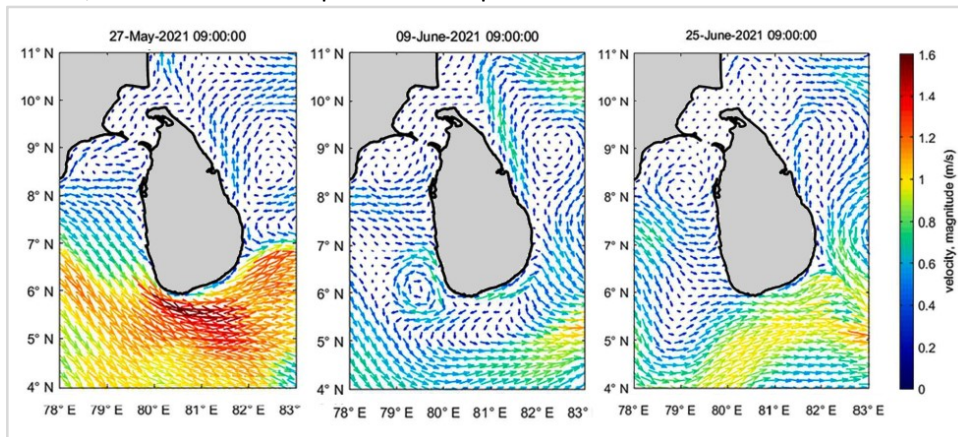


Fig. 2. Current speed (m/s) and direction derived from HYCOM data (HYCOM + NCODA Global 1/12° GOFS 3.1 Reanalysis) between 27th May and 25th June 2021 (Southwest monsoon). Source: Jayathilaka et al. (2022).

After a drop of particulate pollutants in offshore waters, a rise in the occurrence of microplastics, especially of nurdles have been found since the establishment of the Southwest monsoon. This could be due to the detachment of stranding microplastics and other marine debris have detached from the coast and moved offshore to the Southeast (Pattiaratchi et al., 2022).

Since then, microplastic nurdles have been found in increased concentrations from the surface waters, while different polymer categories that were not common in coastal waters in Sri Lanka have been found as microplastics.

Polymer Categories and Sources of Pollution

An array of polymer categories was found in Western coastal waters of Sri Lanka. Polyethylene terephthalate, polyethylene, and polystyrene were among the most occurrent polymer categories in surface waters. However, polymers such as polyvinylchloride, and acrylates that are denser than seawater were present in the surface waters and the upper water column during rough seas, especially during the Southwest monsoon on the West coast.

Conclusions

Among the factors that influence the vertical and horizontal distribution, the monsoon weather plays a key role in both the vertical and horizontal distribution of microplastics in the study area. The active monsoon weather conditions contribute to the vertical mixing of marine particulate pollutants such as microplastics which have resulted in their distribution across the water column. This causes a seasonal-based spatiotemporal variation in the occurrence of microplastics and other marine debris in the ocean environment. As well, extreme events such as depressions and cyclones cause elevated occurrences of microplastics in the water column while seasonal phenomena such as the prevalence of the Sri Lankan Dome shows influences on the movement of microplastics.

The research reveals that the occurrence of non-biodegradable particulate pollutants including plastic nurdles and other polymer debris, *i.e.*, total floating microplastics have increased at least by 19K% per location in the study area immediately after the spill caused by the cargo vessel X-Press Pearl. This includes an increase of non-nurdle microplastics of approximately 300% while the rest of the increase was due to the extreme occurrence levels of plastic nurdles immediately after the spill. The sudden and extreme increase in microplastics due to this incident in this study area indicates the severity of pollution in the rest of the sea area in the Western coast.

Recommendations

Predictions of plastic vertical mixing can commonly be used to correct numerical concentrations obtained by surface net sampling (Kukulka et al., 2012; Reisser et al., 2013; Cózar et al., 2014; Law et al., 2014). More sampling is required to better quantify both profiles of plastic mass and numerical concentration over a broader range of sea states, and translate these observations into prediction models. Such models may need to be three-dimensional, and account not only for wind mixing effects, but also ocean plastic properties (e.g., particle size) and other types of vertical transport processes (e.g., Langmuir circulation). Further monitoring with timeseries data is suggested to analyze the vertical distribution patterns of microplastics in the long run whereas more research on sources of pollution is required to provide information for decision making. Since smallest particles are found in large quantities even up to 15-20 m depths, research studies and assessments on microplastics in biological components could be important.

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PROJECT No : 6.5

HYDROLOGY AND WATER CIRCULATION OF LANKAPATUNA LAGOON

Officer responsible : H.A.S.D Perera, Ruchirajayathilaka, JanaranjanaEkanayaka

Duration : 31 January 2022 to 31 December 2022

Introduction

Lagoon is a highly dynamic environment and Natural phenomena changing with human intervention is highly impact not only environment but also on livelihood activities. Coastal lagoons in Sri Lanka are resulted by of mid-Holocene marine transgression and subsequent barrier formation and spit development enclosing the water body between the land and the sea (Silva et al., 2013) enriched with fish, crustacean and as well as with molluscan fauna for feeding and breeding ground for many aquatic organisms (Colombo, 1977). Coastal lagoons play an important role not only by offering various “natural resources” for regional community but also by providing “natural infrastructure” for hazard protection and/or mitigation, which is commonly called “bio-shield (Tanaka 2009).

Lanka patuna Lagoon which called as Ullackalie Lagoon is a coastal waterbody located in Trincomalee District in the Eastern Province at 8°22'N 'E'North 81°22'East. It's mentioned as choked lagoon cover 13 Km² (5 sq mi) water surface area and consider as shallow with a maximum depth 2 m, widest point is approximately 2 Km and the maximum length is 7 Km. Main freshwater provider is VerugalAru and UppuAru are two small freshwater streams. Newly bridge was built across the lagoon in 2017. The Lagoon enriched with the extensive mangroves and surrounded by evergreen forest and scrubland as well as paddy cultivations. Anthropogenic activities such as bridge and land uses are caused to prevented flushing of the lagoon by natural water flow, causing continues sedimentation in the lagoon. Lankapatuna Lagoon most enriched with most abundant shrimp species and commercially important shrimp fish species. That Lagoon was designated as wildlife sanctuary in 1970. Wetlands such as Lagoons which required the monitoring under some major variables for effective management (Devendra, 2002) described as follows.

Key variables

Water balance:

The water balance, monthly or daily basis, is a crucial component in wetland hydrology. It requires attention to the full range of hydro meteorological variables including precipitation, input from rivers and surface runoff, groundwater input or/and outputs, evaporation and transpiration, river outflow, any tidal exchanges of water, and abstraction of water or returns of effluent.

Water quality:

Plays a dominant role in determining the composition of wetland flora and fauna.

Turnover rate:

(the ratio of throughput to storage) defines the flushing rate of a wetland and is the inverse of the retention period. This has vital ecological significance because it influences chemical and biotic wetland properties such as nutrient accumulation, salinity, and the flushing of pollutants.

Therefore, this project will be a new approach for evaluating present status of the main physical process of the particular lagoons and generating hydrodynamic models to quantify water and predict hydraulic parameters such as water mass movement, and transportation properties in the lagoon. At the same time, biochemical in the lagoon water also will be inspected, aiming at reaching better decisions with regards to lagoon restoration design, water quality control and management actions for improvement of associated environmental conditions and fishery exploitation.

Main objective

- Evaluate the hydrology of the lagoon, including quantity, distribution, flow pattern, and quality of the water and sediment.
- Simulate the hydrologic, hydraulic, water quality and geological condition in the lagoon to overcome the existing and upcoming scenarios
- Evaluate the Water Circulation pattern of Lagoon

Specific Objective/s

- Identify seasonal and temporal salinity variation
- Identify lagoon water circulation including water balance and residence time
- Identify seasonal and temporal variation of Nutrients

Methodology (Study area, Field sampling, data collection and analysis)

Study Site

The Lankapatuna is located 8.416290° - 81.352138° North and 8.354051° - 81.379634° East and area and the length of the lagoon is almost 7.5 km. Total lagoon area covered around 13 Km^2 (5 sq mi) and maximum depth was recorded as 2m. Main freshwater feeders are Verugalaru and Uppuaru stimulate with rain.

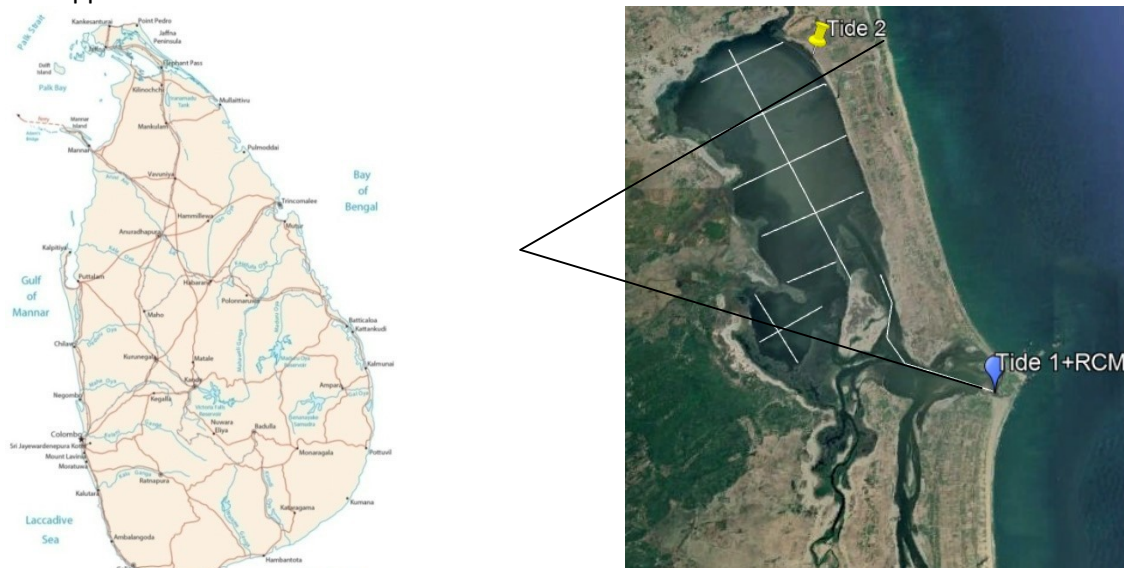


Figure 1: Map of Lankapatuna (Ullackalie) lagoon including cruise track

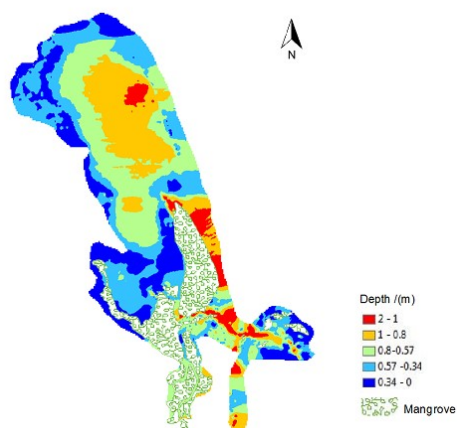


Figure 2: Bathymetry and mangrove patches in Lankapatuna lagoon

Main activities

- Water balance and Water residence time
- Hydrology, Hydrodynamic
- Chemical properties
- Setting up a hydrodynamic modeling of temperature, salinity and water level.

Collection of samples

This research work was started as a baseline survey with lack of literature review.

In order to study the water balance and bio-geochemical properties, major 30 stations, including outside stations and major stations were selected with close to stream outflows were selected for sampling in the lagoon.

Under the activity 1, To investigated the water balance, and Water exchange in the lagoon water level (tide pole), flow rate (flow meter), salinity (SBE 19plus CTD and Autosol), evaporation and precipitation (met. department data) data was collected during the field visit under the activity 1.

Under the activity 2, Chemical properties (Nutrients, TSS) and Geological components (Grain size) were analyzed in the field.

Under the activity 3, The hydrological budget models which called Water balance was estimated. Therefore, the net water balance can be written as follow.

$$\frac{\Delta V}{\Delta t} = Q_p + Q_e + Q_g + Q_r + Q_o \quad (\text{Gunaratne et al., 2010})$$

V= lagoon water volume (m³)

Q_p= mean monthly precipitation (m³s⁻¹)

Q_e=mean monthly evaporation rate (m³s⁻¹)

Q_g=groundwater inflow into the lagoon(m³s⁻¹)

Q_r=surface runoff discharge rate (m³s⁻¹)

Q_o=advection gain/lost (tidal flow) (m³s⁻¹)

This methodology has been described in detail by LOICZ biogeochemical Modelling guidelines for the uses of simple budget models in coastal water bodies, such as lagoons (Gorden et al.,1996). Hydrodynamic modelling of the lagoon will be complex, due to the various conditions and alternatives.

Analysis of sample and Data

Samples was analyzed for both quantitative and qualitative parameters. As on site parameters Salinity and Temperature were measured by SBE 19 plus v2 CTD and Autosol. Nutrient and Sediment analysis were conducted as Laboratory analysis. Tidal prism, Residence time and phase lag were measured by using tidal variation and velocity data. In addition, the descriptive and inferential statistical techniques were employed in the study. Software packages: MATHLAB and SPSS were used to analyze data.

Activities proposed to be completed during the period

- Spatial and Temporal variations of Salinity, Nutrients, Sediments
- Analysis of Water Circulation
- Setting up a hydrodynamic modeling of temperature, salinity and water level.

Results: Activities carried out:

Water Balance

Tidal Fluctuation

Water exchange between lagoon and sea are controlled by the tidal and sub-tidal oscillation. As tidal waves propagate from the ocean through an inlet and into the Back Bay (lagoon), amplitudes decrease, and phase lags develop relative to the oceanic sea-surface elevation fluctuations. If the amplitude reduction is large, the system is considered tidally choked. Tidal choking influences the amount of flushing from the lagoon to the ocean, which is important to coastal ecology, water quality, and sedimentation. Coastal lagoons have been divided into three categories (choked, restricted, and leaky) based on the ability of the lagoon to flush water. In Lankapatuna Lagoon under study periods Semi diurnal tidal pattern was observed during the field visit at the lagoon. Average tidal range is about 14-25cm.

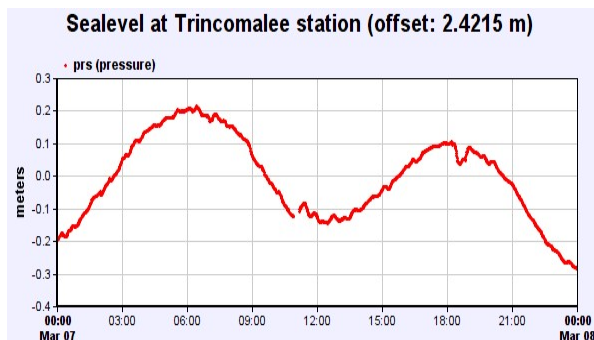


Figure 3: Tidal fluctuation for North-east monsoon

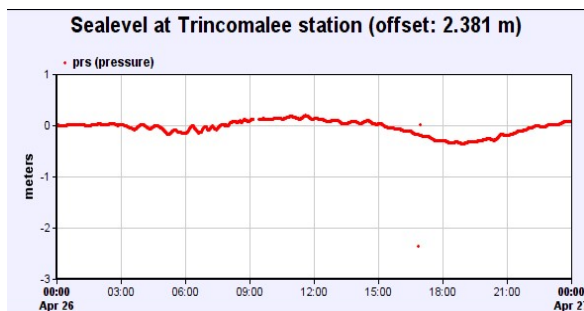
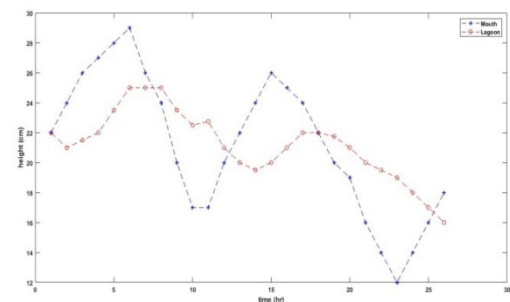


Figure 4: Tidal fluctuation for first inter monsoon

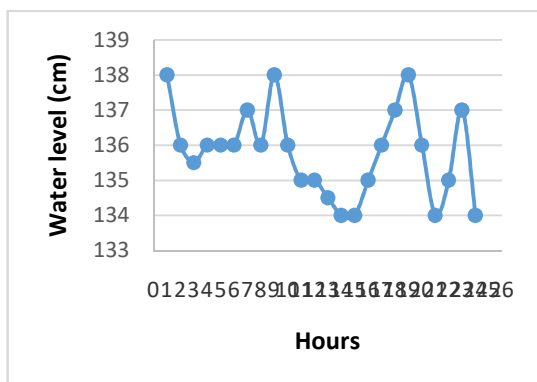
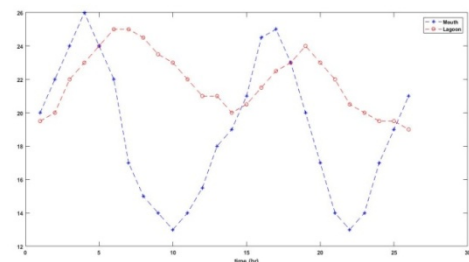


Figure 5: Tidal fluctuation for South-west monsoon

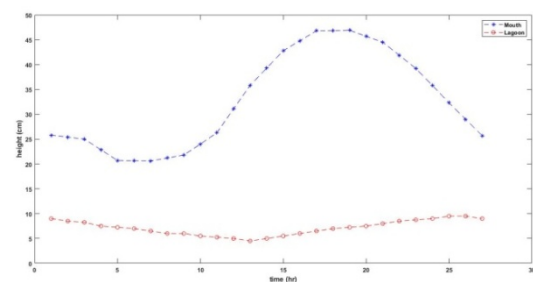


Figure 6: Tidal fluctuation for second inter monsoon

Observations confirmed the sea level changes based on trincomalee sea level station and it's behaved around 60 cm and maximum sea level reduction up to 14 cm on the narrow lagoon mouth and further reduction up to 6 cm when it moves until lagoon head during both North-East and first

inter monsoon. Due to closed of lagoon mouth during August to september tidal fluctuation wasn't observed in South west monsoon. With the precipitation induced in October sand bar was breached and lagoon mouth getting open. At the second inter monsoon period (in November) tidal range fluctuation was 25 cm for lagoon mouth.

Incoming tidal wave loses range due to bottom friction as it travels towards the head. The observed ranges and phase lags result from the combined effects of the incident and reflected waves. Phase lag in Lankapatuna lagoon shown as nearly 2 - 3hr for 6 km distance.

The tidal amplitude in the lagoon is lower 90% than the open sea indicating the choking effect in the system and tidal choking coefficient in the lagoon is 0.23-0.41 where η_l is tidal amplitude in the lagoon and η_o is in the ocean.

$$C_c = \eta_l / \eta_o$$

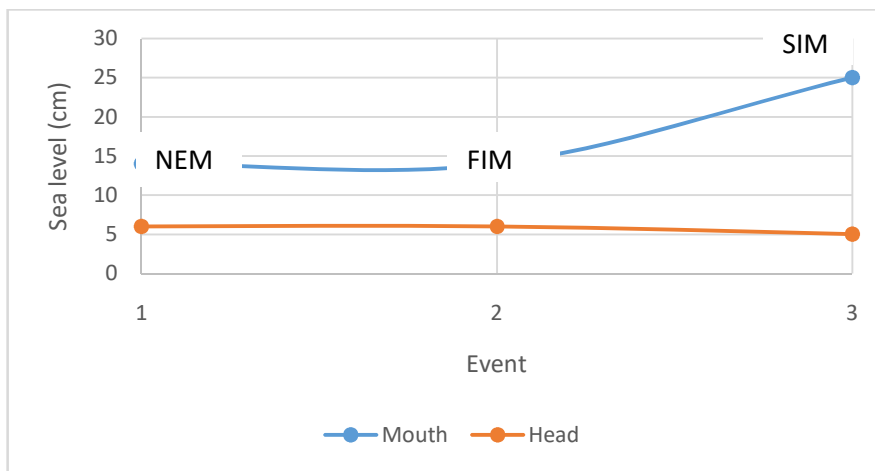


Figure 7: Tidal amplitude versus Monsoon from the Lagoon Mouth to the Lagoon head (November)

In this lagoon, total extinction of the tide occurs before the tidal wave reaches the head (Wijeratne and Rydberg, 2007). This was clearly explained figure 3, which tidal wave decreased gradually when it reached to mouth to head.

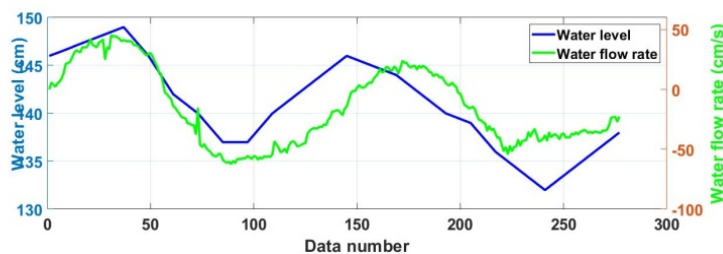


Figure 8: Tidal fluctuation with velocity in North-east monsoon

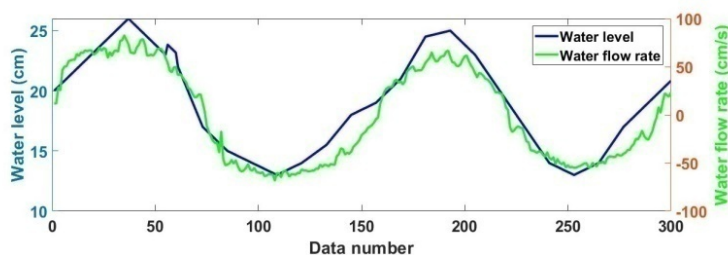


Figure 9: Tidal fluctuation with velocity in first inter monsoon

Maximum flood tidal velocity (259 cm/s) observed during second intermonsoon period (november). However with reduction of surface water discharge by verugal-aru flood tidal getting dominant could be claealr identify with comparing water flow rate data in North east and first intermonsoon. At that time river water discharge drastically reduced 12 m³/s to 7 m³/s. In south west monsoon (August) lagoon mouth was completely closed and no water exchange occur here during ebb and flood tidal events.

Precipitation and Evaporation

Meteorological Data was obtained through Department of Meteorology and Monthly average values are calculated and tabulated.

Table 1: Monthly average Evaporation and Precipitation in Lankapatuna(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Evaporation (mm)	2.74	3.69	3.58	4.54	3.96	5.06	4.91	4.63	4.87	3.56	2.99	3.47
Average Precipitation (mm)	3.51	2.95	1.45	0.23	0.00	0.53	0.00	0.65	0.83	5.27		

According to the Meteorological data which was received from department of meteorology maximum rainfall was observed in October (5.27 mm) with starting second inter monsoon. Maximum evaporation range was recorded during south west monsoon (4.63 mm -5.06mm).

Fresh-water inputs

Two river basins of Verugalaru and Uppuaru empties into lagoon and uppuaru only activate with rainy season. Verugalaru river discharge varied between 12 m³/s -7 m³/s respectively in NEM and FIM. During the rainy season fresh water discharge got dominant

Table 2: illustrates the summary of the estimated average monthly rainfall and evaporation data Study Period (from 2022 January to 20221 December).

Month	Precipitation rate (Q _p)/ m ³ s ⁻¹	Evaporation rate (Q _E)/ m ³ s ⁻¹	Q _p -Q _E
January	48.75	38.05	10.7
February	40.97	51.25	-10.28
March	20.14	49.72	-29.58
April	3.19	63.06	-59.87
May	0.00	55.00	-55
June	7.36	70.28	-62.92
July	0.00	68.19	-68.19
August	9.03	64.31	-55.28
September	11.53	67.64	-56.11
October	73.19	49.44	23.75
November		41.53	
December		48.19	

Tidal prism Residence time and Water exchange:

The tidal prism is the amount of water that flows into and out of an estuary or bay with the flood and ebb of the tide, excluding any contribution from freshwater inflows (Mustoe et al., 2005).

The residence time may be defined as the time it takes for a particular water parcel to leave a water body through its inlet (Wijeratne and Rydberg, 2007). Below mentioned equation was used to measured residence time in Lankapatuna lagoon (March, July and November) figured in Table 3.

$$\text{Residence time} = \text{Lagoon volume} / \text{Tidal prism}$$

Table 3: Puttala Lagoon Residence time

Month	North east monsoon	First monsoon	Inter monsoon	South west monsoon	First monsoon	Inter monsoon
Residence time	4.6 days	14.39 days	infinity	2 days		

According to (Arulananthan, Rydberg, Cederlöf and Wijeratne, 1995) studies residence times for the lagoon water vs the ocean 47 days, for Puttalam lagoon but in here it was shown maximum as 14.39 days. Freshwater discharge close to lagoon mouth and comparatively lowest surface area are the major morphological features that results in here. Analyzed results were explained with climatic conditions getting dry and evaporation in maximum level induce the highest residence time.

In an estuary, time scales of flushing rate and residence time, which are usually used to measure the rate of water exchange between estuary and the adjacent ocean have a major impact on the ecological processes and functions including water chemistry and sedimentation and in turn biophysical environment. The water exchange and residence time in the lagoon is mainly driven by river input (Wijeratne, 2003).

Tidal prism is responded to a function of area of open water and tidal range, it can be changed by alterations of the basin area of estuaries and inlets as in dredging. If lagoon morphology or hydrology changed (estuary or inlet is dredged, or the size changed) the channel will fill in with sediment until it has returned to tidal prism equilibrium.

Bio-Chemical properties

Salinity

Lankapatuna lagoon is explained significant salinity ranges between all four study periods. Maximum gap of surface salinity shown in both North east monsoon and second inter monsoon respectively 6-23 psu. Those seasons were recorded maximum rainfall, however during south west monsoon study period lagoon mouth was closed and evaporation got dominant, river discharge reduced and salinity level fluctuated between 34-37 psu. Also with the reduction of freshwater flow salinity in verugaluru river mouth recorded as 35 psu.

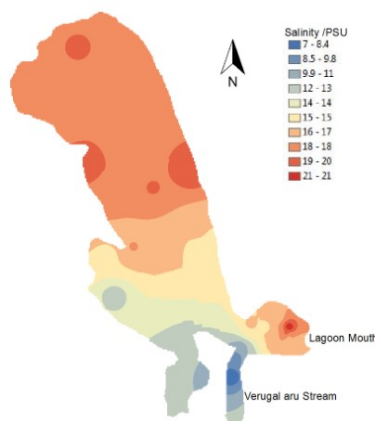


Figure 10: Spatial surface salinity during Northeast monsoon

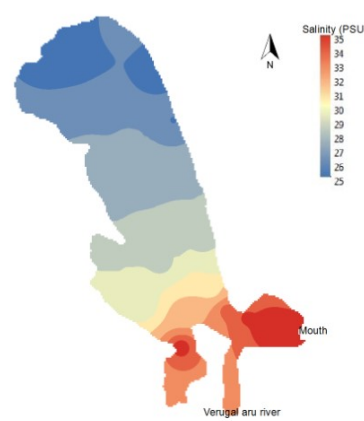


Figure 11: Spatial surface salinity during first inter monsoon

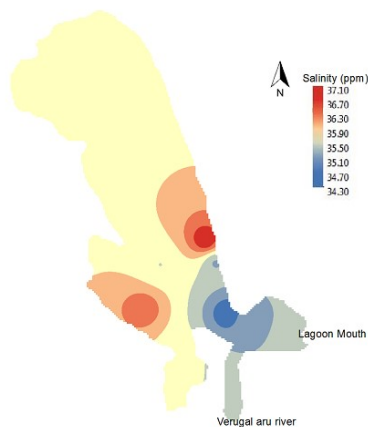


Figure12: Spatial surface salinity during South west monsoon

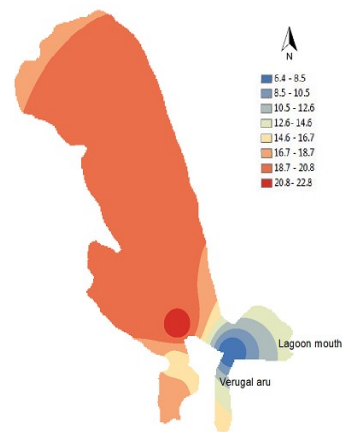


Figure 13: Spatial surface salinity during second inter monsoon

Nutrients

Nitrate

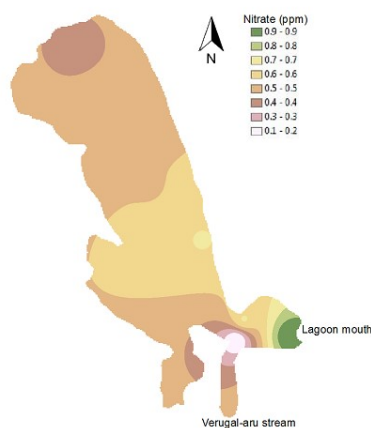


Figure 14: Nitrate content in North East Monsoon

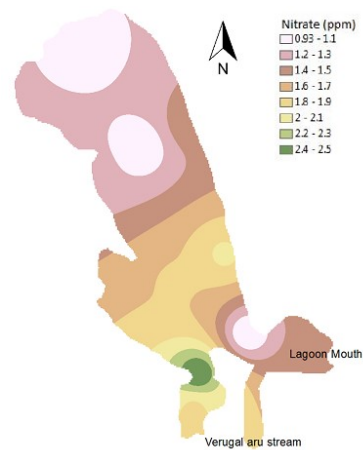


Figure 15: Nitrate content in First Inter Monsoon

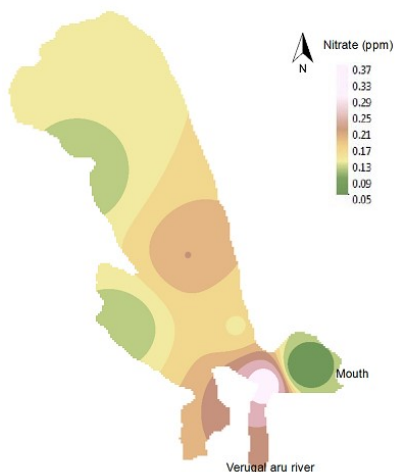


Figure 16: Nitrate in South West Monsoon

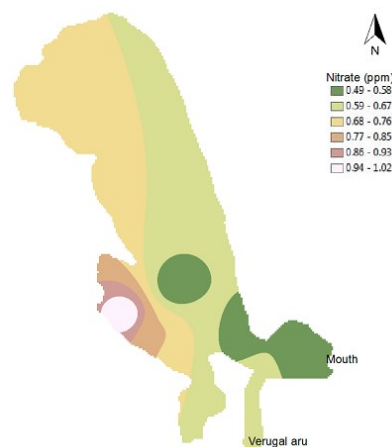


Figure 17: Nitrate in Second Inter Monsoon

Both Nitrate and phosphate concentration was recorded as maximum level (figure 14-21) around the river water discharging area and lagoon mouth explained which nutrients carried out by different landuses. However with reduction of river discharge and flood tidal getting dominant freshwater flux

was forced toward the middle of the lagoon and it was resulted the highest concentrations recorded in middle.

Phosphate

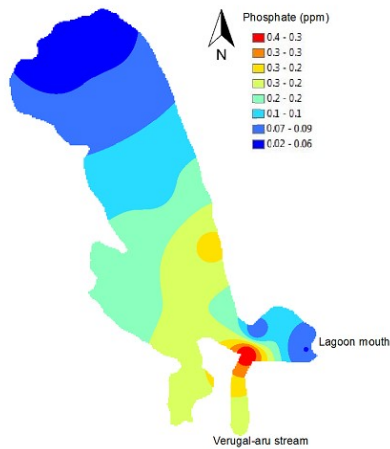


Figure 18: Phosphate content in North east Monsoon

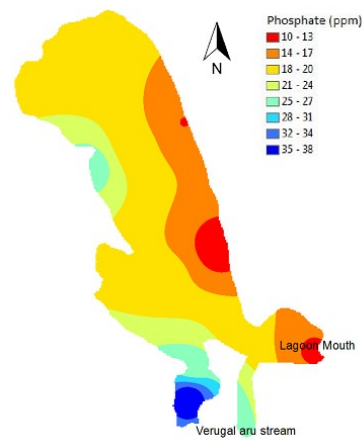


Figure 19: Phosphate content in first inter Monsoon

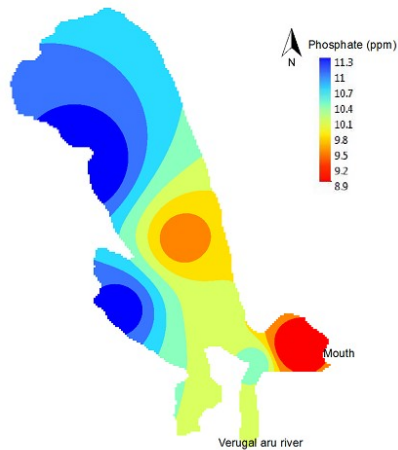


Figure 20: Phosphate content in South west Monsoon

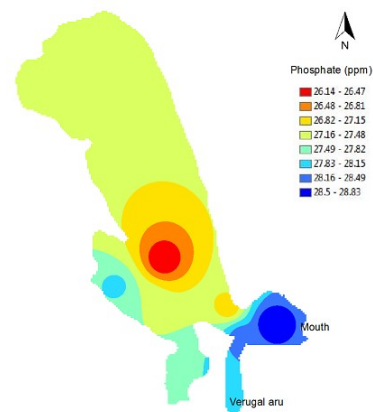


Figure 21: Phosphate content in second inter Monsoon

Landuse pattern in Lankapatuna catchment area didn't consist with any specific aquaculture practices and industrial process. Agriculture practices are the major impact on the lagoon by adding chemical components and sediments.

Modeling the hydrodynamics and salinity of the Lankapattna Lagoon

In order to understand the local hydrodynamics and the spatial variance of salinity in the Lankapattna Lagoon, a 2D model was setup. This will give more insight in the impact of the diversion on salinity (gradients), hydrodynamic and salinity modeling of the lagoon basin is desired. The lessons learnt from this research can be used as a foundation for future modeling initiatives of the coastal lagoons along Sri Lanka's east coast.

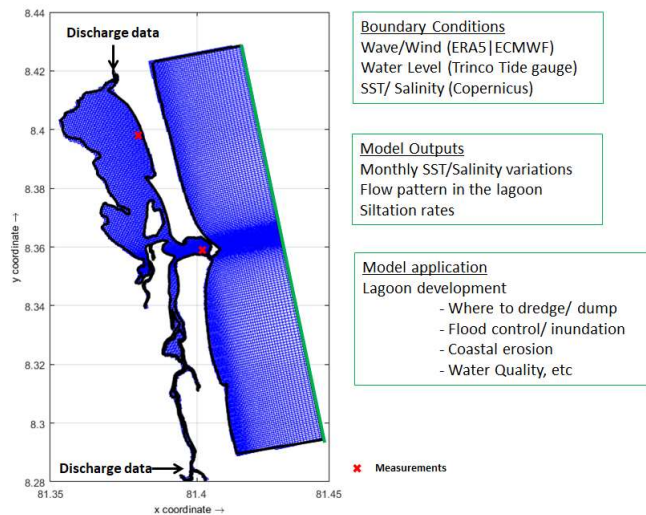


Figure 1: Model grid setup for Lankapattna Lagoon

At present the 2DH hydrodynamic model has been applied to simulate Lankapattna Lagoon hydrodynamics. The flow module of the model is a two dimensional (depth average) hydrodynamic (and transport) which calculates non-steady flow and transport phenomena resulting from tidal and meteorological forcing on a curvilinear, boundary fitted grid in the water. It takes into account also inflows from rivers and other point sources.

The cell dimensions vary from 10 m to 150 m. The smaller cells are applied close to the lagoon mouth, where large velocity gradients are expected. The bathymetry is taken from the National Hydrographic Office of NARA (NHO).

There are two small freshwater streams called VerugalAru and UppuArudischarging into the model area. As we do not have measured river discharge data, the seasonally averaged discharge for dry and wet seasons are used in order to model set up. The average discharge in the wet and dry season of the year is 12 m³/s and 7 m³/s respectively. The salinity of the river discharges is 0 ppt.

The model is forced with the amplitudes and phases of the most important tidal constituents as given in the table 4.

Table 4: Main tidal constituents for the open sea boundary in study area.

Tidal Constitute	Amplitude (m)	Phase (Degree)
M2	0.16	74
S2	0.05	104
N2	0.03	65
K2	0.01	91
K1	0.06	245
O1	0.01	220
P1	0.02	241

Figure 23 shows the water level variation for the Lagoon's inside and outside in March 2022. We do not have sufficient information on measured water level variation in the lagoon section for this period that would allow us to contrast the model results. However, model was calibrated with the water level measured at Trincomelee bay (IOC Lea Level data). The model simulation set the parameters of horizontal eddy viscosity $E = 1 \text{ m}^2/\text{s}$, and horizontal eddy diffusivity $D_h = 1 \text{ m}^2/\text{s}$. for the bottom condition, the Manning friction formula is applied, with coefficient value equal to 0.025.

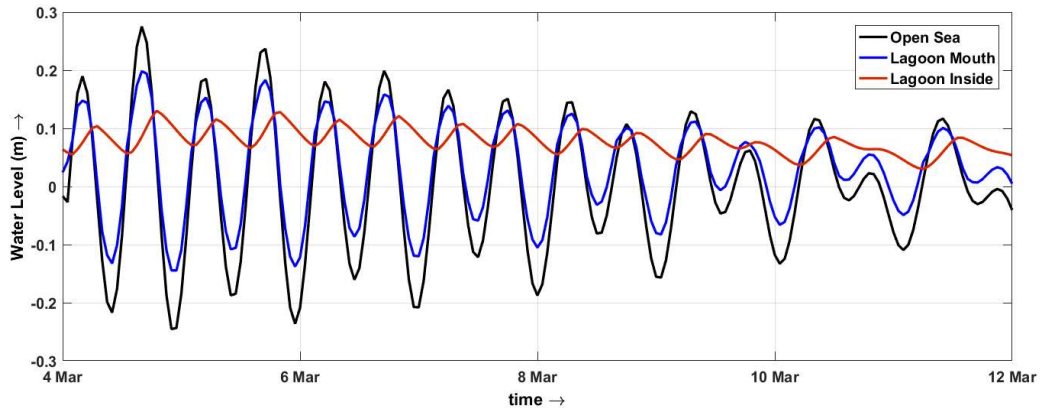


Figure 23: Water levels variations inside the Lagoon , Lagoon mouth and open sea of the Lankapuna Lagoon.

A numerical model was set up to determine the Current pattern and their spatial distribution within the Lankapattna Lagoon. Numerical results of tidal Current (m/s) and their spatial distribution within the Lagoon when it is peak spring flood and ebb tides are shown in the figure 24. The maximum tidal current was recorded as 50 cm/s on a rising spring flood tide while on an ebb tide; the tidal current is little lower through the lagoon mouth. However, inner lagoon shows less than 5 cm/s flow speed. The simulations show that the tide driven currents are stronger as this region is a semi-diurnal, micro-tidal regime with a maximum spring tidal range of 0.7 m.

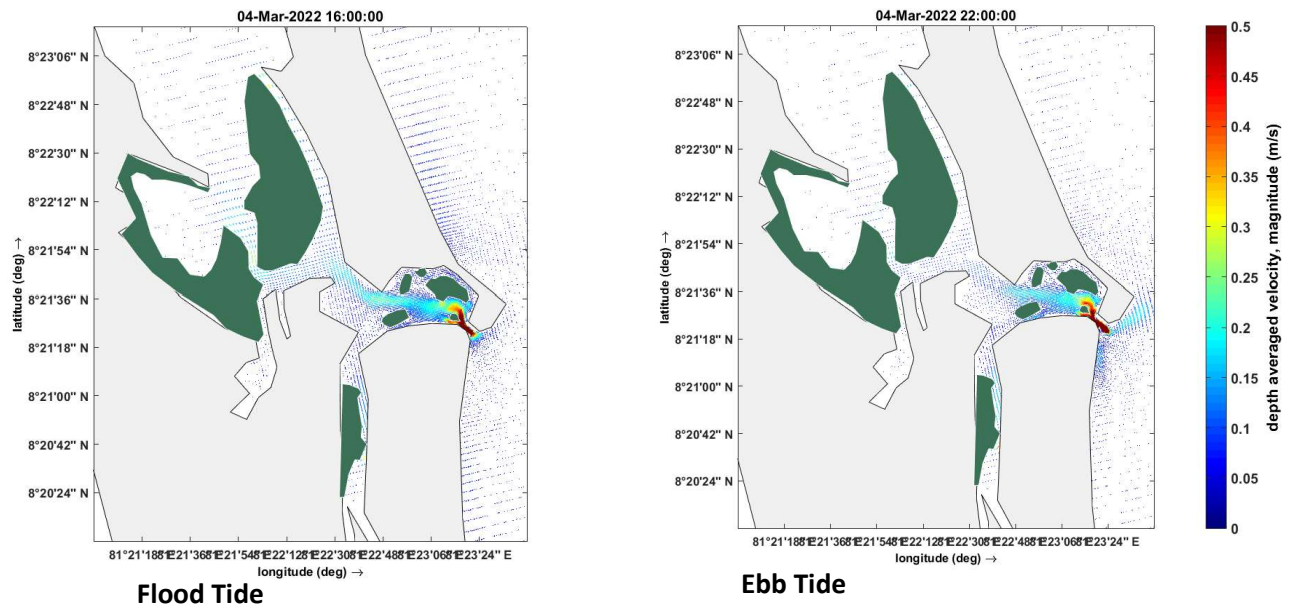


Figure 24: Model results of depth average velocity distribution in the upper layer during Flood tide and Ebb tide in March 2022.

Numerical results of spatial variance of salinity indicate that northern section of the lagoon tend to be less vary during both flood and ebb tides due to the poor water exchange from the sea and inner lagoon (Fig 25).

However, the numerical result of salinity is in good agreement with the most of the measured salinity data.

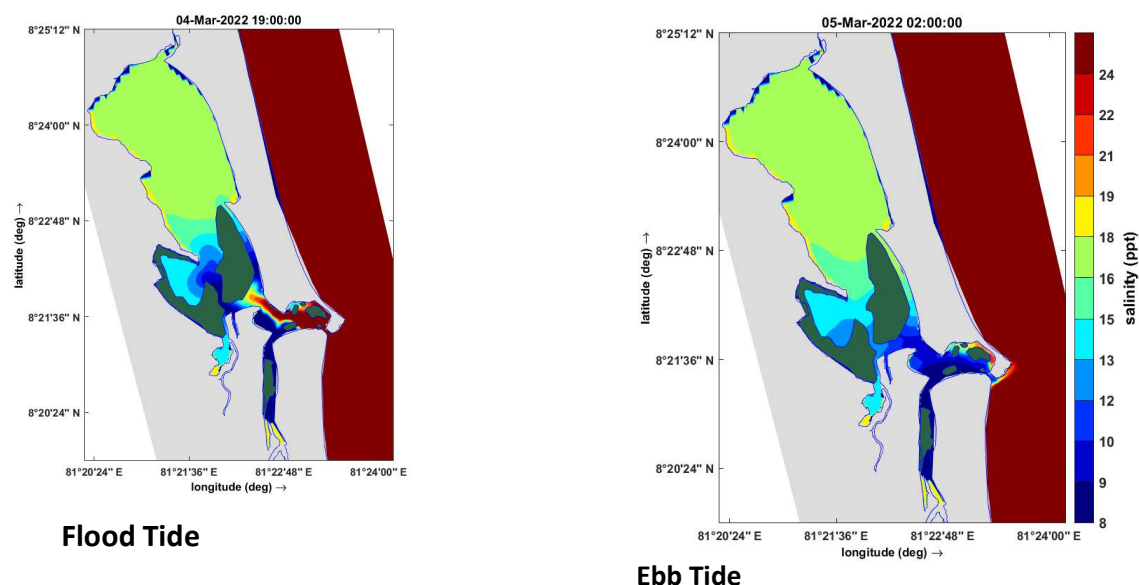


Figure 25: Model results of salinity distribution in the upper layer during Flood tide and Ebb tide in March 2022.

The Lankapattna Lagoon's water level and salinity changes for March 2022 are accurately simulated by the model. Due to computational capacity restrictions and a lack of measurable data, we are currently unable to model the remaining months. A reliable velocity pattern must be constructed in order to model water quality in the Lagoon system. A more accurate description of the conditions at open boundaries can lead to better results. This would enhance the explanation of the lagoon's salinity balance.

Sediment analysis

Grain size analysis of selected sites in Lankapatuna lagoon was measured and results shown in table 5.

Table 5: Grain size analysis in Lankapatuna lagoon's bottom sediment

Sample No.	Ini. Weight	4mm	2mm	1mm	500 μ m	250 μ m	125 μ m	63 μ m	<63 μ m
LAGOON MOUYH	100.72	—	—	0.06	0.35	8.48	78.95	12.59	0.24
1	102.86	—	0.56	3.92	18.56	34.26	27.12	12.85	5.57
2	100.50	0.83	0.58	2.71	16.19	32.92	35.95	9.62	1.52
3	100.36	0.07	0.24	1.83	4.47	23.12	46.90	22.32	1.32
4	101.62	0.44	4.16	12.79	17.68	24.18	26.03	11.25	4.70
5	102.29	0.06	1.95	9.74	15.98	21.94	22.15	21.34	9.05
6	103.17	—	0.15	1.10	3.32	16.56	59.50	18.29	3.99
7	100.73	0.69	0.59	3.98	17.98	28.99	26.89	15.63	5.83
8	124.06	3.84	1.49	6.93	15.48	34.05	38.73	16.57	6.52

More than 90% of all samples grain size was explained most abundant sediment type is sandy sediment and trend toward the fine sand with clay and silty. This condition most suitable for aquaculture practices (shrimps, crabs and Sea cucumber).

Outputs

- Temporal and spatial variability of water balance, water renewal time, circulation, and zonation identification in the lagoon
- Seasonal variation of salinity and nutrients
- Temporal variations of Water Circulation in lagoon
- Setting up hydrodynamic model for lagoon salinity predictions

Outcomes

- Identified spatial usage of aquaculture and effects on lagoon water.
- Temporal and spatial usage of lagoon water and lagoon bed for aquaculture development.
- Management strategies for land-based pollution runoff.
- Ability to provide better awareness to the stakeholders about the hydrology, hydrodynamic of the lagoon in temporal and spatial scale.

Conclusions

Lankapatuna lagoon is a highly dynamic and invaluable ecosystem in eastern coast in Sri Lanka with fewer disturbances by anthropogenic activities. Major fresh water source of Verugalaru is highly impact on the nutrient dynamic and wave energy dissipation. Tidal wave energy distribution was weaken by bottom and wind friction more than 90% and however that is enough to particle distribution and species migration to fulfill their livelihood. It's better to maintain sufficient freshwater flux by managing upper stream anicut in verugalaruriver, which is very important to manage salinity content and sediment accumulation.

Freshwater flux and flood tidal events are the major controlling factors of water quality and sedimentation which induce the bottom friction and together with wind stress alter the hydrodynamic factors. Salinity levels are most appropriate for brackishwater aquaculture practices except August and September and further analysis shall be consistent with bottom dwellers to improve aquaculture practices. So there is a potential to maximize national GDP and to achieve SDG goals in future.

Recommendations

Maintain the natural flow throughout the year will make the suitable conditions for both fisheries and aquaculture practices. Fishing effort should be improving in here and awareness regarding best aquaculture practices with sustainable utilization should introduce step by step. As a remote (rural) area financial support is another important factor for improve the aquaculture practices and alternative livelihood practices shall introduce. Also further analysis including sediment organic content and plankton are recommended for make suitable decision regarding lagoon carrying capacity enhancement.

Constraints

Financial inflation and unhealthy weather conditions are the major challenges were faced.

Financial Allocation (Rs): 430,000/-

Financia (%) : 107.68%

Physical (%): 100%

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11. ☐ Sediment transportation and Erosion

5.7 INSTITUTE OF POST HARVEST TECHNOLOGY

Head of the Division : Dr. S. Ariyawansa

Strategy: Developing Post-Harvest Technologies for Aquatic Resources: Quality, Safety, and Value Addition

IPHT, has a team of eight scientists consisting of one Principal Scientist, three Senior Scientists, and four Scientists. The institute has undertaken two research projects focusing on reducing post-harvest losses and adding value to aquatic resources, particularly fish and seaweeds. Additionally, IPHT has provided testing, training, and awareness programs related to fish quality and safety, processing, and value addition technologies to stakeholders. IPHT Laboratories has enhanced its quality system to adhere to the updated ISO/IEC 17025:2017 standard, and the microbiology unit underwent a compliance audit in December 2022 by the Sri Lanka Accreditation Board. The Accreditation Readiness Programme (ARP) within the United Nations Industrial Development Organization (UNIDO) BESPA-Food project has chosen the chemical and microbiological laboratories of IPHT for the expansion of their accreditation scope. In collaboration with NERDC, IPHT has initiated, coordinated and developed a cooling system with proper storage facilities for a multi-day fishing boat. After the modification IPHT organized a modified multi-day boat launching ceremony, which received patronage from the Prime Minister and other distinguished officials. To determine the impact of this modification, IPHT conducted studies on the assessment of fish quality and economic feasibility before the implementation of the modification to the boat. The findings of a study on managing the formation of histamine in yellowfin tuna suggest the use of commercial disinfectants that contain quaternary ammonium compounds (20-25%), hydrogen peroxide (8-35%), and sodium hypochlorite (5-10%) to clean surfaces that come into contact with the fish. This approach is considered more effective in reducing contamination than relying on detergents alone. The study also found that histamine production by *Klebsiella aerogenes* was high at temperatures of 15°C, but could be managed at 2°C. Moreover, IPHT has made arrangements to upgrade the Maldivian fish industry and dried fish industry in the Southern province. These efforts aim to improve the overall quality and safety of fish products and enhance their market value. In collaboration with NERDC, CEYNOR and the private sector IPHT has developed a set of innovative equipment for the hygienic production of Maldivian fish without compromising the traditional flavor and quality of the final product. As a result, six beneficiaries were able to upgrade their Maldivian fish production. Moreover, the staff at IPHT underwent training as part of the food loss and waste project funded by FAO, and they played an active role in conducting a survey to gather information to evaluate post-harvest fish loss in eight fishery harbours. Nine research publications on various topics related to fish quality, safety, and value addition have been published in journals and proceedings.

PROJECT NO : 4.1

ENHANCEMENT OF QUALITY OF FISH HANDLED IN THE SUPPLY CHAIN

Activity 1 Quality assessment of Skipjack tuna fish before the modification of the multi-day fishing boat

The goal of this study was to assess the quality of Skipjack tuna caught in multi-day fishing operations and brought to the Mirissa fishery harbour in Sri Lanka. This included evaluating the freshness of the fish using sensory, microbiological, and biochemical methods, as well as determining the extent of post-harvest quality loss. Fish samples were collected from multi-day boats (IMUL), on five occasions and analyzed. According to sensory, microbiological, and chemical analyses, fish that were stored for a duration of 0-20 days and 21-40 days exhibited better freshness than those stored for a longer duration of 41-60 days. This suggests that shorter fishing trips could be advantageous in terms of preserving the freshness of the caught fish.

Calculation of Quality Loss for Skipjack Tuna

The study involved collecting data from three fishing trips conducted by the Nimesh Puta boat, which was modified with a cooling system. Results show that the post-harvest quality loss for Skipjack Tuna is approximately 37%. By comparing the PHQL results from similar studies done on the same species of fish, with modified IMUL boat, it would be possible to understand the impact of the IMUL boat modification on PHQL. It can also help in evaluating the cost-effectiveness of the modification and in deciding whether to replicate the modification in other boats.

Activity 2: Evaluation of anti-microbial activity of selected commercial disinfectants used in the fish processing factories and some multiday fishing boats against histamine forming bacteria and spoilage bacteria

A study aiming on evaluating anti-microbial activity of selected commercial disinfectants used in the fish processing factories and some multiday fishing boats against *Klebsiella aerogenes*, *Morganella morganii* and *Pseudomonas* sp. which were isolated from fish contacting surfaces was done. A quantitative suspension test was used to assess the efficacy of selected disinfectants following an exposure time of 5 minutes at different concentrations. Disinfectants used in this study contained triclosan (A), quaternary ammonium compounds (B), hydrogen peroxide (C) and sodium hypochlorite (D) as active agents. Bacterial suspensions were prepared by transferring 18 hours of bacterial cultures into Trypticase Soy Broth (TSB) to obtain a five-hour log phase culture to achieve a microbial population of 10^6 - 10^8 CFU/mL. Cultures were transferred to tubes containing test products and kept for five minutes. After the exposure time 1 mL of each challenged sample was added to 9 mL of neutralizing broth tubes and plated on Trypticase Soya Agar (TSA). Plates were incubated at 37°C for 24 hours. Product A with triclosan indicated a zero inhibition while other three products showed <10 CFU/mL counts for the manufacturer recommended concentrations i.e., A – 5%, B – 0.1%, C – 0.5% and D-5% with a >5 log 10 reduction factor (RF) for disinfectants B, C and D. Comparison of RF of each disinfectant revealed that there is a significant difference ($p < 0.05$) between A and other disinfectants (B, C, D). The bacterial counts were increased with the decreasing concentrations of the disinfectant. According to obtained results, commercial disinfectants with quaternary ammonium compounds (20 – 25%), hydrogen peroxide (8 - 35%) and sodium hypochlorite (5-10%) can be recommended to clean fish contacting surfaces to minimize contaminations rather than cleaning with detergents alone.

Effect of storage temperature on bacterial growth and histamine formation in YFT

YFT samples were obtained from fish processing factories and stored at three different temperatures (0°C, 7°C, 15°C). Samples were analysed for Aerobic plate count and histamine content. Samples were also inoculated on Niven's medium to isolate histamine forming bacteria. Data showed that the samples stored at 15°C increased histamine content rapidly to toxic levels after 3 days. Although the histamine content didn't increase as samples stored at 15°C, samples stored at 7°C were also showed an increase in histamine content. From the data it can be stated that the temperature control should be done to control histamine formation.

Growth of *K. aerogenes* (isolated from early stages of this study and known to be a major histamine forming bacteria) and histamine formation in fish at different temperatures were also studied. In this study also it was evident that at abuse temperatures (15°C) histamine formation by *K. aerogenes* was high. At 2°C histamine formation was controlled.

Based on temperature and time data a risk analysis will be done.

PROJECT No : 4.2

INTRODUCTION OF READY TO EAT FISH-BASED SNACK PRODUCTS AND LIQUID FERTILIZER TO SRI LANKAN MARKET AND POPULARIZATION

Activity 1: Introduction of ready to eat snack type aquatic resource-based product

The objective of this study was to develop a protein-rich, extruded snack that is ready to eat by utilizing fish protein hydrolysate extracted from fish waste. To facilitate the development of the product and the necessary processing equipment (such as a spray dryer, extruder, steam jacket, etc.), academic supervision, and technical guidance for conducting experimental trials, the project was planned as a collaborative effort with the Department of Bio-systems Technology at the Faculty of Technology, University of Sri Jayewardenepura. Due to the critical situation that arose in the country, the planned collaborative project could not commence during the first nine months of 2022. However, the project is set to continue in 2023.

Activity 2: Introduction of liquid fertilizer to the Sri Lankan market and popularization

The tuna export industry generates a significant amount of waste material in the form of yellow fin tuna skin, which contains valuable nutrients that can benefit both animals and plants. However, the high cost of equipment required to produce food-grade ingredients from this resource. As an alternative, we have decided to utilize this resource to produce fertilizer, which does not require expensive equipment or capital investment. However, the liquid fertilizer produced from yellow fin tuna skin did not meet the standards set by the Sri Lanka Standards Institution (SLSI). Therefore, it is not feasible to use fish skin alone for the production of standard liquid fertilizer, and it must be combined with Phosphorous and Potassium as required to meet the standards.

Activity 3: Development of Fermented Fish Product (Jaadi) Using Masked Trigger Fish (*Sufflamen fraenatum*) and Determination of Physio-chemical, Microbial and Sensory Properties

In Sri Lanka, Jaadi is a popular fermented fish product that undergoes controlled fermentation in clay, wooden or plastic containers with salt and garcinia for a minimum of four months. This process inhibits the growth of harmful microorganisms while promoting the growth of beneficial ones, resulting in a product with a robust and pleasing taste that is favored by locals. Although there is a high demand for Jaadi, it is not widely available. However, the Masked Trigger Fish, which is readily available along the Sri Lankan coast, has a less significant demand as a fresh fish and is mostly used for making dried fish. Due to its fleshy texture, this fish is a suitable candidate for value addition. By following the recipe of using 500g of fish, 500g of salt, and 100g of garcinia, a tastier version of Jaadi can be prepared from Masked Trigger Fish. Consumers prefer wooden vats made from Halmilla wood (*Berrya cordifolia*) over glass, plastic, and clay vats for Jaadi production.

Activity 4: Assessing Quality and Shelf Life of Vegan Gummy Candy through Carrageenan and Pectin Ratio Variations

The study aimed to develop a vegan gummy candy using carrageenan, a sulphated galactan polysaccharide found in the cell walls of certain red seaweed species, due to its various beneficial properties. The current commercially available gummy candy contains gelatin, which is not suitable for vegans. Different ratios of carrageenan and pectin were incorporated to achieve the desired texture and sensory properties for the vegan gummy candy. The sensory analysis showed that the combination of 10% carrageenan and 5% pectin, with 250 mL water, 0.5g citric acid, 75mL liquid glucose, 250g sugar, and 8.4 mL rose water, was significantly preferred by the panelists as the first choice. The vegan gummy candy had a pH of 4.18, total soluble solids of 72%, and water activity (a_w) of 0.771. Proximate analysis showed that the vegan gummy candy contained moisture content of 7.09 ± 0.05 , ash content of 0.73 ± 0.03 , fat content of 0.56 ± 0.01 , and protein content of 0.15 ± 0.009 . The study concluded that the carrageenan and pectin mixture in the vegan gummy candy

could serve as a suitable alternative and provide stabilizing properties, all while being derived from a vegan source.

Development Projects

INTRODUCTION OF NEW TECHNOLOGY FOR THE MALDIVES FISH INDUSTRY IN SRI LANKA WITH THE FINANCIAL ASSISTANCE OF THE AGRICULTURE SECTOR MODERNIZATION PROJECT OF VALUE CHAIN DEVELOPMENT PROGRAMME LAUNCHED UNDER WORLD BANK FUNDS

The objective of this initiative was to enhance the hygienic conditions of Maldivian fish and dried fish in the local market by introducing new technology to those already involved in the industry. The NARA and NERDC, along with the Cey-nor foundation, provided expertise in implementing the technology transformation by introducing new equipment and utensils. The World Bank funded the project under the agriculture sector modernization project, with interested participants being selected based on their production scale, available land space, and financial capacity, as the World Bank's contribution covered only 60% of the total budget. The Cey-nor foundation was responsible for designing the fish storage boxes and fish drying tables, while the NERDC designed the biomass dryer, and solar dryers, as per the specifications provided by NARA.

As a result of this project, we have developed all equipment and utensils needed to upgrade the Maldivian fish and dried fish industry in Sri Lanka to produce high quality products ensuring the safety of the product. As a result, six beneficiaries were able to upgrade their Maldivian fish production.

Publications

1. P.H. Ginigaddarage, G.J. GanegamaArachchi, K.W.S. Ariyawansa and C.M. Nanayakkara. Prevalence, isolation and identification of histamine forming bacteria in selected stages of supply chain of Yellowfin tuna export industry in Sri Lanka, Full paper Accepted for publication in Journal of the National Science Foundation of Sri Lanka (2022)
2. P.H. Ginigaddarage, G.J. GanegamaArachchi, K.W.S. Ariyawansa, G.P. Roshan, J. H. Meepearachchi¹, G. Gunasekare and C.M. Nanayakkara Controlling histamine forming and spoilage bacteria on fish contacting surfaces by using selected commercial disinfectants, Proceedings of NARA Scientific sessions, 2022. Pg 37
3. S.M.M.R. Bandara, G.S.A. Senanayake, K.W.S. Ariyawansa, M.G.C.R. Wijesinghe and M.M. Subasinghe. Determination of formaldehyde, TVB-N and TMA in Skipjack tuna and Indian scad caught from multiday boats in Sri Lanka. Proceedings of NARA Scientific sessions, 2022 Pg 41.
4. K.H.S.M.S. Nishshanka, M.C.N. Jayasooriya, K.G.S. Nirbadha, M.G.C.R. Wijesinghe, K.W.S. Ariyawansa, and H.P.K.E. Gunarathna Analysis of heavy metal accumulation of water, sediment, and selected food fish species of brush park fishery in Negombo estuary, Sri Lanka. Proceedings of NARA Scientific sessions, 2022 Pg 60
5. R.A.S.S. Ranasinghe, P.H. Ginigaddarage, S. Ariyawansa, G.P. Roshan, J. H. Meepearachchi, M. Senevirathna and G. Gunasekara. Microbiological quality of exported seafood in Sri Lanka R.A.S.S. Ranasinghe*, P.H. Ginigaddarage, S. Ariyawansa, G.P. Roshan, J. H. Meepearachchi, M. Senevirathna and G. Gunasekara. Proceedings of NARA Scientific sessions, 2022Pg. 36
6. P.S. Jayasinghe, S. Senarath R, Perera, P.Kankanam Gamage "Effect of Drying Techniques on physio chemical properties of semi refined and refined carrageenan extracted using *Kappaphycus alvarezii*" Proceedings of annual scientific session. National Aquatic Resource Research and Development Agency.
7. Ahamed Ijlan Nadha, P.S. Jayasinghe, G. Ganegamaarchchi, R, Perera ,Effect of natural preservatives on the quality and shelf life of Maldives fish powder with *Amblygaster sirm* "Proceedings of annual scientific session. National Aquatic Resource Research and Development Agency.

8. F.F. Rahuman, P.S. Jayasinghe, S. Keerthini, P.P.K. Gamage and R. Perera. Evaluation of quality and shelf life of carrageenan and pectin incorporated vegan gummy candy. Proceedings of NARA Scientific sessions, 2022 pg. 38
9. E A N K Edirisinghe, E A N Chandana, V Senanayaka, D S Ariyaratne, M J PaththuwaArachchi and K W S Ariyawansa (2022), Biomass Fuelled Smoking and Drying System for Producing Maldives Fish for Fishing Community in Southern Sri Lanka, Proceedings of National Engineering Research symposium, Pg 146.
10. Four research articles have been submitted to the NARA journal for publication

Testing Services of IPHT

The Sri Lanka accreditation board (SLAB) conducted the first surveillance audit for microbiological analysis, following a revision of the accreditation status according to ISO/IEC 17025:2018. In total, 435 samples were analyzed, with 268 being tested for microbiological quality and 167 for chemical quality. IPHT issued 170 test reports related to these samples, generating a testing service income of LKR 2,213,325.00. A royalty payment of 40% of the total revenue was remitted to NARA.

Training/Awareness programmes conducted

Date	Name of the programme	Aim	Participants	Place
21/10/2022	Practical session on fishery products processing and packaging	Practical exposure	Students of Ocean university	NARA

Foreign and Local trainings attended

No	Training (Local / Foreign)	Duration	Venue	Participants
Foreign				
01	GRO-FTP - Fish handling and processing - quality management specific line-Iceland	22nd October 2022 to 30th April 2023	Freshwater and marine Research institute, Reykjavik, Iceland	K.G.S.Nirbadha
Local				
01	Amino Acid Profile analysis by Hayleys Lifescience (Pvt) Ltd	17 th to 18 th October, 2022	NARA	K.G.S. Nirbadha M.G.C.R. Wijesinghe M.M. Subasinghe K.H.K.L. Piyasiri
02	Uncertainty Measurements	08 th September 2022 and 16 th September 2022	Department of Measurement Unit, Standard and Service	Sujeewa Ariyawansa K.G.S.Nirbadha M.G.C.R. Wijesinghe M.M. Subasinghe K.H.K.L. Piyasiri
03	Food loss and waste (FLW) assessment in fish value chains	22-30 September 2022	Ari Lagoon, Negombo	S. Ariyawansa P. Ginigaddarage M.M.A.S. Maheepala S. Ariyaratna D.W.L.U. De Silva K.H. Kaumi Piyasiri
	Food loss and waste (FLW) assessment in fish value chains	31 st October – 04 November	Mandara Hotel, Mirissa	S. Ariyawansa P. Ginigaddarage M.M.A.S. Maheepala S. Ariyaratna D.W.L.U. De Silva K.H. Kaumi Piyasiri M. PaththuwaArachchi

				M.M. Subasinghe R.A.S.S. Ranasinghe R. Perera G.P. Roshan PahanPabasara
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Supervision of undergraduates

1. D.M.M.K. Dasanayaka, B.Sc. (Food Production & Technology Management), Wayamba University
2. S.B.A.M.R.S. Arampath, B.Sc. (Bio Technology), Horizon Campus
3. F. R. Fasmiya, B.Sc. (Biosystems Technology), University of Jaffna
4. N. Ijlan, B.Sc. (Biosystems Technology), University of Jaffna
5. B.S.W.Senanayake, B.Sc. (Microbiology), University of Kelaniya
6. G.W.A.S. Lakmini, B.Sc. (Biosystems Technology), University of Colombo
7. H. M. I. Senevirathna, B.Sc. (Biosystems Technology), University of Colombo

5.8 SOCIO-ECONOMIC AND MARKETING RESEARCH DIVISION

Head of the Division : Mr. K.H.M.L. Amaralal

One research projects were conducted by the Socio-economic and Marketing Research Division in 2022. The project onValue chain analysis of Sea cucumber and edible Oyster in Sri Lanka.Sea cucumbers and edible oysters are export-oriented fish varieties that contribute to Sri Lanka's foreign exchange earnings. Both species play an important role in improving the health of the human and ocean ecosystems. The value chain analysis tool is used to assess and identify the entire process and constraints in order to improve the value chain. The study aimed to apply this concept to the long-term development of both fisheries.The findings also revealed that the value chain of the edible oyster fishery was underdeveloped, with only farmers/collectors, middlemen, and local tourist hotels participating. The value chain for sea cucumbers was discovered to be well-established, but only consisted of divers who collected sea cucumbers from the ocean floor, middlemen, and exporters. Actors' earnings varied according to species and grade.

PROJECT No: 8.1

VALUE CHAIN ANALYSIS OF SEA CUCUMBER AND EDIBLE OYSTER IN SRI LANKA

Responsible Officers : K.H.M.L Amaralal
Officer/s responsible : MMAS. Maheepala
KPOL. Sadaruwan
MNDF Abeykoon
WAAM Bandara
DWLU De Silva
T.N.Thilakaratne

Sea cucumbers and edible oysters is an export-oriented fish variety that contributes in foreign exchange earnings of Sri Lanka. Both species contribute an important role in enhancing health of human and ocean ecosystem. Analysis of value chain serves as a tool to assess and identify whole process and constraints aiming for upgrading the value chain. The study intended to apply this concept for the sustainable development of the both fisheries. A pre-tested structured questionnaire was utilized to undertake a survey. A randomly selected sample with representative of fishers (divers), collectors, processors and exporters in Kalpitiya and Mannar districts was drawn. The total sample was 80 which comprised of 65 divers, 10 collectors and processors and 5 exporters. Result revealed that majority (32%) of value chain actors had in a range of 11-20 year experience in sea cucumber fishery while only a few years for the edible oyster fishery. Results further revealed that the value chain of edible oyster fishery was underdeveloped and only comprised of farmers/collectors, middlemen and local tourist hotels. It was found that sea cucumber value chain was well-established but only comprised of divers who collect the sea cucumber from the ocean floor, middlemen and exporters. The profit earned by actors varied depending on species and grades. Results revealed that on average, a diver/collector had earned 77,400 LKR while a middleman had earned 286,860 LKR per month as a profit. The export price range of dried sea cucumber was in the range of 20,000-30,000 LKR per kilo and Singapore, China, Hong Kong, and Taiwan were major export destinations. Government imposed night diving banned was the main challenge while difficult to obtain license, high fuel price and poor post-harvest handling, were major constraints hindered the industry. It is recommended that these constraints need to be solved for the sustainability of the industry. Further, recommend to strengthening of market linkages and information flow, skills of players in the fishery.



Publication

1. ABSTRACTS (National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2022)
2. K.P.G.L. Sandaruwan*, D.W.L.U. De. Silva and N. Liyanapathirana, Assessment of vulnerability of climate change on coastal fishery of Sri Lanka and adaptation strategies
3. J.S. Jayanatha*, U.S.P.K. Liyanage and M.M.A.S. Maheepala, Utilization of inland fish resources and achievements through the comanagement concept in tropical inland reservoir fishery, Bandagiriya, Sri Lanka
4. D.W.L.U. De Silva¹*, E.V.D. Dilhani² , and K.P.G.L. Sandaruwan, The impact of the COVID-19 pandemic on Sri Lanka's fin fish exports to its main trading partners; the United States and the European Union
5. M.T.N. Thilakarathna*, H.P.D.A. Lakmali and K.H.M.L. Amaralal ,An analysis of gender roles in small-scale coastal fisheries in Negombo and Chilaw fisheries districts of Sri Lanka

5.9 MONITORING AND EVALUATION DIVISION

Head of the Division : Mr. A.B.A.K. Gunaratne

The Monitoring and Evaluation division is comprised with Information Technology unit, Library and Information unit. Monitoring and Evaluation division is responsible for project planning, monitoring and evaluation. It performs the duties of ensuring effective monitoring, evaluation and coordination of the research programmes. Preparation of the action plan, monthly progress monitoring of research projects, compilation of annual report, facilitation to knowledge sharing and dissemination are main responsibilities of the division.

INFORMATION TECHNOLOGY UNIT

The mission of the Information Technology Division is to provide the highest quality technology-based services, and support to the organization for its strategic goals and objectives as it applies to research activities and provide effective technology support for audio/visual, multimedia, desktop and web based applications and services.

Information Technology Division conducts research using Geography Information system (GIS) and Remote Sensing (RS) for resources planning and identify suitable areas for aquaculture development and forecasting. GIS technologies applies in the diverse fields and committed to delivering high-quality spatial and attribute data to the internal researches as to allow better decisions to be made based on the best available information. Information Technology Division acts as a store room of spatial data of marine and terrestrial areas. Division is intended to facilitate as a platform to pool all data/information available in respect to aquatic resources, environment and users and develop products for environmental friendly economic development and scientifically based management of aquatic resources/environment.

The Division is responsible to provide all aspects of IT and systems implementation for information gathering, processing, sharing and dissemination among all stakeholders for management, conservation and development of aquatic resources. It provides expertise in computing hardware and software support as well as LAN (Local Area Network) and WAN (Wide Area Network) connectivity to the staff and administrative support of computer networks. And also IT unit maintains IT contracts and software licenses, and coordinates the procurement of IT related hardware and software.

ACTIVITIES UNDERTAKEN

Programme	Project	Allocation (Rs. Million)	Officer Responsible	Period	
				From	To
Open access to knowledge and dissemination of information	9.1. Internet services and online information systems	4.79	A.B.A.K. Gunaratne	Jan – Dec 2022	

PERFORMANCE

PROJECT No: 9.1

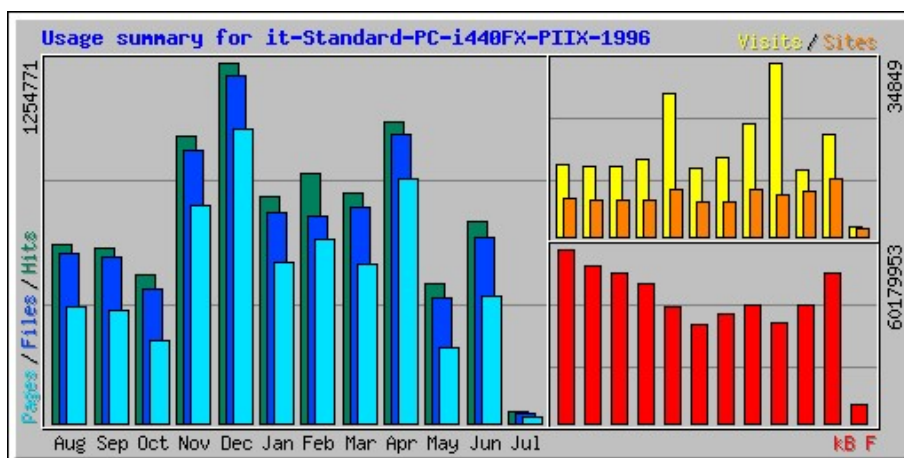
INTERNET SERVICES AND ONLINE INFORMATION SYSTEM

Responsible Officer : A.B.A.K. Gunaratne

Budget : 4.79 million

Main objective of the project is to disseminate the information via World Wide Web and to provide other internet services for scientific staff of NARA and its stakeholder with a view of facilitating information sharing.

Modifications were carried out to the website 98 web pages were added to the site. Average visit per day to the web site was nearly 563 and observed the highest visit counts, 28629 on December 2022..



Summary by Month										
Month	Daily Avg				Monthly Totals					
	Hits	Files	Pages	Visits	Sites	kB F	Visits	Pages	Files	Hits
Dec 2022	40476	38906	32905	923	9260	40230348	28629	1020083	1206099	1254771
Nov 2022	33280	31563	25300	519	7131	48339149	15585	759008	946898	998422
Oct 2022	16635	15059	9329	450	7141	51754830	13974	289207	466830	515704
Sep 2022	20300	19204	13121	465	7247	54054434	13975	393632	576142	609019
Aug 2022	20049	19035	12976	462	7597	60179953	14344	402267	590085	621543
Totals						501207365	209154	6187181	8116581	8732321

PROJECT No :

ANNUAL SCIENTIFIC SESSION 2022

Responsible Officer : D.D.D. Weragodathenna, Secretary of the Organizing Committee

The NARA Scientific Sessions 2022 was held as virtual conference on the 21st of October, 2022. The session theme is "Collective Action for Blue Economy" and totally 78 papers presented under the wide range of themes, including Fisheries and Aquaculture, Aquatic Biotechnology and Animal Health, Oceanography and Hydrography, Fisheries Socio-economic and Marketing, Aquatic

Postharvest Technology, Aquatic Environment, Conservation and Management, Climate Change, Application of GIS and Remote Sensing in Aquatic Sciences.

The Inauguration ceremony was graced by Senior Professor M.J.S. Wijeyaratne, Chairman, NARA. The key note address was made by Mr. Vimlendra Sharan, FAO Representative, Sri Lanka and the Maldives. The Chief Guest Hon. Douglas Devananda, Ministry of Fisheries speech was read by Professor M.J.S. Wijeyaratne, Chairman, NARA. Vote of thanks was delivered by Dr. H.M.P. Kithsiri, Director General/NARA.

The presenters include researchers in various disciplines at NARA, universities and other line institutes of Sri Lanka. Session speakers inspired the gathers, sharing their new findings and innovative ideas to have healthier aquatic environment with substantial economic growth. Over 200 participants joined the session virtually.

LIBRARY AND INFORMATION UNIT

As a special library in the field of Fisheries and Aquatic Resources related subjects, NARA Library is mainly focus to assist the subject specialists, entrepreneurs, decision makers and students and motivate in their innovative research studies output. It mandates to collect, disseminate, preserve and provide information and data for easy reference. It holds over 30,000 documents, e-resources, digital collection and open for access through open access catalogue. Its mission is to be the National and International Networked Information Centre on the subject of “Fisheries and Aquatic Resources” and serve effectively and competently in the rapid information evolution era.

Activities Undertaken

Project	Activities	Allocation	Officers Responsible	Period From – To
1.Collection Development	1.1.Procurement of Information 1.2.Collecting Research Reports and Papers 1.3. Obtaining donations 1.4.Obtaining resources on exchange basis 1.5.E downloads	2.150	L.A.R. Sunethra Aruna Gunarathna Menaka Karunaratne	
2.Library Management	2.1.Add data, update library databases 2.2.Process work of Library resources 2.3.Maintain and regular update the e-repository collection	1.500	L.A.R. Sunethra Aruna Gunarathna Menaka Karunaratne	
3.Referral Services	3.1.Book circulation 3.2.Current Awareness Service 3.3.Selective Dissemination of Information Service (SDI) 3.4.Literature Survey 3.5.Inter-Library Exchange Service	0.500	L.A.R. Sunethra Aruna Gunarathna Menaka Karunaratne	
4.Other Services	4.1 Reproducing Service - Photocopying -Scanning 4.2 Book Binding 4.3 Sale of Publications 4.4 Distribution of NARA publications (Exchange Basis)		L.A.R. Sunethra Aruna Gunarathna Menaka Karunaratne D.H.T. Ajithwansa	

PROJECT No : 01

COLLECTION DEVELOPMENT

Library collection developed by adding 20 books, 27 journals, 11 Sri Lanka Reports, 08 NARA Reports, 07 Newsletters, 05 downloaded e-books and 03 chapters, and 04 CDs. NARA Scientific sessions 2022 was uploaded to e-repository of library & information of NARA. National Geographic Journal continuously received to NARA library throughout the year 2022.

Renewed the IAMSILIC membership for 03 years from 2022-2025. NARA Library has renewed British Council Membership from November 2022 to November 2023 and it facilitates for our staff members to use resources of British council.

PROJECT No : 02**LIBRARY AND RESOURCES MANAGEMENT**

Continued the updating the system by adding data, and editing relevant data for accessing them easily and accurately.

PROJECT No : 03**PROVIDING SERVICES**

293 books were circulated among NARA patrons and the records updated continuously. Rs. 2940/= collected as overdue charges. Member clearance for 32 Nos were done. Literature surveys were done for 145 patrons produced email references to around 15 persons and provided around 10 telephone conversation references. Monthly update of the Visual Screen by showing new arrivals to the library was carried out.

405 Documents were scanned and 541 photocopies supplied to NARA staff. Earned Rs.150/= by photocopying for outsiders. Served by binding 29 Nos. reports to the NARA staff. Reserved conference room facility for discussions, meetings and workshops 62 times.

EXTENSION UNIT

Programme	Project	Allocation (RsMillion)	Officer Responsible	Period	
				From	To
Open access to knowledge and dissemination of information	8.2. Extension services	1.08	Mr. D.S.P. Bandara	Jan – Dec 2022	

PROJECT NO: 8.2

EXTENSION SERVICES

In the year 2022, the activities of the media and Extension unit were largely limited to institutional activities only, and the Covid epidemic and financial difficulties were mainly affected by this.

Activities carried out ;

- The NARA annual report for the year 2020 was printed and given to the relevant institutions.
- Totally ten training workshops were carried out for naval personnel
- In conjunction with World Fishery Day 2022, Active contributed to the "Dala Rala Saviya" program held in Beruwala from 2022.11.11 to 2022.11.21 under the initiative of the State Ministry of Fisheries.
- In the last quarter of 2022, actively contributed by providing to the exhibitions held at the following places.
 - a). Education exhibition held at Gampaha Ratnavali Girls' College (2022.12.15-17)
 - b). Educational exhibition held at Yakkala Anura collage (2022.12.21-22)
 - c).The educational exhibition held at the National Zoo called "Animals our friend" (2022.12.23-30)
- In addition to these activities, in order to maintain the facilities of the Nara Auditorium, the equipment was regularly serviced and repaired, and the maintenance work of the Nara Museum was continued.

5.10 REGIONAL RESEARCH CENTER - KADOLKALE

Head of the Division : Ms. S.H. Udeshika Chathurani

The regional research center is located at Kadolkele, Negombo in Western Province of Sri Lanka, 30 km north of Colombo on the North Western Coast. The research center lies adjacent to the Negombo Lagoon and situated in a mangrove area of 14 ha in extent, which is located in the heart of the Negombo town. The area of mangroves is the largest mangrove patch remaining in northern part of the Negombo lagoon and most significant for the lagoon's productivity and other ecological balance of the system.

Staff of Kadolkele consists of two research scientists, and three helpers. Among them, one helper got retired 2022.

Main objective of the station

Development of national mangrove research and educational center for research, education, sustainable development and conservation of the mangrove area of 14 ha bordering the upper reaches of the Negombo lagoon which is remaining as the only largest single land ward patch. Conservation of land will be immense important to enhance the productivity of the lagoon.

Research studies

One research projects was conducted.

Project	Project number	Allocated amount	Officer Responsible
Impact of water quality and seasonal changes for Sea bass (<i>Lates calcarifer</i>) cage culture sites in Negombo Lagoon	10.4	0.15 Mn	S.H.U.Chathurani J.M.N.M.Jayasundara

PROJECT NO : 10.4

IMPACT OF WATER QUALITY AND SEASONAL CHANGES FOR SEA BASS (*LATES CALCARIFER*) CAGE CULTURE SITES IN NEGOMBO LAGOON

Responsible officers : S.H.U. Chathurani
J.M.N.M. Jayasundara

Introduction:

The Negombo coastal wetland area consists of 10,694 ha, which includes 3164 ha of marsh proper, 3068 ha of Negombo estuary and 4462 ha of high ground located on the western coast of Sri Lanka. The Negombo lagoon is approximately 12.5 km in length and its width varies from 0.6 to 3.6 km. The lagoon receives fresh water from three sources: the Ja-Ela, DandugamOya and the Hamilton Canal.

The Negombo lagoon is one of the most productive brackish water ecosystems in Sri Lanka in terms of associates flora and flora including mangrove, seagrass, fresh, brackish and marine finfish and shellfish species (Dahanayaka, 2008). In total, about 10,000 people directly or indirectly depend on fishing in Negombo lagoon for their livelihood (Jayakody &Dahanayaka, 2005). The fishery is small scale mainly target for fish, shrimps and crabs. Fishing is mainly carried out by traditional fishing crafts such as dugout canoes and log rafts (Theppam). Meanwhile, Negombo lagoon plays an important livelihood for numerous people living in the area. These uses have expanded in the present with increasing urbanization and industrialization of the area.

Ministry of fisheries and Aquatic Resources of Sri Lanka made efforts in recent years to promote other coastal aquaculture activities involving seabass, seaweed, sea cucumber etc. with the objective of promoting exports and also to provide livelihoods for coastal communities.

First attempt at introducing seabass (*Lates calcarifer*) farming in the country has been made in 2006 under the Asian Development Bank assisted Coastal Resources Management Project (CRMP) implemented by the Ministry of Fisheries and Aquatic Resources. The main objective for introducing seabass cage farming by the CRMP was to provide alternative livelihood for fishers in the Negombo Lagoon.

There was a mass mortality of sea bass in the month of June, 2021. Nearly 20000 Kg of fish were died due to sudden depletion of salinity. There were lacks of studies related to water quality in cage culture sites. Due to unavailability of baseline data, this study was planned to monitor the water quality in Munnakkaraya area where the cages are located.

Material and Methods

It was decided to collect data from fifteen cages (monthly) in Munnakkaraya area in Negombo lagoon. During first month it was decided to measure in-situ parameters from 30 cages in each month (two times per month).

Water temperature, pH, electrical conductivity, total dissolved solids, salinity and resistivity were measured using cyberscan series 600 meter, from March to October 2022. Data was analyzed using Ms-Excel.

Results and Discussion

Most of the cages are floating cages and they consist of net proper and frame. The frame is kept a float by plastic barrels. Height of the cages was nearly 2m and 1.5m depth was immersed in water. Floating net cages are anchored using ropes tied to concrete blocks/metal structure or tree to nearby shore.

Fish fingerlings were transported from Ocean pick hatchery which was in Trincomalee. Fingerlings were stocked in cages with smaller mesh size. When they grow up to 100g (after 8-10 weeks) fish was grading and separated into cages with large mesh sizes. Gradually they increased the mesh size of the cages with reference to growth of the fish. Trash fish/fish waste was used feed the fish. It was obtained from fish market from low cost or without paying any cost. Fish were fed in two times per day. When fish were grow up to 1 kg – 2 kg in weight they were subjected to harvesting.

Water quality parameters were within the range of growing of sea bass (*Lates calcarifer*). During the month of June there was salinity depletion and nearly 3000 kg of fish were died. During period of June, most of the fish were died due to bioluminescence toxic algal (*Noctiluca*) bloom.

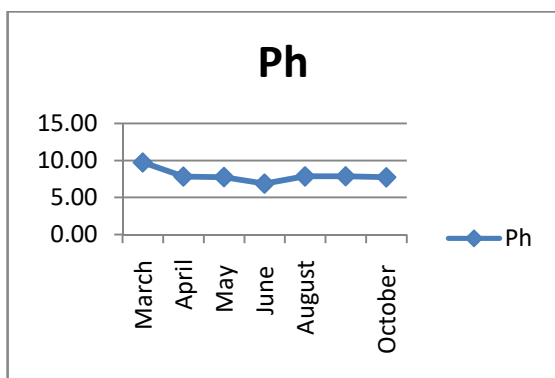


Figure 4 Variation of pH

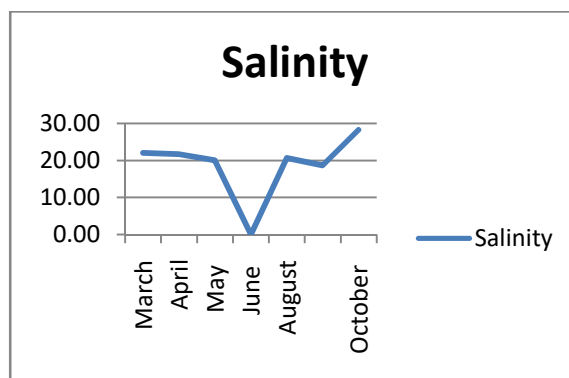


Figure 5 Variation of Salinity (ppt)

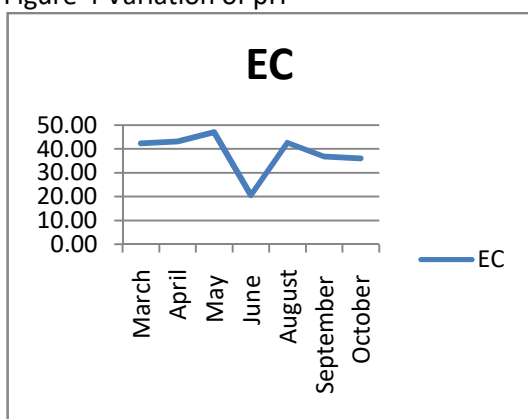


Figure 6 Variation of Electrical Conductivity (ms/cm)

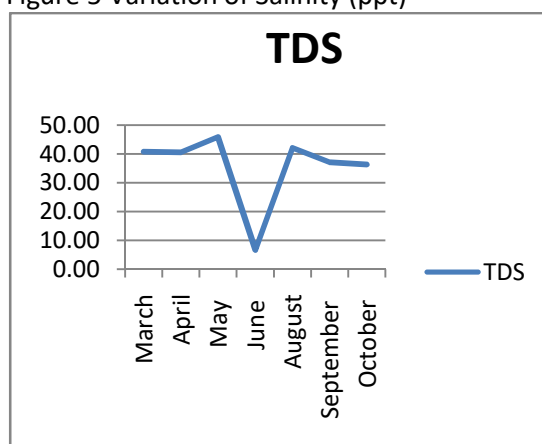


Figure 7 Variation of Total Dissolved Solids (mg/L)

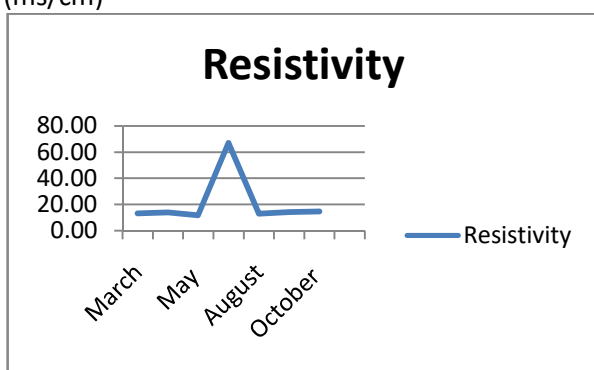


Figure 8 Variation of resistivity (Ω)

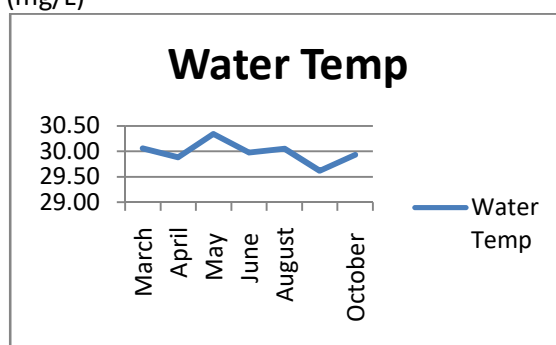


Figure 9 Variation of Water temperature (°C)

It was unable to take 30 water samples from each month. Due to fuel and transportation issues most of the field visits were cancelled. After the month of May most of the cages were harvested and they were cleaned for next culture cycle.

Recommendations

Transport cost and low quality fingerlings were major constrains in cage culture practices in Negombo lagoon. It is needed to expand culture practices for sea bass. Also fishermen who engaged in sea bass culture are requesting for high quality, low priced effective feed. Optimum number of cages that can be operated in each sites needed to be determined based on carrying capacity assessments. Also actions should be taken to minimize the conflicts with other resource users. Further studies needed to assess the water quality parameters to make suitable recommendations.

Constrains

Due to the situation of the country planned field visits were cancelled.

Some selected cages were harvested during the study, hence number of monitored cages were not similar in each month.

Difficult to provide further recommendations by measuring selected parameters.

Three abstracts were published during year of 2022.

1. **Jayasundara J.M.N.M.** & Chathurani S.H.U., 2022.Effect of water quality on fish mortality of brackish water cages at Munnakkaraya area in Negombo lagoon, National Aquatic Resources Research and Development Agency (NARA)-Scientific sessions_2022, Aquatic Environment Conservation, Management and Climate Change. P.92.
2. **Jayasundara J.M.N.M.** & Chathurani S.H.U., 2022.Air-layering of endangered mangrove *Scyphiphora hydrophyllacea* in Kadolkele NARA Regional Research Center of Sri Lanka, towards its conservation, National Aquatic Resources Research and Development Agency (NARA)-Scientific sessions_2022, Aquatic Environment Conservation, Management and Climate Change. P.99.
3. Chathurani S.H.U., **Jayasundara J.M.N.M.**, Pamarathne S.K.S., 2022.Assessment of physico-chemical parameters of water in Negombo lagoon during COVID-19 pandemic , National Aquatic Resources Research and Development Agency (NARA)-Scientific sessions_2022, Aquatic Environment Conservation, Management and Climate Change. P.100.

Field practical sessions and awareness programs were conducted for students and local community.

Other activities

1. Mangrove replanting programme with the collaboration of Department of Forest, Sri Lanka at Liyanagemulla on 10/03/2021
2. Mangrove park cleaning programme with mangrove replantation was conducted on 23/03/2021 collaboration with Sri Lanka Unites (NGO). The programme was conducted with 50 participants and media coverage was provided by Sirasa TV, Negombo news you tube channel and Lankadeepa news paper.
3. Contributed for crab releasing programme on 10/03/2021 and 28/02/2021

Meetings attended

1. District coordination committee meeting at district secretariat Gampaha on 27/01/2021
2. Environmental advisory committee meeting at municipal council Negombo on 05/02/2021
3. Provincial coordination committee meeting at Divisional secretariat Negombo on 05/03/2021
4. District coordination committee meeting (National program for the development of rural economy) at Jayasinghe city center Naiwala on 15/03/2021
5. Provincial coordination committee meeting at Divisional secretariat Negombo on 17/03/2021
6. District coordination committee meeting (National program for the development of livelihood) at Jayasinghe city center Naiwala on 20/03/2021
7. District coordination committee meeting at district secretariat Gampaha on 30/03/2021
8. Provincial development committee meeting at municipal council Negombo on 28/04/2021
9. Meeting on disaster occurred due to X-PRESS pearl ship incident at head quarters of Sri Lanka Red cross society on 23/12/2021

Student trainings/ workshop conducted

Research training was provided

Name of the student	University	Title
Saluni chaneesha madhupanchanee	University of Colombo	Leaf characteristics of selected true mangrove species in Sri Lanka

I.A.U.D.N. Piyathissa	Uva Wellassa University	Develop an Identification tool (mobile application) for mangrove species in Negombo lagoon
W.W.L. Nethmi Wanigasinghe	University of Moratuwa	Report on Mangrove species in Negombo
Kawindya Ratnayaka	University of Sri Jayawardanapura	Root characteristics of selected mangrove species at Negombo lagoon
P.H.T. Lakkana	University of Ruhuna	Biodiversity survey and construction of database on mangroves in South Asia and South East Asia
W.S. Buddhika Wickramasinghe	University of Kelaniya	Mangroves in Negombo lagoon

Practical sessions were conducted,

1. Students from Open university, Sri Lanka visited Kadolkele R.R.C. on 11/03/2021, 18/03/2021 and 25/03/2021 (nearly 100 participants were there)



2. Provide specimens for practical sessions to University of Kalaniya and University of Sri Jayawardanapura

Earnings

1. Approximately Rs 9,000.00 were earned from selling mangrove plants (Handover to the finance division of NARA)

5.11 REGIONAL RESEARCH CENTER – REKAWA

Head of the Division : Dr.M. Gammanpila

PROJECT No : 10.3

SUPPORTING LIVELIHOOD DEVELOPMENT OF SELECTED INLAND AND COASTAL FISHER COMMUNITIES IN SOUTHERN SRI LANKA.

Officer/s responsible : M. Gammanpila
K. W. R. R. Amaraweera
W. K. Suwandhahannadi

Introduction

A giant freshwater prawn, *Macrobrachium rosenbergii*, is becoming an increasingly important targeted species in culture-based fisheries in seasonal and perennial reservoirs in Sri Lanka. At present, there is a considerable commercial demand for freshwater prawns, both in the local and export markets. As such, the culture of *M. rosenbergii* is becoming popular in Sri Lanka due to its rich taste, high price, profitability, and fewer disease incidences, which make it a suitable candidate for extensive and intensive culture both in fresh and brackish waters. During the 2008–2012 period, NAQDA stocked 42.58×10^6 post larvae (PL) of *M. rosenbergii* in 30 major reservoirs, 59 medium reservoirs, and 229 minor reservoirs. However, during the island-wide CBF trial, there was no significant harvest of *M. rosenbergii*, and the contribution of *M. rosenbergii* yield to the total fish yield was 1.6% in major reservoirs and in medium reservoirs. In order to increase production, three net pens size of 500 m² and one net cage were installed in Kattakaduwa and Bandagiriyawewa for growing freshwater prawns for one month period to increase survival before releasing them to the reservoir.

Rekawa Lagoon, located at 6° 05'N and 80° 50'E is a comparatively small coastal lagoon, covering 240 ha of water surface area, located in Hambantota District in the Southern Province, Sri Lanka. A considerable amount of the community in the Rekawa area depends on lagoon fisheries for their livelihood. Presently, there are around 150 fishermen and around 70 fishing crafts operating in the lagoon. Further, during the shrimp season, some part-time fishermen are also involved in fishing. Fisheries in Rekawa Lagoon have been exploited on an artisanal basis for years by small-scale fishers using different types of traditional fishing gear, drift gillnets, cast nets, and fish kraals. The kraal fishery is seasonally operated with the onset of shrimp, mainly *Penaeus indicus*. During stocking practices conducted by NARA, *P. monodon* dominated the shellfish catches the following year. However, present fish production in the lagoon is very low and limited, so fisher communities around the lagoon need to find alternative livelihood opportunities.

Objectives

- Provide strategies for increasing the recapture rate of *M. rosenbergii* production in perennial reservoirs, which will help inland fisher communities increase their income and thus strengthen the rural economy.
- To productively utilize naturally available freshwater and brackish water bodies and to introduce and build up a small-scale aquaculture practice with minimum environmental effects.
- Development of alternative livelihood opportunities for fisher and rural communities for strengthening their economy that achieves food security and improved nutrition.
- Regular monitoring of the status of water quality due to aquaculture practices.

Methodology

The project aimed to improve the survival and recapture rates of freshwater prawn post larvae in Kattakaduwa and Bandagiriya reservoirs, as well as to conduct environmental monitoring and to introduce Tilapia cage culture in Rekawa Lagoon as an alternative livelihood development for fishermen. To increase post-larvae survival, three net pens of 500m² each were constructed in the Kattakaduwa tank in 2021 and the total number of 50,000 post-larvae of freshwater prawns stocked in net pens during February and October 2022, and 25,000 post larvae in net cage size of 6×4m installed in Bandagiriya tank. Growth rate of post-larvae monitored one and half month period and survival rate was measured. The post-larvae was fed 10% of their body weight by commercial shrimp feed with 40% protein, 5-7% of crude fat, 3% of fibre and 11% of moisture content in the feed.

The environmental monitoring study was carried out at selected 8 sampling points located within the Rekawa lagoon, and physicochemical and biological parameters of the lagoon were measured. In-situ parameters such as water temperature, pH, salinity, electrical conductivity, depth, and Secchi depth were measured, whereas Ortho-phosphorus, Nitrate, Nitrite and Ammonia content, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), chlorophyll-a, primary production, and plankton identification were tested in the laboratory. All the tests were performed according to the standard methods for water and wastewater analysis given by the American Public Health Association (APHA).

Four net cage sizes of 2×2 meachwere introduced to two selected fishermen in the Rekawa lagoon, and initially, nearly 500 fingerlings were stocked as an alternative livelihood activity.

Results

Water level of the Rekawa lagoon fluctuated between 30 – 175 cm and the highest average water level of the lagoon was 123cm in November followed by 94 and 91cm in March and July respectively. Similar to that the lowest average secchi depth was also recorded in November (31cm). Salinity fluctuating was the interesting feature that observed during the study period and it ranged between 0 – 19 ppt within eight sampling locations. Lowest average salinity level of 2 ppt was observed in November whereas highest recorded in July and October (12 ppt) followed by August (9 ppt). *Tachysurus* sp. (Anguluwa), *Oreochromis* spp. and *Nematalosa nasus* (Koiya) were the most recorded species and *Tachysurus* sp. can be seen throughout the year. Shrimp catch was comparatively low during the study period than the other years. *Najas marina* was spreading rapidly within Northeast side of the lagoon and this area couldn't be used for the fishing practices. Further algal bloom patches of *Oscillatoria* sp. also recorded in Northeast side of the lagoon in December.

After 54 days in the net pen installed in Kattakaduwa Wewa, a daily weight gain of 7.24 mg/day was recorded in freshwater prawn culture. It showed that prawn larvae growth varied from an initial weight of 9.09 mg to 400 mg during the 54 days of the culture cycle. According to the findings of a similar experiment, the initial length of post-larvae ranged from 12.5 to 39.5 mm, resulting in a length gain of 0.5 mm/day during the 54-day culture cycle with a 50% survival rate.

Another experiment conducted on 25,000 freshwater prawn post larvae (initial weight of 10.99 mg) in a net cage size of 6×4m installed in Badagiriya reservoir resulted in a final weight of 648.95 mg and a growth rate of 13.87 mg/day during 45 days of the culture cycle with approximately 60% survival.

Conclusion

- Higher nutrient inputs may cause an increase in freshwater invasive plants and algal blooms within the lagoon environment.

- The harvest of shrimp was very low this year as the shrimp larvae did not enter the lagoon due to the lagoon mouth not opening at the right time (end of July and early November).
- Introducing aquaculture activities in the Rekawa lagoon could be use as a poverty alleviation tool.
- Stocking and culture of freshwater prawn post-larvae in net cages installed in Bandagiriya tank resulted in higher growth rate compared with net pens installed in a natural environment in Kattakaduwa wewa for at least one month before releasing to the reservoir. It might help increase the growth rate and survival rate, which in turn increases freshwater prawn production in reservoirs. However, regular stocking and releasing of freshwater prawn and continuous monitoring are needed for the final conclusion.

Recommendations

- Opening the lagoon mouth in June – July considering the spawning season of *P. indicus* if natural opening doesn't take place
- Manually control opening the lagoon mouth until the shrimp are grown
- Controlling overfishing by using illegal fishing gears
- Controlling the nutrient inputs to the lagoon
- Monthly monitoring the lagoon water quality and fish catch
- Introducing strategies for maximizing the survival rate and recapture rate of *M. rosenbergii* in culture-based fisheries.
- Introducing tilapia cage culture in Rekawa lagoon as an alternative livelihood activity that helps increase fisher income considerably.

Outputs & outcomes

- Database maintenance on the variation of water quality and fisheries production in Rekawa Lagoon.
- Recommendations for the management of coastal lagoons with a proper scientific background.
- Increase understanding of environmentally friendly, sustainable management of coastal resources.
- Minimized destruction to coastal ecosystems caused by human activity.
- Data on growth and survival of freshwater prawn post larvae stocked in net cages and pen culture in the natural environment.
- Introduction of strategies for maximizing the recapture rate of *M. rosenbergii* in culture-based fisheries.
- Increasing fisher's income by introducing aquaculture as an alternative livelihood activity in Rekawa Lagoon.

Progress:

Financial :100 %

Physical : 95%

Constraints:

- Delay of receiving special cash advance due to financial crisis
- Lack of financial support for repairing and purchasing instruments/chemicals
- Lack of post-larvae at the right time
- Heavy rainfall and flooding resulted in delays in stocking post-larvae in reservoirs.

5.12 REGIONAL RESEARCH CENTER - KALPITIYA

Head of the Division : Dr. R.P.P.K. Jayasinghe

Research Staff: The Regional Research Centre, Kalpitiya (RRC-Kal) consists of 03 Scientists, 01 Research Assistant, 01 Assistant Bungalow Keeper and 4 Helpers.

Overview of the year:

The main task of the RRC-Kal is to decentralize of the programmes and facilities of field-oriented research and coordinate and involve in regional activities with NARA's mandate.

Two treasury funded research projects with project components were carried out by RRC-Kal in 2022. Apart from treasury funded projects, RRC-Kal supported regional organizations and communities in solving issues in fisheries and aquatic resources. The RRC has close contacts with regional government bodies such as Sri Lanka Navy, Department of Fisheries, Department of Wildlife Conservation, Department of Coast Conservation and District Secretariat. In addition to that local and regional fishing communities contact the RRC while they need advice or technical support.

Treasury funded projects carried out by RRC-Kal in 2022:

No	Project	Amount in million LKR
10.5	Biological, fisheries and socio-economic aspects of Gastropod fisheries in the Mannar and Puttalam Districts in Sri Lanka	0.800
10.6	Study some biological aspects of fyke net fishery in selected fishing grounds of Puttalam lagoon	0.100

PROJECT No : 10.5

BIOLOGICAL, FISHERIES AND SOCIO-ECONOMIC ASPECTS OF GASTROPOD FISHERIES IN THE MANNAR AND PUTTALAM DISTRICTS IN SRI LANKA

Objectives:

- Find out the importance of Gastropod fishery as an export-oriented fishery to Sri Lankan economy
- Find out the species specificity, size composition, reproductive pattern, and maturity pathway of target gastropod species
- Estimate the CPUE of gastropod fishery
- Find out the Length-Weight relationship and morphometric data analysis
- Find out the socio-economic aspects of the dependents and a value chain analysis of the gastropod fishery

Findings:

Fishing effort:

Kalpitiya is the main gastropod landing site in Puttalam district and Silawaththurai and Arippu area were noted as the main landing sites in Mannar District. Gastropod shells are selectively harvested via the Skin Diving and SCUBA Diving fishing techniques in Kalpitiya and Mannar. Department of fisheries is responsible for the issuing of license for fishermen (valid for one year). For skin diving 05 persons per boat and for SCUBA diving 02 persons per boats go for the shell collection. Maximum depth of shell collection is about 18 – 20 m for skin dive and about 27 – 30 m for scuba dive. In Kalpitiya, around 200 OFRP boats are being used for gastropod fishery purpose and in Mannar around 1000 boats have been operated. Fishing activity restricted to day time only (07:00H to 17:00H) in order to maintain the sustainable gastropod resource utilization. The gastropod fishery highly correlated with monsoonal changing pattern and influenced by weather changes (wind velocity

and rough sea condition). The calm sea nature highly favoring the diving and easiness of spot the gastropod shells on sea floor. In Kalpitiya, the period of April to July noted as off season and November – February period is the peak season. In Mannar, fishing activity shows some extend of off period between March – June, whereas peak season during October – December.

Target gastropod species:

In Kalpitiya, three gastropod species were recorded among that, major harvested species is *Pleuroploca trapezium* (Horse conch) and *Chicoreus ramosus* (Branched murex) also be a part of target shells. *Turbinella pyrum* (sacred chank/ divine conch) harvested in very limited level during certain peak period only for the solely purpose of ornamental value and export-oriented purpose. In Mannar, total of four species includes above three recorded and *C. ramosus* is noted as the major captured species. *Lambis truncate sebae* (Giant spider conch) harvest is only observed in Mannar and comparatively it owns lower economic value than other three species. Here, both, *P. trapezium* and *C. ramosus* have high economical value for the purpose of edible flesh. *P. trapezium* flesh undergo value added (dried) and mainly targeting local markets while, *C. ramosus* flesh mainly targeting the export-oriented markets. Those species operculum have highest value, that are exported to foreign countries like Malaysia and India for the various purpose.

Catch Per Unit Effort:

According to the dependent fishery data collection over Kalpitiya gastropod fishery landings following findings were obtained. Landing site survey was conducted (in limited sampling period, January – March) to gather catch and effort data. The CPUE varies depending on the species. *P. trapezium* was the largest contributor to gastropod landings during the study period.

CPUE for *P. trapezium* per boat per day = 201 ± 43 shells

CPUE for *T. pyrum* per boat per day = 1 ± 1 shells

Monthly total *P. trapezium* production (MTP) = 236,551 shells

Monthly total *T. pyrum* production (MTP) = 1, 215 shells

Monthly total gastropod catch may fluctuate due to seasonality. Although *C. ramosus* is a target of fishermen, it is not possible to estimate the CPUE or monthly production as the broken shell is discarded back into the sea after the operculum and flesh have been extracted.

Biological analyses:

Due to some limitations and restrictions the sample collection only limited to the Kalpitiya gastropod landing site and the samples were available to obtained only during the period of January – March, which is also known as the most peak season in this area. *P. trapezium* is the largest percentage contribution to the gastropod (above 95%) landings during the study period. The harvested *P. trapezium* shells sizes varied within 200g – 700g and 12cm – 22cm. Shells with weight between 400g – 500g are comparatively dominates the total catch (ca. 28%), where the length class of 18cm – 20cm solely contributes ca.50% of the total catch. The harvest of smaller sized (12cm – 14cm) shells are nearly negligible (1%). The exploitation of matured shell population (54%) was slightly higher than the immature one (46%). In overall, immature male and matured female population harvested in similar (ca.30% each) way and immature female population exploited in very low rate (15%).

Length - weight and other morphometric relationships:

Regression relationships between shell total length (TL) with total weight (TW) and weight without shell (FW) of *P. trapezium* were estimated in order to find out the

length – weight relationship in particular gastropod species.

Regression model between shell total length (TL) and total weight (TW) expressed as follows:

$$\log_{10}(TW) = -0.4976 + 2.458 \log_{10}(TL)$$

nearly 73% (adjusted $R^2 = 72.9$) of the variance of Log (TW) can be explained by the independent variable (TL) included in the model. Moreover, the p-value of the model submits that the estimated model is statistically significant ($p = 0.000$). The constant b value is derived as 2.45 ($b < 3$) whereby, there is a negative allometric growth relationship exist in *P. trapezium*.

Socio-economic findings:

The value of gastropods that are caught and captured in the market depends on various factors such as the species and demand in the market. The price of these gastropods fluctuates greatly, even within the same species. Fishermen usually sort out the caught shells according to their sizes, ranging from 0 to 4, with larger specimens commanding a higher price than smaller ones due to their size parameters. The exported quality of the operculum is so high that it is currently valued at approximately LKR. 10,000 per kilogram in the market. Sources suggest that around 80% of the Branch murex yield is exported to the Middle East, while the remaining 20% is supplied to local hotels. Additionally, gastropod shells, including those of occasionally caught species, are utilized for decoration and in the shell craft industry, making them an attractive material for tourists, especially in jewelry making. The determination of the price of these gastropods is influenced by various stakeholders, from diver fishermen to final processors and exporters. The price is subject to variation as it moves through different stages of the supply chain.

Recommendations:

The accumulation of shells after the flesh harvest, is a major challenge in both locations. Large quantities of empty shells, sometimes amounting to tons, are left behind and continuously accumulate at landing sites with no specific use. It is imperative that better management plans are put in place to address this issue, such as recycling or repurposing the shells for various purposes, such as raw calcium carbonate production.

Fishermen did not maintain the proper logbook system and billing system for the gastropod fishery products in both locations. Despite the size limitation for gastropod shell harvest in mandate, there is no any strict monitoring and regulation were succeeding on that. So, these need to be monitored and regulated by DFAR immediately in order to maintain the sustainable recourse utilization.

Outputs:

- Scientific records about Gastropod fisheries and fishing efforts in Mannar and Kalpitiya
- Species composition and related information on Gastropod fisheries
- Exploitation pattern and catch rates of gastropod shells related to the length, weight, sex and maturity categorizations
- Length - weight and other morphometric relationships
- Socio-economic status and related information on Gastropod fisheries
- Recommendations for the sustainable fishery resource management

PROJECT No: 10.6

STUDY SOME BIOLOGICAL ASPECTS OF FYKE NET FISHERY IN SELECTED FISHING GROUNDS OF PUTTALAM LAGOON

Objectives:

- Find out the importance of fyke net fishing in Puttalam lagoon fishery
- Find out the fyke net fishing tactics and gear operational patterns
- Study the target species, by-catch species composition and its biological variations that entangled in fyke net fishing

Findings:

Gear operational techniques and Fishing effort:

There were seven fishing grounds were prominently recorded along shallow regions of Puttalam lagoon such as Pulluppitiya (L1), Mandalakudah (L2), Mattuthivu (L3), Kottanthivu (L4), Malkanthivu (L5), Nedunthivu (L6) and Elamaga Ivura (L7). Within those regions, fyke net fishing community managed to entangles numerous fyke net trap sets at different points. The gear opened with rectangular frame attached net and extended in a cone shaped structure. The posterior part of the gear supported by five differently sized steel rings and known cod end that placed at the distal part of gear. Total length of fyke net ca.3.6 m and mesh size range between 0.50"- 0.75". There is a leader line net (total length 18m) also part of fyke net.

Fyke nets are fixed in a specific fishing ground, taking into account the wind direction and water movement. The gear is set perpendicular to the direction of the wind and water current. Another set of leader line nets, fixed parallel to the fyke net's position, helps to direct the movement of fish towards the trap. Fishing activity is carried out year-round without an off-season, with a focus on catching shrimp. Fishermen consider the peak shrimp catching seasons to be October-February and June-August. Additionally, the monthly lunar cycle significantly affects the shrimp catch rate, with a higher catch rate during the full moon period due to increased water current and movement. During a single fishing day, there are typically two harvesting times. The fishing gear is set at around 17:00 and checked for harvesting at 20:00. Then, the gear is checked again at 05:00 and removed from the fishing ground. The fyke nets are placed at shallow region of lagoon (depth below 1.5 m and within 2km from the shore) and fishermen commonly used non-motorized vallam as a fishing craft (NTRB).

Target species and catch composition:

This fishery is focused on catching shrimp in shallow coastal lagoon fishing grounds. The main catch consists of shrimp species, while fish species, mostly undersized, are also caught as bycatch in the nets. Main target shrimp species is *Metapenaeus moyebi* and generally it's in high abundance rate in total catch (smaller sized). Other shrimp species such as *Penaeus merguensis*, *Penaeus indicus* and *Penaeus semisulcatus* also entangled frequently. Puffer fish, *Siganus* sp (juvenile/ undersized) and *Terapon* sp (high catch only during the wind season) are some prominent fish species that contribute the fyke net bycatch.

Findings of independent survey and biological analyses:

Total of 45 species (represents 35 families) of aquatic organisms were recorded as fyke net catch composition throughout the year that includes penaeid shrimps (5) as target species as well as finfish (35), crabs (3), mollusc (1) and cnidarian (1). *M. moyebi* is the most dominant species among shrimps, contributing to 46% of the total annual shrimp production. *P. merguensis* is the second-highest harvested species, accounting for 24% of production, followed by *P. indicus* and *P. semisulcatus*, both of which contribute 14% to the total production. The average shrimp catch gets its peaks in January (0.635 kg/ trap) and lowest catch (0.114 kg/ trap) reported during June. Average catch rate of bycatch, gets its own peak in January (0.984 kg/ trap) and lowest values reported in December (0.033 kg/ tarp). The highest proportion of shrimp catch (about 90%) reported in December and followed by July with 69%.

The highest (0.561 kg/ trap) and lowest (0.155 kg/ trap) amount of average shrimp catch were reported in IM 1 and SW monsoon respectively. Comparatively NE and IM 1 show highest catch rate and it may favor due to the calm wind season in northwest coastal region. The lowest catch rate during the SW influenced by the rough wind nature during those periods. Seasonal variation in catch proportion between shrimp and bycatch reveals almost all seasons, by catch dominating the target shrimp catch.

The caught population of *P. indicus* is dominated by smaller individuals weighing less than 10g, comprising over 75% of the population throughout all seasons. In the SW period, this percentage increases to 95%. The smaller sized (less than 15g) groups of *P. merguensis* and *P. semisulcatus* contribute more for the shrimp catch in all seasons. This clearly indicates that, most of the penaeid shrimps except *M. moyebi* (naturally have the maximum growth with smaller size itself), caught via the fyke net fishery is comparatively smaller sized stocks. All four penaeid shrimps shows the dominance of female population throughout the year. There was no any clear evidence for the inter fluctuation between male and female in any season.

Except *M. moyebi* all other penaeid populations are strongly dominated by immature stage (above 70%) throughout the year. This also evidently shows the shallow coastal region highly interrelated with the early development of penaeid juveniles and sub-adults. *Siganus* sp is recognized as a major bycatch fish species that also has commercial potential for the fishery. Biological analyses indicate that during almost all seasons, fish populations caught in fyke nets are very small in size (2cm - 10cm and below 20g). Therefore, proper management plans and increased awareness among fishermen are crucial for conserving this wild fishery stock and maintaining sustainable resource levels.

Recommendations:

Most of the time under-sized and commercially important by-catch species are released to the wild during the harvesting, however some fishermen used to collect whole catch with entangled commercially valued juvenile fish populations like *Siganus* sp. So, proper monitoring, awareness and regulation should be implemented by DFAR in order to maintain the sustainable fishery resources in particular coastal lagoon regions.

To reduce bycatch in shrimp fisheries, researchers recommend implementing bycatch reduction devices (BRDs) as an alternative to traditional fishing methods. Farias *et al.* (2019) stated that, the use of a guiding panel and fan upper panel in the BRD design reduced the vertical opening, which in turn led to a reduction in bycatch and an increase in shrimp selectivity for the fyke net. This approach also reduced the negative impact on bony fish stocks caused by traditional unmodified fyke nets. For instance, to reduce bycatch in shrimp fisheries, researchers recommend implementing bycatch reduction devices (BRDs) as an alternative to traditional fishing methods. Farias *et al.* (2019) stated that, the use of a guiding panel and fan upper panel in the BRD design reduced the vertical opening, which in turn led to a reduction in bycatch and an increase in shrimp selectivity for the fyke net. This approach also reduced the negative impact on bony fish stocks caused by traditional unmodified fyke nets.

Outputs:

- Scientific records about fyke net fisheries and fishing efforts in Puttalam lagoon.
- Species composition and its abundance variation in fyke net fishing grounds.
- Monthly and seasonal catch data and its variation trends on fyke net fishery.
- Seasonal variation of length, weight, sex and maturity level of penaeid shrimp in fyke net fishery and particular fishing ground.
- Recommendations for the sustainable fishery resource management in particular fishing area.

Other activities undertaken by RRC-Kalpitiya

1. Circuit Bungalow: Accommodation facilities for researches and visitors. A considerable amount of funds has been earned by the RRC from the circuit bungalow.
2. Boat facilities are provided for research. RRC-Kal has boats and could be used in research activities.
3. Depuration of oysters with a cost. Income generating activity for NARA.
4. Educational guiding programmes and scientific supports for school and university students

5. Site inspections for clearing the investor's application for the approval of development project by Sri Lanka Tourism Development Authority (SLTDA).

Workshops/ seminar/ meetings attended by RRC-Kal Scientists

1. Workshop on Fisheries Acoustic Independent Survey, Swept Area Trawl Survey and Fish Stock Assessment via StoX (version 3.3.0) software package conducted by NARA/Sri Lanka and Institute of Marine Research/ Norway under NOR-LANKA Bilateral Project on 31st January – 11th February, 2022.
2. EAF-Nansen program (virtual training course on pelagic fishery biomass estimation) conducted by FAO collaborated with Institute of Marine Research (IMR), Norway. 09th – 13th May, 2022.
3. SCPTA- Training program on managing coastal biodiversity under urbanization pressure (virtual), conducted by Singapore Environment Institute and National Environment Agency, collaboration with Foreign Ministry of Singapore, Ministry of Foreign Affairs, Sri Lanka and Ministry of Fisheries, Sri Lanka. 18th – 22nd July, 2022.
4. Seminar on Illegal fishing activity and its impacts in Jaffna lagoon in Jaffna fishers collaborated with Department of Fisheries/ Jaffna. 31st October – 02nd of November 2022.
5. Workshop on Eco tourism and mangrove conservation conducted by Coastal Conservation Department/ Kalpitiya. 14th December 2022.

Undergraduate students' research works supervised by Head/RRC-Kal

1. W. N. N. Dabarera/ Department of Plant Sciences, University of Colombo. Comparative analysis of diversity and exploitation of endophytic fungi of selected species from Pandanaceae family
2. D. A. Arokiam/ Department of Plant Sciences, University of Colombo. Diversity of halophilic fungi in Kalpitiya lagoon and their bioactivity
3. R.H.M.K.O. Rajakaruna/ Department of Plant Sciences, University of Colombo. Biological and chemical diversity of seagrass inhabiting endophytic and epiphytic fungi
4. D.K.H.Thalagala/ Department of Plant Sciences, University of Colombo. Fungal degraders in mangrove ecosystems: A case study at Kalpitiya and Aththaragoda mangroves
5. G.S.N. Kumari/ Department of Plant Sciences, University of Colombo. Lichen inhabiting fungi in Kalpitiya mangrove and their bio activities
6. M.K.D.Fernando/ Department of Plant Sciences, University of Colombo. Endophytes of mangrove plants; Their antimicrobial and anticancer potentials

Publications

Full papers:

1. U.S.P.K. Liyanage, R.P.P.K. Jayasinghe, J-O Krakstad, and K. Arulananthan. 2022. Distribution and Abundance of the Blue Whale (*Balaenoptera musculus indica*) off Sri Lanka during the Southwest Monsoon 2018. *Journal of Marine Science and Engineering* 10 (11):1626. doi10.3390/jmse10111626
2. N. N. Wijayawardene, D-Q Dai, P.K. Jayasinghe, S.S. Gunasekara, Y. Nagano, S. Tibpromma, N. Suwannarach and N. Boonyuen Ecological and Oceanographic Perspectives in Future Marine Fungal Taxonomy. 2022. *Journal of Fungi* 8(11): 1141; doi.10.3390/jof8111141
3. N.N. Wijayawardene, S. Rajakaruna, D-Q Dai, S. Jayasekara, L. Warnakula, K.G.S.U. Ariyawansa, E.Y. Fernando, P. Jayasekera, S.C. Karunarathna, D. Singhalage, K. Ukuwela, R.G. U. Jayalal, R.P.P.K. Jayasinghe, C.K. Muthumala, S. Madawala, I.G.N. Hewajulige, D.U. Rajawardana, A. Ediriweera, S. Ediriweera, D. Alawathugoda, K.M.W. Rajawatta, X-C Jin, E.P. S. Chandana, C. Nanayakkara and S. Wijesundara. 2022. Necessity of a National Fungarium and a Culture Collection for Fungi in Sri Lanka. *Chiang Mai Journal of Science* 49(2): 248-271. Doi:10.12982/CMJS.2022.027
4. N.N. Wijayawardene, A.J.L. Phillips, D.S. Pereira, D-Q Dai, A. Aptroot, J.S. Monteiro, I.S. Druzhinina, F. Cai, X. Fan, L. Selbmann, C. Coleine, R.F. Castañeda-Ruiz, M. Kukwa, A. Flakus,

P.O. Fiuza, P.M. Kirk, K.C.R. Kumar, I.S.I. Arachchi, N. Suwannarach, L-Z Tang, T. Boekhout, C.S. Tan, R.P.P.K. Jayasinghe, M. Thines. 2022. Forecasting the number of species of asexually reproducing fungi (*Ascomycota* and *Basidiomycota*). *Fungal Diversity* doi:10.1007/s13225-022-00500-5

Abstracts:

1. K.H.K. Bandaranayake, R.P.P.K. Jayasinghe and S.S.K. Haputhantri. 2022. Present trends of small meshed gillnet fishery on the West coast of Sri Lanka. Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2022. 1p
2. R.P.P.K. Jayasinghe, S. Thanusanth, S.S. Gunasekara, W.K.A.M.T.S. Aththanayaka, S.C.V.U. Senevirathna and A. Totland. 2022. Fisheries independent trawl survey to estimate biomass and density of shrimps and fish in Sri Lankan coastal waters. Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2022. 2p
3. S. Thanusanth, R.P.P.K. Jayasinghe, W.K.A.M.T.S. Aththanayaka, M.M.A.S. Maheepala, S.C.V.U. Senevirathna and M.S.M. Fahim. 2022. Status of shrimp trawl fisheries in the shallow seas off Kalpitiya and Mannar on the Northwestern coast of Sri Lanka. Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2022. 5p
4. W.K.A.M.T.S. Aththanayaka, H.M.U. Ayeshya, S. Thanusanth, S.C.V.U. Senevirathna, C.B. Madagedara and R.P.P.K. Jayasinghe. 2022. Present Status of mangroves and sea grasses in the upper Western border of Puttalam Lagoon, Sri Lanka
5. Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2022. 61 p.
6. M.P. Hendawitharana, R.P.P.K. Jayasinghe, M.M.C. Karunarathne and S.S.K. Haputhantri. 2022. Present status of the shallow reef patches at the Bar Reef Marine Sanctuary, Sri Lanka: 2021 Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2022. 70 p.
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9. L. N. Kosgahakumbura, T. Muhammad, J. B. Gamage, S. Gunasekera, P. Cárdenas, R. P. P. K. Jayasinghe, and C. M. Hettiarachchi. 2022. Determination of cytotoxicity of some selected marine sponge extracts of Sri Lanka against the histiocytic human lymphoma cell line U-937. The tri annual publication of the Institute of Chemistry Ceylon. Abstract No TO 14. Vol. 39 No. 1, 36p.
10. J. Gamage, L. N. Kosgahakumbura, S. Gunasekera, P. Cárdenas, R. P. P. K. Jayasinghe and C. M. Hettiarachchi. 2022. Marine sponge *Axinella donnani* as a potential drug source. The tri annual publication of the Institute of Chemistry Ceylon. Abstract No TO 13. Vol. 39 No. 1, 35p.

5.13 REGIONAL RESEARCH CENTER – KAPPARATHOTA

Head of the Division : Mr. Upul Liyanage

PROJECT No: 10.1

STUDYING THE SUITABILITY OF DETERRENT PINGERS AGAINST DEPREDAATION OF HOOKED YELLOWFIN TUNA AND ASSESSMENT OF MARINE MAMMAL ABUNDANCE

Operational interactions between odontocetes (i.e., toothed whales) and longline gear are a global phenomenon that may threaten the conservation of odontocete populations and the economic viability of longline fisheries. The global odontocete bycatch rates are highly variable between 0.002 and 0.231 individuals killed per set and at least 20 species may be involved. According to the previous study in 2021 five species of marine mammals are responsible for depredation in Sri Lankan fisheries. Information about marine mammal population size, migration patterns and life history characteristics are scarce, although utmost important for the longline fisheries management as well as marine mammal conservation because some of the main fish importing countries are concern about the bycatch and mitigation measures taken. Information about the financial impact of depredation on pelagic longline fisheries is also scarce, although estimates as around 1.3 million of rupees per fishing trip. Such biological and financial losses may be unsustainable with the fuel and other operational costs incurred. Recent developments in acoustic and physical mitigation technologies have yielded mixed results. Further testing remains necessary before widespread implementation would be possible.

Therefore, considering importance of longline fishery as a export oriented commodity and biological importance of the marine mammals we were ordered to import 200 units of deterrent pingers for the trial with other methods currently used by the fishes. Unfortunately, foreign currency crises, deflation of the currency and late supply of the additional fund requirement due to price increment delayed the importation of pingers. The required additional funds received at the end of the year and thereafter ordered to import. The implementation part of the trial delayed until importation completed.

5.14 REGIONAL RESEARCH CENTER – PANAPITIYA

Head of the Division : Mr.D.A.Athukorala

PROJECT No : 10.2

DEVELOPMENT OF ORNAMENTAL FISH FEED AND ORNAMENTAL FISH CULTURE AT PANAPITIYA REGIONAL RESEARCH CENTER- NARA

Officer/s responsible : Mr. D. A. Athukorala (NARA),
Dr. H. C. Chalanika (NARA)
Mr. H.S.W.A. Liyanage (NAQDA)

Budget : 0.4 Mn

Ornamental fish farming in Sri Lanka offers an excellent business opportunity for individuals due to the high demand for ornamental fish in both local and international markets. Moreover, the government has recognized the export of ornamental fish as a key strategy to increase export earnings and alleviate the current economic crisis in Sri Lanka. Therefore, it is crucial to develop cost-effective feeds for ornamental fish, provide small-scale fish farmers with high-quality fish feeds, and ensure timely provision of ornamental fish brooders and fingerlings. Additionally, the introduction of poly-culture fish farming techniques for ornamental fish culture can help reduce the operational costs associated with ornamental fish farming.

Objectives:

The ornamental fish industry in Sri Lanka has been gaining popularity due to the high demand for ornamental fish in both local and international markets. To support the growth of this industry, there are several components that need to be addressed to ensure sustainable and profitable ornamental fish farming. The first component is to introduce cost-effective, quality ornamental fish feeds to small-scale ornamental fish farmers. Imported ornamental fish feeds can be expensive and may not be easily accessible for small-scale farmers. By introducing scientifically tested feed formulas to small-scale fish feed producers, they can produce cost-effective, quality feed for ornamental fish farming. This not only benefits the small-scale farmers by reducing their production costs but also generates income by selling ornamental fish feeds. The second component is to supply good quality KOI Carp and other popular ornamental fish fingerlings and brooders for the ornamental fish farmers. By providing timely and quality fingerlings and brooders, farmers can ensure healthy and sustainable fish production. This can also generate income by selling KOI Carp and other popular ornamental fish fingerlings and brooders. The third component is to study the feasibility and economics of polyculture of ornamental fish in mud ponds. This is a strategy that can help increase the overall profit from ornamental fish farming. by diversifying their production.

Overall, the development of these components can help promote sustainable and profitable ornamental fish farming in Sri Lanka. It is essential to provide support and resources for small-scale farmers to ensure that they can participate in this industry and benefit from its growth.

Activities carried out:

Koi carp and other popular ornamental fish varieties were bred at Panapitiya Regional Research Center and sold for small-scale ornamental fish farmers. Three formulated ornamental fish feed types (Nursery, Grower/02 mm and Grower/5mm) were produced at Panapitiya Regional Research Center. After being used produced feeds for the ornamental fish at Panapitiya Regional Research Center, and for ornamental fish at NARA Head Office; the excess feed production was sold to the small-scale ornamental fish farmers. Income generated by selling fish feeds was handed over to NARA head office.

Extension work:

- Advisory services for ornamental fish farmers in Kalutara district on ornamental fish culture, water quality control in ornamental fish farming.
- Advisory services for small-scale ornamental fish feed producers in Kalutara district on fish feed preparation.
- Practical training on “ornamental fish feed production” was conducted for 20 participants of small-scale ornamental fish farmers and small-scale fish feed manufactures in Kalutara district.

Results:

Table 1. Fish feed production progress

Month	Grower Feed (Kg)	Nursery Feed (Kg)	Total Production (Kg)	Income (Rs)
January	74.50	14.00	88.50	28590.00
February	53.00	31.25	84.25	38105.00
March	67.00	410.75	77.75	27080.00
April	281.75	11.25	293.00	39175.00
May	106.70	7.00	113.70	39030.00
June	92.25	6.50	101.75	48330.00
July	126.25	0.00	126.25	46330.00
August	137.75	56.00	193.75	83595.00
September	237.75	50.25	288.00	164015.00
October	177.75	63.00	240.75	138220.00
November	139.00	76.25	215.25	124642.50
December	256.75	43.50	300.25	170405.00
Total Income Rs.				947,517.50

Total feed sale - 2123.2 Kg

Total income - Rs. 947,517.50

Table 4. Ornamental Fish production progress

Month	Koi Carp (nos)	Guppy (nos)	Red Guppy (nos)	Sword Tail (nos)	Molly (nos)	Platy (nos)	Income (Rs)
January	-	-	39	74	-	184	9,648.00
February	-	-	54	98	-	62	4,260.00
March	-	-	122	29	-	123	5,600.00
April	-	-	29	30	-	160	3,550.00
May	-	-	27	152	-	100	4,230.00
June	296	-	30	114	-	140	39,090.00
July	13	-	13	36	-	24	2,150.00
August	36	-	22	62	-	72	5,970.00
September	12	34	4	807	-	199	22,415.00
October	198	51	20	173	5	93	244,495.00
November	91	48	12	1044	2	64	48,395.00
December	42	82		114	9	66	22,420.00
Total Income Rs.							412,223.00

Total Income - Rs: 412,223.00

Physical Progress : 91 %

Output:

- Developed ornamental fish feed formulas
- Economical ornamental fish feeds for ornamental fish farmers
- Quality ornamental fish brooders and other ornamental fish stages for ornamental fish farmers.

Outcome:

- Increased production of quality ornamental fish and locally made economical ornamental fish feeds
- Reduction of money spend to foreign ornamental fish feeds
- Increased foreign exchange earnings.

Constrains:

- Insufficient number of helpers and other staff for the center
- Insufficient water supply in dry weather period which led to low ornamental fish production.

6. ANCILLARY SERVICES

6.1 PURCHASING & SUPPLY UNIT

Head of The Division	:	Mr.N.S.Hewagama
Purchasing & Supply Officer	:	Ms A.T.P.Kumari De Silva

Introduction

The premier function of the division is to provide all necessary services and supplies in a formal and systematic manner in accordance with procurement guide lines in order to carry out research & development activities of divisions of National Aquatic Resources Research & Development Agency and Regional Research Centers.

Overview of the Division

Purchasing & Supply Division was established with effect from 23/05/2007. The functions and responsibilities of the unit are as follows.

- Supply goods and services relevant to the all divisions
- Handle all tender works
- Procurement works relevant to all divisions
- All insurance matters
- Prepared by payment voucher
- Air freight and clearance of goods
- Auction work relevant to disposal items
- Provide details to all divisions on their requirement

Performance

- According proper tender procedures Mainly purchase of ongoing projects,
 - Purchase of Lab Equipment & Chemical Items
 - Purchase of marine diesel for vessel & maintenance
 - Purchase of Boat equipments & Net
 - Boat/spare parts for repair for boat
 - All diving equipment
 - Covering net
- Purchase of equipments & materials for work sites
 - Iron /Aluminum goods
 - Brick/Cement
 - All types of electrical accessories
- Purchase of all vehicle Parts & Service
 - Supply of Tyre, Battery
 - Upholstering, supply of canopies for vehicle
 - Supply of vehicle DVD, radio, reverse camera
- Purchase of all technical equipment & Accessories
 - Computer/ Laptop computer
 - Photocopy machine, Printer
 - Air conditioner
 - CCTV camera etc,
- Purchase of Stationery Items
 - Library books
 - Stationery required for office
 - Photocopy & Printer Toner

- Purchase of sanitary items
 - Soap & all cleaning equipment
- Furniture & other goods
 - Office Cupboard
 - Office table &,chair
- Construction for office building
 - Minor repairing
 - Aluminium works
 - Construction for building (ICTAD/NCCAL)
- Supply of Services
 - Supply of meals & festival equipment for ceremonies
 - Printing work
 - Security service & Cleaning service
 - Office Transport service
 - Custom clearance & forwarding work
 - Currating & Tailoring work for office

The selection of supplies is use of supplier registration 2022 & rainbow pages & paper advertisement. Calling of tenders, Bid from local and foreign supplies for goods /equipments /Lab equipments/Chemicals following tender procedures as per the given specifications. Purchase of goods for day to day use by utilizing a petty cash Imprest and maintain records.

For the year 2022, the division has maintained about 050 Tenders following the tender procedures & 123 major files are process.

- A. Clearance of goods received as donations, purchase of goods from foreign sources or airfreight of goods for repairs. Take actions where necessary to obtain tax relief when clearances of goods received from foreign sources are done & sending equipments for repair Etc: Abroad subject to normal mail & airfreight charges.
- B. Insure all vehicles /motor- cycles/equipment of NARA through proper tender procures. Obtain insurance coverage for the personal perform duty at sea and land.
- C. To provide a smooth service to the NARA,the staff of the unit has been responsibility.

6.2 SERVICE AND OPERATION DIVISION

Head of the Division : Mr.S.K.S. Liyanaarachchi

Overview of the Year

Engineering & Maintenance Division is a supportive division of the institution. Engineering & Maintenance division provides and maintains all the services and develops the infrastructure facilities in line with the work programs of the institution.

Activities

Engineering & Maintenance Division has several activities. They are categorized as follows;

1. Rehabilitation works of NARA Head Office & Regional Centers' buildings.
2. Installation and maintenance of air conditioners & electrical/electronic appliances & maintenance of electrical distribution system.
3. Mechanical & other maintenance works.
4. Repair & maintenance work of Samuddrika Research Vessel.
5. Repair & maintenance of vehicles.

For the year 2022, in addition to that, day to day maintenance, below mentioned work has been completed.

01: REHABILITATION OF NARA & OTHER REGIONAL CENTERS BUILDINGS.

Description	Quoted Tender Sum	Remarks
Renovation of Admin ceiling	8,200.00	Completed
DG's office cupboard repairing	14,100.00	Completed
Renovation of MBRD biotechnology laboratory	63,000.00	Completed
Renovation of 65/433 quarters.	47,000.00	Completed

02. INSTALLATION AND MAINTENANCE OF AIR CONDITIONERS & ELECTRICAL/ELECTRONIC APPLIANCES

- Renewal of service agreements of A/C units & installation of a new unit to IPHT QC / Lab and replacing 05 nos of outdoor units.
- Renewal of Service Agreement for Office Equipment(Fax, Photocopy Machine, PABX system, Fingerprint Machines).
- Renewal of Service Agreement for Lab Equipment (IPHT & IARAD)

03. MECHANICAL & OTHER MAINTENANCE

- Fabricated new steel bracket and installed new Castro wheels for the book racks of the library.
- Fabricated s.s. inducer bracket for MBRD.
- Fabricated s.s. inducer bracket for NHO.
- Installed new water misting nozzles for the hydroponics system at IARAD poly tunnel.
- Fixation new pipe line and installed a boll couch valve for overhead tank.

04. MAINTENANCE WORK OF SAMUDDRIKA VESSEL

- Provided required spare parts & services for the day to day maintenance of the research
- Vessel and maintain as per the Bureau Veritas Classification requirements.

05. REHABILITATION OF VEHICLES (09 NOS.)

There are 20 vehicles & 14 Motor cycles in NARA fleet and 25 out of fleet taken for rehabilitation during the year. The vehicles undergone rehabilitation were;

Reg No. –

61-4803	PB-7365
61-6251	NA-7487
32-2951	NB-1486
PA-5935	NC-5724
PA 5262	300-7308
PC-4035	KX-8224
GY-0027	GD-8084
PB-8107	JR-8552
PH-1712	US-5160
PF-7675	US-5197
PH-0667	US-5254
PH-0673	VL-2710
PH-0676	

In addition to the above, Rs.5,296,513.78 spent for services, running repairs, license and insurance of the fleet during the year. 20 vehicles & 14 Motorcycles were effectively utilized for the running of 283183km during the year.

Annual Fleet Cost –Year 2022

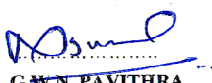
a) Rehabilitation running repairs, Services cost Insurance & License fee (From recurrent Budget)	Rs. 5,296,513.78
b) Vehicle Monitoring System	Rs. 367,199.58
c) Fuel Cost	Rs. 7,653,377.05

* Excluding drivers salary, overtime, subsistence and maintenance staff cost

NATIONAL AQUATIC RESOURCES RESEARCH AND DEVELOPMENT AGENCY
STATEMENT OF FINANCIAL POSITION AS AT 31ST DECEMBER 2022

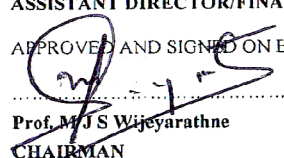
	Notes	31.12.2022		31.12.2021	
		Rs.	Cts.	Rs.	Cts.
ASSETS					
CURRENT ASSETS					
CASH AND CASH EQUIVALENTS	1	28,763,189.91		207,445,405.18	
TRADE AND OTHER RECEIVABLES	2	21,546,892.59		18,557,169.38	
INVENTORIES	3	1,513,019.44		2,684,049.16	
PREPAYMENTS	4	2,136,832.70		3,477,336.74	
		<u>53,959,934.64</u>		<u>232,163,960.46</u>	
NON-CURRENT ASSETS					
RECEIVABLES-DISTRESS LOAN	5	11,078,373.88		12,181,368.54	
INFRASTRUCTURE, PLANT AND EQUIPMENT	6	179,601,461.40		242,156,776.40	
LAND AND BUILDINGS	6	3,536,402,867.63		3,575,552,184.56	
CAPITAL WORK IN PROGRESS	7	23,295,312.00		28,331,335.88	
INVESTMENTS	8	150,242,239.67			
		<u>3,900,620,254.58</u>		<u>3,858,221,665.38</u>	
TOTAL ASSETS		<u>3,954,580,189.22</u>		<u>4,090,385,625.84</u>	
LIABILITIES					
CURRENT LIABILITIES					
ACCOUNTS PAYABLES	9	119,402,248.75		147,122,321.71	
ACCRUED EXPENSES	10	25,878,728.30		50,215,348.04	
		<u>145,280,977.05</u>		<u>197,337,669.75</u>	
NON-CURRENT LIABILITIES					
PROVISION FOR GRATUITY	11	105,551,760.75		137,382,364.75	
		<u>105,551,760.75</u>		<u>137,382,364.75</u>	
TOTAL LIABILITIES		<u>250,832,737.80</u>		<u>334,720,034.50</u>	
NET ASSET		<u>3,703,747,451.42</u>		<u>3,755,665,591.34</u>	
ACCUMULATED FUNDS	12	284,479,598.31		422,673,980.59	
RESERVES	13	3,419,267,852.10		3,332,991,609.53	
TOTAL EQUITY AND LIABILITIES		<u>3,703,747,450.41</u>		<u>3,755,665,590.12</u>	

THE SIGNIFICANT ACCOUNTING POLICIES AND NOTES ANNEXED FORM AN INTEGRAL PART OF THESE FINANCIAL STATEMENTS.

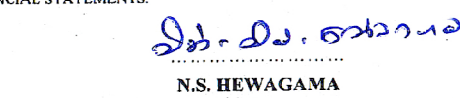

G.W.N. PAVITHRA

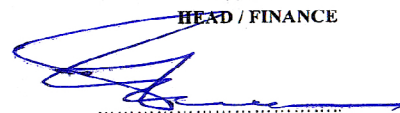
ASSISTANT DIRECTOR/FINANCE

APPROVED AND SIGNED ON BEHALF OF THE BOARD.


Prof. M.J.S. Wijeyaratne
CHAIRMAN


Dr. T.D.K.D. Thennakoon
DIRECTOR GENERAL


N.S. HEWAGAMA
HEAD / FINANCE


BOARD MEMBER
Prof. A. Navaratharajah

COLOMBO 21th March 2023

NATIONAL AQUATIC RESOURCES RESEARCH AND DEVELOPMENT AGENCY

PERFORMANCE STATEMENT FOR THE YEAR ENDED 31ST DECEMBER 2022

		2022.12.31		31.12.2021	
	NOTE	Rs.	Cts.	Rs.	Cts.
REVENUE					
GOVERNMENT GRANT	14	462,021,998.69		534,358,391.23	
OTHER INCOME	15	19,095,550.18		8,210,556.71	
AMORTIZATION OF LOCAL & FOREIGN GRANT	16	113,987,013.59		113,093,808.36	
PROJECT CONSULTANCY INCOME	17	98,206,013.08		23,436,602.22	
GRATUITY SURPLUS	18	19,222,512.50		-	
TOTAL REVENUE		712,533,088.04		679,099,358.52	
EXPENSES					
PERSONNEL EMOLUMENTS	19	316,267,160.70		338,144,024.54	
TRAVELLING & SUBSISTENCE	20	166,373.00		744,294.00	
SUPPLIES & CONSUMABLES USED	21	3,485,367.50		2,341,193.76	
MAINTENANCE EXPENDITURE	22	17,390,743.24		24,398,731.11	
CONTRACTUAL SERVICES	23	41,083,668.61		34,700,185.34	
RESEARCH & DEVELOPMENT EXPENDITURE	24	61,524,498.69		122,203,391.23	
DEPRECIATION & AMORTIZATION EXPENSES	25	113,987,013.59		113,093,808.37	
OTHER OPERATING EXPENSES	26	11,659,427.36		16,232,326.57	
PROJECT CONSULTANCY EXPENDITURE	27	79,491,371.35		30,699,328.22	
TOTAL EXPENSES		645,055,624.04		682,557,283.14	
SURPLUS (DEFICIT) FOR THE YEAR		67,477,464.00		(3,457,924.62)	

THE SIGNIFICANT ACCOUNTING POLICIES AND NOTES ANNEXED FORM AN INTEGRAL PART OF THESE FINANCIAL STATEMENTS.

NATIONAL AQUATIC RESOURCES RESEARCH AND DEVELOPMENT AGENCY

CONSOLIDATED CASH FLOW STATEMENT FOR THE YEAR ENDED 31ST DECEMBER 2022

	31.12.2022	31.12.2021
CASH GENERATED FROM OPERATING ACTIVITIES		
OWN INCOME	10,649,323.85	7,749,036.05
OTHER INCOME	48,817,389.69	86,875,303.59
RECURRENT GRANT	400,500,000.00	412,155,000.00
CONSULTANCY RECEIPTS	90,457,202.93	76,599,281.62
	550,423,916.47	583,378,621.26
PAYMENTS		
GRATUITY PAYMENTS	11,581,229.96	10,597,968.49
OTHERS	489,857,623.48	251,074,562.17
PERSONAL EMULUMENTS	9,173,204.33	276,684,186.12
CONSULTANCY EXPENDITURE	55,576,957.92	68,255,028.63
	566,189,015.69	606,611,745.41
CASH GENERATED FROM OPERATING ACTIVITIES	(15,765,099.22)	(23,233,124.15)
CASH FLOWS FROM INVESTING ACTIVITIES		
PURCHASE OF PROPERTY PLANT AND EQUIPMENT	(3,813,117.00)	(19,027,570.40)
WORK IN PROGRESS	(1,264,295.39)	(18,430,044.17)
FIXED DEPOSIT INVESTMENTS	(150,000,000.00)	
CASH GENERATED FROM INVESTING ACTIVITIES	(155,077,412.39)	(37,457,614.57)
CASH FLOWS FROM FINANCING ACTIVITIES		
CAPITAL GRANT RECEIVED	34,920,000.00	175,500,000.00
PROJECT EXPENDITURE	(42,759,703.66)	(75,033,140.19)
CASH FLOWS FROM FINANCING ACTIVITIES	(7,839,703.66)	100,466,859.81
INCREASE/ (DECREASE) IN CASH AND CASH EQUIVALENTS DURING THE YEAR	(178,682,215.27)	39,776,121.09
CASH AND CASH EQUIVALENTS AT THE BEGINNING OF THE YEAR	207,445,405.18	167,669,284.09
CASH AND CASH EQUIVALENTS AT THE END OF THE YEAR	28,763,189.91	207,445,405.18

NATIONAL AQUATIC RESOURCES RESEARCH AND DEVELOPMENT AGENCY
STATEMENT OF CHANGES IN EQUITY FOR THE YEAR ENDED 31ST DECEMBER 2022

	ACCUMULATED FUND			ACCUMULATED EXPENDITURE OVER INCOME	REVALUATIO N RESERVES	OWN INCOME 5%	NON FUNCTIONA L PROJECTS	TOTAL
	GOVERNMENT CONTRIBUTION	FOREIGN GRANT	LOCAL GRANT					
BALANCE AS AT 1ST JANUARY 2021	372,753,715.33	5,585,468.97	53,174,824.12	(755,148,912.16)	4,087,954,743	2,630,158.95		3,766,949,998.21
FUNDS RECEIVED DURING THE YEAR	175,500,000.00	19,590,996.38	7,333,638.40			123,905.25		202,548,540.03
FUNDS UTILISED DURING THE YEAR	(122,203,391.23)							(122,203,391.23)
FUNDS TRANSFERS DUE TO REALLOCATION	(103,802,473.76)	(1,469,206.11)	(7,822,128.49)					(113,093,808.36)
ADJUSTMENTS				51,355,016.92				51,355,016.92
ADJUSTMENTS FOR THE YEA	38,337,330.66	(4,914,793.68)	(9,390,000)	(50,465,377.82)				(26,432,841)
NET SURPLUS/ (DEFICIT) FOR THE YEAR				(3,457,924.61)				(3,457,925)
BALANCE AS AT 31.12.2021	360,585,181.00	18,792,465.56	43,296,334.03	(757,717,197.67)	4,087,954,743	2,754,064.20		3,755,665,590
BALANCE AS AT 01ST JANUARY 2022	360,585,181.00	18,792,465.56	43,296,334.03	(757,717,197.67)	4,087,954,743	2,754,064.20		3,755,665,590.12
FUNDS RECEIVED DURING THE YEAR	34,920,000.00		2,397,130.00	15,009,893.44		2,211,649.70	5,306,016.35	59,844,689.49
FUNDS UTILISED DURING THE YEAR	(61,524,498.69)							(61,524,498.69)
ADJUSTMENTS				(3,728,780.92)				(3,728,780.92)
ADJUSTMENTS								
FUNDS TRANSFERS DUE TO REALLOCATION	(104,036,020.89)	(7,722,920.73)	(2,228,071.97)					(113,987,013.59)
NET SURPLUS/ (DEFICIT) FOR THE YEAR				67,477,464.00				67,477,464.00
BALANCE AS AT 31ST DECEMBER 2022	229,944,661.42	11,069,544.83	43,465,392.06	(678,958,621.15)	4,087,954,743	4,965,713.90	5,306,016.35	3,703,747,450.41

THE SIGNIFICANT ACCOUNTING POLICIES AND NOTES ANNEXED FORM AN INTEGRAL PART OF THESE FINANCIAL STATEMENTS.

Chairman
National Aquatic Resource Research and Development Agency

Report of the Auditor General on the Financial Statements and Other Legal and Regulatory Requirements of the National Aquatic Resource Research and Development Agency for the year ended 31 December 2022 in terms of Section 12 of the National Audit Act, No. 19 of 2018

1. Financial Statements

1.1 Qualified Opinion

The audit of the financial statements of the National Aquatic Resource Research and Development Agency for the year ended 31 December 2022 comprising the statement of financial position at 31 December 2022 and the statement of financial performance, statement of changes in equity and cash flow statement for the year then ended, and notes to the financial statements, including a summary of significant accounting policies, was carried out under my direction in pursuance of provisions in Article 154 (1) of the Constitution of the Democratic Socialist Republic of Sri Lanka read in conjunction with provisions of the National Audit Act No. 19 of 2018, National Aquatic Resources Research and Development Agency Act No. 54 of 1981 and Finance Act No. 38 of 1971. My report to Parliament in pursuance of provisions in Article 154 (6) of the Constitution will be tabled in due course.

In my opinion, because of the significance of the matters. discussed in the basis for qualified opinion section of my report, the accompanying financial statements give a true and fair view of the financial position of the Agency as at 31 December 2022, and of its financial performance and its cash flows for the year then ended in accordance with Sri Lanka Public Sector Accounting Standards.

1.2 Basis for Qualified Opinion

- (a) In accordance with Section 29 of Sri Lanka Public Sector Accounting Standard no 2, in preparing the statement of cash flows under the direct method, the net cash flow from operating activities which was compared with the general operating surplus or deficit, had not been disclosed as part of the cash flow or as a note in the financial statements.
- (b) Although the purchase of property, plant and equipment amounted to Rs. 3,813,117 under investment activities in the cash flow statement of the year under review, since actual purchase value was Rs. 18,904,661, investment activities had been understated by Rs. 15,091,554.
- (c) Although Rs. 40,826,124 had been paid for the project expenses, the cash out flow under operating activities had been understated by not showing it under operating activities in the cash flow statement. Also, instead of being shown under operating activities in the cash flow statement, the project expenses shown under financial activities were Rs. 42,759,704.
- (d) According to section 47 of Sri Lanka Public Sector Accounting Standard no 7, Non-current assets of cost of Rs. 4,628,125,254 as at 31 December 2019 had not been revalued. Also, out of the currently used lands of Rs. 3,231,216,479, the ownership of Rekawa, Kadolkele and Kalpitiya lands had not been taken over and in the year 2014, the revalued value of Rs. 268,750,000 had been accounted.
- (e) Although 03 acres of land had been leased for a period of 30 years from 16 February 2022 for the construction of a multi-species fish hatchery complex in Kalpitiya Kuduwa area, before taking over, i.e. in the year 2020, constructions were done on that land worth Rs. 1,631,963 and were shown in the works in progress without completing the constructions. Since this project was not completed and stopped in the middle, the necessary actions had not been made as per section 77 of Sri Lanka Public Sector Accounting Standard no 07.
- (f) As at 31 December 2022, Rs. 284,479,598 received as grants in this year and previous years had not been accounted as income in accordance with Section 95 of Sri Lanka Public Sector Accounting Standard no 11. In addition, computer equipment worth Rs. 4,141,347 purchased for a project had not been credited to the income of the year as assets and government grants. Also, the amount of Rs. 7,814,050 paid as purchase advance had not been debited to the advance account and not been credited to the income as government grants.
- (g) Although it was the agency's policy to prepare accounts in accordance with Sri Lankan Public Sector Accounting Standards, contrary to that, Sri Lankan Public Sector Accounting Standards 17 and 20 had been followed for leased properties and government grants.

- (h) Due to non-accounting of the bill paid on 31 December 2022 for the contract for the construction of a marine hatchery, work in progress had been under-accounted by Rs. 298,615, advances by Rs. 1,171,733 and retention money by Rs. 1,470,247. Meanwhile, in the contract related to the construction of the boundary fence in Kalpitiya, the retention money and the work in progress account had been understated by Rs. 268,380.
- (i) Since the amount of Rs. 981,852 paid for laboratory cupboards installed in the building had been accounted under research and development expenses, so the building account and the profit of the year under review had been understated.
- (j) Although it was confirmed that no amount is due from the officers with personal file numbers 707, 724 and 901, but as at 31 December 2022, staff loans of Rs. 142,012, Rs. 57,275 and Rs. 12,047 had been stated to be due. Although it was confirmed that there is nothing to be collected from the former Director General, it was also shown that a balance of Rs. 370,718 to be due from that officer under the employee debtor balance.
- (k) Depreciation of Rs. 4,267,179 had not been allocated for the fixed assets of Rs. 42,671,795 in the year under review.
- (l) A fish food production machine worth Rs. 16,868,610 was received as a donation in the year 2018 and the value of the machine had not been accounted. This machine was installed on the land of a private company for the production of fish feed and the machine was leased and as per condition 8 of the agreement, monthly instalments of Rs. 150,000 each were to be paid to the agency from 05 June 2020, but no amount had been paid so far, so it should have been received an amount of Rs. 4,650,000 for 31 months had been lost to the agency and had not been accounted as receivables. Board of Survey reports did not reveal this machine, so its existence had not been confirmed.
- (m) Among the trade and other receivable balances of Rs. 21,546,893, the recovery of advances, other debtors. and employee loans of Rs. 1,328,522 which exceeded 05 years was uncertain.
- (n) According to the main ledger and note No. 11, although the gratuity expenditure related to the year under review was Rs. 11,148,995, that amount had not been accounted as expenditure. The balance to be paid at the end of the year according to the ledger was Rs. 135,936,911, but it had been shown as Rs. 105,551,761 in the financial statements and Rs. 19,222,513 had been recorded as income for the year under review.

- (o) If all the remaining money after the completion of the work is not claimed, it should be credited to the state revenue, but Out of Rs. 6,370,037 of non-performing projects, Rs. 5,306,016 had been transferred as non-performing funds and an amount of Rs. 1,203,186 had been accounted as income in the year under review.
- (p) According to 7.1.4 of Public Finance Circular No. 1/2020 dated 28 August 2020, 20-35 percent of the consulting service income should be allocated for the institution and credited to a fund according to 7.1.5 of the circular. However, the charged amount of Rs. 18,714,642 had been accounted as income in the year under review without being credited to a fund. A medical fund was built to reimburse the medical bills of officers who do not belong to this circular, 5 percent i.e. Rs. 2,211,650 had been allocated during the year under review and the balance of the fund was Rs. 4,965,714 as at 31 December 2022.
- (q) Among the balance of Rs. 25,878,728 payables to external parties, written evidence such as bills, agreements for the balance of Rs. 8,143,254, which exceeded 05 years, had not been submitted to the audit and actions had not been taken to investigate about these balances and credited to the state revenue if not claimed.
- (r) In accordance with Guideline No. 11 of section 7.2 of Part II of Public Finance Circular No. 01/2020 dated 28 August 2020, fees shall be estimated based on direct costs and overhead costs and after deducting the direct cost incurred from the fee charged, 20-35 percent of the remaining amount should be retained, 5-10 percent should be used to pay for overhead cost and 65 to 85 percent should be used to pay the officials who directly and indirectly involved. However, the ledger did not show separately the direct cost, overhead cost and the direct and indirect cost paid to each officer, an amount of Rs. 79,491,371 had been incurred as consultancy service costs of during the year under review. Thus, it was not possible to be satisfied about the correctness of this since the cost incurred for each item was not confirmed. Also, according to this circular, the fee charged for consulting services is estimated based on direct cost, overhead cost and profit, and the manner in which those fees are calculated had not been submitted to the audit.
- (s) At the end of the year 2021, an amount of Rs. 302,866 had been paid to a private entity that was not under the creditor's individual balance of Project V-5066 in the year under review and an amount of Rs. 202,679 had been accounted as payable to that creditor at the end of the year, and its correctness was not confirmed by the audit.

I conducted my audit in accordance with Sri Lanka Auditing Standards (SLAuSs). My responsibilities, under those standards are further described in the Auditor's Responsibilities for the Audit of the Financial Statements section of my report. I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my opinion.

1.3 Other information included in the agency's 2022 annual report

The other information comprises the information included in the 2022 Annual Report but does not include the financial statements and my auditor's report thereon, which I have obtained prior to the date of this auditor's report. Management is responsible for the other information.

My opinion on the financial statements does not cover the other information and I do not express any form of assurance conclusion thereon.

In connection with my audit of the financial statements, my responsibility is to read the other information identified above when it becomes available and, in doing so, consider whether the other information is materially inconsistent with the financial statements or my knowledge obtained in the audit or otherwise appears to be materially misstated.

If based on the work I have performed on the other information that I have obtained prior to the date of this auditor's report, I conclude that there is a material misstatement of the other information, I am required to report that fact. I have nothing to report in this regard.

1.4 Responsibilities of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation of financial statements that give a true and fair view in accordance with Sri Lanka Public Sector Accounting Standards, and for such internal control as management determine is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the Agency's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Agency or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the Agency's financial reporting process.

As per Section 16 (1) of the National Audit Act No. 19 of 2018, the Agency is required to maintain proper books and records of all its income, expenditure, assets and liabilities, to enable annual and periodic financial statements to be prepared of the Agency.

1.5 Auditor's Responsibilities for the Audit of the Financial Statements

My objective is to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes my opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with Sri Lanka Auditing Standards will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users. taken on the basis of these financial statements.

As part of an audit in accordance with Sri Lanka Auditing Standards, I exercise professional judgment and maintain professional scepticism throughout the audit. I also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for my opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Agency's internal control.
- Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the management.
- Conclude on the appropriateness of the management's use of the going concern basis of accounting and based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Agency's ability to continue as a going concern. If I conclude that a material uncertainty exists, I am required to draw attention in my auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify my opinion. My conclusions are based on the audit evidence obtained up to the date of my auditor's report. However, future events or conditions may cause the Agency to cease to continue as a going concern.
- Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

I communicate with those charged with governance regarding, among other matters., significant audit findings, including any significant deficiencies in internal control that I identify during my audit.

2. Report on Other Legal and Regulatory Requirements

2.1 National Audit Act, No. 19 of 2018 includes specific provisions for following requirements.

2.1.1 Except for the effect of the matters. described in the basis for qualified opinion, I have obtained all the information and explanation that required for the audit and as far as appears. from my examination, proper accounting records have been kept by the Agency as per the requirement of section 12 (a) of the National Audit Act, No. 19 of 2018.

2.1.2 The financial statements presented is consistent with the preceding year as per the requirement of section 6 (1) (d) (iii) of the National Audit Act, No. 19 of 2018.

2.1.3 The financial statements presented includes all the recommendations made by me in the previous year as per the requirement of section 6 (1) (d) (iv) of the National Audit Act, No. 19 of 2018.

2.2 Based on the procedures performed and evidence obtained were limited to matters. that are material, nothing has come to my attention;

2.2.1 To state that any member of the governing body of the Agency has any direct or indirect interest in any contract entered into by the Agency which is out of the normal cause of business as per the requirement of section 12 (d) of the National Audit Act, No. 19 of 2018.

2.2.2 To state that the Agency has not complied with any applicable written law, general and special directions issued by the governing body of the Agency as per the requirement of section 12 (f) of the National Audit Act, No. 19 of 2018 except for following observations.

Reference to law/ direction	Observation
(a) Code of Financial Regulations of the Democratic Socialist Republic of Sri Lanka (i) FR 137 (5)	By December 2022, an amount of Rs. 7,814,050 had been paid for the goods received in the year 2023 contrary to the regulation.
(b) Section 11 of Part Two of the Finance Act No. 38 of 1971	The amount of Rs. 15,000,000 received to the agency from the ministry, other government institutions and private institutions and remaining to be spent in the future had been invested in short-term fixed deposits without being deposited in the treasury as per the Act.
(c) Code of Procurement Guidelines (i) 5.4.5	In the two procurements for the purchase of Anti-Depredation Pinger and Temperature Depth Recorder, the total amount of Rs. 7,931,201 had been paid before the goods were received in the year 2022 and actions had not been taken to obtain any advance security.
(ii) 8.9.1 (b)	Contracts had not been signed for the above two equipment and the purchase of a Light Weight Dual Frequency Echo Sounder worth of Rs. 1,889,975.
(iii) Supplement 35 of the Code of Procurement Guidelines	Although the direct contract procurement method should have been followed only up to Rs. 500,000, on the contrary, the direct contract method had been followed for the two procurements mentioned in (c) (i).

- (d) Ministry of Finance, Asset Management Circular No. 05/2020 dated 02 October 2020 The two seized vehicles bearing registration numbers 58-1378 and 251-0577, which were identified to be disposed on 05 February 2019, had not been disposed.

2.2.3 To state that the Agency has not performed according to its powers, functions and duties as per the requirement of section 12 (g) of the National Audit Act, No. 19 of 2018.

(a) The following objectives and functions mentioned in Section 4 of the National Aquatic Resources Research and Development Agency Act No. 54 of 1981 had not been fulfilled.

- (i) Improvement and development of fishing crafts, fishing gear and equipment and fishing methods.
- (ii) To promote and carry out the social and economic aspects of the fishing industry including the welfare of fishermen and their dependents.
- (iii) The processing, preservation and marketing of fish and related products.
- (iv) To coordinating the activities of institutions engaged in the exploitation, planning, research, development, control and management of aquatic resources.
- (v) According to Section 18 of Act No. 32 of 1996, as amended by the National Aquatic Resources Research and Development Agency Act No. 54 of 1981, a scientific or technical committee should have been appointed, but such committee had not been appointed.

2.2.4 To state that the resources of the Agency had not been procured and utilized economically, efficiently and effectively within the time frames and in compliance with the applicable laws as per the requirement of section 12 (h) of the National Audit Act, No. 19 of 2018.

(a) The Tharani Craft, which was produced at a cost of Rs. 12 million in the year 2011, had been remained idle for over 10 years without being any use due to technical faults.

- (b) The amount of Rs. 3,900,673 paid for the Central Laboratory Complex project which was coming up from the year 2018 and the amount of Rs. 1,631,963 which was paid for the construction of a hatchery complex for Kalpitiya which was coming up from the year of 2020 had been an idle expense.
- (c) A board of Survey conducted on 13 September 2023 at the main warehouse revealed that 154 plastic containers worth Rs. 832,344, an air conditioner and a bottle cooler had been purchased and had not been used for a period of 02-03 years.
- (d) A stock of 9391 oyster models with a value of Rs. 7,512,800 had not been used for many years.

2.3 Other audit observations

- (a) An amount of Rs. 57,022,577 had been spent as maintenance and operational expenses for six regional research centers owned by the Research Institute during the year under review and 52 officers had been assigned to these centers. Since the action plan of these centers and the corresponding performance as at 31 December 2022 were not submitted to the audit, the audit of the performance of those centers was not satisfactory.
- (b) The contract for the construction of a Marine hatchery Center was awarded to a private company on 7 October 2020 at a cost of Rs. 34,993,077 and an amount of Rs. 15,937,388 including the advance had been paid to the contractor by 31 December 2021, but the construction was stopped in the middle and the cost was idled. Due to this, the performance advance of Rs. 2,432,290 could not be collected and the performance security worth Rs. 1,746,654 had been expired on 18 March 2022. Actions had not been taken by the management to extend the date or convert to cash the security and the audit did not reveal the officials responsible for the loss and the actions taken against them.
- (c) The officer, No. 80210 had gone abroad in Australia for postgraduate studies from 24 October 2002 to 01 April 2004 and had entered into an agreement worth Rs. 5,932,721 with NARA Institute. According to the agreement, he was supposed to work in the institute for 10 years, but he was considered to have left the service because he did not return to work on the scheduled date. Actions had not been taken to collect the agreed amount from the respective guarantors or to take legal action against them and a case was filed in the Colombo District Court to pay the remaining value of the bond after deducting the money due and payable from the concerned officer, worth Rs. 5,874,798 in 2 instalments in 05 years and settled in 2022 and the approval of the governing board had been also given for that. But management of the agency had not been paid attention to collect the interest amount due for

15 years which the amount due from this officer was not paid from the year 2005 to 2022 and the expenses incurred for the proceedings from the relevant officer.

- (d) When purchasing a Light Weight Dual Echo Frequency Sounder machine, the depth reading range of the depth reading device was procured to be 200 mm, but the procurement given as 75 mm had been accepted and an amount of Rs. 1,889,975 had been paid in December 2022. The technical evaluation committee had recommended that the limit of 75 mm was sufficient and the facts on which it was based were not disclosed to the audit.
- (e) 200 Anti-Depredation Pinger devices had been purchased from a private company for research and use of modern equipment to harvest non-harvested fish species and an amount of Rs. 5,289,276 had been paid. Although there were 16 specifications mentioned in the tender document, when getting the prices from the supplier, only one of the 16 specifications, Frequency, was entered and the prices had been obtained and the procurement had been awarded to this bidder. Although this equipment was purchased as an urgent requirement, 195 of the 200 units purchased had been remained unused in the institution till 12 September 2023.
- (f) In order to strengthen the fishing ground forecasting system in Sri Lanka, Temperature Depth Recorder equipment had been purchased at a cost of Rs. 2,641,925. Although the depth range of the specification was from 5 to 500 meters according to the agency's requirement, the procurement had been awarded to the supplier who had completed only one of the 17 specifications that the supplier had submitted for a range of 1 to 270 meters. And in the specifications of the agency, the battery lifetime was stated as 9 years but by the supplier, the warranty period was stated as one year, not as the battery lifetime.
- (g) According to the project agreement of the project called “Development of a recreational beach area/ sea water strip from Kollupitiya to Dehiwala” implemented by the Ministry of Metropolitan and Western Province Development, for the direct staff of the agency, on actual performance Rs. 14,171,572 (excluding allowed amount for two consultants) had been approved. Exceeding that value, Rs. 21,235,730 had been paid to the direct staff in the year 2021. So far approval had not been obtained for them and actions had not been taken to recover the money paid without approval so far.

W.P.C. Wickramaratne
Auditor General

NATIONAL AQUATIC RESOURCES RESEARCH AND DEVELOPMENT AGENCY

Crow Island, Mattakkuliya, Colombo 15

My No.} NARA/FA/2023

Your No.}

Date} 2024/04

The Auditor General,
National Audit Office,
No. 306/72,
Polduwa Road,
Baththaramulla

THE REPORT OF THE AUDITOR GENERAL ON FINANCIAL STATEMENTS AND OTHER LEGAL AND REGULATORY REQUIREMENTS OF THE NATIONAL AQUATIC RESOURCES RESEARCH AND DEVELOPMENT AGENCY FOR THE YEAR ENDED 31ST DECEMBER 2022 AS PER SECTION 12 OF THE NATIONAL AUDIT ACT NO. 19 OF 2018.

The actions taken by considering the Audit and Management Committee recommendations of the Institute regarding the queries in the above report depicted by the Auditor General are hereby submitted for information and necessary actions.

Section of the Audit	Observations of the Report of the Auditor General	Actions Taken to Adjust
1.2 (a)	When preparing cash flow statement in direct method as per Section 29 of Volume 2 of Sri Lanka Public Sector Accounting Standards, disclosures had not been made for net cash flow, that is generated from operating activities, as a part of the cash flow or in the financial statement after comparing excess or deficiency that are operated normally.	Steps have been taken to rectify this in the financial statements of 2023.
(b)	During the year under review, Rs. 3,813,117/= had been adjusted as purchasing property plant and equipment under investing activities of cash flow statement. However, the actual value of purchasing is Rs. 19,904,661/=. Therefore, investing activities have been shown with a deficit of Rs. 15,091,554/=.	Steps have been taken to rectify this in the financial statements of 2023.
(c)	Although Rs. 40,826,126,124/= had been paid for project expenses, that amount was not depicted under the operating activities of the cash flow statement. As a result, the cash flow of operating activities had been adjusted with this deficiency. Further, the project expenses that was depicted under financing activities instead of operating activities was Rs.	Steps have been taken to rectify this in the financial statements of 2023.

	42,759,704/=.	
(d)	As per Section 47 of the Sri Lanka Public Sector Accounting Standards No. 7, an amount of Rs. 4,628,125,254/= of non-current assets had not been revaluated as of 31 st of December 2019. Further, out of the lands valued at Rs. 3,231,216,479/=, the ownership of Rekawa, Kadolkelle and Kalpitiya lands has not been vested, and a revaluated value of Rs. 268,750,000/= in 2014 has not been accounted.	Necessary steps have been taken by now. Actions have been taken for the revaluation of assets of the institute. The reacquisition of lands is being processed. Revaluated values are carried forward in the accounts.
(e)	A land of 3 acres in the Kudawa area of Kalpitiya was taken for lease for 30 years with effect from 16th of February 2022 to establish a multi-species fish breeding complex. However, in 2020, before vesting the ownership of that land, the construction of that complex was carried out at a cost of Rs. 1,631,963/=. Therefore, this was depicted under work in progress without completing the constructions. Necessary actions were not taken as per Section 77 of Sri Lanka Public Sector Accounting Standards No. 7 because constructions were not completed and stopped halfway.	Necessary legal actions regarding this land are in progress. Establishing a multi-species fish breeding complex has not been finished. Necessary actions have been taken to obtain required provisions under the patronage of the Indian government. It has not been recorded that a bad debt had occurred to take actions as per Section 77 of the Sri Lanka Public Sector Accounting Standards No. 7.
(f)	Rs. 284,479,598/= which was received as donations in this year and previous years as at 31 st of December 2022 was not accounted as "revenue" as per Section 95 of Sri Lanka Public Sector Accounting Standards No. 11. Other than this, a buying cost of Rs. 4,141,347/= for a project was not debited as computer assets and government donations, for the revenue of the year. Further, an amount of Rs 7,814,050/=. which was paid as an advance payment of buying, was not credited for revenue as government donations after debiting in advance payment account.	Actions have been taken to rectify this when preparing Final Accounts for 2023. Actions have been taken to rectify Rs. 4,141,347/= in assets and Rs 7,814,050/= in accounts.
(g)	Although the policy of the Agency is to prepare accounts as per the Sri Lanka	Steps have been taken to rectify this in the financial

	Public Sector Accounting Standards, contrary to this, Sri Lanka Accounting Standards 17 and 20 were followed for lease and government donations.	statements of 2023.
(h)	The bill paid as at 31 st of December 2022 for the contract for the construction of Marine Breeding Centre was not accounted for. Therefore, the works in progress was depicted with a deficit of Rs. 298,615/=, advance payments were depicted with a deficit of Rs. 1,171,733/= and retained money was depicted with a deficit of Rs. 1,470,247/=. In addition, the account for retained money and works in progress for the contract on constructing boundary fence of Kalpitiya was depicted with a deficit of Rs. 268,380/=.	Steps have been taken to rectify this in the financial statements of 2023.
(i)	An amount of Rs. 981,852/= paid for the laboratory cupboards fixed to the building was accounted under research and development expenses and therefore, building account and profit of the year under review were accounted with a deficit.	Steps have been taken to rectify this in the financial statements of 2023.
(j)	Although it has been confirmed that no money to be recovered from the officers bearing the personal file numbers 707, 724 and 901, Rs. 142,012 was depicted as receivables from the staff loans as at 31 st December 2022. Although it has been confirmed that there are no receivables from the then Director General, it has been depicted under staff debtor balances that Rs. 370,718/= has to be received from that officer.	It has been depicted under the Staff Debtors that Rs. 142,012.11/= has to be paid by Mr. M.I.G. Rathnasooriya. He has informed to deduct the balance of the bond, which has to be settled, from his gratuity. This was not settled in 2022 and steps have been taken to settle in 2023. An amount that should be received from Mr. B.U.T. Dhanushka bearing the Personal File No. 724 is depicted under Staff Debtors due to duplication. Steps have been taken to rectify this in the financial statements of 2023. It was depicted under Staff

		Debtors that Mr. T.Y.D. KasthuriArachchi bearing the Personal File No. 901 should pay an amount of Rs. 12,047.75/=. He has duly paid that amount under receipt No. 029242, 029869 and 030474. The amount of Rs. 50,000/= paid under receipt No. 029869 has been accounted as a revenue. Steps have been taken to rectify this in the financial statements of 2023.
(k)	In the year under review, Rs. 4,267,179/= of depreciation was not provided for fixed assets of Rs. 42,671,795/=.	Steps have been taken to rectify this in the financial statements of 2023.
(l)	A fish feed manufacturing machine valued at Rs. 16,868,610/= was received as donations in 2018 and the value of that machine has not been accounted for. This machine was fixed in a land of private company to manufacture fish feed and that machine was leased. As per the 8 th condition of the Agreement, a monthly premium of Rs. 150,000/= has to be paid to the Agency from 5 th June 2020. However, no amount has been paid until now. Therefore, the Agency has lost an amount of Rs. 4,650,000/= that should be received for 31 months, and has not accounted as receivables. This machine was not revealed by the Board of Survey and therefore, the existence was also not confirmed.	The value of the machine was accounted in the Financial Statement of 2023. This payment has not been made as machinery faults were reported. Currently, as there are faults, the company selected by calling Expressions of Interests has also informed the Agency to take back the machine.
(m)	Out of trade and other receivable balances of Rs. 21,546,893/=. the charging of advance payments of Rs. 1,328,522/= of over 5 years, other debtors and staff debtors were in uncertain condition.	Other balances have been settled except Rs. 239,000/= and Rs. 105,000/= that should be received from the Presidential Secretariat and the municipal council respectively.
(n)	Although according to the main ledger and minute No. 11, the cost of gratuity for the year under review is Rs. 11,148,995/=	Steps have been taken to rectify this in the financial statements of 2023.

	and that amount has not been accounted as expenditures. Although according to the ledger, the balance that should be paid at the end of the year is Rs. 135,939,911/=, that has been accounted as Rs. 105,551,761/= in the Financial Statements and Rs. 19,222,513/= as revenue in the year under review.	
(o)	All the money remaining after completing the works should be credited to the government revenue if there is no claim. However, out of inactive projects of Rs. 6,370,037/=, Rs. 5,306,016/= has been transferred as inactive funds, and Rs. 1,203,186/= has been accounted as revenue for the year under review.	Actions have been taken as per the Audit and Management Committee recommendations. Although these balances have been depicted as unclaimed balances for a long time, these are balances that have not been transferred relevant to the institute as projects have been completed and the balance amount of the project should be nil at the end of the project. This has been adjusted to the revenue. Since the adjustments related to the relevant year are made within the same year, arrangements have been made to prevent such situations. Although an amount of Rs. 1,203,186/= has been identified under "ceenara" project, this has been rectified by a journal minute after identifying it as a revenue under the National Hydrographic Office.
(p)	According to Section 7.1.4 of Public Finance Circular No. 1/2020 dated 28th of August 2020, a percentage of 20-35 from the revenue of the consultancy services should be reserved for the institute, and according to Section 7.1.5 of the Circular, should be credited for a fund. However,	Actions will be taken after discussing at the next Audit and Management Committee meetings.

	the recovered amount of Rs. 18,714,642/= has not been credited for a fund and is accounted as revenue of the year under review. A medical fund has been raised for the settlement of medical bills of the Officers who are not relevant to this Circular and 5% of that medical fund, that is, an amount of Rs. 2,211,650/= has been reserved in the year under review. The balance of that fund as at 31st of December 2022 is Rs. 4,965,714/=.	
(q)	In the balance of Rs. 25,878,728/= payable to external parties, the written evidence, such as bills and agreements, for the balance of Rs. 8,143,254/=, the value of over 5 years, have not been submitted to the audit. Further, actions have not been taken to detect these balances, and credit to the government revenue if there are zero claims.	Steps have been taken to make adjustments and settled in the Financial Statement, 2023.
(r)	As per Guideline 11 of Section 7.2 of Volume II of Public Finance Circular No. 01/2020 dated 28th of August 2020, charges should be estimated based on the direct cost and overhead cost and, direct cost should be deducted from the charged fees and, from the remaining amount, a percentage of 20-35 should be deposited, a percentage of 5-10 should be kept for the payment of overhead cost and a percentage of 65-85 should be kept for the payments of Officers who involved directly and indirectly. However, direct and indirect payments for each Officer, direct cost and overhead cost have not been separately depicted in the ledger, and in contrast, Rs. 79,491,371/= had been depicted as consultancy payment cost in the year under review. Therefore, dissatisfied with the accuracy as the costs for each item have not been depicted separately. Further, according to this Circular, the cost charged from the consultancy services should be estimated based on the direct cost, overhead cost and profit and, the way of estimating those costs has not been submitted to the audit.	Duly accounted in the ledger. Officers have been informed to submit reports in accordance with the requirement of the Audit and necessary actions have been taken.

(s)	At the end of 2021, Rs. 302,866/= has been paid to a Private Company which is not under V-5066 project creditor balance and accounted that Rs. 202,679/= should be paid for that creditor at the end of the year. Therefore, the accuracy of that was not confirmed to the audit.	Duly accounted in the ledger. Officers have been informed to submit reports and documents in accordance with the requirement of the Audit and necessary actions have been taken.
Law/Order Reference (a) Financial Regulations of the Democratic Socialist Republic of Sri Lanka (i) FR 137(5) (b) (c) Procurement Guidelines (i) PG 5.4.5 (ii) PG8.9.1 (b)	Contrary to the Financial Regulations, Rs. 7,814,050/= has been paid as at December 2022 for the goods received in the year 2023. An amount of Rs. 15,000,000/= which was granted from the Ministry and other public and private institutes remains for payment. However, as per the Act, this amount has been invested in short-term fixed deposits without being deposited in the General Treasury. When purchasing Temperature Depth Recorder for Anti-depredation Pingers, the full amount of Rs. 7,931,201/= for both procurements has been paid before receiving goods in 2022. Moreover, steps have not been taken to obtain even a performance bond. An agreement has not been signed for all three equipment; the above two and a	As NARA is a research institute, steps will be taken in future to discuss with the Department of Public Finance of the Ministry of Finance on the difficulties faced when importing required goods and take actions to rectify them. Discussions regarding this have been conducted with the Ministry of Finance and actions will be taken as per the instructions. As NARA is a research institute, steps will be taken in future to discuss with the Department of Public Finance of the Ministry of Finance on the difficulties faced when importing required goods and take actions to rectify them. Steps will be taken in future to discuss with the

(iii) PG Supplement 35 (d) Assets Management Circular 05/2020 dated 02nd October 2020	Light Weight Dual Frequency Eco Sounder valued at Rs. 1,889,975/=. Although the Direct Contract Procurement Method should be followed only for Rs. 500,000/=-, contrary to this, the Direct Contract Procurement Method has been followed for both procurements mentioned in (c) (i). Two vehicles bearing the registered No. 58-1378 and 251-0577 identified to dispose on 05th February 2019 have not been disposed.	Department of Public Finance of the Ministry of Finance on the difficulties faced when importing required goods and take actions to rectify them. Actions will be taken regarding this as above. These vehicles have been disposed by now.
2.2.3 (a) (i) (ii)	According to the requirement mentioned in Section 12(g) of the National Audit Act No. 19 of 2018, except for the following observations, it has been acted irrelevant to the powers, functions & duties of the Agency. Following objects and functions were not performed mentioned in the Section 4 of the National Aquatic Resources Research and Development Agency Act No. 54 of 1981. Improvement and development of fishing craft, fishing gear and equipment, and fishing methods. Promoting and carrying out the social and economic aspects of the fishing industry, including the welfare of fishermen and their dependants.	Under this, to prevent the declining fish population due to the depreciation of marine fish resources, fish accumulated equipment was fixed in selected areas of the country. Train compartments and busses which are removed from usage were used for this. Doing such activities and supervision is continuing. Livelihood Development programmes of selected families in Sri Lanka have been implemented.

		Livelihood programmes related to seaweed cultivation, sea cucumber cultivation, and oyster cultivation have been introduced. These activities are continuing.
(iii)	The processing, research and marketing of fish and related products.	Programmes under this are being continued, and Fish Smoke Units for the upgrade of qualitative dry fish production and introduction of programmes for the qualitative production of maldivian fish have been implemented in 2022 collaboratively with NERD.
(iv)	Coordinate the activities of institutions engaged in exploitation, planning, research, development, control and management of aquatic resources.	The Ministry of Fisheries always obtains required consultancy services recommendations from the NARA. The institutions such as the Department of Fisheries and Aquatic Resources, the Department of Coast Conservation and Coastal Resource Management and the National Aquaculture Development Authority obtain the support of the NARA for required recommendations and coordination of activities.
(v)	According to the Section 18 of amended Act No. 32 of 1996 and the National Aquatic Resources Research and Development Agency Act No. 54 of 1981, although a Scientific and Technical Committee should be appointed, such Committee has not been appointed.	Actions have been taken to appoint these committees.
2.2.4	According to the requirement mentioned in Section 12 (h) of the National Audit Act No. 19 of 2018, except for the following	

	observations, the resources of the Agency had not been utilized economically, efficiently and effectively within the time frames and in compliance with the applicable laws.	
(a)	The vessel "Tharani" manufactured spending 12 million in 2011 has been inactive for 10 years without any usage due to technical faults.	Actions are being taken to exhibit this vessel under the museum of NARA.
(b)	The cost of Rs. 3,900,673/= paid for the Central Laboratory Complex Project since 2018 and the cost of Rs. 6,631,963/= paid for the establishment of Breeding Complex in Kalpitiya were unutilized expenditures.	Although these activities are delayed due to the difficulties of obtaining funds from the General Treasury, alternative fund generating methods are being considered.
(c)	It was revealed, when physically observing the main Stores on 13th September 2023 that, 154 plastic containers valued at Rs. 832,344/=-, an Air Conditioner and Bottle Refrigerator were bought and had not been used for 2-3 years.	Plastic Containers will use in future when necessary. Other equipment is used.
(d)	9391 of oyster shells valued at Rs. 7,512,800/= have not been used for years.	According to the recommendations of the Audit and Management Committee, the Fishing Technology Division has been assigned to prepare a strategy for making use of these oyster shells.
2.3	Other Audit Observations	
(a)	A cost of Rs. 57,022,577/= has been paid as maintenance and operational cost of six Regional Research Centres of the Agency in the year under review and 52 Officers were assigned to these Centres. The Action Plan and performance as of 31st December 2022 of these Centres have not been submitted for the audit and because of that, the audit cannot be satisfied with the performance of these Centres.	Steps will be taken to rectify this mistake.
(b)	A contract was given to a private company on 7th October 2020 for a value of Rs.	If there is any amount to be recovered regarding this

(c)	34,993,077/= for the establishment of a marine breeding centre. A total cost of Rs 15,937,388/= including the advance has been paid for the contractor as of 31st December 2021. However, that was an unutilized expenditure as the constructions have been stopped half-way. Therefore, the paid amount of Rs. 2,432,290/= could not be recovered and the performance bond of Rs. 1,746,654/= has also expired on 18th March 2022. The management has not taken steps to extend the period or cash of that bond and the identification of Officers responsible for the loss and the actions taken against those officers has not been revealed to the audit. The Officer bearing the No. 80210 had travelled to Australia from 24th October 2002 to 01st April 2004 for postgraduate studies and entered into an agreement with NARA for a value of Rs. 5,932,721/=. According to the agreement, although a 10-year service period should be completed, actions have been taken considering him on vacation of post as he has not reported for duty on the applicable date. Actions have not been taken to recover the money from the sureties or to take legal action against them. Further, a case has been filed in the District Court, Colombo. After deducting the payable and receivable amount from the Officer, it was agreed to pay the remaining balance of Rs. 5,874,798/= within 5 years in 2 instalments. The case was settled in 2022 and the Governing Board approval has also been granted. However, this Officer has not paid the amount from 2005 to 2022. Therefore, the management of the Agency has not taken steps to charge the Interest payable for 15 years on that amount and the cost of litigation from that Officer.	construction, it could be recovered as some works are in progress. Case No. DMR/3930/10 was filed in the District Court of Colombo in 2010 as per the agreement signed between Mr. Niell Hemantha Dassanayaka and NARA to charge only the bond value of Rs. 5,932,721/= of Mr. Niel Hemantha Dassanayaka. Only the bond value of Rs. 5,932,721/= has been mentioned as the value of the case. In the meantime, the first Respondent sent an email on 23rd September 2020 addressing the Chairman of NARA mentioning that he is ready to pay the total cost of the case. This condition was submitted to the Governing Board. Considering the whole situation, the Governing Board approval was granted for the conditions submitted by him to recover the bond value at the lowest cost for the Institute. Case No DMR/3930/10 is currently closed in the District Court of Colombo so that further
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		steps can be taken if he is unable to act according to these conditions. Further, legal actions will be taken to recover the remaining cost.
(d)	When purchasing a Light Weight Dual Frequency Eco Sounder, the procurement for the range of depth reading of the Depth Reading machine was 200 mm. However, the procurement for 75 mm was accepted and paid an amount of Rs. 1,889,975/=in December 2022. The Technical Committee has recommended that the range of 75mm is sufficient and the facts that were based on had not been submitted to the audit.	There are many companies manufacturing these machines. Out of those companies, only one company could be considered. When purchasing these machines, foreign exchange has been paid while agreeing the conditions of the supplier. When these actions are taken, the Procurement Board's approval is granted based on the recommendations of the appointed Technical Committee.
(e)	For the usage of research and modern equipment to harvest non-harvesting fish, 200 Anti-depredation Pingers have been purchased from a private company and paid Rs. 5,289,276/=. Although there were 16 specifications, when calling bids, out of 16 specifications, only the frequency was included and this procurement was awarded. Although this equipment has been purchased mentioning that it is an urgent matter, 195 out of 200 were not used and remained in the institute up to 12th September 2023.	This equipment has been purchased from the only existing international supplier. The existing equipment was accepted and took action as per the final recommendation of the Technical Committee. Actions will be taken in the future after having discussions with the Department of Public Finance regarding such issues.
(f)	The Temperature Depth Recorder valued at Rs. 2,641,925/= was purchased for the strengthening of the fishery ground forecast of Sri Lanka. In the specifications, the depth range has been mentioned as from 5m to 500m according to the requirement of the Agency. That procurement was awarded for the supplier who has completed only one specification out of 17 submitted by the company which supplied ranges from 1-	The existing equipment was accepted and took action as per the final recommendation of the Technical Committee. Actions will be taken in the future after having discussions with the Department of Public Finance regarding such issues.

(g)	270. Further, the supplier who has mentioned the battery life as 9 years has mentioned the warranty period as one year. According to the agreement on the “Development of Recreational Beach Area/Sea Waterfront from Colpetty to Dehiwala” project implemented by the Ministry of Megapolis and Western Development, an amount of Rs. 14,171,572/= upon the actual performance has been approved for the direct staff (except the amount approved for two consultants). Exceeding that value, an amount of Rs. 21,235,730/= has been paid for the direct staff in 2021. Approval has not been obtained for that until now, and actions have not been taken to recover the amount paid without approval.	All the payments made for the direct and indirect staff were included in the estimations. This ambiguity has emerged upon mentioning only the Technical Officers and the Officers who fulfil the main tasks of this project based on the requirements and responsibilities of the project. Actions will be taken not to occur such situations.
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