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BOOK OF ABSTRACTS

“Technological Innovations for Fisheries and Aquaculture Development”



17th December 2020



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



**National Aquatic Resources Research
and
Development Agency**

Annual Scientific Sessions – 2020

***“Technological Innovations for Fisheries
and Aquaculture Development”***

17th December 2020

**National Aquatic Resources Research and Development
Agency (NARA)
Colombo 15
Sri Lanka**

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Fisheries and Aquaculture

Effect of bait type on catch efficiency in the Sri Lankan longline fishery operated targeting yellowfin tuna (*Thunnus albacares*)

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Yellowfin tuna (*Thunnus albacares*), one of the key species in the tuna fishery of Sri Lanka is an important food fish due to its high economic value and extensive international trade. The longline is one of the main fishing gears used in the Sri Lankan tuna fishery which targets yellowfin tuna as the main species. Four years (2016-2019) logbook records of the Sri Lankan longline fishery were used to assess the catch efficiency of the longline gear with respect to the bait type used in the fishery. The popular baits used in the longline fishery are squids (*Loligo duvauceli*), bigeye scad (*Selar crumenophthalmus*), flying fish (*Cheilopogon* spp.), milkfish (*Chanos chanos*), scads (*Decapterus* spp.) and artificial baits. Use of artificial baits in the fishery has been abandoned since 2018, and low-cost milkfish bait production has been started locally. Squids were the prominent bait used but its share has reduced (48% in 2017; 35% in 2019) at present due to the increased use of milkfish (2% in 2017; 19% in 2019). Statistical analysis was carried out using one-way ANOVA to find out whether there was any significant difference in the catch rates of the longline fishery for different bait types. Tukey's post-hoc test was used to determine the difference in the effectiveness of each bait type. The study revealed that there was a significant difference in the catch rates among different bait types ($F_{(5, 98689)} = 109.47$, $p < 0.001$) but, according to Tukey's post-hoc test, there were no significant differences in the catch rates ($p > 0.05$) between flying fish, squids and artificial baits. The longlines having *Decapterus* spp. as a bait reported the highest average catch rate in terms of the number of fish per 100 hooks: (1.24 ± 1.47) followed by bigeye scad (0.99 ± 1.23), squid (0.90 ± 1.12), flying fish (0.87 ± 1.00), artificial bait (0.80 ± 0.89) and milkfish (0.70 ± 0.93). The present study further confirmed that locally available baitfish is better than imported squid for catching yellowfin tuna.

Keywords: yellowfin tuna, longline, Indian Ocean, bait, CPUE

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Estimation of small pelagic fish stock abundances on the Northeast Shelf of Sri Lanka using acoustic methods

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Acoustic surveys are reasonably precise tools for estimating fish abundance distribution of small pelagic species often aggregating in large schools. However, these tools are largely underutilized in Sri Lankan fisheries research. A survey was conducted from 5th to 7th August, 2019 along the Northeast Coast of Sri Lanka (8°36'-09°30'E, 81°15'-08°59'N) to establish time-series data collection on small pelagic resources with fisheries acoustic surveys. A Simrad EK15 single beam echosounder was used at the frequency of 200 kHz in the survey using RV *Samuddrika*. Simultaneous pelagic fish sampling survey was conducted at landing sites along the survey area. Raw acoustics data were post-processed in LSSS 2.6 application, and stock abundances were estimated using StoX 2.6. Estimated abundance for the acoustic categories, PEL1 (herring-type fish) and PEL2 (mackerel-type fish) were 164 tonnes (CV 59%) and 7,281 tonnes (CV 34%) respectively. The sampling variance was relatively high, indicating that the estimates are associated with considerable uncertainties. Besides, the target strength versus length relationship for the target species and the acoustic frequency are not well described in the literature, and the estimated biomass was, therefore, only an index. Importantly, indices from repeated surveys are well suited for revealing trends in stock development over time. PEL1 was identified as dense school concentrations and had strong acoustic backscatter properties. PEL2 was identified as more dispersed pelagic zone fish schools which may be due to less strength backscatter properties from mackerel-type fish. PELAG (squid) was found in dense concentrations close to the shelf break. The implementation of the acoustic time series program is a key for successful fisheries independent surveying in Sri Lanka. More importantly, when this information is used together with landing statistics, this approach is useful for defining management strategies for pelagic fisheries.

Keywords: acoustic survey, stock abundance estimation, EK 15, Sri Lanka, pelagic fish

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Exploitation of *Amblygaster sirm* (Walbaum, 1972) in the Eastern Coastal waters of Sri Lanka

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A study on the fisheries aspects of *Amblygaster sirm* (Walbaum, 1972), the key target species in small meshed gillnet fishery was carried out in Kalmunai and Batticaloa fisheries districts in the Eastern Coastal waters of Sri Lanka. Field sampling was conducted at six landing sites, three from each district on a monthly basis from October 2018 to September 2019. During the field visits, the total landed catch of *A. sirm* from randomly selected boats using small meshed gillnets was recorded together with the catches of other species. Fishing effort was recorded in terms of number of boats operated per day. The gillnets were of 2 or 3 drift gillnet pieces with 3.2 cm and 3.8 cm mesh sizes, while the length of a gillnet was of 5-7 m. Outboard engine Fiberglass Reinforced Plastic (OFRP) boats powered with 15 and 25 HP outboard engines were used as the major fishing boats in this fishery. According to the results, *A. sirm* could be considered as the most abundantly recorded species in the small meshed gillnet fishery in this region. The estimated monthly mean Catch Per Unit Effort (CPUE) (48.1 ± 7.1 kg; $p < 0.05$) was significantly different between fishing months. Nevertheless, mean CPUE was not significantly different between fish landing sites ($p > 0.05$). The results of the present study can be used as baseline information to develop a management plan for the small mesh gillnet fishery for *A. sirm* resources in the Eastern Coastal waters of Sri Lanka.

Keywords: *Amblygaster sirm*, exploitation, Catch Per Unit Effort (CPUE), small meshed gillnets

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Present status of beach seine fishery in the Alas Garden and Sandy Bay areas of the Trincomalee District, Eastern Province of Sri Lanka

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Beach seine is one of the traditional fishing gear operated in the coastal waters of Sri Lanka. Present status of the beach seine fishery in the Alas Garden (8°36'21.5" N, 81°13'13.9" E) and Sandy Bay (8°33'43.7" N, 81°14'33.5" E) areas of the Trincomalee District was studied. Catch composition, species-wise standard length (cm) and weight (g), and by-catch of the beach seine operations in both sites were collected by making weekly field visits from August to November 2019. Seven beach seines were operated in the Alas Garden area whereas 15 beach seines were operated in the Sandy Bay area. On average 1-2 beach seines were operated per day in each site. In Alas Garden area, beach seines were operated from 2.00 pm to 6.00 pm and in Sandy Bay area, beach seines were operated from 5.30 am to 9.00 am and 3.00 pm to 6.00 pm. Beach seines in both sites were operated up to 2-2.5 km from the beach and, the operation area was around 2.5 km². A total of 28 fish species belonging to 15 families were identified in Alas Garden of which 14.3% (04 species) were identified as by-catch species. Catches by weight were mainly dominated by *Chanos chanos* (17.8%), *Euthynnus affinis* (17.7%), *Rastrelliger kanagurta* (15.5%), *Scomberomorus commerson* (13.5%), *Caranx heberi* (7.1%), *Gerres erythrourus* (5.1%). Beach seine catches in Sandy Bay area consisted of 21 species belonging to 14 families and 100% of them were economically important species. Catches by weight were mainly dominated by *E. affinis* (30.2%), *Gerres oblongus* (17.1%), *Amblygaster sirm* (13.0%), *Lethrinus microdon* (12.6%), *Hemiramphus lutkei* (5.4%) and *R. kanagurta* (5.1%). Bycatch management was observed during the study. *O. cubicus* were put back to the water following the instructions of the fisheries officer. Further, juvenile fishes were collected and sold to the crab farmers.

Keywords: coastal fishery, economy, beach seine, catch composition

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The influence of environmental factors on growth and survival of oyster, (*Crassostrea madrasensis*) cultivated in Negombo Estuary

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Growth of marine bivalves is affected by the interactions of several environmental variables, particularly water salinity, temperature and food supply. Possible influences of environmental parameters on growth and survival of oysters (*Crassostrea madrasensis*) placed in three plastic cages of 30x25 cm² at five locations, Thaladuwa, Munnakkaraya, Pitipana, Wedikanda and Dungalpitiya in Negombo Estuary, Sri Lanka were investigated over a period of seven months. Daily Weight Gain (DWG), Specific Growth Rate (SGR) and survival rate of oysters were determined. Environmental factors that are known to affect growth and heavy metal contents in the tissues of oysters were also determined. One-way ANOVA indicated significantly higher ($p < 0.05$) daily weight gains (0.22 ± 0.01 and 0.16 ± 0.01 g/day) in Pitipana and Munnakkaraya sites. Oysters at Pitipana, which was the site that recorded the highest salinity (mean = 20.9 ± 0.34 ppt) and the highest chlorophyll-a (5.41 ± 1.49 µg/L), had a significantly higher growth rate (0.22 ± 0.01 g/day) compared to the growth rate (0.04 ± 0.02 g/day) of oysters in Thaladuwa, where significantly lowest salinity (13.29 ± 1.13 ppt), highest turbidity (19.26 ± 0.99 NTU) and ammoniacal nitrogen (0.368 ± 0.078 mg/L) were recorded. DWG showed a significant second order polynomial relationships with chlorophyll-a ($R^2 = 0.44$, $P < 0.05$) and salinity ($R^2 = 0.28$, $p < 0.05$). Negative exponential relationships of DWG were evident with higher level of ammoniacal nitrogen ($R^2 = 0.24$, $p < 0.05$) and phosphate ($R^2 = 0.25$, $p < 0.05$). The high concentrations of Lead (1.883 mg/kg) recorded here exceeded the EU permissible limit of 0.5 mg/kg (wet weight) in the tissues of oysters placed in the site, where urban waste water is released to the lagoon. These preliminary results indicated that phytoplankton biomass and salinity positively influenced growth of *C. madrasensis* in the Negombo Estuary, whereas there would be health concerns due to heavy metal accumulation in oyster tissues in polluted areas of the estuary. The findings of the present study are therefore useful for understanding the potential impacts of environmental and anthropogenic changes on oyster resources and for long-term sustainability of oyster fisheries and aquaculture.

Keywords: chlorophyll-a, environmental effect, oyster resource management, heavy metals

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Development of crop calendar for GIFT strain (*Oreochromis niloticus*) in flood-prone Nilwala River, Matara District of Sri Lanka

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Fish crop calendar is a tool that describes timely information on fish breeding, stocking, rearing, feeding and harvesting periods of fish culture. This study was conducted in five flood affected Divisional Secretariat Divisions of Matara District, i.e. Matara, Thihagoda, Malimbada, Athuraliya and Kamburupitiya to develop a crop calendar for GIFT strain by investigating fish culture activities and changes of climatic conditions. The rainfall and hydrological data associated with Nilwala River were collected from January 2010 to December 2019 from Panadugama station that comes under the Department of Irrigation, Matara. The participatory process and structured questionnaire were used to identify important climatic change events such as heavy rain, flood and drought in the flood prone land of Nilwala River. Since there is no proper irrigation system for fish or rice culture, farmers have to solely depend on rainwater. Information on suitable fish species and the best date to stock fish seeds can be decided through local experience of expertise. According to the crop calendar, the rainy season falls in the months of April, May, June, October and November. Dry season falls in the months of February and July and flood season comes in May, October, November and December. Fish farm activities such as pond preparation, repairing pond dykes, water intake and sluice structures, draining and drying the ponds were conducted in the months of January and February for the first crop and July and August for the second crop. Water filling and fertilization were performed in the months of March and April for the first crop and repeated in the months of September and October for the second crop. Stocking of fish seeds for the first and second crops are formed in the months of March and April and later in September and October. The harvesting time spreads over in the months of July and August for the first crop and January and February in the following year for the second crop. The culture period of GIFT strain prevails 4-5 months and their seeds can be purchased from fish breeding centers throughout the year for the same price. In conclusion, crop calendar supports fish farmers and extensionists in taking correct decisions on fish culture activities in real-time. It also helps to plan all fish farm activities and the cost of production. All the government departments, research organizations and NGOs should help fish farmers of flood-prone land of the Nilwala River to improve and apply knowledge for the challenges and adaptable measures.

Keywords: GIFT tilapia, flood-prone, fish culture, Nilwala River basin, Sri Lanka

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Study of the growth performances of hydroponically cultured *Anubias barteri* var. *nana* 'pertite' (Anubias) in different substrate media

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Anubias barteri var. *nana* 'pertite' is an exotic ornamental aquatic plant which has a very high market demand and high economic value. Slow growth rate is a major obstacle identified in the process of propagation of this plant. Medium selection could be a considerable factor which can affect the growth in hydroponic system. Thus, this study was aimed at finding out the most suitable planting media among selected substrates for the better growth performances of *Anubias*. A sixty-day experiment was conducted to evaluate the growth performances of *A. barteri* var. *nana* 'pertite' in a hydroponic system using different types of locally available growing media: crushed stones (T1), pieces of coconut husks (T2), clay stones (T3) and wood scrapings (T4) and each treatment had three replicates. Two months old, hardened healthy tissue cultured plants were employed in the study. Albert's solution of 0.005 mg/L was used as the fertilizer. The growth parameters viz. plant wet weight, numbers of leaves, leaf length, leaf width, length of the rhizome and root length were taken to assess the plant growth at the significance level of $p < 0.05$. Sampling and fertilization were done fortnightly. Coconut husks proved to be the best media when considering the plant wet weight (1.28 ± 0.05 g) followed by wood scrapings (1.21 ± 0.07 g) and there was no significant difference between the two treatments. Clay stones showed the poorest weight gain of the plant (0.8 ± 0.03 g). Coconut husk media showed the highest number of leaves (19.00 ± 0.58), leaf length (2.66 ± 0.09 cm), leaf width (1.46 ± 0.03 cm) and rhizome length (0.67 ± 0.09 cm). Wood scraping media obtained the maximum root length which was significantly different with other treatments (5.53 ± 0.98 cm). The overall results revealed that the best substrate is coconut husks among the selected substrates for the hydroponic cultivation of *A. barteri* var. *nana* 'pertite'.

Keywords: hydroponic system, substrate, hardening

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An experimental cage culture trial to investigate the growth performance of Nile tilapia, *Oreochromis niloticus* fed with low cost formulated ration

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Feed cost is the highest operating cost in aquaculture. An economical and efficient formulated feed would play a major role in enhancing tilapia aquaculture. However, it was noted that there are no proper formulated feeds for tilapia aquaculture in Sri Lanka. Farmers are used to feeding tilapia with wide variety of food though it does not fulfill the nutritional requirement of the fish. To address this issue, a cage culture trial was carried out to evaluate the growth performance using four nutritionally balanced formulated feeds. Twelve cages (2 m x 2 m x 1 m) were installed in one pond to provide the same water quality to all experimental fishes. All treatments with three replicates and all male tilapia fingerlings (initial total weight = 254.50 ± 7.9 , 274.7 ± 1.26 , 252.8 ± 7.68 , and 272.9 ± 4.08 g) were stocked at the density of 25/m³. Three formulated feeds, A, B and C were prepared using locally available ingredients having protein percentages adjusted to 30, 33 and 35 respectively while a commercial fish feed with 38% protein was used as control feed. The cost per kg of feed A, B, C and Control were Rs. 102, 116, 118 and 175 respectively. Temperature, pH, DO and toxic ammonia were measured biweekly and were in acceptable ranges. All fish were fed twice daily at 5% body weight. The trial lasted for 6 months. The average weight gain per fish (g) and specific growth rates of fish fed on Feed A, B, C and control feed were 163.12 ± 2.53 , 160.34 ± 2.34 , 165.54 ± 3.91 and 124.63 ± 2.99 g, and 3.46 ± 0.14 , 3.37 ± 0.15 , 3.45 ± 0.16 and 3.20 ± 0.00 respectively. Final average weights of fish were 165.72 ± 2.53 , 163.14 ± 3.17 , 168.09 ± 4.10 and 127.41 ± 1.19 g ($p > 0.05$) respectively and the Food Conversion Ratios (FCR) were 1.93 ± 0.04 , 1.93 ± 0.28 , 2.13 ± 0.47 and 2.39 ± 0.04 ($p > 0.05$) while the Food Efficiency Ratios (FER) were 0.51 ± 0.01 , 0.53 ± 0.07 , 0.53 ± 0.14 and 0.41 ± 0.00 ($p > 0.05$) respectively. Percentage survival of four treatments were 87.00 ± 1.00 , 85.33 ± 1.85 , 85.00 ± 1.52 and 85.66 ± 2.60 ($p > 0.05$) respectively. Since the results did not show a significant difference, considering the price per kg, feed A can be recommended as an economically feasible feed for tilapia food fish culture. Further, 30% crude protein is sufficient for tilapia all male fish grow out period.

Keywords: all male tilapia, cage culture, formulated feed

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Re-reporting of *Pinctada* sp. (bivalve species, family: Pteriidae) in Gulf of Mannar, Northern Province, Sri Lanka

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The Gulf of Mannar in the Northern Sri Lanka is well known for pearl oysters. The pearl industry in Sri Lanka had played a significant role since the colonial period as a main source of foreign income. Rediscovery of the pearl oyster beds may provide additional source of income for the coastal communities in the area. Therefore, the objective of this study was to rediscover the possible pearl oyster beds in Gulf of Mannar, to obtain *Pinctada* sp. bivalves and spats for artificial culture. Literature survey and interviews with fishermen, divers and villagers in the Mannar area were used to extract information on possible oyster beds. Based on the information gathered, an underwater survey with line intersect transect method was conducted during March 2019, at Silawathura (Point 01 - E 79° 46.1330, N 08° 41.0423) and (Point 02 - E 79° 44.1432, N 08° 45.3556) Northern Province in Sri Lanka. Sampling sites were located 13 km away from the mainland in 10 m to 12 m deep water. The length of a transect was 30 m and 1 m² quadrates were used for the survey. Total number of 12 and 10 transects were used in point 1 and 2 respectively. A quadrate was placed every 3 m distance along the transect. Specimen were identified up to the genus level based on shell characteristics. Morphometric measurements were taken using a manual caliper (precision of 0.1 mm) so that compromised Shell Height (SH), Shell Width (SW), Shell Thickness (ST) and weight (g) were measured of 120 specimens from each site. The density was recorded as 20 individuals per m² (Indi.m⁻²) in point 01 and 5 Indi.m⁻² in point 02. Morphometric parameters recorded as SH, SW, ST and weight were 46.97±4.30 mm, 37.55±4.30 mm, 16.15±2.00 mm and 14.62±3.28 g in point 01 and 48.75±2.38 mm, 39±3.22 mm, 19.05±1.46 mm and 18.30±3.51 g. Conservation guidelines are required to secure their small population and its natural habitat in the Gulf of Mannar.

Keywords: bivalve, *Pinctada* sp., Gulf of Mannar, rediscovered

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Aquatic Environment, Conservation and Management, Climate Change

Temporal variation of physico-chemical parameters and primary productivity in Malala Lagoon, Sri Lanka

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Malala Lagoon is located on the Southeastern Coast of Sri Lanka in the Hambantota District, having 6.5 km² area. Variation of primary productivity in Malala Lagoon was determined with relation to water quality parameters during a six-month study period from July to December 2019. The results obtained were interpreted in relation to the selected environmental parameters including water depth, Secchi depth, water temperature, pH, conductivity, salinity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), chlorophyll a (Chl-a), nitrate, nitrite, ammonia and phosphate concentrations. Mean water depth ranged from 0.99-1.72 m during the study period and the Secchi depth changed from 0.15 m to 0.9 m. There were no significant differences ($p > 0.05$) in the physico-chemical parameters between sampling sites among the study sites. A significant positive correlation was observed between Chl-a concentration with nitrate concentration ($r = 0.926$; $p < 0.01$). The mean Gross Primary Production (GPP) varied from 0.56 ± 0.08 to 1.07 ± 0.51 mgC/l/h. The maximum GPP was recorded in August, along with a maximum phosphate concentration (0.07 mg/L) and maximum phytoplankton density (17,183,333 individuals/m³). The mean GPP values showed a significant positive correlation with the mean phosphate concentration ($r = 0.896$; $p < 0.05$) and mean phytoplankton density ($r = 0.872$; $p < 0.05$). Presence of blue-green algae within the study area should be taken seriously as that could be an indication of development of eutrophication in the lagoon.

Keywords: primary productivity, nutrients, Malala Lagoon, phytoplankton, water quality

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Comparison of fish biodiversity indices with water quality parameters as a measure of ecological degradation in lower catchment of Kelani River basin

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The Kelani River basin has been subjected to many pollution assessment studies over the past few years. Study to observe the changes of fish species diversity with pollution is vital to understand the biological damages that have happened due to this pollution. A study was conducted in selected locations of the lower catchment of Kelani River in order to evaluate the variation of fish species present with the water quality parameters. Water samples and fish specimens were collected once in three months in thirteen selected sampling locations (L1-L13) from May 2019 to May 2020 in lower Kelani River basin. Physico-chemical parameters of water such as pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrate nitrogen, ammoniacal nitrogen and dissolved phosphate were measured in conformity with the Standard Methods and fish species diversity indices such as Shannon Diversity Index (H'), Pielou's Evenness Index, Simpson's Index (D) and Simpson's Index of Diversity (1-D) were calculated. The results for the water quality assessment revealed that the Mattakkuliya (L1), Thotalaga (L2), Kolonnawa (L4), Ambathale (L5) and Kaduwela (L7) were more highly polluted than the other selected locations when compared to the pH, DO, BOD, COD, nitrogen, ammoniacal nitrogen and dissolved phosphate with the proposed tolerance limits for fish and aquatic life published by the Central Environmental Authority. Fish species belonging to family Cyprinidae showed the highest distribution and *Rasbora daniconius* (Dandiya) could be considered as the most abundant fish species which was present in almost all the locations of lower Kelani River basin. Within the polluted locations *Dawnkinsia singhala* (Sri Lankan filemented barb/ black spot barb) which was previously identified as *Puntius filementosus* could be observed as the most abundant fish species having high percentage frequencies and distributed in all the polluted locations with the disturbances of lower catchment. In addition, the highest H' recorded in L5 which was 2.47 with 13 species richness, which can be concluded as the H' value goes up when the number of species increases. Furthermore, the lowest H' value recorded in L3 which was 1.22, comparatively received low species richness as well. Similarly, location L3 received the lowest Pielou's evenness value (0.63) and L12 (Wak Oya) got the highest value (0.96) showing that the species have similar distribution compared to the other locations. Therefore, it is evident that the species richness is always not a better indication of pollution and some species prefer to live in disturbed areas than the non-disturbed areas. Identification of species presence in polluted locations could be used as an early detection to identify possible polluted locations of the Kelani River basin.

Keywords: Kelani River, water quality, diversity indices, lower catchment

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Study on diversity and abundance of phytoplankton in Mawella Lagoon with reference to water quality parameters

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The present survey was focused on studying the phytoplankton diversity and abundance with reference to physico-chemical parameters of water quality of the Mawella Lagoon, Hambanthota District, Sri Lanka. Field sampling was conducted with ten randomly selected sampling locations from November 2019 to January 2020. In-situ analysis was carried out for water temperature, pH, dissolved oxygen, electrical conductivity, salinity and turbidity of the lagoon. The collected water samples were analyzed in accordance with Standard Methods for the Examination of Water and Wastewater (APHA 22nd edition, 2012). Plankton samples were collected using a 15 µm plankton net. All phytoplankton taxa were identified up to possible taxonomic levels using standard identification keys and their diversity and abundance were calculated. The statistical analysis was performed by the SPSS 20 and Minitab 17 software. Results of the study revealed that, mean water temperature, dissolved oxygen, pH, electrical conductivity and turbidity were 29.28±0.27 °C, 7.11±0.28 mg/L, 8.38±0.06, 2.69±0.03 mS/cm, and 34±0.27 NTU, respectively. Salinity varied from 0 to 6 ppt possibly due to seasonal opening of the sea mouth and loss of regular salt water exchange of the lagoon. The mean NH₄-N, NO₃-N, NO₂-N, phosphate, biological oxygen demand, chlorophyll-a (Chl-a), total suspended solids, total hardness, alkalinity, and chloride were recorded as 0.052±0.003 mg/L, 0.01±0.0004 mg/L, 0.02±0.0002 mg/L, 0.006±0.001 mg/L, 3.10±0.33 mg/L, 10.74±2.44 µg/L, 5.99±0.42 mg/L, 332.14±3.25 mg/L, 215.02±7.92 mg/L and 472.52±7.9 mg/L, respectively. Class composition of the phytoplankton was represented by, Chlorophyceae (78%), Bacscillariophyceae (11%), Zygnematophyceae (2%), Euglenophyceae (7%) and Cyanophyceae (2%). The Shannon Wiener Diversity Index ranged from 0.84 to 1.24 in the sampling locations. In accordance with Pearson Correlation, species abundance was negatively correlated with the total suspended solids and positively correlated with Chl-a. Overall results indicated that, the lagoon has favourable conditions with reference to the water quality parameters, except the total suspended solids and the salinity level.

Keywords: Mawella Lagoon, water quality, phytoplankton diversity, phytoplankton abundance

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Assessment of sediment quality and macro benthic invertebrates in Malala Lagoon, Sri Lanka

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Malala Lagoon is located at Hambantota district in the Southeastern Coast of Sri Lanka and consists of 650 ha of water. It has been affected by the drainage flow of Kirindi Oya Irrigation & Settlement Project and Badagiriya Irrigation Scheme. This study ascertains the lagoon health associated with the physico-chemical environment and macro benthic invertebrates as a bio-indicator. Sediment and benthos samples were collected by Ekman Grab from thirteen sampling locations of the lagoon which were selected according to stratified random sampling method. According to the line transect technique, another four samples were collected to investigate benthic diversity. Further, water samples were collected from four randomly selected inlets during the period October to December, 2019. Measured mean nutrient load and concentrations of nitrite-N, nitrate-N, ammoniacal-N and orthophosphate of inlet water were 3.08 kg/day, 1.81 kg/day, 30.67 kg/day, 1.04 kg/day and 0.02 ± 0.01 mg/L, 0.01 ± 0.003 mg/L, 0.2 ± 0.09 mg/L and 0.007 ± 0.001 mg/L respectively. Percentages of sand, silt and clay, organic carbon, nitrate-N, ammoniacal-N and orthophosphate of the sediments were measured and mean values were recorded as $97.16 \pm 0.05\%$, $0.41 \pm 0.03\%$, $2.43 \pm 0.02\%$, $10.85 \pm 1.05\%$, 0.02 ± 0.01 mg/L, 2.21 ± 0.06 mg/L and 0.06 ± 0.007 mg/L respectively. Moreover, abundance and diversity of benthos were measured and six macro benthic species that belong to five families were identified. *Villosa amygdala* was the most highly abundant species. Shannon-Wiener Diversity Index, Pielou's Evenness and Simpson's Index ranged between 0.04-0.28, 0.02-0.16 and 0.17-0.34 respectively. It illustrated poor species diversity in Malala Lagoon. Macro benthos correlated only with water ammoniacal-N. Therefore, it is concluded that there is a direct impact of nutrient inflow to alter the hydrology, sediment quality and benthic diversity of the lagoon. All these physicochemical and diversity index measures confirmed that the health of Malala Lagoon was in a poor condition.

Keywords: Malala Lagoon, nutrient loading, sediment quality, macro benthic invertebrates, diversity

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Spatial variation of water quality and plankton distribution in Valaichchenai Lagoon, Batticaloa District

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Study was aimed to assess the spatial variation of physico-chemical water quality parameters and plankton species distribution alongside twelve different sampling locations (L1 – L12) of the Valaichchenai Lagoon. Survey was carried out from January to June, 2018 and sampling was conducted fortnightly. All water quality parameters were measured *in-situ* by standard procedures. Species distribution and composition of phytoplankton and zooplankton along sampling locations were also analyzed in a qualitative manner. Results revealed that, salinity, turbidity, electrical conductivity, total dissolved solids and nitrate showing the distinct spatial variation ($p < 0.05$) along sampling locations. However, temperature, pH, dissolved oxygen and phosphate had changed within a narrow range and lacked the spatial variation ($p > 0.05$). The mean salinity ranged between 1 ± 0.98 ppt and 22 ± 8.04 ppt, which predominantly determined the species distribution and other abiotic conditions of the lagoon. The highest mean nitrate level (3.8 mg/L) and highest mean phosphate level (0.61 mg/L) were recorded in L7. Different land usage patterns, domestic wastes, aquaculture and industrial discharges highly deteriorate the water quality especially in the region of L7. Findings elucidated that a total of 142 phytoplankton species belonging to seven divisions were identified, in which Bacillariophyceae was the most diverse group (about 49%). Totally 62 species of zooplankton representing protozoans and multicellular eukaryotes were recorded in which rotifers and ciliates owning the highest species composition along the lagoon. The presence of bio-indicators such as *Microcystis aeruginosa*, *Oscillatoria limosa*, *Euglena* sp., rotifers and ciliates in most locations serve as a piece of evidence that the lagoon is subjected to organic pollution. The vulnerability of eutrophication in certain sites was also proven by the plankton species composition. Proper mitigation measures against pollution inputs and long term, seasonal monitoring studies are frequently needed to ensure the sustainable utilization of the lagoon.

Keywords: bio-indicator, eutrophication, lagoon, plankton, water quality

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Assessing groundwater quality for drinking purposes in Norochcholai area in Puttalam District of Sri Lanka

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Groundwater is an essential natural resource for drinking, domestic purposes, agriculture, and industry. Many people in Norochcholai area in Puttalam District of Sri Lanka depend on groundwater to meet their water requirements. Most of them engage in intensive agricultural practices using groundwater. This water-intensive agricultural activities with high input of pesticides and chemical fertilizers have contributed to the contamination of groundwater resource in this area. The present study was conducted to assess the groundwater quality in the Norochcholai area for drinking purposes. Selected physico-chemical parameters were tested in 18 random sampling stations, including dug wells and tube wells, for 4 consecutive months from October, 2019 to January, 2020. The physical, chemical, and biological properties of groundwater were compared with the Sri Lankan Standards for Potable Water (SLS 614, 2013). Groundwater of the Norochcholai area was characterized by high Electrical Conductivity ($1775.74 \pm 81.26 \mu\text{S/cm}$), Chloride concentration ($220.27 \pm 16.48 \text{ mg/L}$), Total Dissolved Solids ($891 \pm 40.97 \text{ mg/L}$), Total Hardness ($534.64 \pm 31.81 \text{ mg/L}$) and Total Alkalinity ($199.79 \pm 13.67 \text{ mg/L}$) and they exceeded the standard limits. The pH value of groundwater was within the permissible range (7.30 ± 0.03). Mean Nitrate-Nitrogen was recorded as $39.537 \pm 2.69 \text{ mg/L}$ and mean Ammoniacal Nitrogen was recorded as $0.272 \pm 0.09 \text{ mg/L}$ indicating nutrient leaching in the area. Chemical Oxygen Demand was recorded as $15.48 \pm 1.78 \text{ mg/L}$ and exceeded the standard limits. Further, results revealed that all tested dug wells and some tube wells were contaminated with faecal coliform and *E.coli*. As most of the tested physico-chemical parameters in groundwater samples have exceeded the permissible limits of Sri Lankan Standards for Potable Water, it is possible to conclude that the groundwater in the Norochcholai area is not suitable for drinking purposes.

Keywords: ground water, physico-chemical parameters, Norochcholai, potable water

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Assessment of fishers' experiences on Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG) in the Northwestern Coast: Findings from the first comprehensive scientific assessment in Sri Lanka

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This is the first scientific assessment conducted in Sri Lanka on “Abandoned, Lost or otherwise Discarded Fishing Gear” (ALDFG). Although ALDFG has eventually become a global concern at present, crucial information, especially on sources, types and impacts of ALDFG are insufficient due to lack of assessments in the local context, where the experiences of fishermen have never been assessed. A survey was conducted during 2018 and 2019 in the Northwestern Province to assess the status of ALDFG that are generated from the three fishery types; offshore, coastal and artisanal. Fishermen (n=120) were interviewed with the aid of a semi-structured questionnaire to assess their experiences on the origin, categories, self-reported factors by fishermen on the causes generating ALDFG. Fishing nets, lines, ropes, rods, hooks, and clothes were among the 18 major categories of ALDFG identified in the study. Although accidents are not frequent in offshore fisheries, fishing gear are damaged either by wrong practices or by entangling on submersed objects. In both coastal and artisanal fisheries, the major causes for the losses of fishing gear are poor weather conditions and activities of “other fishers” causing entanglements of fishing gear with passing vessels and vice versa, whereas in offshore fisheries, the major causes were accidents and the activities of “other fishers”. Expiration and weakening of fishing gear were also found as a notable cause to generate ALDFG. Results indicate that the actual number of incidents on generating ALDFG could be greater than an estimation. Moreover, improper storage and disposal of fishing gear were also identified as critical issues. Thus, a proper management mechanism is suggested to record incidents, recover ALDFG from the environment, facilitate fishermen for proper storage and disposal of fishing gear, thereby disseminating knowledge to both fishermen and authorities on managing ALDFG.

Keywords: ALDFG, fishing gear, ghost gear, marine debris

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Using sea weeds for remediation of oil contamination

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Oil contaminations which mostly occurs in the ports and harbours can cause severe damage to the biological diversity in the environment. Seaweeds have shown high tolerance for a range of contaminants including oil. Therefore, the objective of the current experiment was to study the oil absorption ability of different seaweed species under laboratory conditions. Three seaweed species; *Ulva* sp., *Sargassum* sp. and *Gracilaria* sp. representing green, brown, and red algae respectively were collected from areas apparently unpolluted by oil. The samples were cleaned thoroughly with seawater. Each cleaned seaweed sample (10 g) was placed in three separate containers. 99 mL of seawater and 1 mL of engine oil were mixed and added to each seaweed sample container and was left for two hours. Each seaweed sample was removed from the containers and each of the remaining solutions were collected. Each sample was poured into 100 mL separatory funnels separately. 20 mL of 4% Chloroform was added to each funnel. The content was mixed well while loosening the lid of the separatory funnel from time to time in order to release the gas generated. The liquid mixtures in the funnels were kept overnight until the organic and inorganic layers separated. The lower layer of chloroform with dissolved oil was collected and measured. The absorbed amount of oil in each species was measured. Results revealed that *Ulva* sp., *Sargassum* sp. and *Gracilaria* sp. absorbed 75%, 50%, and 60% of oil from contaminated water, respectively. This proves that seaweeds have oil absorption capability while *Ulva* sp. showed highest absorption among the species. Therefore, to use these seaweeds in oil spills remediation projects in the country, it is recommended to use the findings of the study as baseline data to conduct more research in ex-situ and in-situ as well.

Keywords: oil, marine algae, pollution, *Ulva* sp., separatory funnel

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Aggregation of floating microplastics in coral-dominated eco-systems in Sri Lanka

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This study assessed microplastics (in the range: 0.3 – 5.0 mm) in surface waters around two major coral-dominated ecosystems in Sri Lanka; The Bar-Reef marine sanctuary (Northwestern Coast), and the Pigeon Island National Park (Eastern Coast) during 2018 and 2019. Plastic-based marine pollution, in particular, microplastic pollution is an emerging threat in Sri Lanka, due to the assumed impacts which those litter could impose on the natural environment. Theoretically, microplastics could carry toxic chemicals, result in bio-accumulation along food chains, and destroy sensitive eco-system components such as corals, that may ultimately bring lethal impacts to marine biodiversity. Thus, the objectives of this study were to assess the abundance, categories, sources of pollution, weathering status and aggregation of Floating Microplastics (FMP), that have been accumulated in surface waters in aforesaid ecosystems. The average abundance of FMP (0.3 – 5.0 mm) at the Bar Reef marine sanctuary, ranged from 0.54 to 30.43 particles Per Square Meter (PSM) in 2018, and 0.60 to 30.81 PSM in 2019, whereas the average FMP at the Pigeon Island National Park varied from 0.24 to 16.83 PSM in 2018, and 0.26 to 17.09 PSM in 2019. At all monitoring circumstances, the abundance of FMP at the Bar Reef marine sanctuary was notably higher, compared to the concentrations recorded from Pigeon Island National Park. Results indicated an increase in the abundance of FMP in both coral reef systems. Compared to 2018, the abundance of FMP at Bar-Reef marine sanctuary has been increased by 9.47% whereas that in Pigeon Island National Park has been increased by 5.94%. This study provides the first evidence on the aggregation of floating microplastics in waters around coral-based eco-systems in Sri Lanka.

Keywords: marine microplastics, Bar Reef, Pigeon Islands

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Assessment of physico-chemical characteristics and abundance of aquatic invertebrates in Bentota River basin, Sri Lanka

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The Bentota River basin is located in the country's Southwestern coast, approximately 55 km South of Colombo City and spreads over Niyagama, Elpitiya, Karadeniya, Walallawita, Beruwala, Mathugama, Palindanuware, Agalawatta and Bentota DS divisions and ends at Bentota town. Only few studies related to the river basin except for adhoc water quality studies have been conducted in the lower part of the basin. Less attention has been paid to the water quality and aquatic invertebrates in the Bentota River basin as a whole. This study focused on the physico-chemical characteristics and the status of aquatic invertebrates in the Bentota River basin extending from upper catchment to lower catchment. The study was conducted from February to October 2017 and twenty-seven Sampling Locations (SL) belonging to nine different sub catchments were selected to compare water quality status. In situ analysis were made for water temperature, pH, dissolved oxygen, electrical conductivity and turbidity at the sampling sites, while other parameters were analyzed in the laboratory. Water samples were collected at each SL and stored at 4 °C during transportation to the laboratory. The samples were dried at 105 °C to measure Total Suspended Solids (TSS). Dissolved phosphate (PO_4^{3-}), ammoniacal nitrogen ($\text{NH}_4\text{-N}$), nitrate nitrogen ($\text{NO}_3\text{-N}$) and nitrite nitrogen ($\text{NO}_2\text{-N}$) concentrations were measured by colorimetric method using a UV spectrophotometer (APHA, 2012). Biological Oxygen Demand (BOD) was determined using Winkler method. Data were analyzed by using SPSS statistics software. The lowest and highest water temperature were recorded in Welipenna SL (25.0 °C) and Pannila SL (35.5 °C) respectively. Sub catchment-6 recorded the highest EC of 5570 $\mu\text{S/cm}$ near to sea mouth while lowest EC (19.1 $\mu\text{S/cm}$) was recorded in Bambarawana from sub catchment-5. The highest mean concentrations of $\text{NH}_4\text{-N}$, $\text{NO}_3\text{-N}$, $\text{NO}_2\text{-N}$ and PO_4^{3-} were recorded in sub catchment-3 as 0.11 ± 0.07 mg/L, 0.04 ± 0.07 mg/L, 0.02 ± 0.04 mg/L, and 0.19 ± 0.31 mg/L respectively. All tested water quality parameters were within the acceptable limits for fish and aquatic life as recommended by Central Environmental Authority, in Sri Lanka. In addition, 19 species of aquatic invertebrates belonging to 9 taxonomic orders were identified. Water mites (Order-Trombidiformes) were found to be the most abundant aquatic invertebrate species in Bentota River basin. It is concluded that the water quality status of the river basin is favourable for aquatic life.

Keywords: Bentota River, water quality, aquatic invertebrate, sub-catchments

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Analysis of plastic and polythene waste inputs in selected coastal areas of Sri Lanka

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Marine habitats are contaminated with man-made debris and it represents one of the major categories of marine debris by material type on a global basis. The sea along the Western, Southern and Northwestern Provinces of Sri Lanka is composed of a large coastal community and is highly affected by the increasing urbanization and industrialization activities. These anthropogenic activities have increased the amounts of organic and inorganic waste input into the system and would have an impact on the overall coastal ecosystem. As dumping of plastic and polythene waste into the marine environment is harmful to the aquatic biota, this research was initiated with the objectives of identifying and classifying dumping of plastic and polythene waste inputs into the marine environment. The collected debris material particles were categorized by the material type. Marine debris was surveyed on selected sites mainly focusing on river discharge outlets, estuary mouths and tourist destination sites at the Northwestern (Negombo and Chilaw) coastline and Southern (Bentota and Horawala) river basin during the study the period from January to December 2019. The marine debris collected in Negombo area is classified by material, plastic bottles (45%), packaging material (25%), fishing items (20%), caps/lids (5%) and food wrappers/containers (5%). The marine debris collected in Chilaw area classified by material type used were plastic bottles (35%), packaging material (22%), fishing items (32%), caps/lids (6%) and food wrappers/containers (5%). The debris collected in Bentota River classified by material type were plastic bottles (32%), packaging material (29%), fishing items (11%), caps/lids (14%) and food wrappers/containers (14%). The debris collected from the ferry port at Horawala as classified by material type were plastic bottles (5%), packaging material (2%), fishing items (2%), caps/lids (6%), food wrappers/containers (5%) and plant leaves and fruits (80%). Beaches close to a river mouth or a city and those with a barrier had greater debris accumulations. The West Coast had significantly greater macro debris density, possibly due to strong sea currents.

Keywords: marine debris, plastic and polythene, man-made debris, waste management

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Aquatic Post Harvest Technology

Comparative study on quality and safety aspects of marine fishery chain of selected fishery harbours in Sri Lanka

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This investigation aimed to carry out a comparative study on quality and safety aspects of the marine fishery chain of selected fishery harbours in Sri Lanka. Beruwala, Dikkovita and Kudawella fishery harbours were selected as the study locations out of 21 existing harbours in Sri Lanka based on the marine sector fish production, infrastructure facilities, number of multi-day boats and socio-economic factors. Information was collected from 50 multi-day boats at each of the above fishery harbours using a validated questionnaire. Questionnaire consisted of 49 statements under the 3 main aspects of marine fishery chain namely, harvesting, on-board handling and unloading. The level of satisfaction for the questions were given in a scale of 1 to 4, where the highest satisfaction was given a value of 4, slight satisfaction was given a value of 3 and slight un-satisfaction and highest un-satisfaction were given values of 2 and 1, respectively. Collected data were statistically analysed based on 5 quality and safety criteria such as; design of the boat, fishing gears and harvesting practices, method of preservation, method of handling and on-board hygiene and safety and method of unloading, handling practices and hygiene and safety using sign test ($p < 0.05$) to identify whether those quality and safety criteria comply with the quality and safety requirements. Both Beruwala and Kudawella fishery harbours complied only with 2 quality and safety criteria such as fishing gears and harvesting practices and method of handling on-board hygiene and safety, while Dikkovita fishery harbour complied with 4 quality and safety criteria except method of preservation. Mann-Whitney test ($p < 0.05$) was used to compare the median values of all three fishery harbours for the above quality and safety criteria and it can be concluded that Dikkovita fishery harbour maintains significantly ($p < 0.05$) high quality and safety standards compared to the other two fishery harbours, with a level of high satisfaction.

Keywords: quality and safety aspects, marine fishery chain, questionnaire survey, multi-day boats

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Analysis of Cadmium (Cd), Lead (Pb) and Mercury (Hg) levels in water, sediment and two fish species in Chilaw Lagoon

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Heavy metal contamination in aquatic ecosystems has become an emerging environmental issue and their stable physico-chemical properties create bio-concentration in marine environments. This study was carried out to assess the level of three metals; namely Cd, Pb and Hg in water, sediment and two food fish species, *Liza parsia* (gold spot mullets) and *Etroplus suratensis* (pearlspot) in Chilaw Lagoon, Sri Lanka. Microwave-assisted digestion was done for water sediment and fish tissue samples and were tested for Cd and Pb using atomic absorption spectrophotometer with graphite tube atomizer. Hg was tested using cold vapour generator with atomic absorption spectrophotometer. Metal level in the water, sediment and fish species were analyzed by one-way analysis of variance. Results revealed that the average concentration of Cd and Pb in water were 0.098 ± 0.091 , $3.486 \pm 2.925 \mu\text{g L}^{-1}$ and the Hg concentration was below the detection limits (minimum detection level: Cd-0.02, Pb-0.05 Hg-10) respectively. In sediments the average concentrations of Cd, Hg and Pb were 0.691 ± 0.487 , 0.723 ± 0.613 and $9.479 \pm 6.047 \text{ mg kg}^{-1}$ (dry weight basis) respectively. Edible fish tissues of *Liza parsia* contained Cd 0.613 ± 0.520 , Hg 0.0367 ± 0.026 , Pb 0.2053 ± 0.206 , where as *Etroplus suratensis* contained Cd 0.2600 ± 0.246 , Hg 0.0426 ± 0.026 , Pb $0.256 \pm 0.266 \text{ mg kg}^{-1}$ (wet weight basis). No significant difference ($p > 0.05$) was observed for Hg and Pb contents in the two fish species except Cd. The accumulated levels of the three heavy metals in the edible fish tissue of both fish species followed the order $\text{Hg} < \text{Cd} < \text{Pb}$ and content of metals in the lagoon varied as $\text{water} < \text{fish} < \text{sediment}$. According to the EU/EC 1881/2006 legislation the maximum levels of Cd, Pb and Hg in edible fish tissues are 0.05, 0.30 and 1.0 mg kg^{-1} (wet weight basis). Based on the levels of testing, Hg and Pb content in edible fish tissues were below the standard levels except Cd.

Keywords: Atomic Absorption Spectrophotometer, Chilaw Lagoon, *Etroplus suratensis*, *Liza parsia*

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Development of seaweed (*Gracilaria edulis*) and oyster mushroom (*Pleurotus ostreatus*) incorporated vegetarian sausage

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Vegetarianism is the practice of abstaining from meat-based foods. However, sausage which is a minced meat food item is preferred by all types of consumers due to its unique sensory properties. Thereby, this study was planned to develop a vegetarian sausage from locally available seaweed (*Gracilaria edulis*) and oyster mushroom (*Pleurotus ostreatus*). The experiment was laid out in Completely Randomized Design in triplicates which consisted of six treatments incorporating different ratios of mushroom (MR), seaweed (SW) (w/w); 60% MR + 20% SW, 50% MR + 30% SW, 40% MR + 40% SW, 30% MR + 50% SW, 0% MR + 80% SW and 80% MR + 0% SW and other ingredients. Samples were vacuum packaged and stored at -24 °C. Proximate composition, energy value and iodine content were evaluated. Microbiological quality and pH were analyzed at two week intervals for 150 days. Sensory evaluation was conducted with 15 trained panellists adopting Friedman test. Parametric data were analyzed using Analysis of Variance. The sensory results revealed that 50% MR + 30% SW treatment had the highest scores for all sensory attributes. It consisted of 3.93± 0.16% crude fat, 8.59± 0.8% crude fibre, 6.61 ± 0.03% crude protein, 8.21 ± 1.17% carbohydrate, 88.68± 2.02 kcal/100 g energy and 1.53± 0.12 mgL⁻¹ iodine content. Yeast and mould were not detected and total plate count was 7.8x10² CFUg⁻¹ initially and further decreased to 1.3x10² CFUg⁻¹ in accordance with the Sri Lanka standards (<1x10⁴ CFUg⁻¹) for a period of 150 days at -24 °C storage. pH was significantly reduced (p<0.05) in the storage period, however, it was within the acceptable limit. In conclusion, the vegetarian sausage incorporating 50% MR with 30% SW (w/w) had better organoleptic and nutritional properties and could be stored at -24 °C in vacuum packed conditions for 150 days without any quality deterioration.

Keywords: mushroom, sausage, seaweed, vegetarian

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Prevalence of antimicrobial resistance in *Escherichia coli* isolated from shrimp (*Penaeus monodon*) farming systems in Puttalam District, Sri Lanka

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Antibiotics have been used extensively to manage serious health problems in commercial aquaculture systems. However, the use of a wide range of antibiotics inappropriately has resulted in the emergence of antibiotic-resistant bacteria in those systems. This study aimed to test the antibiotic resistance of *Escherichia coli* isolated from pond water, bottom sediments and shrimps (*Penaeus monodon*) from farms, in Puttalam District, Sri Lanka. Total Coliform Count (TCC), Total Faecal Coliform Count (TFCC), and *E. coli* count of pond water, bottom sediments, and shrimp samples of five different farms were analyzed using Most Probable Number (MPN) technique. The susceptibility to antibiotics belonging to different families, β -Lactams: Amoxicillin (AMX; 30 μ g); Tetracycline: Tetracycline (TE; 30 μ g) and Oxytetracycline (OTC; 30 μ g); Macrolides: Erythromycin (E; 15 μ g), Chloramphenicol (C; 30 μ g) were used with 04 replicates to test the antibiogram against *E. coli*. Disk-diffusion method was performed to analyze antibiotic susceptibility. In shrimp tissues, mean values of TCC, TFCC, and *E. coli* counts ranged from 0.4 to 41.9 MPN/g, 0.2 to 27.9 MPN/g, and 0 to 27.9 MPN/g, respectively. In pond water samples, TCC, TFCC, and *E. coli* counts ranged from 15-98.8 MPN/100 mL, 5.3-73.7 MPN/100 mL and 0-22 MPN/100 mL, respectively and in bottom sediments ranged from 0.5-1.6 MPN/g, 0.3-0.8 MPN/g, and 0-0.4 MPN/g, respectively. A total of 67 *E. coli* bacteria were isolated and 48 isolates (71.64%) were resistant to at least one drug out of the total number. A high index of resistance to E (15 μ g) 70.15% was reported. In contrast, none of the *E. coli* strains were resistant to C (30 μ g). Multidrug resistance to two or more antibiotics was observed in 24 isolates. Multiple Antibiotic Resistance Index varied within the range of 0 to 0.8 for the antibiotics used. High coliform count indicated faecal pollution in shrimp culture environment and high indices of resistance and multidrug-resistant *E. coli* strains may be a consequence of inappropriate use of antibiotics.

Keywords: antibiotics, *Escherichia coli*, *Penaeus monodon*, shrimp farms, susceptibility

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Determination of the effect of lemon grass (*Cymbopogon citratus*) and storage conditions on shelf life of yellowfin tuna (*Thunnus albacares*) fish powder

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Fish provide essential nourishment to humans, especially protein and a high percentage of omega-3-polyunsaturated fatty acids. Value addition to by-products in the fishery industry is important for optimum utilization of the resource. This study was conducted to determine the effect of lemon grass (*Cymbopogon citratus*) and optimum storage conditions for yellowfin tuna (*Thunnus albacares*) fish powder produced from off cuts which is a by-product in the fish export industry. Tuna trimmings were thawed, washed, steamed, squeezed, dried and powdered to obtain a fine fish powder. Treatments were planned considering packaging method (vacuum/ polypropylene), storage temperature (room temperature/ frozen storage), and lemon grass incorporation (with or without) and samples were analyzed for a 10-week period. The proximate composition of yellow fin tuna fish powder was 81.61% protein, 12.14% moisture, 3.39% fat and 3.57% ash. Fish powder incorporated with 10% lemon grass, vacuum packed and stored in the freezer showed the highest shelf life among all the treatments and in the 10th week mean values of increase in water activity, aerobic plate count, yeast and mould count and free fatty acid percentage were 0.016 ± 0.007 , 1.82×10^4 CFU/g, $< 1 \times 10^1$ CFU/g, $1.96 \pm 0.012\%$ respectively. Lemongrass was effective in the shelf life enhancement of fish powder. Vacuum packaging is more effective over polypropylene packaging and frozen storage enhance the shelf life of yellow fin tuna fish powder. Further studies are suggested for 10% lemon grass incorporated yellow fin tuna fish powder, vacuum packed and stored in freezer since at the end of 10 weeks, the quality parameters (microbiological and chemical) were in the recommended range.

Keywords: yellowfin tuna, lemon grass, fish powder, shelf life, storage conditions

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A preliminary total fat and fatty acid screening in the gonad of four sea urchin species found in Sri Lanka

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The total fat and fatty acid compositions of gonadal material was examined for the sea urchin *Astropyga radiata*, *Tripneustes gratilla*, *Diadema setosuma* and *Stomopneustes variolaris*. Sea urchin gonad fatty acid profiles are a powerful ecological tool for understanding tropical relationships of sea urchin. The main aim of this study is to identify the descriptive differences of total fat content and fatty acid content of sea urchin gonads collected through convenient sampling around Sri Lanka, specifically at Kokkilai, Pulmudai, Midigama, Sallikovil, Kottegoda, Nayaru and Nilwella. Sea urchins were dissected and carefully removed urchin gonads were analyzed for total fat and fatty acid profiles using Bligh and Dyer method and Gas Chromatography. Total fat content ranged from 1.18% in *D. setosum* to, 3.31% in *S. variolaris* on wet weight basis. The saturated fatty acid content of total fat ranged from 50.88% in *T. gratilla* to 72.11% in *S. variolaris*. Omega-3 composition varied among species from 2.74% in *S. variolaris* to 19.96% in *A. radiata*. Total EPA and DHA content varied significantly amongst species and it ranged from 2.53% in *S. variolaris* to 19.96% in *A. radiata*. Fat content of sea urchin gonads did not vary significantly in East and South Coast samples ($p>0.05$). This study establishes descriptive evidence to show that the fatty acid content of sea urchin gonads differs with species.

Keywords: sea urchin, fatty acid, total fat

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Isolation of histamine forming bacteria from yellowfin tuna (*Thunnus albacares*) in chilled storage

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Histamine formation in fish is considered as a major concern as it may cause certain illnesses when histamine formed fish is consumed. Since histamine formation occurs due to the presence of histamine forming bacteria, this study was conducted to isolate histamine forming bacteria from yellowfin tuna (*Thunnus albacares*) at chilled storage and to check their ability to form histamine. Fresh yellowfin tuna samples (n=21) were obtained from a fish processing establishment in January, 2020 and samples were stored at chilled conditions (0-4 °C) the same way that the cold chain is maintained. Samples were analysed at three-day intervals for histamine content, Aerobic Plate Count (APC), Enterobacteriaceae count (VRBA medium) and histamine forming bacteria on Nivens medium. Plates were incubated at different temperatures (37, 25 and 7 °C). The average histamine content of the samples was 2 ppm at the initial stage and it reached 30 ppm on the 18th day. Average APC at 37 °C, 25 °C and 7 °C varied from 2.9×10^5 to 1.3×10^7 CFU/g, 2.0×10^5 to 8.0×10^6 CFU/g and 2.5×10^5 to 9.0×10^6 CFU/g, respectively. Average Enterobacteriaceae count at 37 °C, 25 °C and 7 °C varied from 5.0×10^1 to 2.0×10^5 CFU/g, 3.2×10^5 to 2.1×10^6 CFU/g and 3.0×10^4 to 2.5×10^6 CFU/g, respectively. Fourteen histamine forming bacterial isolates were identified which produced histamine less than 100 ppm in the 1.0% L-histidine supplemented tripticase soy broth. Isolated bacterial species were recorded as *Aeromonas* sp. (4/14), *Pseudomonas* sp. (7/14), *Psychrobacter* sp. (1/14) and *Vibrio* sp. (2/14). Though the histamine content of the tested fish samples increased with the number of days, it did not reach toxic levels and isolated histamine forming bacteria did not produce toxic amounts of histamine in the histidine broth.

Keywords: yellowfin tuna, histamine, histamine forming bacteria

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Oceanography and Hydrography

Spatial variability of tidal dynamics in Jaffna Archipelago

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Global tide models TPXO7.2, FES 2014 and Regional tidal model of Bay of Bengal developed by Oregon State University (OSU) do not accurately simulate the tidal dynamics of very shallow waters of Northern waters of Sri Lanka. This study aimed at accurately modelling the spatial variability of tidal dynamics with the degenerated amphidromic system in Northern waters. Assimilation approach which integrates hydrodynamics and empirical observations is the most effective in coastal waters to develop tidal models. Therefore, an assimilative barotropic tidal model for eight major constituents including both diurnal (K1, P1, O1, Q1) and semidiurnal (M2, S2, N2, K2) was developed over the Jaffna archipelago using OSU Tidal Inversion Software (OTIS). The model has a 400 m spatial resolution and includes best currently available bathymetric soundings at National Hydrographic Office and 15 arc second GEBCO_2019 grid bathymetry. All available coastal tide gauge observations and satellite altimetry data were used to develop the model. Accuracy of the model was evaluated by comparing the model results with observations. Mixed-mainly semi diurnal is the main tidal regime of the region, but completely diurnal tidal curve can be observed at Kayts channel. However, the tidal phase changed to 180° moving from Delft region to Kankesanthurai. Performance of the inversion model was computed in terms of Root Mean Square (RMS) deviation. RMS misfit does not exceed 6 cm for the computation domain. The accuracy of the tidal elevations of the model was evaluated at the location of coastal tide gauges at Point Pedro, Kankesanthurai and Delft Island which were not assimilated to the model. Degenerated amphidromic point for semidiurnal constants can be observed around Mandativu. Diurnal constituents have their amphidromic point shifted to Northwest-ward relative to semidiurnal constituents.

Keywords: Tidal Modelling, data assimilation, OTIS, Jaffna, Amphidromic System

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Prospecting sand resources suitable for construction industry, off Galle, Sri Lanka

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Sand is one of the major aggregates in the construction industry. The accelerated development in construction industry lead to the depletion of inland sand reserves and excess mining of sand arouse many environmental issues. Offshore sand is identified as a promising alternative for river sand. The objective of this study was to prospect offshore sand resources from Galle to Rathgama area. Thirty surface sediment samples were collected and analyzed for grain size distribution, statistical and textural parameters as they are important determinants of different construction aspects. The samples were then analyzed for other parameters; shell content, chloride and heavy mineral content. The mean grain size varied between the range of 0.073 mm to 1.25 mm while the median (D50) was in between 0.07 mm to 1.8 mm. Both the mean grain size and the median were in the recommended range according to British Standards limits. The majority of the samples were found to be moderately well sorted which is suitable for the construction industry. A distinct band of sand was identified and the length and width of the sand band were ~7 km and 1.5 km respectively. The deposit was located 1.5 -3 km from the coast and the depth was 12 m to 28 m indicating the deposit can be exploited according to dredging regulations in Sri Lanka. The chloride content by weight was ~0.28% and the shell content higher than 5 mm was below 5%. Though the shell content was in the recommended range according to British Standards, the chloride content was higher than the recommended range. It can be reduced by stockpiling after the extraction and flushing by rain water or artificial washing which might take several years depending on the percentage of chloride. The heavy mineral percentage was 0.12% to 12% by weight. Ilmenite was the prominent heavy mineral found and others were garnet, monazite and zircon. However, further studies should be done to estimate the volume of the deposit.

Keywords: grain size analyses, construction material, offshore sand, chloride content

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Seasonal water temperature at coral reef on the East and West Coast, Sri Lanka

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Ocean warming has an impounding impact on the coastal sensitive ecosystems, especially on the coral reefs. Persistent raise in temperature for a longer period causes stress on the coral reefs than diurnal or shorter fluctuations. This study is intended to assess the temporal and spatial temperature variability at two coral reef hot spots, located on the East and West coasts. Automatic temperature recorders, preset to collect data at one hour intervals were deployed at Pigeon Island and Bar Reef at 5 m depth during 2018-2019. In addition, temperature data at 10 m depth was collected at Bar Reef in 2018. Annual water temperature fluctuation at 5 m depth is $\sim 5^{\circ}\text{C}$. Water temperature rises through the inter monsoon and reach highest values at the end of May and October, just prior to the Southwest and Northeast monsoons respectively. The maximum temperature in 2018 and 2019 were 31.1°C and 32.31°C , recorded in May just prior to the onset of Southwest monsoon. The lowest temperature 26.1°C was recorded in January at the end of the Northeast monsoon. The temperature fluctuations during the study period at Bar reef and Pigeon Island are identical except during the first inter monsoon. The temperature variation between the 5 and 10 m depth vary by $\sim 0.1^{\circ}\text{C}$, except for two shorter periods, extending about a week, once at the end of May and the other at the beginning of October, that is just prior to the onset of the Southwest and Northeast monsoon respectively. During May the lower layer is warmer by almost 1°C , while in October lower layer is $\sim 1.5^{\circ}\text{C}$ cooler. The temperature fluctuation shows close correlation with the fortnightly tide, revealing stronger stratification during the neap. The shorter events of stratification are critical periods for sensitive coral habitats, since during these events temperature of the upper layer could easily be heated up.

Keyword: temperature variation, coral reef, monsoon

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Modelling of Coastal Sediment Dynamics on the Northeastern Coast of Sri Lanka

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Coastal sand dunes act as an important natural barrier against coastal erosion and storm surges by protecting life and property within the coastal zone. Manalkadu, the Sri Lanka's longest chain of sand dunes is lying between coastal stretches between Point Pedro and Chundikkulam in Jaffna District. Coastal sediment transport plays an important role in the supply and sediment transport into the back-beach environment by formation of dunes via Aeolian process. This study quantifies the variations in wave characteristics and the resulting variations in potential sediment transport rate along the coastal stretches of natural sand dunes between Point Pedro to Chundikkulam. Lack of available field data found in such coast lines yield numerical modelling which is a promising method to derive a qualitative regional sediment transport. Wind fields and deep-water wave climates were obtained from National Centre for Atmospheric Research Final (NCEP FNL) and ERA interim from European Centre for Medium-Range Weather Forecasts (ECMWF) respectively. For the wave transformation, Simulating Waves Nearshore (SWAN) numerical model was applied, forced by offshore wave/wind. The Delft3D-FLOW model was used to estimate the long-shore sediment transport rates and related morpho-dynamics using input reduction and morphological acceleration techniques. Analysis of wave climate data indicates that the significant wave height varies between 0.25 m to 2.0 m having most probable wave heights around 1.25 m. The distribution of wave direction is mostly from 40-80 degrees (Northeastern) and from 200-240 degrees (Southwestern). Overall, the numerical results of the net alongshore sediment transports are directed Northward between Chundikkulam and Thalayadi with the transport capacity between 30,000-45,000 m³/year. Afterwards, the transport direction changed in magnitude along the coastline up to Point Pedro.

Keywords: sediment transport, ERA Interim, SWAN, morphological acceleration, morpho-dynamics

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Identification of ENSO signals on sea level observations around Sri Lankan waters

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The SDG goal of UN 'Climate Action' reveals the necessity of urgent action against climate change and its impact by threatening life and limiting land with sea level rise via the anthropogenic activities. Sea level variation was derived using tide gauge observations from 2006 to 2018 and satellite altimetry data obtained by four satellite missions of Topex/Poseidon, JASON1, JASON2 and JASON3 from Radar Altimeter Database System (RADS) from the National Oceanic and Atmospheric Administration (NOAA) from 1992 to 2018. Tide gauge data was collected from the Colombo Station which is maintained by the National Aquatic Resources Research and Development Agency (NARA). The Mean Sea Level (MSL) data obtained by the tide gauge and satellite were compared by super positioning same axis for the accuracy and quantification. The Root Mean Square Difference (RMSD) of MSL derived using tide gauge observation showed approximately 84 % of the variance of MSL estimated using satellite altimetry. The time series of sea surface temperature exhibited 0.33 °C of difference during 1979 to 2018 in the West Coast of Sri Lanka. The long term MSL trend of satellite altimetry showed 2.585 mm/year while tide gauge was 2.904 mm/year and annual trend difference between two data sources was 0.319 mm in Colombo. Sea level energy density spectrum indicated Niño signal approximately 4-6 year's frequency. The NOAA Oceanic Niño Index (ONI) was compared with Kirinda, Mirissa, Colombo, Kalpitiya, Point Pedro, Trincomalee, Mullathivu, Batticaloa sea level fluctuations during El Niño (warm) with positive peaks and during La Niña (cool) with negative peak. According to the ONI, most of the historical El Niño events (1994:1995, 1997:1998, 2002:2003, 2009:2010, 2015:2016) and La Niña events (1995:1996, 1999:2000, 2006:2007, 2011:2012, 2017:2018) were superimposed with sea level time series.

Keywords: sea level, El Niño, La Niño, sea surface temperature

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Development of a tool to supplement efficient compilation of Electronic Navigational Chart utilizing paper chart

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Electronic Navigational Chart (ENC) is a new hydrographic product recognized by the international maritime instances as the equivalent of the traditional paper chart and designed to be used in Electronic Chart Display and Information System (ECDIS) onboard ships. The acquisition of data and its permanent updating for the purpose of cartographic production are time consuming, intense and very cost effective, either at human or material resources level. Therefore, there is an inadequate coverage of ENCs all over the world. Though there is a decreasing usage of paper nautical charts, they are still being used with sufficient coverage. Thus, it would be more productive, if the ENCs could be compiled utilizing existing paper charts to enhance its coverage over the world oceans. As the dynamic environment of the sea causes frequent changes in the seabed, ENC production and updating must be quick and frequent. Therefore, the aim of this study was to develop a new tool to supplement efficient compilation of ENCs utilizing paper charts. First, ENC product was obtained based on paper charts following the IHO-S-57 Standard which is known as the transfer standard for digital hydrographic data. Then, considering the difficulties in symbol assigning through the compilation, the new tool Symbol Master was introduced. It is an external tool which can be used as a symbol guide. CARIS the Marine GIS Experts: CARIS S-57 Composer and ArcGIS were the tools that were used for the ENC production and the Symbol Master was developed in the Android Studio environment. An ENC was successfully developed for the Galle Harbour area and the developed tool supports the ENC developer in choosing the appropriate symbols effectively.

Keyword: CARIS, Electronic Chart Display and Information System, Electronic Navigational Chart, IHO S-57

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Mapping land-use changing patterns of Muthurajawela Wetland using GIS and remote sensing techniques

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Urban pressure from rising populations and development projects cause changes in land-use types directly and indirectly. As a unique ecosystem, wetlands are vital in maintaining the balance of the natural processes in the surrounding environment. Muthurajawela Wetland is also under pressure with anthropogenic activities like the recently built Colombo-Katunayake expressway. This study was conducted to analyze land-use changes for both spatial and temporal scales under three different scenarios: before, during and after the expressway construction. Two Landsat satellite images were taken into consideration in each scenario to classify the images into marsh, inland water bodies, boggy areas and urban areas. They were classified using Maximum Likelihood Classification method in ArcGIS (10.5.1) software. Accuracy of the most representative classification was assessed using Kappa statistics derived from an error matrix created from Ground Control Points obtained during the field work and high-resolution images from Google Earth Pro. According to the area calculation, the marsh (52%) was the prominent land-use type in the overall time period. Inland water bodies and boggy areas illustrated changes during four time periods without a continuous pattern and urban areas showed an increment of the land-use coverage during the construction period. Marsh areas decreased during the period of construction. It directly caused the land-use type change and indirectly to the environment. Land-use change in a short time period can change normal equilibrium of the environment and have negative effects.

Keywords: wetland, expressway, land-use changes

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Head/tail breaks for visualization of ocean turbidity using satellite imagery

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Ocean turbidity is a measure of clarity in sea water which is related to the existence of suspended particles. Sri Lanka being an island in the Indian Ocean, needs to carry out research and studies on ocean turbidity in multi disciplines including environmental protection, hydrography, sedimentary deposits, tourism, marine biology and fisheries. In recent research, satellite derived data has been identified as one of the popular alternatives for in-situ turbidity detection. This study intends to capture the underlying turbidity pattern in nearshore of Sri Lanka using head/tail breaks classification scheme which is based on the notion, “far more small things than large things”. Head/tail breaks is applicable for heavy-tailed distributions of data where both the number of classes and the class intervals are determined naturally. Further, a comparison of geo visualization potential has been made with the Jenks natural breaks optimization. In the study, the Normalized Difference Turbidity Index (NDTI) was applied on the images acquired from Landsat 8 sensor during the period January to July 2020 for turbidity detection. High NDTI values exist in river mouths, capes and bay areas of the coastal belt. Heavy tail breaks distribution displayed a more comprehensive turbidity pattern. The study concludes that head/tail breaks scheme provides a more detailed geo visualization while the natural breaks classification scheme is more appropriate for general classifications.

Keywords: head/tail breaks, turbidity, geo visualization, NDTI

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Observed inter-annual variability of the sea surface salinity in the Northern Arabian Sea

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This paper used satellite derived salinity data from Aquarius, SMOS and in-situ Argo float array, to study Sea Surface Salinity (SSS) variability in the North Arabian Sea in inter-annual timescale from 2011 to 2017. In order to understand the applicability, statistical quality checking was conducted on the data sets in the relevant region. Satellite data measurements were compared with in-situ Argo data sets. During the quality inspection process this study found SMOS, Aquarius satellite and Argo data were useful for studying mean state because of their similarity with WOA (09). Compared with Argo and Aquarius, the SMOS satellite data was not suitable for individual measurements due to their large noise. SSS in North Arabian Sea has strong inter annual variability. This variability was mainly associated with the ocean circulation and advection. The study found that 2012 and 2016 as specific years for SSS in the Central North Arabian Sea (CNAS), which were strongly negative and strongly positive anomalies respectively. The low SSS during 2012 is mainly associated with the intense monsoonal activities where low salinity water is advected from upwelling regions of Oman coasts. Due to the decrease of the monsoon strength during 2016, the prevailing high salinity water from the most Northern parts of the Arabian Sea brought high salinity dense water to the CNAS in an extreme manner than in normal years.

Keywords: inter-annual variability, sea surface salinity, Arabian Sea

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Aquatic Biotechnology and Animal Health

Feeding predation in some commercially important scombrid fish: a molecular perspective

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The feeding habits of different types of fish can be studied by analyzing their stomach contents. However, identification of prey items found within the stomach becomes an impossible task when the prey is partially or fully digested. The use of DNA sequencing for identification of prey species becomes very useful in such instances. In this study, the stomach contents of the commercially important fish species, skipjack tuna (*Katsuwonus pelamis*), kawakawa (*Euthynnus affinis*), frigate tuna (*Auxis thazard*) and bullet tuna (*Auxis rochei*) were analyzed for prey identification. Initially a qualitative analysis was carried out for the morphologically identifiable prey items found in the stomachs of the fish. Subsequently, DNA barcoding was carried out for the prey items that were partially degraded, which could not be identified morphologically. The mitochondrial COI region of 13 prey items were amplified and sequenced for identification using already established protocols. Prey items identified by sequencing were cephalopods, while crustaceans and some fish species were also identified. The fish species identified were *Amblygaster sirm* (spotted sardinella), *Sardinella longiceps* (Indian oil sardine), *Euthynnus affinis* (kawakawa), *Selar crumenophthalmus* (bigeye scad) and *Trachinocephalus myops* (lizardfish). Cephalopods identified were *Amphioctopus aegina* (sandbird octopus), *Uroteuthis duvauceli* (Indian Ocean squid) and *Sepia pharaonis* (Pharaoh cuttlefish), while the crustaceans identified were *Penaeus indicus* (Indian prawn), *Metapenaeus dobsoni* (kadal shrimp), *Solenocera crassicornis* (coastal mud shrimp), *Lysiosquilla maculata* (zebra mantis shrimp) and *Percnon guinotae* (crab). The identification of *Euthynnus affinis* as a prey item of frigate tuna shows that these fish feed on juveniles of their own group. These prey item identifications confirmed that the fish species skipjack tuna, kawakawa, frigate tuna and bullet tuna are all nonspecific feeders. This exhibits the value of molecular tools in the identification of prey species which have lost their distinguishable features due to digestion.

Keywords: feeding, prey, molecular identification

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Spatial variation and species diversity of leaping blenny fish (family: Blenniidae) in Southern Coastal region of Sri Lanka

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Leaping Blenny fish are an amphibious group of fish that breathes air without water and live in rocky shore areas. They belong to the family Blenniidae, which includes 345 fish species. There are nearly 35 identified species of leaping blennies in Sri Lanka. Spatial variation of leaping blennies is highly varied with the different habitats and substrates along coastal waters. The present study aimed to identify the spatial variation and species diversity of leaping blenny fish in the Southern Coast of Sri Lanka by using molecular tools. Four distant sites were selected from Ambalangoda to Tangalle, Ambalangoda (6° 14' 07" N 80° 3' 12" E), Pigeon Island-Matara (5° 57' N 80° 32' E), Unawatuna (6° 01' 6" N 80° 15' 9" E) and Tangalle (6° 01' N 80° 47' E). 15 individual fish samples were collected from each site from December 2019 to February 2020 and muscle tissue samples were preserved for DNA extraction. DNA of the tissue samples was extracted and the mitochondrial cytochrome c oxidase I gene was amplified and sequenced. The sequences were matched with the universal database at NCBI for species identification. The genetic relationships among sequences were analysed using Neighbour-Joining method using MEGA X software. As a result of this study, four blenny fish species were identified, *Alticus monochrus*, *Alticus saliens*, *Entomacrodus striatus* and *Entomacrodus vermiculatus*. Among identified species, *Alticus monochrus* was the most abundant blenny fish species in the Southern coastal area and was found in all four studied sites. The least abundant blenny fish species was *A. saliens*, and it was found only in Unawatuna. Species which can be identified as site-specific species are *A. saliens*, *E. striatus* and *E. vermiculatus*. Their average size was approximately 13.5±0.5 cm. All species were identified with more than 92% similarity. Morphometric characters are dependent on environmental conditions and factors such as their growth rate and age. The results of the study show that species identification using molecular techniques is important when morphological identification is questionable. Therefore, morphology together with molecular tools can be used to describe the species richness in poorly studied marine fish groups in Sri Lankan waters. The leaping blenny fish that were sampled formed 2 clades within the phylogenetic tree. *A. monochrus* was found in both clades. *E. vermiculatus*, *E. striatus* and *A. saliens* were restricted to only one clade. This provides evidence that *A. monochrus* shows more spatial variation than the other species. However, more sampling is required to verify these findings.

Keywords: Leaping blenny fish, Blenniidae, molecular tool

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A new *Decapterus* species record: *Decapterus maruadsi* from Sri Lankan waters

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Decapterus species locally known as “Linna” belonging to family Carangidae (jack family), consists of mackerel scads, round scads and horse mackerel. The species belonging to this genus shows a wide distribution in the Indo-Pacific Ocean. The most common *Decapterus* species found in the Indian Ocean are *Decapterus macarellus*, *D. macrosoma*, *D. russelli*, *D. tabl* and *D. kurroides*. However, only three species, *D. macarellus*, *D. macrosoma* and *D. russelli* have been recorded in Sri Lanka so far. Due to similarities in morphological characters, the species level identification of *Decapterus* species is sometimes misleading and the species that inhabit Sri Lankan waters is still debatable. Therefore, the present study was carried out to examine the *Decapterus* species that inhabit Sri Lankan coastal waters using DNA based methods. The Dr. Fridtjof Nanson ecosystem survey was carried out to study the marine biodiversity in Sri Lankan waters. From the pelagic and bottom trawl catch of the survey, 65 samples representing all areas around the country were used for the genetic analysis. Muscle samples were preserved in 100% ethanol and DNA was extracted by the Qiagen's DNeasy Blood and Tissue Kit. Mitochondrial Cytochrome c oxidase I (cox1) gene with 630 bp was amplified by Polymerase Chain Reaction (PCR) by using Fish-F1 and Fish-R1 primers. PCR products were sequenced using Sanger sequencing method. Sequence similarities were checked by using NCBI BLAST service. All the sequences were aligned with more than 98% sequence identities with the existing sequences in the NCBI database. The study revealed the presence of four species *D. russelli*, *D. macarellus*, *D. macrosoma* and *D. maruadsi*. Importantly, *D. maruadsi*, mostly recorded from the East Indian and West Pacific Oceans, was found as a first record in Sri Lankan waters. The new species record may be due to the migration of the species as a result of the marine environmental climatic changes or sometimes the newly recorded species may not have been identified due to morphological features not being very clear. Phylogenetic relationships among species were assessed using Neighbour Joining method in MEGA 10 software with 1000 bootstrap value by using *Selar crumenophthalmus* as an out group species. This analysis revealed that *D. russelli* and *D. maruadsi* also share a close phylogenetic relationship while *D. macrosoma* and *D. macarellus* share a close phylogenetic relationship. This preliminary study showed that there is more species diversity in Sri Lankan marine waters beyond the existing known range and emphasizes the need for broad range exploration of species using genetic methods with morphological identifications in the future.

Keywords: *Decapterus* spp., *D. maruadsi*, CoxI gene, Dr. Fridtjof Nanson survey

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Identification of morphologically similar reef fishes (Perciformes, Lutjanidae) using a molecular approach

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Reef associated fish species can be commonly found in coral reef ecosystems. In Sri Lanka, reef fishes are a popular source of food in local and export markets. Close characters among some reef fish species cause difficulty in distinguishing the correct species only by looking at their morphology. For instance, *Lutjanus quinquelineatus* and *Lutjanus notatus* are very similar in morphology. Mis-identification of fishes at their species level will cause mis-predictions which will affect fisheries management decisions. Hence, it is very important to identify fish to their correct species level for sustainable conservation and management. It has been proved that biotechnological applications can be used to identify fish up to their correct species level accurately by using species-specific molecular tags. This preliminary study was carried out to study the DNA barcodes of *Lutjanus quinquelineatus* and *Lutjanus fulviflamma*, two economically important reef fish species of Sri Lanka. Muscle samples were preserved in 100% ethanol and DNA was extracted from twelve samples (six from each species) using Qiagen's DNeasy Blood and Tissue Kit. Polymerase chain reaction was carried out for the common fish "barcode" region of mitochondrial COI gene using Fish F1 and R1 primers. PCR products were bi-directionally sequenced and sequencing results were analyzed by using BioEdit and bioinformatic tools in NCBI BLAST. Sequence alignment with NCBI BLAST search resulted in more than 99% identity. The results implied that many species were mis-identified such as, *Lutjanus quinquelineatus* (Five-lined snapper) as *Lutjanus notatus* (Blue-striped snapper), *Lutjanus fulviflamma* (Black-spot Snapper) as *Lutjanus johnii* (John's snapper). Multiple sequence alignment of the *Lutjanus notatus* resulted in Single Nucleotide Polymorphisms in the 135th (G/T) and 249th (C/T) bp positions, showing that there are a few nucleotide level variations among the individuals of the same species. The study showed that there have been mis-identifications in some reef fish during field data and sample collection, which emphasize the fact that it is very important to upgrade the current reef fish guide in Sri Lanka and identification of correct morphological features to discriminate reef fish species accurately to prevent such errors in future.

Keywords: *Lutjanus*, morphologically similar species, DNA barcoding

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Pacific oyster (*Crassostrea gigas*) microbiome in the pathogenesis of *Ostreid herpesvirus-1* (OsHV-1) infections

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Mass mortality disease outbreaks in Pacific oysters (*Crassostrea gigas*) have been reported globally, leading to drastic economic losses. Although *Ostreid herpesvirus-1* (OsHV-1) have been identified as a major pathogen associated with this heavy mortality, the oyster microbiome is also thought to play a role resulting in a polymicrobial pathogenesis. Hence, this study focused on evaluating the changes in the oyster microbiome, with particular reference to *Vibrio* spp., during progression of an experimental OsHV-1 infection. Pacific oysters (n=348) that were grown in three estuaries and free from OsHV-1, were recruited to the laboratory. Following an acclimation period of three days, the oysters were challenged with OsHV-1 (6.5×10^5 OsHV-1 DNA copies μL^{-1}) by intra-muscular injection and were sampled on days 0, 1, 2, 3, 5 and 7 post-injection. OsHV-1 and *Vibrio* genomic DNA in nucleic acid extracts were quantified using real-time PCR assays while that from oysters before (A) and soon after OsHV-1 challenge (B); moribund oysters (C); survivors of OsHV-1 (D); and oysters that were not challenged with the virus (E), were used for microbiome analysis. The microbiome was identified by sequencing and analyzing the bacterial 16S rRNA gene (V1-V3). The bacterial diversity in oyster tissues changed after OsHV-1 injection ($p < 0.05$). Oysters with the highest mortality also had the highest quantity of OsHV-1 and *Vibrio* ($p < 0.05$). This group also had a higher initial bacterial diversity which decreased in the moribund oysters ($p < 0.05$). The diversity of the microbiome of surviving and control oysters from two estuaries did not change compared to their pre-challenged counterpart. A strong correlation was observed between OsHV-1 and *Vibrio* quantity in OsHV-1 infected oysters ($r = 0.6$; $p < 0.001$). In conclusion, the higher *Vibrio* load with higher OsHV-1 DNA content and higher mortality suggests a role of *Vibrio* in mortality associated with OsHV-1 infections. Further studies are needed to evaluate the direct and indirect influences of *Vibrio* and other members of the resident microbial community of oysters during OsHV-1 infection.

Keywords: *Crassostrea gigas*, microbiome, *Ostreid herpesvirus-1*, Pacific oyster

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Fisheries Socio-Economic and Marketing

The importance of processed food trade: A case study of the seafood trade in Sri Lanka

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World demand for processed seafood has increased due to the limitation for fine-dining outside the houses with the lockdown situation of the COVID 19 pandemic. Emerging opportunities in the processed seafood market could be a great advantage for Sri Lanka to earn more foreign income. But access to the international seafood market is a tough challenge because that market is severely controlled by Non-Tariff Measures (NTMs). This research intends to quantitatively compare the impact of NTMs between processed and unprocessed seafood, and the research qualitatively explores ground-level barriers to upgrade raw seafood production up to processed seafood production. The international data sources were extracted to prepare a panel dataset that included 107 products in level six of the harmonized system (HS-6) exported to 107 countries between 2001 and 2019. The primary data were collected through face-to-face interviews with 75 of the key players in the seafood value chain by using pre-tested questionnaires during 2019. Significantly high NTMs and tariff rates are enforced on processed seafood (NTMs-24, tariff-17%) than unprocessed seafood (NTMs-19, tariff-9%). Processed food production enhances labour usage of the country because 3.5 human hours are required to produce one kilogram of raw seafood while 5.5 labour hours are required for processed seafood. The revenue from seafood export can be increased 44% through processed seafood export because of the price of processed seafood (USD 26) and the price of raw seafood (USD 18). However, only one percent of the Sri Lankan processed seafood adds value up to the ultra-processed level. This study found that the elasticity values of tariff and non-tariff measures (NTMs) are very much higher for processed seafood than the unprocessed seafood (0.91 and 0.20). The conversion of unprocessed seafood into processed seafood can improve the export revenue but will increase the vulnerability of seafood exports due to the stringent NTMs. It is recommended to improve postharvest quality along the seafood value chain, product diversification, and institutional support to comply with NTMs and multilateral trade agreement with the importing country to shield the negative impacts of NTMs.

Keywords: processed seafood, non-tariff measures, gravity model, export performance, Sri Lanka

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Analysis of marketing performance of herring (*Amblygaster sirm*) supply chain in the West Coast of Sri Lanka

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Herrings are one of the dominant fish species in the coastal fish catch in Sri Lanka and also one of the highly consumed small pelagic fish species in the country. It is important to evaluate dynamics of supply chains of fish production in order to capture the changes in the supply chain that take place with the changes of technology and the socio-economic conditions of the country. Therefore, this study was undertaken to investigate key economic agents, their roles and functions in herring fisheries and to estimate the economic efficiency of the various marketing channels. The study was conducted in the West Coast in Sri Lanka covering Negombo, Chilaw and Puttlam fisheries districts. Data were collected from 100 value chain participants using a questionnaire survey conducted from January to August 2020. The marketing channels were mapped and those were analysed by using three marketing performance indices; marketing efficiency index, average composite distance in km and fishermen share in consumer rupee. Five dominant supply channels were identified and named based on the unique agent found in each supply chain; wholesaler's channel, mobile vendor's channel, road side vendor's channel, Ceylon Fisheries Corporation (CFC) channel and super markets' channel. The results revealed that the majority of marketing channels were dominated by the assembler. The highest marketing cost was incurred by the supermarkets (LKR 40/kg) followed by the CFC outlets (LKR 33/kg) while the lowest was from wholesaler (LKR 17/kg). The highest marketing efficiency index (1.98) was reported by mobile vendors' marketing channel whereas the highest fishermen share in consumer rupee was found in the CFC channel. The highest average composite distance in km was reported in the wholesaler's channel. However, based on the overall marketing performance, evaluated based on concerned three performance indices, CFC channel was the best marketing channel for the herring fishery in the study area, in which both the fishermen and the end consumers were benefitted.

Keywords: composite distance, fishermen share, marketing, marketing efficiency index

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Consumer preference of inland fish consumption in urban and rural fish consumers with special reference to Colombo and Polonnaruwa Districts of Sri Lanka

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Inland fishery and Aquaculture production show an increasing trend in Sri Lanka at present. However, lack of demand and low price have badly affected aquaculture fish supply and inland aquaculture in the country. Therefore, this study was conducted to identify the consumers' preference level and to find out challenges and opportunities in the value chain of inland fish specially tilapia. Data were collected via interviews based on structured questionnaires completed by randomly selected consumers (304) of Polonnaruwa and Colombo Districts. The data were analyzed using SPSS software, and descriptive statistics and Cross tabulation was used to examine differences between preference levels of two different districts. Results revealed that a higher quantity of marine fish was consumed by the consumers of Colombo (5.11 kg), while a higher quantity of inland fish was consumed by the consumers of Polonnaruwa District (5.38 kg). Around 98% of consumers of Polonnaruwa District preferred to purchase tilapia for their consumption, while only 38% of consumers in the Colombo District liked tilapia. Consumers of the Colombo District stated that unavailability of tilapia fish in the market and the lack of attractiveness of the outer appearance are barriers of tilapia fish consumption. According to the significance value (.000) of chi-square, it is clear that the consumer preference for tilapia is higher in Polonnaruwa than in Colombo. It is recommended to conduct consumers' awareness programmes and consumers' surveys on cooking systems and programmes on identification of the quality of fish. To improve the fish supply chain, implementing management plans for the tanks that are not administrated by National Aquaculture Development Authority (NAQDA), Ceylon Fisheries Corporation (CFC) involvement in fish purchase and Public, Private and fishers' community participation for Inland fisheries are recommended. Institutional coordination to minimize illegal fishing is also important to improve productivity of the tanks.

Keywords: consumers' preference, tilapia fish consumption, value chain analysis

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Effects of procurement practices on the performance of public sector organizations: with special reference to the National Aquatic Resources Research and Development Agency (NARA)

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For any organization, procurement is an important and expensive business activity as organizations spend a considerable amount (>70%) of their revenue and operational budget on goods and services. Thus, the main objective of the present study was to establish the role of procurement practices on the performance of NARA. The specific objectives were to set up a procurement planning procedure on the performance of NARA. It was indirectly expected to determine the role of procurement controls on the performance of NARA, to establish the role of procurement monitoring and to examine the role of staff training. The study adopted the Descriptive Research Design (DRD) and the selected study population was the procurement personnel in NARA. Stratified random sampling and simple random sampling techniques were employed with the 40 respondents. The study showed that procurement planning, controls, monitoring and staff training in procurement practices are playing a major role in the performance of NARA. It is recommended to review the existing procurement practices and to implement all suggestions made for improving organizational performance which will be assessed by the different criteria explained in the framework, such as procurement planning, procurement controlling, procurement monitoring and staff competency.

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