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"Innovative Aquatic Research Towards Blue-Green Economic Development"

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

National Aquatic Resources Research and Development Agency

International Scientific Sessions - 2018

"Innovative Aquatic Research Towards Blue-Green Economic Development"

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Colombo 15
Sri Lanka

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Fisheries and Aquaculture

Maturity and gillnet selectivity of *Sardinella gibbosa* (Clupeidae) in small-meshed gillnet fishery along the West and Northwest coasts of Sri Lanka

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Many of the coastal fish resources in Sri Lanka are being threatened due to many reasons including over exploitation. *Sardinella gibbosa* is one of the key species available in commercial landings and are mainly harvested using small mesh gillnets. The present study on gillnet selectivity for *S. gibbosa* was conducted in the West and Northwest coasts of Sri Lanka from January to December 2017, to determine the optimal length of fish being caught for each meshed gillnet with respect to length at maturity and to provide mesh size regulations towards the sustainability of the resource. Total length of fish against different mesh sizes used in the fishery were collected in each month at the main fish landing sites; Kandakuliya, Chilaw, Negombo and Beruwala. Ten percent of total operated boats were sampled at each field visit. A total of 1367 fish which were randomly selected at the landing sites analysed for their maturity. The study revealed that gillnets having a wide range of mesh sizes (2.03, 2.29, 2.54, 2.7, 2.86, 3.02, 3.33, 3.49 and 3.81 cm) to catch *Sardinella* sp. while the mesh sizes of 2.03, 2.54, 2.86 cm are being widely used. The total length of recorded *S. gibbosa* in the commercial fish catch ranged from 8.0 cm to 16.5 cm. The optimum selections of fish lengths for mesh sizes of 2.03, 2.54, 2.86 cm were 8.98, 10.92 and 11.93 cm respectively. Also the selection factors for above these mesh sizes were 4.42, 4.29 and 4.17 cm respectively. Using the probability of capture, gillnet selection curves were constructed for the three mesh sizes. According to the maturity study conducted, it was confirmed that the length at 50% maturity of *S. gibbosa* was at 12.0-12.5 cm. Further, it was determined that gillnets with mesh sizes of 2.03 cm and 2.54 cm mainly target immature fish (below 12 cm) and the study further revealed the necessity of restricting certain mesh sizes in order to avoid recruitment overfishing.

Keywords: small pelagic fishery**,** gear selectivity, length at maturity, *Sardinella gibbosa*

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Current status of the spiny lobster fishery in Hambanthota District

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Spiny lobster fishery in Sri Lanka is a small-scale artisanal fishery which provides significant support for coastal livelihoods of some districts. The coastal stretch of Hambanthota District from Tangalle to Kirinda provide habitats for five species of spiny lobsters and this district has been identified as the major lobster producing area of the country. Overharvesting of the resource with increasing demand, violation of the South coastal spiny lobster regulations implemented in year 2000 and environmental degradation such as habitat losses are identified as key issues for the declining of the stock. For implementation of a proper management mechanism to maintain the stock at a sustainable level, the knowledge on current status of the fishery is important. Major spiny lobster landing sites and collecting centers in the Hambanthota District were visited twice a month from March 2017 to November 2017 except in the months of September and October. Biological data (species caught, sex, carapace length. (CL) and total length (TL), presence or absence of external eggs), and fisheries data (craft and gear used, total catch (kg) were obtained. Lobsters are commercially harvested in Hambanthota District mostly using bottom set gill nets of mesh sizes ranging from 3 ½'' to 4 ½'' (85.2%) and traps (14.8 %) are rarely used. Among the three types of crafts, fiber reign forced plastic boats (FRP), motorized traditional craft, and non motorized traditional crafts operated in lobster fishery, 56% of the fishermen use None Motorized Traditional Crafts (NMTC) for fishing operation which are vulnerable to bad weather condition during the Southwest monsoon period. Scalloped spiny lobster *Panulirus homarus,* the dominant species contributed 85.6 percent (n=1828) to the catch and two more species *P. penicillatus* and *P. versicolor* contributed 5.77% (n=132) and 5.9% (n=137) respectively. *P. longipes* and   *P. ornatus* were found to be rare species in the catches *(n=32 and 37)*. Number of undersized lobsters of *P. homarus* (CL > 6.0 cm) found in the catches was very small (n=29, 1.6%) but more than half (59.6 %) of the *P. ornatus* are below the minimum legal size (CL > 10.0 cm). Modal length class (CL) of the dominant species was 6.5-6.9 cm and the annual mean length of the species for combined sexes, males and females are 7.17±1.87 cm, 7.12±2.41 cm and 7.18±0.96 cm respectively. The mean carapace length of *P. versicolor* (8.08 ±4 cm) is bigger than other three species except *P. ornatus*. Average annual (Except closed season) egg bearing percentage (to total female) of the females in the catch 41.54% is considerable amount. Within the months of August and November 57 and 50.3% of egg removed females (to total female) of *P. hamarus* were found in the catch respectively. Therefore, strictly enforcement of the implemented regulation regarding conservation of berried female is strongly recommended.

Keywords: Hambantota, spiny lobster, *P. homarus*

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Assessment of present status of sea cucumber fishery in Mullaithivu District

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Fisheries industry is one of the major export industries which contribute significantly to the Sri Lankan economy. Among those, Sea cucumber fishery plays an important role in the Sri Lankan fisheries export market due to the high value of this commodity in the export market. Diving with Self Contained Underwater Breathing Apparatuses (SCUBA) is the major fishing method for above fishery. Current study is conducted to assess current status of the sea cucumber fishery in Mullaithivu District, which supply significant amount of sea cucumbers to the export market. Fishermen's personal recorded data were collected throughout the fishing season from April to October; 2017 along the coast of Mullaithivu where fishermen are concentrated. For that period, 297 permits had been issued for SCUBA diving by the Department of Fisheries and Aquatic Resources for sea cucumber and chank fishing in particular district. During the study, it was observed that the *Bohadschia marmorata* (96%) is the most prominent species caught in day fishing while *Holothuria spinifera* (3%) was the second largest species caught. *Actinopyga miliaris*, *Bohadschia vitiensis* and *Thelenota anax* were in minor quantities (less than >1%). In the month of July, the catch was peaked and the average catch per boat per day was about 1500 individuals. The majority of the catch was comprised of medium size (12-15 cm) (59%) and small size (10-12 cm) (32%) immature (L_{50} is 20 cm) *B. marmorata* individuals in both night and day catches. *H. spinifera* (72%) is the most prominent species in the night fishing. However, *B. marmorata* was the most harvesting species contributed around 76% of the total catch while *H. spinifera*; was the second most harvesting species (23%). It was revealed that the present stock status of the commercially important sea cucumbers is in finest condition with compare to other areas but, extensive removing of immature individuals for a longer period could be caused for a depletion of stocks within a short time period. Therefore, it is recommended implementation of an effective harvest control rule in particular by limiting fishing operation licenses with other management measures like minimum size regulations.

Keywords: sea cucumber, stock status, catch

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Fisheries and some aspects of reproductive biology of sandbird octopus, *Amphioctopus aegina* (Gray, 1849) in the Northwestern coastal waters of Sri Lanka

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Exploring unexploited fishery resources with high export potential is beneficial for a country like Sri Lanka. At present, there is no target fishery for octopus in Sri Lanka and they are mainly landed as a by-catch of the trawl fishery. This study aimed to find out the fishing potential of newly introduced fishing gear and to explore some aspects of reproductive biology of *Amphioctopus aegina*. The study was carried out from January to December, 2017 at Pesalai and Pukkulam. Fishing potential was explored using newly introduced fishing trap by means of experimental fishing trials. Mean catch rates were examined under different soaking times in terms of number of days. Catchability of individuals at different depths was tested. Catch and effort data were also obtained from the trawl catches at Pesalai since the particular species is landed as a by-catch in trawl fishery. Variations in Gonado Somatic Index (GSI) of *A.aegina* were assessed to find out reproductive seasonality. Sex ratio and the size at first sexual maturity (L_{50}) were also analyzed. The highest mean catch rate, 58 individuals/100 traps was recorded for 15 days soaking time. It was also noticed that the highest average number of individuals were captured at the depth of 10 m. The peak spawning season reported in October, preceded by July and February, respectively. Male to female sex ratio was 3.8:1, while the lengths (Dorsal Mantle Length) at first sexual maturity (L_{50}) for males and females were 6.2 cm and 5.1 cm, respectively. Catch and effort analysis showed that 10 % of trawl catch represented by octopus, remarkably dominated by *A. aegina*. The study concluded that there is a reasonably high potential for harvesting octopus using the new trap while, it mostly depends on the soaking time. Catch proportion provides an initial evidence for resource availability and potential for developing an octopus fishery aiming an export market. However, a quantitative assessment needs to be carried out to determine the true potential of the resource for sustainable exploitation. Further, the findings on length at sexual maturity and spawning season reveal when and at which length the octopus should not be harvested and therefore it is important for the proper management and conservation of its stock.

Keywords: *Amphioctopus aegina,* GSI, fishing trap, soaking time, Sri Lanka

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Effect of lunar phase on swordfish (*Xiphias gladias*) catch rates in the Indian Ocean

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Swordfish (*Xiphias gladias*) is billfish which primarily oceanic, epipelagic species cosmopolitan in tropical and temperate waters. Swordfish are caught by mainly longline fisheries in the Indian Ocean. It is still a debate the impact of lunar phase for catches of swordfish and other billfishes. The purpose of this study was to investigate potential relationships of lunar cycle and catch rates of swordfish in Sri Lankan offshore/high-seas fishery. Fishing operations from 2006-2012, consisting 821 catch events were used in this study. Since most longline fishing is done at night, the proportion of the illuminated lunar disk was used as a proxy for relative light levels during the fishing operation. One-way ANOVA statistical analysis was conducted using R-statistical software. Results of ANOVA revealed that there is no significant difference ($p > 0.05$) between the catch rates of billfishes due to the lunar cycle. Geographical locations, fishing methods, fluctuations of environmental parameters and differences in feeding strategy may be contributing for the catch rates.

Keywords: swordfish, *Xiphias gladias*, lunar effect, Indian Ocean

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Development of formulated diets for culture of seabass (*Lates calcarifer*, Bloch) juveniles in floating net cages

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This study was carried out to develop nutritionally balanced and cost-effective diets for culture of seabass juveniles using locally available fish meal varieties. Three experimental diets were prepared using locally available feed ingredients and three fish meal; D1: CM fishmeal, D2: Agristar fishmeal and D3: Seychelles fishmeal. Thai Union Feed No. 904 (D4) used as the control feed. A total number of 624 seabass juveniles with an initial weight of 86.84±2.14 g were equally and randomly distributed in 12 experimental floating net cages of 1.4 m x 1.4 m x 2 m, installed in the Negombo Lagoon. Each experimental diet was randomly assigned to these cages in three replicates. Sample consisting of 10 fish from each net cage was weighed bi-weekly to adjust the feeding rate. Feeding was done twice a day up to satiation and recorded the actual weight of feed consumed by fish in each net cage. Cages were cleaned weekly to facilitate water exchange. After 66 days all fish in each cage counted and weighed. The diet D1 that was incorporated with CM fish meal showed significantly ($p<0.05$) poor growth performance and Feed Conversion Ratio (FCR) than other three diets D2, D3 and D4. However, diets D2, D3 and D4 did not show significant difference ($P>0.05$) on the growth performance (final weight, weight gain and specific growth rate) and on the FCR. The overall mean (mean ± SE) survival rate of the fish fed with four diets was 93.93 ± 3.25% and was not influenced significantly by diets ($p>0.05$). The production cost of the diets D1, D2 and D3 was 165, 155 and 225 Sri Lankan Rupees (LKR) respectively, while the cost of commercial feed D4 was 330 LKR. Based on the results of this study D2 was identified as the most cost-effective feed for the culture of seabass juveniles in floating net cages.

Keywords: seabass, formulated feeds, FCR, growth performance

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The effect of fish meal protein replacement with corn protein concentrates (EMPYREAL 75, CARGILL CORNMILLING, USA) in nursery diets of koi carp fry (*Cyprinus carpio*)

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Thirty five days feeding experiment was carried out with koi carp (*Cyprinus carpio)* to determine the possibility of replacing fish meal (FM) by corn protein concentrate (CPC) in formulated diets. Three hundred fry of koi carp (initial average body weight (BW) 0.195 g) were randomly and equally distributed in to the 15 glass tanks (capacity 45 L), fed with five different isoenergetic (gross energy, 3200.29 ± 0.25 kcal kg^{-1}) and isonitrogenous diets (protein content, 382.26 ± 6.09 g kg^{-1}). Triple nine fish meal was used as the control diet as well as the sole protein source, the other four diets were prepared by replacing FM protein levels of 25 %, 50 %, 75 % and 100 % with CPC. Three replicates were maintained for each treatment. All the experimental diets were readily accepted by the fish and no mortality were recorded during the trial. The results of the experiment indicated that there were no significant differences in Feed Conversion Ratio (FCR), Specific Growth Rate (% SGR) and Protein Efficiency ratio (PER) of koi ($P < 0.05$) fed the diets with 25% and 50% replacement levels compared with the fish offered the control diet (100 % FM), however, the final BW and specific growth rate values in the 50% replacement diets were about 40.23% and 14.67% higher than those of the control. The length-weight relationship (LWR) revealed the positive allometric relationship (regression co-efficient, b- values ranging from 3.53- 4.50) in control diet and 50% replacement diet respectively. It indicated that those diets are in favor of increase in body mass of fish than in length under the experimental conditions. The highest PER and dry matter digestibility recorded at the FM 50 % replaced diet. After end of the 35 days experimental period, it was found that higher SGR (1.46 ± 0.52), PER (0.94 ± 0.29), survival (100 ± 00), lower FCR (3.22 ± 0.76), highest dry matter digestibility (65.16 ± 0.00) and positive allometric growth were obtained by feeding koi with the diet of 50% replaced FM by CPC. Therefore, 50% of FM protein can be replaced by CPC without loss in growth performance under the condition of this study.

Keywords: koi, corn protein concentrate, fish meal, growth performance

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Partial replacement of local fish meal by brewers yeast (*Saccharomyces cerevisiae*) in the diets of sea cucumber (*Holothuria scabra*) juveniles

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The effects of brewers yeast in juvenile sea cucumber diets were investigated to examine the appropriate replacement level of CM fish meal® by dry brewers yeast powder. The feeding trial was conducted in a re-circulating tank system of the hatchery of Regional Research Center, NARA, Kalpitiya for 55 days. Four diets (T_1: 0% of brewers yeast (Basal diet; Control); T_2: 10% of local fish meal (LFM) replaced by brewers yeast; T_3: 30% of LFM replaced by brewers yeast; T_4: 50 % of LFM replaced by brewers yeast) were formulated. Twelve round and conical fiberglass tanks of 250 Lwere used and each feed randomly assigned to three replicates. 144 sea cucumber juveniles averaging 0.88±0.04 g were allocated into12 tanks as12 juveniles per each. After 55 days of feeding trial, final body weight, percent weight gain (PWG) and specific growth rate (SGR) of fish fed T_1 was significantly lower than those of fish fed T_2 ($P<0.05$). SGR of fish fed T_2 was significantly higher than that of fish fed T_4 ($P<0.05$). No significant differences were recorded in final weight and PWG of fish fed T_1, T_3 and T_4 diets ($P>0.05$). No significant differences were recorded in SGR of fish fed T_1 and T_3, T_3 and T_2; and T_1 and T_4 ($P>0.05$). The results of the study showed that the optimum replacement level of CM fish meal® by brewers yeast was closer to 10% without any effect. However increasing levels of Brewers yeast in the diet of sea cucumber can produce adverse effects. Also it shows brewers yeast would be a potential feed ingredient to enhance the growth and survival of juvenile sea cucumber (*Holothuria scabra*).

Keywords: brewers yeast, local fish meal, juvenile sea cucumber, *Holothuria scabra*

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Partial replacement of fish meal by cassava leaf meal in the diet of *Xiphophorus maculatus* juveniles to improve their growth parameters

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Feed industries need to identify cost-effective protein sources to replace fish meal in the feed due to limited supply and high price. Cassava Leaf Meal (CLM) was evaluated for its ability to partially replace fish meal in the diet of *Xiphophorus maculatus* (platy) juveniles. Four experimental diets were prepared at $33.5\pm2.1\%$ crude protein level by replacing 0%, 5%, 10%, and 15% of fish meal by CLM, where the 0% served as control. Ninety six individuals of 21-days old mixed-sex platy juveniles (0.185 ± 0.012 g per fish) were randomly allocated to 12 glass tanks ($60\times30\times30$ cm^3 each) at a stocking density of 8 fish per tank. Each treatment had three replicates. The diets were fed to the juveniles daily up to satiation for six weeks. Feed consumption, Livebody Weight (LW), Live Weight Gain (LWG), Specific Growth Rate (SGR), Feed Conversion Ratio (FCR), and survival were measured on fish samples and analyzed in SAS software package. The results showed that mean daily feed consumption of *X. maculatus* was significantly high ($P<0.05$) at 0% ($5.19\pm0.89\%$ of LW) and 5% ($5.25\pm1.08\%$ of LW) inclusion level of CLM. Final LW was significantly high ($P<0.05$) at 5% inclusion level of CLM (0.31 ± 0.03g). Average LWG and SGR were significantly high ($P<0.05$) at 0% ($59.40\pm27.63\%$ and $2.91\pm0.24\%$) and 5%(68.8% and $2.87\pm0.13\%$) inclusion levels of CLM. In conclusion, current study shows that CLM can replace the 5% of fish meal in the diet of *X. maculatus* juveniles without compromising their normal growth.

Keywords: *Xiphophorus maculatus*, cassava leaf meal, specific growth rate

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Field trial for evaluating the acceptance of formulated feed for fattening of mud crab (*Scylla serrata*)

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Fattening of water crabs (mud crabs with low flesh content) is popular among small scale crab farmers as market price of fattened crabs is several folds higher, when compared to that of water crabs. Considering the vast resources of brackish water areas available in the country and the potential of crab farming as a foreign exchange earner, Government is promoting both small scale and large scale crab farming in the country. Use of trash fish is the traditional method of feeding crabs under fattening/grow out culture. As the availability of trash fish is a limiting factor due to its seasonal changes, an economically profitable nutritious feed is a timely need to meet the increasing demand for crab fattening and culture activities. Experimental crab fattening trials (T1-T3) in triplicate were conducted using two formulated feeds F1 (protein 40%) and F2 (protein 32.5%) with trash fish (F3) as the control feed. Each cage (4ft x4ft x 4ft) were separated into 08 equal compartments/ rooms containing a single crab in each compartment to avoid cannibalism. Water crabs with initial weight of 164.5±26.6-189.5 ±1.5 g were stocked at the rate of eight crabs in each of the 8 compartments in each cage. Experiment was conducted for 21 days until hardening of shells. Study results showed that the crabs fed with three different feeds F1, F2 and F3 had 82.6 ±9.18,44.85±1.4and58.76±39.9 percentage weight gain (p> 0.05)   respectively. According to the results the treatment T1, T2 and T3 indicated that there was no significant difference (P>0.05) in specific growth rate 2.87± 0.23 ,1.76 ± 0.04 and1.97 ± 1.25 respectively), food conversion ratio (1.28±0.14, 2.35±0.07 and 3.6±2.83 respectively) and the food efficiency ratio (0.78±0.08, 0.42±0.01 and 0.53±0.38 respectively). Survival rates were similar (87.5%) in both T1 and T3 where in T2 it was 81.5%. Results of the present study revealed that crabs are accepting formulated feeds either under fattening and/or grow out culture and feed containing 32.5% protein also can be used without any significant effect on growth.

Keywords: formulated feed, crab fattening, protein

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Some important aspects of manta ray landed at three major fishery harbours in Sri Lanka

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Present study provides some information about the current status of the manta ray fishery in Sri Lanka based on the data obtained from three major fish landing sites namely; Mirissa, Beruwala and Negombo. Data were collected from January to December, 2017. Manta rays are mainly caught as a by-catch of tuna fishery by the inboard engine multiday fishing boats operated with gillnets of mesh size 6'' and 5 ½''. Two species of manta rays namely; *Manta birostris* and *Manta alfredi* were recorded during the present study. Of the observed 46 specimens, *Manta birostris* represented 96% of the total catch and the largest specimen observed had a Disc Width (DW) of 432 cm while the smallest specimen had a DW of 118 cm. The estimated average DW during the study was 262 cm. Among the observed individuals, *M. alfredi* included only 4% of the total catch and the largest had a DW of 197 cm, while the smallest had a DW of 129 cm. The estimated average DW of *M. alfredi* was 162 cm. Of the observed specimens only 5% were adults while the remaining 95% represented immature and sub adults, indicating that nursery grounds might be located close to the fishing grounds. Therefore, releasing of live manta rays entangled in fishing gear is recommended as a conservation and management measure.

Keywords: manta, *Manta birostris*, immature, adults

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Growth, reproductive biology and stock structure of *Euthynnus affinis* (kawakawa) in Sri Lankan waters

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The growth conditions of a fish species can be assessed by several indicators such as the length-weight relationship, Fulton's condition factor and Hepato-Somatic Index (HSI). To study the growth conditions of the neritic tuna species *Euthynnus affinis* (kawakawa), fish samples of this species were collected from different coastal areas of Sri Lanka representing the Southern, Western, North-Western and Eastern provinces. A total of 483 samples were collected from October 2015 to September 2017. The weight range of the fish samples collected was 45 to 3590 g and the length range was 16.1 to 63.3 cm. The largest fish sample was collected from Beruwela. The length - weight relationship for the species was $W=0.13L^{3.124}$. The power value of this equation being over 3 indicates that the species has a positive allometric growth pattern. The Fulton's condition factor (K) was shown to be 1.43 and the HSI showed a high value, indicating high energy reserves in the species. The K factor being higher than 1.4 and the HSI being a high value throughout, show that the fish are in a less polluted, healthy growing environment and are showing a healthy growth pattern. The length at first maturity was shown to be 46 cm. The GSI peaked during May and October indicating that the spawning season of *E. affinis* is during this period. Nineteen mitochondrial D-loop region sequences of *E. affinis* samples collected were used to determine the origin of the stocks of the different areas studied. These sequences revealed that there is a single stock of *E. affinis* in all the regions studied.

Keywords: kawakawa, *Euthynnus affinis*, growth, length-weight relationship, stocks

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Performance of newly developed culture basket types for suspended rack culture of edible *Perna perna* (brown mussels) in the Puttalam Estuary, Sri Lanka

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It is essential to find out suitable culture method to increase the community based farming of edible *Perna perna* in Puttalam Estuary. The present study was carried out to select appropriate culture method to investigate the growth and convenience of handling in *Perna perna* culture in relation to prevailing water quality parameters in the existing culture sites in Puttalam Estuary, Sri Lanka. Experimental culture of *Perna perna* (brown mussels) was conducted using hanging type newly developed culture structures at oyster farming location. Spats were collected from Negombo Lagoon and brought to the culture location. Three types of culture structures were studied; plastic box structure, round pouch made by flexible net and round pouch made by hard net. Culture structures were hanging vertically from wooden framed racks allowing them to be compared. After the seven months of culture period, there was no significant difference in growth rate (GR_L) of cultured *Perna perna* in three different culture structures over the experimental period ($P < 0.05$). The highest final length was obtained in plastic box structure. There was no significant difference in growth rate (GR_W) ($P > 0.05$) against the tested culture structures in Anawasala (Janasavipura) farming site. Suspended rack culture, the plastic box structure seemed preferable because it was stronger, lasted longer and allowed easy handling, cleaning and maintenance. Material cost is not different with other two structures and relatively easy to purchase compared to hand made other two structures. The physical water parameters at the location were not greatly different.

Keywords: *Perna perna,* rack culture, Puttalam Estuary

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The impact of using winch for beach seine fishery in the Northwest coast of Sri Lanka

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This study was undertaken from Pukkulam to Sindathriya from January to April and October to December 2017 with the aim of investigating the impact of using winch for beach seine fishery. Initially, a framework survey was carried out along the study area to identify the beach seine centers and operation procedure. Out of 173 beach seine centers, 6 manual operators (Lansigalma, Udappuwa, Thalawila) and 6 winch operators (Sinnapaduwa, Mokkuthoduwawa Mohoththuwarama) were selected as sampling sites. The selected beach seine landing sites were visited two times per month to collect information on fish catch, fishing gear details, fishing duration, distance from the coast to operating area, hauling procedure, species composition of the catches and labour involvement. The study showed which is the estimated mean value of operational length from the shore for manual operation as 1.82 km (SD ± 0.77 km) has significantly lower than the value of winch operators 3.46 km (SD ± 1.06 km). The estimated mean true operation time of manual operators 3.34 hours (SD±1.37 h) and winch operators 5.28 hours (SD±1.08 h) were significantly different from each other ($p<0.001$, $t= - 6.36$). The results of this study showed that mean catch per haul for manual operators was 308 kg (SD ± 291 kg) and winch operators 286 kg (SD ± 293 kg) were not significantly different each other ($t = 0.30$, $p > 0.765$). Estimated total man power for single manual operation was 36.47 (SD ± 7.26) relatively higher than winch operations 25.42 (SD± 4.19) ($p< 0.001$, $t=7.37$). Since the introduction of winch mechanization scheme, manpower for hauling process has reduced and operation duration and operational area has significantly increased, whereas there was no significant difference of estimated average catch. Therefore, new regulations are needed to be introduced for beach seine fishery as longer duration beach seine operations may be a hindrance to other coastal fishing activities.

Keywords: beach seine fishery, Northwest coast, winch operators, manual operators

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Stock status and biological aspects of data poor kelee shad, *Hilsa kelee* (Cuvier, 1829) small scale purse-seine fishery off Mannar Peninsula, Sri Lanka

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Hilsa kelee is one of the key target species in Small Scale Purse Seine Fishery (SSPSF) locally called as "Surrukku del" conduct in shallow coastal waters in Thalaimannar. The *H. kelee* is a clupeid mainly occurs in coastal waters in the tropical region and locally called as "Karattaya". The SSPSF in the area has continuously increased over the years and the current status of fishery is unknown. The present study was undertaken to study current stock status and some biological aspects of *H. kelee* in SSPSF fishery. Based on the baseline survey results, "Thalaimannar Pier" landing site was identified as main landing site for the data collection. Study was conducted from December, 2016 to November, 2017 at the "Thalaimannar Pier". During the monthly field survey, randomly selected boats were sampled to collect biological information in relating to Total Length (TL), Fork Length (FL), Total Weight (TW), Somatic Weight (SW), sex, Gonad Weight (GW) and gonadal development stages. Length-Based Spawning Potential Ratio (LBSPR) was assessed for the *H. kelee* fishery by Barefoot Ecologist's Toolbox. Length-weight relationship was analyzed for combined sex, male and female separately. The Gonado Somatic Index (GSI), length at 50% maturity (L_{50}) and 95% maturity (L_{95}) were analyzed based on the gonadal weight and development stages. A total of 1291 specimens of *H. kelee* were analyzed during the study period. The estimated value of LBSPR was 0.56. The results show that fishery is still in a healthy stage. The specimens measured during the survey varied between 11.4 and 22 (mean=17±2.1cm) of total length, 9.2 and 20.2 (mean= 14.5±1.8 cm) of fork length, and total weight varied between 17.29 and 119.74 (mean=55.63±21.24 g) and somatic weight varied between 15.36 and 106.92 (mean = 50.46±19.09 g). The length-weight (L-W) relationship obtained for combined sexes showed a positive allometric growth (W=0.00874 TL $^{3.07}$, R^2=0.95), L-W relationships obtained for females and males also showed a positive allometric growth: (W=0.00865 TL $^{3.08}$, R^2=0.95) and (W=0.00959 TL $^{3.04}$, R^2=0.95) respectively. The sex ratio between males and females were1:1.2 and concluded that there is a significant difference from the theoretical sex ratio i.e., 1:1 (P<0.05). The GSI analysis indicated that there are two spawning seasons of *H.kelee*; the main spawning takes place during March-May, followed by a secondary spawning season during July-August. The estimated length at 50% maturity (L_{50}) and 95% maturity (L_{95}) were 18.1 cm and 22 cm respectively. As fishery in healthy state, maintaining the resources at the current level is advisable to obtain more economic benefits for the involved community.

Keywords: purse-seine fishery, *Hilsa kelee*, length-based spawning potential ratio, allometric growth, Gonado Somatic Index

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Some aspects of reproductive biology and growth of tomato hind, *Cephalopholis sonnerati* (Valenciennes, 1828) (Teleostei: Epinephelidae) in Western and Southern coastal waters of Sri Lanka

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This study aims to understand some aspects of reproductive biology and growth of tomato hind (*Cephalopholis sonnerati*) found in Western and Southern coastal waters of Sri Lanka. Specimens (n=84) were obtained from Chilaw, Negombo and Beruwala in the West coast on a monthly basis via aport sampling survey from January to December in 2017. A batch of *C. sonnerati* specimens (n=79) from the Southern coastal waters was donated by the Sri Lankan Customs which also used for the study. The results obtained under the study include the Length-Weight Relationship (LWR), Fulton's condition factor (K), Hepato-Somatic Index (HSI), size at maturity and fecundity of *C. sonnerati*. Respective relationships/ values of parameters were obtained for the two regions separately. The average Total Length (TL) and average Standard Length (SL) of the species in the west coast was 28.3 ± 7.8 cm and 23.4 ± 6.6 cm respectively. The estimated respective values for the Southern coastal waters were 34.4 ± 5.5 cm (TL) and 28.9 ± 5.0 cm (SL). The Fulton's condition factor (K) estimated for the Southern population was 1.69 while it was 1.75 for the Western population. The HSI values of *C. Sonnerati* estimated for the Western and Southern regions were 0.009 and 0.007 respectively. The estimated Length-Weight Relationships of *C. Sonnerati* for the Southern and Western populations were $W=0.0117L^{3.1035}$ and $W=0.0092L^{3.195}$ respectively. The size at 50% maturity of *C. sonnerati* estimated by pooling the data was 33.8 cm (TL). This study revealed that majority (73%) of landings in the West coast comprised with immature fish with the average size of 28.3 ± 7.8 cm (TL). Average fecundity estimated by pooling the data was 12149 ± 2404 eggs/g. The study provides some basic information about *C. sonnerati* and results would be useful especially for fishery biologists and fishery managers to propose appropriate management strategies where necessary.

Keywords: *Cephalopholis sonnerati,* length-weight relationship, hepato-somatic index

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Impact of artificial aggregating devices on the production of bigfin reef squid (*Sepioteuthis lessoniana*) in the coastal seas in Northwestern Province of Sri Lanka

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This research was focused on enhancement of export oriented fishery products of squids as they are considered as important food fish to country's social and economic life. Among many exported seafood varieties, the volume contribution by squid is modest at present. Among different squids, bigfin reef squid (*Sepioteuthis lessoniana*) fetches a high price both in local and export markets. Over the recent past, a declining trend in abundance of bigfin reef squid and also destruction of preferred substrates for spawning in the coastal waters has been noted by the local fishermen. Traditional fisheries in some parts of the country affix deployed clusters of mangrove twigs and submerging them at sea for three to five days as squid aggregation devices for them to mate and spawn and thereby improve the abundance of squids for jigging. But, submerging mangrove twigs is considered as an environmentally destructive fishing practice. The present study was conducted by deploying artificial aggregated structures made of iron for fish aggregation and squid eggs attachment. Study was conducted from November 2016 to May 2017 in the coastal sea off Sinnapaduwa. The artificial aggregating devices were set up at three different water depths (10 m, 15 m and 20 m) in twelve locations. Squid egg attachment on aggregator devices and also other species associated with the devices deployed at three different depths were visually monitored by employing SCUBA divers. Monitoring results show that, presence of squid eggs in nine locations and results of analysis showed that presence of squid eggs were significantly different between 10 to 15 m ($p<0.05$) depth and 10 to 20 m ($p <0.05$) depth while there was no significant difference in the presence of squid eggs between 15 to 20 m depth ($p >0.05$). Therefore, depths of the attractor from water surface have a significant effect on squid egg attachment in attractor.

Keywords: spawning, bigfin squids, artificial aggregating devices, squid eggs

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The current status of Negombo Lagoon fishery

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Sri Lanka has a large number of productive lagoons and Negombo Lagoon is one of the most productive lagoons among them. Several studies have been carried out regarding fisheries in Negombo Lagoon and this study focuses on the current status of Negombo Lagoon fishery. Fisheries data were collected from 10 major lagoon fishery landing sites from February to September 2017. The selected fish landing sites were visited every other week to collect information on fish catch, fishing effort (craft/gear combinations operated on the sampling dates), gear details (mesh size, pieces of nets, days of operation), and species composition of the catch. From the total number of craft operated, 30-60% was sampled at each sampling site. A variety of fishing gear and methods are being used in the Negombo Lagoon and those are operated targeting various types of fish and non fin fish species. These gear and methods are mostly practiced using Non motorized Traditional Boats (NTRB) or without crafts. Cast net, trammel net, stake net, stake net, gill net, scoop net and brush piles were identified as major fishing gear operated in the lagoon. Among these gear Gillnet recorded highest mean catch (10.6 kg/operation). The number of finfish species recorded during the study period was 67; representing 36 families. Among dominant fish varieties, *Mugil cephalus* (flathead mullet) contributes to 35% of the total catch, followed by *Arius* spp (20%), *Chanos chanos* (milkfish) (15%), *Siganus* spp. (Orawa) (10%), *Lates calcarifer* (Modha) (10%), *Etroplus* spp (Koraliya) (7) and *Oreochromis* spp (thilapia) (3%). Among the shrimps, *Penaeus indicus*, *P. semisulcatus* and *Metapenaeus moyebi* were the most abundant species. It is important to identify the long term trends in the fishery in order to identify the impact on fishery with regard to heavy fishing and rapid urban development around Negombo Lagoon and those trends could be used when formulating an effective management plans for the sustainable utilization of the fishery in Negombo Lagoon.

Keywords: Negombo, lagoon, fishery

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Morphological and biochemical characterization of the Genus *Dictyota* (J.V. Lamouroux*) –* Dictyotales Phaeophyceae

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Many of marine macro algae or seaweeds have not been explored for their taxonomy based on morphometry and biochemical variations. The genus *Dictyota* is brown seaweed playing an important role in marine environments, both as food and as habitats. *Dictyota* occur throughout the world, distributed from temperate to tropical marine waters. Many species of this genus is known to be invasive in nature. The genus *Dictyota* is the most species-rich genus of the family Dictyotaceae. It is also one of the most abundant seaweed in tropical marine habitats, where many *Dictyota* species occur .The main objective of the present study was to delineate the species of genus *Dictyota* based on morphometric characters and bio-chemical composition. These brown algae varieties have medicinal properties and are commercially very important for the food and feed additives. In addition, the relevant species were abundant in selected study areas. Study was conducted from August 2015 to July 2016, based on three major landing sites in India and one species was collected from the southern coast of Sri Lanka. Among the six species belonging to Genus *Dictyota, Dictyota ceylanica* was collected from Sri Lanka. Morphometric analysis showed that *Dictyota bartayresiana* was recorded with the maximum length while *D. ceylanica* and *D. volubilis* were recorded with the lowest length. The pattern of branchlets was more or less similar in all species. Among the species maximum width of the thallus was recorded in *D. linearis* (34.37mm) and lowest width was recorded in *D. ceylanica* (5.3 mm)*.* All the species of *Dictyota* were tested for ash content, crude protein and the unsaturated fatty acids (PUFA). All the species were recorded to contain more than 14% crude protein of their dry weight. The percentage ash content of *D. dichotoma* was around 27.65% while the respective values for *D. maxima, D. ceylenica* and *D. volubillis* were 21.95%, 14.67 and 14.56% of dry weight. Saturated fatty acids contents were major portion of the *D. bartayresiana* and it was 74.75% of total fatty acids. Palmitic acid is the dominant saturated fatty acid. PUFA was highest in *D. ceylanica* and linoleic acid C18:1 (n-1) was the dominant. Mineral composition included five major and four trace elements. Potassium was found in maximum amount in all six species while sodium was highly present in *D. linearis* (4.96%). The results of study provides an insight into the extraction of commercially important ingredients for fish feed, medicines and human consumption.

Keywords: *Dictyota,* seaweed*,* morphometric analysis, PUFA

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Sterilization procedure for Java fern (*Microsorum pteropus)*

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Java fern is one of the most popular-high-value plants in the aquarium industry due to aesthetic appeal and ease of care. The objective of this study was to identify the most suitable sterilization procedure for the explants of the Java fern as the sterilization procedure is the most critical step in the successful micropropagation. The leaves (as explant) were taken from the mother plant (from NARA plant house) and were washed with teepol for 20 minutes followed by running tap water for overnight. Then they were treated with ascorbic acid (0.5 g/L) for 5 minutes, followed by washing with a disinfectant. Concentration of the disinfectant was varied among treatment. Six treatments were conducted. Each treatment consists of ten samples of three replicates. Afterwards, explants were rinsed with sterile distilled water and were cultured on Murashige and Skoog medium (1962;MS). Samples were observed for seven days in one-day intervals. Significantly low survival rate (80 % survival, $P < 0.05$) was observed in treatment 3, which used 70% ethanol for 1minute, 4% Clorox for 10 minutes and 10% Clorox for 10 minutes for sterilization. Survival rates (100 % survival) of explants after treating them with treatment 1, which used 70% ethanol for 1 minute, 4% Clorox for 10 minute, 6% Clorox for 10 minute; treatment 2, which used 70% ethanol for 1 minute, 0.1% $HgCl_2$ for 1 minute , 4% Clorox for 10 minutes and 6% Clorox for 10 minutes; treatment 4, which used 70% ethanol for 1 minute, 4% Clorox for 10 minutes, 10% Clorox for 10 minutes, 0.1% $HgCl_2$ for 1 minute; treatment 5,which used 70% ethanol for 1 minute, 6% Clorox for 10 minutes, 10% Clorox for 10 minutes; and treatment 6, which used 70% ethanol for 1 minute, 0.1% $HgCl_2$ for 1 minute , 6% Clorox for 10 minutes, 10% Clorox for 10 minutes; were not significant to each other. As mercuric chloride is a highly toxic compound, treatment 1 and 5 were safer methods compared to treatments 2, 4 and 6 and thus we recommend those for sterilization of the Java fern explants in tissue culture.

Keywords: Java fern, sterilization, *in vitro*

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An attempt on selection of prospective aquaculture sites based on selected biophysical attributes in Rekawa Lagoon, Southern Sri Lanka

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Lagoon fisheries production can be enhanced significantly through aquaculture, provided appropriate culture sites, methods and species are selected. Site selection is the process by which the sites are compared with the needs of cultured organisms and the proper functioning of aquaculture farms. The aim of the study was to identify the most appropriate locations for farming of identified culture organisms through biophysical attributes of a prospective sites in Rekawa Lagoon and surrounding waters which will help to zoning the lagoon in different activities in the proposed management plan. Six water quality parameters were monitored fortnightly from July to December at eight selected sites in Rekawa Lagoon in 2017. There was no significant difference of salinity, temperature, DO and pH among study sites (One-way ANOVA; $p>0.05$). Mean±SD salinity, temperature, DO and pH of the lagoon were 12.84 ±5.16 ppt, 30.21±5.16 $^{\circ}$C, 5.93±2.74 mg/l and 7.39±0.54 respectively. Further, nitrate and phosphate concentrations were not varied significantly among the study sites (One-way ANOVA; $p>0.05$). Mean±SD nitrate and phosphate concentrations were 0.67±0.51 mg/l and 1.02±1.34 mg/l in the lagoon respectively. However all the water quality parameters at each site were within the acceptable range for aquaculture especially for culture organisms in brackish water. Thus, culture methods and suitable species with proven technology were selected based on geomorphology of the site such as water depth, water flow and other site specific characteristics. Based on water quality and geomorphological features of the 11 study sites, four sites (Godigamuwa canal, Boraluwa area, area between Kunuthotupola & Suduwalla, Hettiyapokuna) and three culture methods (pond, cage and pen culture), five culture species (*Lates calcarifer*, *Tilapia nilotica*, *Penaeus monodon*, *Scylla serrata* and *Chanos chanos)* were identified in the initial assessment of Rekawa Lagoon and associated areas. Experimental trials should be conducted in the prospective areas with adoption of appropriate technology for the recommended species to confirm the site suitability.

Keywords : aquaculture, water quality, Rekawa Lagoon, culture species

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Aquatic environment, Coastal and marine pollution
& Coastal habitat diversity

Preliminary study on physico-chemical characteristics and determination of selected pollutants in Mirissa Harbour, Southern coast, Sri Lanka

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This study was done at Mirissa fishery harbour, which is one of major fish landing sites located in southern coast of Sri Lanka. It was designed to determine physico-chemical characteristics (viz., temperature, pH, salinity, dissolved oxygen, biological oxygen demand, nitrate and nitrite) and to measure the levels of some pollutants (Oil and grease content in water, Pb, Mn both in water and sediment and presumptive coliforms). Water samples were collected monthly from five randomly selected stations during August to October 2013. Water samples were taken from the surface, middle and bottom layers of each station. Within the study period, conspicuously differences of physico-chemical parameters were observed between inside and outside the harbour. Physico-chemical parameters of temperature (28.0-34.0 °C), pH (7.60-8.60), salinity (32-40 ppt), Secchi depth (1.27 m 3.57 m), DO (2.42 - 7.80 mg/l), BOD (4.05 - 26.20 mg/l), orthophosphate (5-20 μg/l), nitrite (0.10 – 0.59 μg/), nitrate (0.042 -0.932 μg/l) were measured. At the station 4, BOD value of 18.8 mg/l exceeded the recommended BOD value (<4 mg/l harbor water) given by the Central Environmental Authority of Sri Lanka. Orthophosphate in water exceeded the limit of 0.015 mg/l and that orthophosphate contributing to formation of algal blooms. This study reveals that water quality in harbour directly affects the environmental pollution in the area. Awareness programs among stakeholders, recycling of waste water managing the point and non-point sources of pollutants, improve the sanitary facilities at fishery harbor, monitoring programs to assess the pollution are suggested to minimize the harbour pollution.

Keywords: fisheries harbours, pollution, water quality, Mirissa

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Assessment of physico-chemical characteristics of water in Kokkilai Lagoon, Sri Lanka

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Kokkilai Lagoon covers an area of approximately 30 km² and located in low country dry zone in Mullaithivu and Trincomalee Districts, Sri Lanka. The objective of the study was to determine current status of water quality which is important for conservation of aquatic environment. Study was conducted from April to October 2017 in sixteen randomly selected sampling locations representing the entire lagoon. Water Temperature (WT), pH, salinity, Electrical Conductivity (EC), Dissolved Oxygen (DO), turbidity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), nutrients, chlorophyll-*a*, BOD, COD, oil and grease were measured according to the standard methods for water and waste water analysis by APHA. Heavy metals and pesticide residues were analysed according to USEPA 200.8 method and FD-MTHD-010:2013V1.0 method using GC-MS respectively. Data was analysed with Minitab 17 statistical software. Pearson Correlation resulted, positive significant correlations between salinity-EC (r=0.79, p=0.00) and pH-DO (r=0.67, p=0.00). According to One-way ANOVA results, chlorophyll-*a*, BOD, COD, TDS were significantly varied among months from April to July (p<0.05). Further, pH salinity EC and turbidity were also significantly varied in April, July, October (P<0.05). Water temperature was significantly different from July and October (p<0.05). Thus, water quality parameters had been seasonally fluctuated between monsoon and inter-monsoon periods. Mean values of water temperature (30.12±1.60ºC), pH (8.1±0.3), DO (7.5±2.0 mg/l), salinity (37.0±8.2 ppt), BOD (1.6±1.0 mg/l) and ammoniacal nitrogen (0.06±0.16) were within the limits of 'Proposed quality standards for different use classes of coastal water in Sri Lanka' by Central Environmental Authority (CEA) 2001. Arsenic, Lead, Cadmium, Chromium concentrations were below the limit of detection (<1 μg/l) and within the standards. Pesticide residue content was also below the limits of detection. According to the results, present status of water is favourable for fish and aquatic life and this information can be used as baseline data for future scholarly studies and sustainable utilization.

Keywords: Kokkilai Lagoon, water quality, physio-chemical parameters

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Nutrient behaviour and its impact on primary productivity and benthic community in Dedduwa Estuary, Bentota River, Sri Lanka

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Dedduwa is economically and ecologically important natural water body located in Bentota, Sri Lanka and this water body is inter connected with the sea. This study was conducted to understand the nutrient behaviour in the Dedduwa Estuary and to study its impact on the aquatic environment. Water sediment and plankton samples were collected from nine randomly selected locations from August to October 2017. Primary productivity and Carlson's trophic state index (CTSI) was determine during the study period. Total phosphorous, chlorophyll-a and secchi depth were considered for Carlson's trophic state index. Primary productivity values were obtained from two sample locations and Shannon Weiner Index (H) was used to determine the benthic macro-invertebrates diversity. Physico-chemical characteristic of the estuary on following parameters such as water temperature, pH, dissolved oxygen, salinity, turbidity, total suspended solids, biological oxygen demand, chemical oxygen demand, chlorophyll and oil & grease were ranged from 31.8 - 30.0 ^{0}C, 7.34 -7.18, 5.17 - 7.49 mg/L, 7.14 - 8.49 mg/L, 15.90-7.68 NTU, 7.3-14.0 mg/L, 1.27-3.22 mg/L, 10.26-2.64, 0.01-0.47 mg/L, 2.55-3.56 mg/L respectively. Electrical conductivity and salinity were less fluctuated than other water quality and sediment parameters. Phytoplankton were presented in all the locations within 82.85-243.74 no/mL range. Nevertheless, benthic macro invertebrates were not evenly distributed within examined nine locations and they were identified only in one location as total individual counts 42. All benthic macro invertebrates are belongs to phylum- Mollusca, two classes (Grastropoda and Bivalvia) and four families (Thiaridae, Calyptraeidae, Cardiidae and Sphaeriidae) respectively and dominant species is *Tarebia granifera* spp (69.05%). Then highest total carbon value of 24.56% was also reported at the location DDE6 .The diversity of benthic macro invertebrates was 0.83 and the highest Margalef's richness index of benthic macro-invertebrates was recorded as 7.49 at DDE6 and according to Shannon Weiner Index (H) for phytoplankton diversity was 2.68 in entire estuary. The low concentration of dissolved nutrient was found to be having a direct effect to less primary productivity and phytoplankton abundance, while phytoplanktos were found to be connected to the food web as a food source for macro invertebrates. The primary productivity 0.54 mg C./L/D and 0.67 mg C./L/D was indicated the moderate primary productivity and Carlson's trophic state index (CTI=46.61) shows mesotrophic status in the Dedduwa Estuary resulted a reduction in population of macro-invertebrates.

Keywords: sediment, water quality, primary productivity, benthos

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Study of the temporal variation of nutrients in Southern coastal waters of Sri Lanka during the Southwest monsoon

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Sri Lanka is a tropical island, which is influenced by annual reversing monsoonal cycle. This monsoonal cycle is consisted of Southwest (summer) monsoon and Northeast (winter) monsoon periods, which extend from June to September and from December to March, respectively and as well as two transitional inter monsoon periods (May and November). These monsoonal changes may alter the chemistry and the productivity of the ocean. Therefore, this study was carried out to verify the temporal variability of physico-chemical characteristics including nutrients in Southern coastal waters of Sri Lanka. Four sampling points were investigated along the coastal belt near to Gin River mouth for six months period (June, 2017 to November, 2017). The concentration of NO_3^-, NO_2^-, PO_4^{3-} and SiO_4^{-4} in seawater were analyzed while DO, TDS, temperature, pH and salinity values were recorded in-situ at each point. In this study, the lowest monthly average phosphate concentration was recorded as 0.1 ± 0.03 µmol/L in November, 2017. This value was lower than the production limiting level (0.3 µmol/L). Therefore, phosphate can be the limiting nutrient, which affect the productivity in this coastal water. Highest concentrations of phosphate (1.09 ± 0.67 µmol/L), nitrate (26.11 ± 10.89 µmol/L) and nitrite (0.63 ± 0.03 µmol/L) were recorded in August and September, when the Southwest monsoon was peaked. This denoted the presence of Southern coastal upwelling as Southwest Monsoonal Current prevailed near the Southern coast of the island during this period. Furthermore, this incident can be further evident by lower sea surface temperature ($\sim26^{\circ}C$) and higher average chlorophyll-a (~1 mg m^{-3}) distributions, shown by satellite images retrieved from this region. Based on the results, this study confirms that nutrients in the Southern coastal waters of Sri Lanka temporally vary during the southwest monsoon.

Keywords: Southwest monsoon, nutrients, coastal upwelling, Southwest monsoonal current, Southern coastal waters

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Organic and inorganic carbon content in surface marine sediments of Northern near shore area of Sri Lanka

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Marine sediments hold substantial proportion of ocean carbon budget which is vital for the functioning of marine ecosystems. The current study aimed to access the organic and inorganic carbon contents in surface marine sediments of Northern nearshore area of Sri Lanka between 79°57'50.62"/80°11'31.337"E and 9°55'49.967"/9°55'51.66"N during September 2017. Sediment samples were collected from 40 uniform nearshore grid-locations and were preserved at 4ºC. Organic carbon (% OC) was determined indirectly using Loss-on-Ignition (LOI) accompanying temperature gradients of 105ºC and 550ºC to estimate % organic matter (OM), conversion factor 1.724 was used to determine % OC. Inorganic carbon (% IC) was determined; treating 5 g of oven-dried sample with 20 ml of 3M HCl. Weight loss incurred by digestion of carbonates was used to obtain the percentage loss. The % OM (n=40) ranged between 0.41% and 3.04%. Indirect OC (%) estimations resulted respective 0.24% and 1.76% with a mean±SD of 0.83±0.39%. Linear-regression analysis for % OC with water-depth (m) and distance from coastline (km) was insignificant ($P>0.05$) with respective R^2: 0.0036 and 0.0541. The IC content varied largely between samples compared to OC. The IC content ranged between 2.84% to 23.29% with a mean±SD of 8.95±5.11%. There was a significant negative relationship between IC and distance from coastline (Linear-regression; $P<0.01$; $R^2=0.51$). However, the relationship of IC with the water-depth was insignificant (Linear-regression; $P>0.05$; $R^2 = 0.22$). The IC and OC showed a significant positive relationship between the variables (Linear regression; $P<0.05$; $R^2= 0.69$). Present study revealed OC and IC were low in the study area. The OC showed the patchy distribution. High IC accumulation takes place near thecoast. The IC accumulation correspond to the OC content in the study site. The current study provides baseline data for the future research.

Keywords**:** marine sediment, organic carbon, inorganic, Northern Sri Lanka

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Mangrove ecosystem-capacity to improve water quality of coastal environment

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Mangrove areas are located at the interface between land and sea and thus influenced by both terrestrial and marine factor. Population growth in coastal zones has resulted in increased solid waste production, urban nonpoint source runoff, conversion of mangroves to agricultural, industrial or residential areas. This changing land use pattern has in turn led to decline in water and sediment quality and mangrove habitat loss in Karnataka. With increased awareness of the importance of mangroves the government departments have planted mangroves in various estuarine areas to improve the mangrove habitat. The objective of the present study was to understand the changes in water quality over a period of time in an ecosystem where mangroves were planted, a non-mangrove habitat and a natural mangrove ecosystem. Water and sediment quality data were collected for a period of 6 years (2011-2016) from the area selected for study to understand improvement in water quality over a period of time as per the water quality indexing of USEPA, 2012. The data obtained was analysed using SPSS software. The results obtained were judged against the corresponding baseline range concentrations specified by National Coastal Assessment Report (USEPA, 2012). The growth of mangroves at the planted site was also monitored taking into consideration the plant height, number of leaves and branches. The sediment organic carbon and texture at sampling sites were estimated on a monthly basis. An increasing trend of "Fair" water quality rating was observed in mangrove planted area while a decreasing trend was observed in non-mangrove area for the period. The sand, silt, clay and organic carbon was significantly different (P<0.001) at the three stations .The study showed that mangroves improved the water and sediment quality over a period of time provided external sources of pollution are controlled.

Keywords: mangrove ecosystem, pollution indicators, water quality, sediment texture

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Marine debris and its potential impacts on mangrove ecosystem in Negombo Lagoon

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Marine debris is recognized as a worldwide threat to marine organisms, ecological processes and economies. Marine habitats are contaminated with man-made debris and represent the major categories of marine debris by material type on a global basis. The study was conducted in two mangrove inhabited sites in Negombo Lagoon for a six months period during September 2016 to February 2017 to assess the debris cover and their impacts on mangroves. Debris cover was estimated in 10x10 m block which is divided into 1 m^2 quadrats and 20 quadrats from the 100 m^2 block were sampled in each site on monthly basis for macro debris (> 2.5 cm). The collected debris particles were categorised by material type. The study revealed that 9.83±1.05% of the substrate of the mangrove ecosystem is covered by debris. The Kadol kele site was covered by 18.80±1.74% (n=120) while Mole Kadolwetiya was covered from 0.85±0.03% (n=120). The debris cover was varied significantly between two site (p=0.00). But there was neither significant difference of debris cover among months (p=0.41) nor month and site interaction (p=0.24; Two-way ANOVA). Significantly higher debris cover was found in Kadol Kele than that of Mole Kadolwetiya. The composition of debris by material types showed that the packaging items were dominated with a 40% followed by consumer items (21%), fishing items (8%) and rubber items (13%). The results of two-way ANOVA indicated that there are significant differences on abnormal roots, impacts to seedling density, under-growth concentration and physical damages of flora at Kadol kele and Mole kadolwetiya at p=0.05. The study revealed that the mangroves in Negombo Lagoon are highly polluted with marine debris and their impacts on mangroves are recognized. Thus, it is recommended to make remedial measure to reduce the debris accumulation on mangroves to conserve these valuable coastal habitats.

Keywords: mangroves, Negombo Lagoon, marine debris, packaging items, impacts

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Seasonal variation of selected heavy metals in sediment and mud crabs (*Scylla serrata)* tissues in Negombo Estuary

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Heavy metal pollution is of particular concern as they have deleterious effects on biota through mobilization and accumulation in various tropic levels. The objectives of this study were to assess the seasonal variations (rainy and non rainy periods) heavy metal levels of the lead (Pb), mercury (Hg), cupper (Cu), zinc (Zn) and cadmium (Cd) in sediment and edible muscle tissues in mud crabs in selected sites. Sampling was done one year period from January to December 2016. Crab samples were collected from four main locations of Negombo Estuary as Pitipana, Munnakkaraya, Duwa, and Katunayake sites. The levels of Hg were analyzed by cold atomic absorption spectrophotometer, whereas the other metals were analyzed by flame furnace atomic absorption spectrophotometer. The range of monthly mean concentrations of metals (mg kg^{-1}) in sediments were Pb, 1.15 ± 0.30 to 9.8 ± 3.2; Cd, 0.09 ± 0.01 to 0.36 ± 0.23; Hg, 0.14 ± 0.02 to 0.58 ± 0.4 ; Cu,7.7 ± 2.3 to 11.3 ± 2.4 and Zn, 126.1 ± 30.5 to 154.6 ± 21.4. The range of monthly mean of measured metals in the edible tissues (mg kg^{-1}) were from Pb, 0.03 ± 0.02 to 0.07 ± 0.03; Hg, 0.2 ± 0.012 to 0.3 ± 0.23; Cu, 0.25 ± 0.12 to 0.37 ± 0.21; Zn, 2.2 ± 0.18 to 4.2 ± 0.35 and Cd, 0.02 ± 0.01 to 0.12 ± 0.11. The results reveal that mean concentration of Cu and Cd levels in crab tissues were exceeded the EU permissible threshold limits. The seasonality in the heavy metals of sediment and crab tissue were observed with a peak periods from May/June and October/November respectively.

Keywords**:** heavy metals, seasonal variations, sediment, crab tissue

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Plastic litter enumeration and characterization in coastal water, off Colombo, Sri Lanka

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This study addresses the morphological characterization and quantification of plastic debris (0.30-100 mm) at seven sites (Uswetakeiyawa, Kerawalapitiya, Dikowita, Modera, Kollupitiya, Bambalapitiya and Wellawatta) along West coast of Sri Lanka during August-November 2017. Coastal plastic debris were collected by towing a floating net, with mesh of 0.30 mm horizontally at the surface. Collected samples were examined and plastics were recovered through visual and microscopic observation. Visually identified plastics (1-100 mm) were confirmed through hot needle test and remaining plastic residuals were subjected to wet peroxide oxidation method and observed under light microscope. All the plastics recovered were sorted into categories based on the size (macroplastics, mesoplastics, large microplastics and small microplastics) and shape (filaments, films and fragments). Except microscopically identified plastics, visually identified plastics were sorted according to the colour (black, white, transparent and coloured). Mean abundance of total plastics was 140.34 ± 13.99 items/m^3 by number and significantly varied among the sites at p=0.05. The 99.6% of the plastics collected were microplastics (0.3-5 mm) which were significantly higher in Wellawatta (316.04 ± 64.10 items/m^3) and Modera by number of items than that of other sites. Overall mean abundance of visually identified plastics (1-100 mm) was 0.67 ± 0.14 mg/m^3 in terms of weight. Abundance of white colored plastics significantly varied among sites (p<0.05) and highest number of white plastics was recorded from Uswetakeiyawa (0.36 ± 0.08 items/m^3) due to intense tourism and fishery related activities in the affected site. Site-specific anthropogenic activities are a key factor influence on accumulation rate of plastic filament. Hence overall abundance of total plastic filaments was (87.00 ± 9.55 items/m^3) significantly different among sampling sites (p<0.05). Highest number of plastic filaments was accumulated in Wellawatta (166.97 ± 25.26 items/m^3). Since all the study sites are contaminated with plastics, control measures are recommended to mitigate the plastic litter pollution.

Keywords: plastics, Colombo, coastal water, filaments, hot needle test

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Quantitative analysis of micro-plastic contamination in beach sand at the Western and Southwestern coastal stretches in Sri Lanka

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Microplastics have become a major global environmental crisis at present due to their ubiquity, bio-availability and ability to carry toxic chemicals. This study quantified microplastic litter in coastal sand in the Western and the Southwestern coasts during 2017. Monthly sampling was done at three selected sites, namely, Colombo, Beruwala and Hikkaduwa (n=216). Density separation was carried out using NaCl solution (1 M) and all floating solids were subjected to a wet peroxide oxidation using aqueous Fe (II) (0.05 M) and hydrogen peroxide (30%), below 75°C. Plastic particles including microplastics were identified via microscopic imaging and a *'hot-needle test'*. Afterwards, the average monthly abundance of micro-plastics (AMA) was calculated in terms of (i) number of particles per m^3 (N) and (ii) weight of particles (W) in gm^{-3} whereas the AMA values were compared with other categories of plastics. The results disclosed that vast majority of plastic debris in beach sand were microplastics. Beaches in Colombo are highly polluted with micro-plastics [N: 329,700±19,596 (83.23%); W: 72.37±4.13 (13.59%)] compared to those in Beruwala [N: 183,400±9,521 (62.46%); W: 28.33±2.15 (9.33%)] and Hikkaduwa [N:135,700±7,920 (72.88%); W:29.99±3.91 (8.72%)]. The results disclosed that there are spatial variations in the distribution of microplastic particles where beaches adjacent to fishery harbors, populated residences, and water channel openings both in Beruwala and Hikkaduwa contained significantly a large AMA (p<0.05). Moreover, beaches located in popular tourist destinations contained more microplastic litter compared to others. The overall AMA of microplastics in Colombo, Beruwala and Hikkaduwa were N: 216,267±7,417 (74.07%) and W: 43.57±2.86 (11.07%). Since pollution control in all locations is crucial, relevant authorities may pay attention to waste disposal at and closer to fisheries harbors, markets, water canals and popular beaches by residents and industries. It is important that the awareness of the society is re-checked and an ecology-concerned society is build via timely dissemination of knowledge and apposite policy reforms.

Keywords: microplastics, coastal pollution, beach sand

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Assessment of floral diversity and analysis of extenuation engagements posed for the threats and issues on Pigeon Island National Park, Trincomalee, Sri Lanka

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This study was focused on identifying and estimating the floral diversity in Pigeon Island National Park, and to identify and analyze the engaged activities of stakeholders for the imminent threats and issues on Pigeon Island. The research was carried out from March to June 2017 and twenty one plots (16x16 m^2) were randomly laid in the Pigeon Island and floral diversity was estimated. Moreover, data were collected through questionnaire survey and investigated project activities followed by outcome evaluation to analyse threats and issues and the mitigation actions shadowed by the stakeholders of the Pigeon Island National park. Diversity and evenness of each plot was calculated using Shannon-Wiener diversity index and Pielou's evenness index respectively. Results showed that the study site is composed of 72 different floral species and Shannon-Wiener diversity index and evenness ranged from 0.593- 3.429 and 0.704-0.972 respectively. There were significant differences of diversity and evenness among plots (P<0.05). The results indicated that the average plant species diversity (H') of Pigeon Island area studied was 3.69 and evenness (E) was 0.75. It was reveals that Pigeon Island National Park consists of high biological diversity (Diversity index=3.69) of flora. Analyzed outcome evaluation revealed the need of implementation of management measures created for the long term sustainability of the park by the stakeholders and the developed Pigeon Island Management Plan with community co-management prescriptions. Accomplishment of the co-management system through Pigeon Island Management Committee is also vital to coordinate with all other stakeholders for the effective management measures.

Keywords: co-management plan, flora diversity, Pigeon Island, Shannon-Wiener diversity index

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Coastal and marine pollution due to the urban development activities: Special reference with Negombo coastal area

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Urban development is a system of residential expansion that creates cities. Although the urban development is planned by civil and design engineers, project managers, architects, environmental planners and surveyors, it causes direct and indirect issues to the environment and human beings. There are plenty of developing countries facing various problems due to the urban development activities. Coastal and marine pollution is the most important among them. Therefore, the research conducted under the topic of "Coastal and Marine Pollution due to the Urban Development Activities: Special reference with Negombo Coastal Area". The study area is located in the western coastal belt of Sri Lanka. Objectives of the research is to identify the coastal and marine pollutions due to the urban development and to identify impacts of pollution on coastal and marine ecosystems. Both quantitative and qualitative research methods were used in this research. Unstructured interview, questionnaire survey and observations were used for primary data collection. Moreover, secondary data were collected through published and unpublished materials. According to this research, coastal pollution and marine pollution has identified since last two decade in study area. Even though many management activities were carried out to solve these problems, due to lack of money, political abuse and organizational procedural issues lead to the failure of intension. Therefore, using the environmental management process, suggest about underground development and establish a green city to appropriate organizations, as well as provide the awareness programs to the society and encourage the sustainable development are necessary steps to achieve the objectives of this research.

Keywords: urban development, coastal area, pollution, management

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City imageability through integration of coastal lagoon landscapes in city planning and development - with special reference to Negombo Lagoon, Sri Lanka

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Coastal landscapes are dynamic systems which are continuously evolving with time. Constant movement of wind and water and the coastal processes influence the formation of different coastal landforms. These coastal landforms highly influences the imageability of a city through its fascinating shapes and forms. Therefore the coastal landscapes are some of the highly populated areas on earth. Developed countries have identified coastal lagoons as a significant coastal landscape element and have implemented the city planning proposals considering its ecological, economic, cultural and aesthetical importance. In Sri Lanka, the coastal lagoons are conserved and protected considering their ecological importance. But the potential of integrating the coastal lagoons, in city development by identifying the lagoon as an imageable landscape element to enhance the city identity has not been considered yet. This research aims to identify a conserved coastal lagoon, in a state of a natural, identical, imageable landscape element to enhance the city identity and serve as a landmark. The selected case study for the research is the Negombo Lagoon. A survey on evaluating the characteristics from selected assessments were conducted and the results provide vast suggestions on how to assist the city planning decisions, in order to create a memorable city identity using the coastal lagoons. The study also depicts the deficiencies which has caused at present as a result of the chaotic development. The analysis is reinforced by the observations and findings from literature and the interviews conducted with professionals. The study promotes research on other significant coastal landforms to enhance the coastal city identities and promote tourism through natural, conserved coastal landscapes and contribute to the national economy. The results of this study will provide a sound basis for city planning and development, using an innovative approach to use the natural coastal landforms for the economic development of Sri Lanka.

Keywords: coastal lagoon, landscape characteristics, land use and landscape planning, imageability and identity, city planning and development.

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Present status of three coral reef ecosystems in Sri Lanka: Hikkaduwa, Pigeon Island and Bar Reef

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For nearly five decades, coastal habitats and the resources in Sri Lanka are being depleted at an alarming rate. This is mainly due to increasing coastal population and rapid unplanned development. The coral reefs and reef communities have also been degraded due to anthropogenic activities as well as natural reasons. Therefore, the selected coral reefs (Hikkaduwa and Pigeon Island national parks and Bar reef marine sanctuary) were monitored to assess their current status and the bio-physical impact due to coral bleaching and anthropogenic activities. The selected reef site's reserved snorkeling areas were surveyed using the point intercept transects of 50m length and were laid perpendicular to the costs between 03 and 05 m depths. During the survey the 16 types of benthic cover categories were recorded and corals and associated fish diversity around the point intercept transects were assessed. The total number of 42 coral species in 20 genera from 12 families and 81 reef fish species in 45genera from 23 families were recorded from the three sites. Three indices were used to compare the three sites: Shannon-Wiener Diversity Index (H), Simpson's Diversity Index (D) and Pielou's Evenness Index (J). The scrutinized biological aspects of the three study sites were taken as the indicating parameters of the coral reef present status and their healthy conditions and scientific recognizer of the level of degradable or on edge of extinction of the coral reef. Among the three sites, Pigeon island reef represented the highest H value (3.53) and the lowest D value (0.95) and the lowest J value (0.89) compared with other reef ecosystems. It was concluded that the most diverse coral reef ecosystem is Pigeon Island. Hikkaduwa coral reef shows the lowest H value (3.28), and the highest D value (0.97) and the highest J value (0.95) and concluded that Hikkaduwa coral reef has the lowest diversity. The observed lower diversity at Hikkaduwa could be due to high anthropogenic influence compared to others. Both species richness and evenness increase the diversity and coral reefs having higher diversity are prioritized for management and conservation.

Keywords: Bar reef, Hikkaduwa, Pigeon Island, coral reef

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Recent study on *Hippocampus* (Syngnathidae) diversity in the Western and Northwestern coasts of Sri Lanka: remarks on extraordinary species diversity

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Hipppocampus species or seahorses are attractive marine fish species of family Synagthidae. There are 33 different seahorse species in the world, and all are threatened species listed in Appendix II of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). They are being traded in both live and dead forms, but the majority in dried and destined for use in traditional medicine. Sri Lanka is also in international trade of seahorse but do not know exact species diversity as there had not been exclusive studies on them. Therefore, present taxonomic study was carried in 2016 and 2017 with the specimens collected from Western to North-western coastal region and the dry specimens detained by Sri Lanka Custom Department in 2015. The objectives were to explore exact species diversity and to propose conservation strategy. They were identified to species level using their morphological features. Present results confirmed the occurrence of five different species in the coastal region studied. They were identified as *H. histrix, H. kelloggi, H. kuda, H. spinosissimus* and *H. trimaculatus*. Of them *H. kuda* and *H.kelloggi* was respectively found as the most common and the rarest species respectively. All these species are well known inhabitants of the Bay of Bengal region. Therefore, present records may be due to extension of their range to the Northern Sri Lanka due to coastal current of the Bay of Bengal or presence of their most preferable seagrass meadows habitats in this region. However, record of West African, Australian and North American seahorse spp. viz. *H. angustus, H. angustus* and *H. reidi* among the detained specimens observed is questionable. This may be due to their actual occurrence in our coastal areas or in neighboring sea area. If not it can be predicted that Sri Lanka acts as the hub for illegal trading of seahorses. Therefore, it is important to conduct further studies on the *Hippocampus* species in all coastal areas around Sri Lanka to get a precise idea on their species diversity. This would help for effective implementation of the CITES as well for conservation and management of the seahorse species in Sri Lanka.

Keywords: *Hippocampus,* species diversity, CITES, coastal Sri Lanka

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Waterbird diversity in Kavutharimunai in the Northern Province, Sri Lanka

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Sri Lanka has a rich marine and coastal biodiversity along its 1338 km coastline. The northern coastline is the longest coastline (403 km) in Sri Lanka. According to International Union for Conservation of Nature (IUCN), Sri Lanka is blessed with 453 species of birds including 240 resident and 213 migratory birds, of which, 164 (35 %) are waterbirds. The study was carried out in Kavutharimunai which is located at the tip of the Kavutharimunai-Pooneryn Road, surrounded by sand dunes, salt marshes and mangrove vegetation. Diversity and abundance of water birds were collected once a month from December, 2016 to May, 2017 at line transect which is divided into three counting blocks of 500 m x 500 m to study spatial variation of waterbirds. Forty-eight (48) waterbird species belonging to 11 families were recorded during the study, of which 28, 25 and 22 waterbird species were recorded in blocks 01, 02 and 03 respectively. Even though the species richness (22) was low, the highest Shannon diversity (2.43) and Evenness (0.79) indices were recorded in the block 03 due to the even distribution of waterbird species. The lowest indices of Shannon diversity (1.76), Evenness (0.55), Simpson (0.11), Margalef (0.02) and the highest Berger Parker dominance index (0.57) were recorded in the block 02 due to the high abundance and uneven distribution of waterbird species. Sand shores exposed in Block 02 in Kavutharimunai is an excellent place to observe attractive shorebirds species such as Black-tailed Godwit (*Limosalimosa*; 75.09%), Greater Black-headed Gull (*Larusichthyaetus*; 1.77%), Brown-headed Gull (*Larusbrunnicephalus*; 10.33%), Gull-billed Tern (*Sterna nilotica*; 1.63%), Caspian Tern (*Sterna caspia*; 5.31%), Great-crested Tern (*Sterna bergii;*1.91%) and Lesser-crested Tern (*Sterna benghalensis;* 2.62%). Thus, it can be concluded that Kavutharimunai is excellent place for the development of avitourism in the northern region of Sri Lanka, especially to observe shorebird and seabird watching by ferry.

Keywords: waterbirds, diversity indices, avitourism, Kavutharimunai

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Diversity of flora and fauna in Rekawa Lagoon, Southern coast of Sri Lanka

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Lagoons form a particular type of natural capital which generates a number of values, contributing positively towards improving human well-being. This study aims to generate a baseline data on flora and fauna in the Rekawa Lagoon and conducted during 2017. The lagoon is small, with a surface area of 2.58 km^2 and connected to the open ocean via 3 km long shallow and narrow canal which is intermittently closed due to the sand bar formation at canal mouth. The fish species diversity and composition were studied at five selected major sampling sites and two minor landing sites. Sediment samples were collected at 12 sites and analysed for macro-invertebrates. Seagrass sampling were carried out using three transect (100 m) which laid perpendicular to the shoreline at 20 m intervals. Nine mangrove transects (30 m x 10 m) were selected randomly which laid perpendicular to the shoreline to study the mangrove diversity. A total of 29 finfish and shellfish species belonging to 19 families were reported. Of the finfish species *Nematolus nausa, Arius* sp. and *Etroplus suratensis* were dominated. *Penaeus indicus* and *Scylla serrata* (mud crab) were among valuable crustacean species caught in the lagoon. A total of 16 species of benthic invertebrates (6 polychaete species, 4 bivalve species, 4 gastropod species, one amphipod species and one decapod species) belonging to 13 families were recorded during the study. Eleven species of true mangroves belong to 7 families and 9 species of mangrove associates were also reported. Family Rhizophoraceae had the highest species composition with four mangrove species. Among 15 identified seagrass species in Sri Lanka, three species were identified in the Rekawa Lagoon belongs to 2 families. Family Hydrocharitaceae showed the highest species composition with two species (*Halophila decipiens* and *Halophila ovalis)*. This study provides the diversity of some flora and fauna species in the Rekawa Lagoon. However detailed study has to be conducted for their distribution, abundance and composition.

Keywords : Rekawa Lagoon, mangroves, seagrass, fish, diversity

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Coral rubble and rock associated crypto-fauna at Polhena reef, Sri Lanka

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Though coral reefs are complex ecosystems subjected to global decline and causal relation to the coral death is not comprehensively understood. Increasing body of literature suggest on micro scale processes of coral reef ecosystems as an approach to understand how coral reef function as a system. The trophic relations to coral reef associated organisms are important aspect that subjected to the present study. We selected to study coral reef crypto-fauna (March 2017) to compare with other benthic monitoring in Polhena Coral Reef in Sri Lanka from January 2016 to December 2016. Coral rubble/ rock (weight 100-400 g, n=10) were randomly sampled at 1.5 m depth from Polhena reef, crypto-fauna were manually collected and identified to the lowest possible taxonomic level. The majority of the rock associated crypto-fauna at Polhena reef was represented by polycheates (60.3%) followed by micro crustaceans (33.3%). In addition, crabs, mollusks, echinoderms (brittle starts, feather stars) and fish (goby) were recorded in little frequencies ($\leq$ 2.1%). The data from present study showed that the amount of marine life associated to the dead coral rubble and coral heads. Therefore further studies need to be conducted with extensions of more samples in spatial and temporal scales accounted with molecular biological methods so that taxonomic identification to understand the ecological role of crypto-fauna in coral reefs at the face of climate change and anthropogenic stressors.

Keywords: coral reef, crypto-fauna, climate change

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Oceanography

Characteristics of sea level change along China coast during 1968-2017

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Based on tide level data observed by tide gauges, the characteristics of sea level change along China coast are investigated. Results show that: (1) Sea level change along China coast shows a fluctuant ascending trend. The rising rates are 3.3 mm/yr and 4.1mm/yr during 1980-2017 and 1993-2017 respectively. (2) Sea level change along China coast presents remarkable regional characteristics. Compared with multi-year average, sea level from Guangdong to Hainan coast increased obviously with an average range of more than 100 mm. Sea level from the Yellow Sea coast to the Northern Jiangsu Province shows a small increase, which is less than 40 mm. (3) Sea level is the lowest in 1960s, which rises slightly latter in 1970s and descends again in 1980s. Sea level in 1990s was higher than that in 1980s. Sea level along China coast from 2011 to 2017 is on its high level in history, and it is respectively 80 mm, 55 mm, and 25 mm higher than it is in 1960s, 1980s and 1990s. (4) Sea level rise in China coast presents prominent inter-annual and inter-decadal variability, of which the significant periods are 2-3a, 4-7a and 11a. The oscillation of 4-7a is most prominent in South China Sea and East China sea, whose amplitude is close to 1.1 cm. (5) Sea level along China coast takes on strong seasonal variation. Seasonal sea level change is larger in the north than in the south, and annual variation decreases from the north to the south. The lowest lunar-mean sea levels are usually in winter and spring, while the highest levels are usually in summer and autumn. From north to south, highest lunar-mean occurs from July to October, with a difference of nearly 3 months, and annual sea level variation varies from 60 cm to 20-30 cm correspondingly.

Keywords: China coast, sea level change, long-term trend, period, seasonal sea level

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Eulerian currents at surface waters of selected sites of off Colombo

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Coastal currents are influenced by many factors such as local and seasonal winds, river discharge, tidal currents and topography. Eulerian currents (currents at a fixed position) were monitored at surface water of five sites (Kelani River Mouth, Proximity to dredging and reclamation area of the Port City, Canal mouth of the Port, and off Beira Lake outfall) quarterly in 2017 to assess the spatial variability. The current speeds and directions were measured using Acoustic Doppler Current Profiler (ADCP) set up in mooring mode to obtain upward looking measurements in the water column. The current speeds of the area varried from 0.02 to 0.30 ms^{-1} with a mean (±SD) of 0.083±0.053 ms^{-1}. Current speed varied significantly at all study sites except at the dredging site at p=0.05 (One-way ANOVA). The significantly higher speeds were recorded at Beira Lake and Canal mouth at 1st quarter than that of other three quaters of 2017. At the Kelani River mouth, significantly higher speed was recorded at the 3rd quarter than that of other three quarters. Significantly higher speed at reclamation site was recorded at 4th quarter than that of other three quarters. The mean±SD velocity at dredging site is 0.089±0.021 ms^{-1} and there is no significant defferene among four quaters at p=0.05. Current directions were not very clear most of the time at different sites. Also, the impact of south-west monsoon winds not clearly visible from the data. The speed and the direction at study sites are affected by a combination of many factors and it is not possible to explain the exact reason for the variability of coastal currents. Localized changes of currents may affect the water quality, especially on TSS, turbidity and the biota of the area. The continuous monitoring of coastal current is required to study the impacts of development projects such as Port City, harbours, beach nourishment etc. on current.

Keywords: eulerian currents, Port City, acoustic doppler current profiler, biota

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Impact of vertical temperature structure on tuna fishery in the Indian Ocean

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Longline is a common fishing gear that operates to harvest the deep-sea fish resources such as yellowfin tuna (YFT) which is associated with thermocline. The objective of this work is to investigate hook penetration depths of Sri Lankan longlines and its impact on catch variability. The temperature Depth Recorders (TDR) were used in longlines operations to find the depth penetration of longlines in selected vessels during the period from July 2012 to February 2014. Temperature profiles were obtained from Copernicus Marine Environmental Monitoring Service were analyzed with monthly mean catch data sets of YFT. Horizontal spacing of branch-lines and their appropriate depth penetration showed a linear relationship (r^2= 0.99). Buoy-line and branch-line lengths were ranged between 20-30 m and 40-45 m respectively while, 6-7 hooks per basket have been used. Depth penetration of hooks was ~65 m close to buoy-lines while it is ~90 m in the middle of a basket. Catch per unit effort was ranged between 15-70 kg/100 hooks. The thermocline depth was varied between 100-125 m during the study period. The improved catch rates were shown in places where the fishing lines have reached to the thermocline depth. Sagging depth will not be linear, if line-shooters are used by Sri Lankan longliners. The catch rates are affected by the temperature structure of the ocean as well as the other environmental conditions such as oxygen, food availability etc. Hence, a predictive model was developed to determine thermocline depths based on spatial temperature-depth profiles using Copernicus data. Model output provides thermocline depths in 1-degree grid space and longlines can be configured to reach the appropriate hooking depths for successful fishing operations.

Keywords: longline, sigmoid model, thermocline

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Investigation of bottom boundary layer dynamics in the shallow waters

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The current investigations were focused on the dynamics of bottom boundary layer in East China Sea where water depths are comparatively shallow. The bottom boundary layer (BBL) is a well-mixed homogeneous layer that extends from outer free flow to the seafloor. It is usually separated from the overlying stratified waters by a distinct density interface. However, stratification in the quasi-homogeneous near-bottom layer may gradually increase towards the water interior, and hence the thickness of such layers is not easy to determine. In many cases BBL dynamics are influenced by tides but a certain number of cases show the non-tidal formations. The Acoustic Doppler Current Profiler (ADCP) data which was collected in East China Sea was used during the investigation. The results indicated friction velocity varies between 1.8×10^{-2} and 8.8×10^{-2} ms^{-1}, with a mean value $\langle u_{*l1} \rangle$ = 5.6×10^{-2} ms^{-1}. The friction velocity estimated from log wake method is closer to the classical logarithmic layer method which is represented by $\langle u_{*lw} \rangle$ = $0.94 \langle u_{*l} \rangle$. The modified logarithmic layer gives approximation of $\langle u_{*ml} \rangle$= 2.9×10^{-2} ms^{-1} while $\langle u_{*l1} \rangle$ = 5.3×10^{-2} ms^{-1}. These results indicated the upper log-layer u_{*l2} appears to be overestimated by 2.6 times compared to u_{*ml}. The estimates of friction velocity associated with the latter, assuming that it can be approximated by the classic log-layer formula, appeared to be larger than in the lower layer by a factor of 1.65. However, even the lower log-layer u_{*l1} appeared to be unreasonably high, which suggests that u_{*l1} could be substantially overestimated due to the fact, pointing to the fact that seemingly logarithmic sections of the observed velocity profiles are not solely governed by the classic log-layer formula. Some other dynamics appears to be at play, wherein variable such as the drag, stratification, and rotation of the tidal vector may be important. The classical log-wake model at times gave a perfect agreement with observed velocity profiles in and above the log-layer but it did not change the estimates of friction velocity much. This also corroborates the claim that other form of dynamics may be in action in the BBL.

Keywords: bottom boundary layer, friction velocity, logarithmic layer

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2D numerical modeling of flow and sediment transport using wave climate schematization method - a case study of West coast of Sri Lanka

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This study quantifies the variations in wave characteristics and the resulting variations in potential longshore sediment transport rate along the coastline between Mount Lavinia and Negombo, Sri Lanka. Over the last 25 years, this coastal belt has been subjected to dramatic interventions due to the influence of rapid social-economic development in the country. Construction of Colombo south harbour jetty, extensive adjacent river sand mining, ongoing Colombo Port City Project and mega sand dreading off Negombo coast for reclaiming purposes are examples of human interventions in this coastal zone. Lack of available field data found in such a coastlines yield numerical modelling 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 longshore sediment transport rates and related morphodynamics using input reduction and morphological acceleration techniques. Results of the alongshore sediment transport capacity computations clearly indicate the variable characteristics of different parts of the study zone. The annual alongshore sediment transport capacity computed in the study area oriented northward comply very well with the observations. Coastal belt between Mount Lavinia and Colombo, the wave climate and, subsequently, the annual alongshore transport reach the highest values indicating a relative dynamic environment and then found to decrease with a strong gradient northward. The explanation of these negative steep gradients and the environmental forcing/human interventions that govern the regional sediment transport are discussed in this paper.

Keywords: sediment transport, ERA Interim, SWAN, Morphological, acceleration, morphodynamics

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Quality assessment of Automated Weather Station (AWS) data for abrupt weather changing during Cyclone Roanu

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Real-time meteorological observations can be provided by Automated Weather Station (AWS) gathering data from a network through various communication channels. The AWS was deployed in the south of Sri Lanka, at 5.936108°N, 80.574900°E, and facing toward the north Indian Ocean. wind, precipitation, relative humidity, downward solar radiation, air temperature and air pressure simultaneously records in this region, with the aim of offering the reliable dataset in advances for our understanding of the variability in boundary layer. To increase the reliability of the system, many of the crucial parameters are measured redundantly with duplicate sensors or sensors of different principle. Furthermore, it is a valuable resource for ocean model parameterization and validation which has been investigated using the comparison with the ERA-Interim reanalysis data. The archived AWS dataset from Dec. 2015 to Oct. 2016 is examined in detail to understand the one-year seasonal variability and the episodic event, Cyclone Roanu. This abrupt weather change has been noted by the low air pressure, high relative humidity, high precipitation and reduction of downward radiation in May 2016. The analysis shows that AWS recorded pre-cyclone conditions and started to respond since 13th May 2016. The AWS recorded post-cyclone conditions which are illustrated by reduction of downward radiation with precipitations after 28th May 2016. These signals are evident for sustainability of AWS to the cyclonic conditions.

Keywords: AWS, Southern Sri Lanka, wind

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Eddy heat and salt transport in four typical regions in the Bay of Bengal

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Basin-scale eddy (turbulent) heat and salt transport in the Bay of Bengal (BOB) were estimated using Stammer's (1998) eddy diffusivity method using sea surface height data and climatological hydrographic data. It was found that high level of eddy transport (heat/salt) in the BOB were mainly located in four regions; the Western boundary of the Northern BOB (NB), the Western BOB (WB), Southern and Eastern part of Sri Lanka in the Southwestern BOB (SWB) and the region West of Malacca Strait in the South-Eastern BOB (SEB). A relatively large northward eddy heat transports were observed in NB and SWB while the largest southward eddy heat transport was located in WB. The eddy salt transport in the BOB were mainly northward with the largest northward transport in SEB and the second largest in SWB while the maximum southward eddy salt transport was observed in WB. Based on seasonal mean eddy transport estimations, pre-summer monsoon and summer monsoon were identified as the prominent seasons of eddy heat transport in NB and SWB while it was being post-summer monsoon for WB and SEB. Similarly, pre-summer monsoon and post-summer monsoon were identified as the seasons of maximum mean eddy salt transport in NB and WB, respectively whereas it was winter monsoon for SWB and SEB. Furthermore, the seasonal eddy kinetic energy (EKE) modulation through the seasonally intensifying East India Coastal Current (EICC) and Southwest/Northeast Monsoon Current (SMC/NMC) were identified as one of the main factors effecting the seasonal eddy transport modulation in NB and SWB regions, respectively.

Keywords: eddy diffusivity, eddy heat transport; eddy salt transport

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Spatial and temporal variation of mixed layer depth in the Southern Sea of Sri Lanka

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The southern sea of Sri Lanka is most important region of the Indian Ocean as it is more dynamic and productive during the summer monsoon. According to the geography of Sri Lanka, behavior of summer monsoon highly effective on upper most layers of the ocean than winter monsoon along the southern coast. Mixed Layer Depth (MLD) is highly sensible to the variation of physical factors of uppermost layers of the ocean. Study of MLD variation is most important factor for fishery forecasting and validation. This study mainly focused on behavior of MLD during the monsoon seasons with observed temperature/salinity maxima and minima. MLD was calculated using salinity and temperature profiles. Sea Surface Temperature (SST) and Sea Surface Salinity (SSS) contour maps were generated using satellite and reanalysis data. The highest SST in 2016 was recorded during first-inter monsoon period. This study shows significant relationship between MLD and wind speed ($R^2 = 0.49$ $p < 0.05$). Due to the high wind speed, MLD of 33.7 m was identified in March 2016 (First-inter monsoon). Wyrtki jets and wind stirring can be considered as responsible for enrichment of the mixed layer through cool thermocline water in first-inter monsoon period. MLD of first-inter monsoon period was very thicker than the winter monsoon period and winter monsoon is identified as a very low wind mixing season of this area.

Keywords: mixed layer depth, inter monsoon

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Aquatic Post Harvest Technology

A comparative study on the nutritional composition of raw and differently processed *Cyprinous carpio*, *Strongylura leiura* and *Nemapteryx caelata* fish species in Sri Lanka

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This study examined the effect on proximate composition and fatty acid composition of differently processed three fish species from three water sources namely marine, brackish and inland waters. The fish species were selected based on their availability and current commercial importance and they were *Cyprinous carpio* (common carp), *Strongylura leiura* (banded needle fish) and *Nemapteryx caelata* (engraved catfish). The flesh of raw fish and processed fish (fish cake, fish ball, fish pickles, cooked with coconut milk (Kirata) and cooked with spices (Mirisata) were analyzed. Among the fish species, raw needle fish reported the highest protein (18.3%) and ash (1.3%) contents. Cat fish in raw form reported the highest level of fat (2.3%). The pickle prepared from needle fish contained the highest level of protein (27.9%) followed by the pickle of catfish (27.3%). Carp fish pickle reported the highest level of fat (11.8%) followed by catfish pickle (8.1%). Fatty acid content of raw fish ranged from 43.9 to 62.4% for saturated fatty acids (SFAs), 15.1 to 67.3% for polyunsaturated fatty acids (PUFAs) and 20.1 to 30.6% for monounsaturated fatty acids (MUFAs). Among the SFAs, Palmitic acid was the main fatty acid while Oleic acid and Palmatoleic acid were the main MUFAs in all three raw fish samples. Docosahexaenoic acid (DHA) was the main PUFA present in raw fish (5.8- 59.6%) samples and carp fish reported the lowest (5.8%). Of the value added fish products namely fish pickle, fish ball, and fish cake, Lauric acid (38.4- 56.2%) was prominent in all fish species. Palmitic acid (10.5- 29%), Myristic acid (17.3- 22.1%) and Oleic acid (5.6- 23.4%) were the next abundant fatty acids found in value added products of three fish species. Three fish species prepared for kirata, contained higher amount of Lauric acid (47.5- 50%) followed by Myristic acid (17.7- 19.3%) and oleic acid (7.6- 16.9%). Fish processed for mirisata, showed high content of Palmitic acid (25.7- 39.3%) followed by Oleic acid (13.3- 23.4%). In conclusion, the composition of fatty acids of the above three fish species has been changed by value addition and processing of fish.

Keywords: common carp, banded needle fish, engraved cat fish, fish processing, proximate composition, fatty acid composition

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Determination of biotoxins in *Crassostrea madrasensis*: a case study of Puttalam Lagoon in Sri Lanka

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Shellfish culture is a major sector of aquaculture production worldwide and microalgae have the capacity to produce potent phycotoxins which bioaccumulate through levels of the food chain. There are lack of data on the marine toxins stress on scientific-based risk assessment in Sri Lanka. This study was carried out for the detection and quantification of some selected biotoxins in *Crassostrea madrasensis* collected from five sampling stations in Puttalam Lagoon. Randomly collected 16 samples of oysters (2 samples/month) from January to September excluding April and an algae sample in October, 2017 were analyzed for 4 types of biotoxins namely okadaic acid (OA), domoic acid (DA) saxitoxin (ST) and brevetoxin (BT) which are commonly associated with shellfish poisoning. Samples analysis were done according to competitive Enzyme-linked Immunosorbent Assay (ELISA) testing protocol, using max signal (USA) okadaic acid (DSP), domoic acid (ASP) saxitoxin acid (PSP), beacon brevetoxin (NSP) Plate Kit (Cat.# 20-0200) and Thermo Scientific SKANIT software for Microplate Reader. The maximum permissible levels (MPL) established for DSP (160 ppb) and ASP (2×10^4 ppb), PSP (800 ppb) were not exceeded in any of oyster sample. The DA concentration in *C. Madrasensis* was ranged from 0.073 ± 0.012 ppb to 0.167 ± 0.011 whereas ST was ranged from 0.141 ± 0.000 ppb to 0.982 ± 0.181 ppb and BT from 1.382 ± 0 to 1.603 ± 0 ppb. OA monthly concentrations did not show any significance ($p > 0.05$) in the concentrations and averaged as 0.179 ± 0.116 ppb during the experimental period;. In conclusion, results indicated an existance of DA producing phytoplankton in January was low and high in February. ST producers were low in February and high in July. BT generators were low in June and high in September. But, any of the quantified concentrations of OA, DA, ST and BT in *C. madrasensis* from Puttalam Lagoon were not exceeded their MPL intended to meet export quality criteria and requirements for human consumption.

Keywords: marine biotoxins, phytoplankton, ELISA, okadaic acid, domoic acid, brevetoxin, saxitoxin

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Validating Torrymeter as a sensor tool for freshness assessment of *Katsuwonus pelamis, Decapterus russelli* and *Lethrinus nebulosus*

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Fish freshness is determined by microbiological, chemical, organoleptic and rapid sensing instruments. Torrymeter is a portable sensor tool that can measure freshness of fish as a quick, easy and non-destructive method. In Sri Lankan context, Torrymeter is yet to be practiced. The present study was carried out for validation of Torrymeter to determine freshness of Skipjack tuna (*Katsuwonus pelamis*), Indian Scad (*Decapterus russelli*) and Spangled emperor (*Lethrinus nebulosus*). Freshness of each fish which were stored in chilled condition (0-4 °C) were measured over for seven days to obtain Torrymeter (Model 14-10949) readings, Total Volatile Basic Nitrogen (TVB-N), Total Plate Count (TPC), and Overall Quality Index Method (OQIM). Torrymeter data were correlated with respective values of later three methods. Torrymeter, TPC, TVB-N, and elaborate OQIM values obtained for freshness of fish showed linear relation with storage period. Obtained Torrymeter readings were analyzed by Chi-square test of Analysis of variance with TPC, TVB-N, and OQIM and correlation coefficient was calculated. High correlation coefficients of Torrymeter readings with TPC, TVB-N, and OQIM showed for spangled emperor that corresponds 85.7% to all three methods, while Indian scad showed 85.7%, 96.2% and 85.7% for the same. This result suggest that Torrymeter can be used to measures freshness of spangled emperor and Indian scads accurately. However, poor correlation (1-3%) was observed for Torrymeter reading of skipjack tuna with values of other freshness determination methods indicating the unsuitability of using Torrymeter for determination of freshness of skipjack tuna which had bruised skin/damaged tissues due to bad fish handling practices.

Keywords: fish freshness; organoleptic quality index method; torrymeter; TVB-N

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An assessment of heavy metals and *Escherichia coli* contamination of selected seaweeds collected from southern coastal area of Sri Lanka

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Seaweeds are one of the potential marine bio-resources for food and feed use that contain substantial amounts of minerals, vitamins, essential amino acids and dietary fibre. Considering the current level of environmental pollution and non-hygienic conditions where they grow, seaweeds possess a high risk of contaminating the food supply chain with potentially harmful *Escherichia coli* and heavy metals. Present study aimed at investigating selected heavy metal contaminations and microbiological safety in terms of *E. coli* level in three selected edible seaweeds collected from southern coastal areas of Sri Lanka. Seaweeds used in this study were *Ulva reticulata, Caulerpa racemosa* and *Sargassum wightii*. Mercury, cadmium, arsenic and lead levels of the three species were determined using atomic absorption spectroscopy. Single variable factorial experiment was conducted to assess the suitable heat treatment to achieve optimal microbial safety level. Heat treatment was carried out at 90 ˚C for 1, 3 and 5 min. Two replicates were used for each sample. *E. coli* level in fresh and heat treated seaweed samples were determined using most probable number (MPN) technique. Mercury level (0.030 ± 0.014 ppm) was significantly high ($p<0.05$) in *C. racemosa* and both cadmium (0.112 ± 0.018 ppm) and arsenic levels (2.042 ± 0.171 ppm) were significantly low ($p<0.05$). *E. coli* was detected within the range of 59 ± 22.6 to 350 ± 155.6 MPN/g in fresh seaweed samples and it could be reduced up to non-detectable MPN levels by providing the heat treatment at 90 ˚C for 3 min. All the heavy metals tested were significantly ($p<0.05$) lower than the regulated EU Standard Commission Regulation (EC) No 1881/2006 limits for vegetables and leafy greens. Pertaining to the above results, all three seaweed species were safe to consume with respect to heavy metal levels and after mild heat treatment to mitigate *E.coli* growth.

Keywords: *Escherichia coli*, seaweeds, heavy metal

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Effect of three different culinary methods (Kirata, Mirisata, Ambulthial) on Eicosapentaenoic acid (EPA) and Decosahexaenoic acid (DHA) contents of three fish species (yellowfin tuna, swordfish, and spotted sardinella)

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Marine fish is very popular in Sri Lanka, although very little is known about the possible different behaviors of the fatty acids contained in fish by different culinary methods. Wet heat cooking; Kirata, Mirisata, Ambulthial are the main culinary methods of fish in Sri Lanka. The aim of the study is to investigate the effect of above three culinary methods on EPA and DHA contents of yellowfin tuna (*Thunnus albacares*), swordfish (*Xiphias gladius*) and spotted sardinella (*Amblygaster sirm*) in order to determine the healthiest option. Based on the Total Diet Study Guidance, 33 (11x 3) fish samples (1 kg in each) were collected from a fish stalls, fish venders, Ceylon Fisheries Cooperation outlets, and Supermarket outlets in Gampaha. Raw and cooked; Kirata, Mirisata and Ambulthial samples were analyzed for fatty acid composition by gas chromatography equipped with flame ionization detector (GC-FID). Ambulthial is generally the healthiest option presented in this study, as the result showed the highest retention of EPA and DHA compared to the Kirata and Mirisata culinary methods. However, the choice of cooking ingredients and the moisture level may also influence the retention of EPA and DHA contents in cooked fish.

Keywords: fatty acid, gas chromatography, culinary treatments, marine fish

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Sources of faecal and pathogenic bacteria in fish landed at Beruwala and Negombo fishery harbours

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Bacterial contamination of fish is one of the major causes in rapid quality losses of fish. Therefore, this study investigated the initial sources of contaminations of fish supply chains beginning from Beruwala and Negombo fishery harbours. Samples of tube-well water (n=10), harbour basin water (n=10), bilge water (n=18), ice from the ice-plants (n=10), used-ice from boats (n=20), swabs from deck of boats (n=20) and swabs from fish holds of boats (n=20) were analysed for faecal coliforms, *E. coli*, *Salmonella* and *Listeria monocytogenes* from May to December, 2017. *Salmonella* and *L. monocytogenes* were confirmed by 16S ribosomal DNA analysis. Faecal coliforms and *E. coli* in Tube-well water collected from the Beruwala fishery harbour varied from 80 to >1800 and from 35 to 250 MPN/100 ml, respectively, while both contaminants were found in a range from 2 to 11 MPN/100 ml in the Negombo fishery harbour. *Salmonella* and *L. monocytogenes* were absent in tube-well water of both harbours. Harbour basin water obtained from both harbours was highly contaminated with faecal coliforms and *E. coli* with the ranges of 50–55000 and 25–25000 MPN/100 ml, respectively. About 30% samples of harbor basin water were detected with *L. monocytogenes*. *Salmonella* was detected in bilge water of 30 and 12% of boats in Beruwala and Negombo. *L. monocytogenes* was found in bilge water of 10 and 50% of boats in Beruwala and Negombo, respectively. Bilge water of boats in both harbours contained faecal coliforms and *E. coli* in high levels. Ice from ice- factories found contaminated with faecal coliforms and *E. coli* in the ranges of 13->1800 and 13->1800 MPN/100 ml, respectively, while 10 and 20 % of these ice samples were also contaminated with *Salmonella* and *L. monocytogenes*, respectively. Used ice for chilling fish in boats were also found contaminated with faecal coliforms (130-180000 MPN/100 ml), *E. coli* (25–180000 MPN/100 ml), *Salmonella* (5% of the samples) and *L. monocytogenes* (20% of samples). Swabs collected from boat decks and fish holds (fish contacting surfaces) contained faecal coliforms and *E. coli* in the range of 2->1800 MPN/100 ml in 100 cm^2. Twenty percent of the swab samples of fish contacting surfaces contained *L. monocytogenes*. However, *Salmonella* was absent in all the swab samples. High fecal contaminations and the presence of pathogenic bacteria in more instances in main utilities and facilities found by this study imply that there haven't been adequate improvements in infrastructure and fish handling practices as results of previous studies show the same conditions.

Keywords: Faecal coliform, *Salmonella*, *L. monocytogenes*, ice, harbour basin water, fish contacting surface

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Thermal effect on the proximate composition and energy value of squids and cuttlefish species

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The thermal effects on nutritional quality of two species of squids (*Loligo duvauceli, Sepioteuthis lessoniana*) and cuttlefish (*Sepia latimanus, Sepiella inermis*) were investigated before and after thermal processing. Proximate composition and energy values were analysed according to AOAC official procedures. The moisture content of all fresh fillet was around 80%, although the highest moisture content found in the *S. latimanus* (85.54±2.44%) followed by and *L. duvauceli* (83.15±1.05%) of squid species. The total ash content was around 1% of all fresh fillet, and *S. inermis* showed the highest ash content (1.12 ±0.04%, w.w). The protein content is higher in the squid (17.13±1.44%-17.93±0.76%, w.w) than the cuttlefish (16.38 ±0.78-16.85±1.50, w.w). The fat of all species were found around 1%. After subjecting the fresh fillets for thermal treatment at 90°C for 10 minutes, the moisture content and ash content were reduced significantly ($p<0.05$) in all species. But the protein and fat content were increased when compared to the fresh fillets due to the removing of free water from the muscle tissues. The highest protein (20.12±2.51%, w.w) and fat content (3.86±0.93%, w.w) were found in the *L. duvauceli* species and the difference is significant ($p<0.05$) than other three species. The energy value (4607.90±130.46 - 5058.16±79.61 cal/g, d.w) in the fresh fillet slightly decreased (4482.54±79.61- 4956.50±243.91 cal/g, d.w) after the thermal treatment but the difference is not significant ($p>0.05$). Results reveal that thermal treatment has less impact on nutritional composition of the selected squids and cuttlefish species.

Keywords: squid, cuttlefish, proximate composition, energy value, thermal processing

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Production of natural oyster sauce by utilizing Indian oyster (*Crassostrea madrasensis*)

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Indian oysters (*Crassostrea madrasensis*) are esteemed seafood with high nutritional value. Introduction of natural oyster sauce formulation is one of the high potential alternative for small scale production. Oysters muscle (890 g) was obtained from *Crassostrea madrasensis* (n=100) collected from Gangewadiya, Kalpitiya Lagoon and treated with 7% NaCl (890 ml) and water (1780 ml) (ratio of 1:3, muscle weight: brine weight). Oyster extraction was obtained following low flame heating of the setup for 30 minutes (80 ºC). Extraction (445 ml) was duplicated and 20 g, 10 ml, 75g, 0.6 ml and 175 ml of sugar, soya sauce corn flour, chocolate brown coloring and caramel were respectively added to samples which then cooked for 20 min and 40 min periods. Protein, fat, moisture, ash content, sugar content, water activity, pH and salt content were analysed in triplicates for duplicated samples to determine nutrient content and physico-chemical nature. Two samples of ambient and refrigerated storage were analyzed (40 min. cooked) in duplicates to determine shelf life of product in terms of sensory and microbial parameters of aerobic plate count (APC) and yeast and mold count. Higher acceptance was reported for sample cooked for 40 minutes with median hedonic scores 5.5, 6.0 and 6.0 for appearance, texture and taste respectively (Mann-Whitney U test; $P<0.05$). APC varied between samples during storage period (Two-way ANOVA). Refrigerated sample recorded the lower mean log CFU/g (1.88 ± 1.66) for APC, than the sample stored at ambient (5.03 ± 0.66). After 7-day storage, samples stored in ambient conditions recorded the lowest mean log APC (CFU/g) (4.272 ± 0.009) and no counts for the refrigerated samples. After 21-day storage of samples in ambient conditions recorded the highest mean log APC (CFU/g) (5.742 ± 0.003). Highest APC log CFU/g for the refrigerated sample was recorded after 14 days storage (2.000 ± 0.000). Initially, no colonies were observed in samples which were stored under two conditions. Yeasts and molds were not observed in two storage conditions during this study. Median hedonic scores of appearance, texture and taste did not show variation between ambient stored and refrigerated samples as well as between storage periods (Friedman test; $P>0.05$). Higher sensory acceptance was recorded for aroma in ambient stored samples (6.46) than refrigerated samples (6.29) (Friedman test; $P<0.05$). Innovated cottage based oyster sauce formulation had higher acceptability and thus be a better alternative for value addition of oysters.

Keywords: oyster sauce, cottage industry, proximate analysis, aerobic plate count, sensory evaluation

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Production of low-salted dried fish and quality evaluation

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Salted dried fish is a common, low cost protein source among the South-East Asian people. The local traditional dried fish processing techniques resulted high salt contents in dried fish products. The objective of the study was to develop a method to produce dried fish using least amount of salting and to preserve the protein value. *Scomberoides commersonnianus* (Talang queenfish or "kattawa") and *Sardinella gibbosa* (gold striped sardinella or "salaya") fish were selected. The minimum strength of brine which increase water phase salt (WPS) value more than 3.5% in wet salted fish was determined using a series of brine solution with different salt strength after 45 min of salting. Physical parameters, nutritional value and shelf life of low-salted dried fish were determined using the standard methods. Salting at 10% brine for 45 min was selected as the best salting conditions based on WPS value in salted wet fish. Protein content of low-salted dried kattawa fish was 56.30 ± 1.57 % wet basis whereas in traditional dried kattawa fish contain 45.15 ± 2.28 %. In low-salted dried salaya fish, protein content was 48.27 ± 1.18% and it was 37.17 ± 1.34 % in traditional dried salaya fish. Salt content of 6-8% was determined in low-salted dried fish samples whereas 12-13% was determined in traditional dried fish of both kattawa and salaya. It has been found that low salted kattawa and salaya dried fish can be kept more than three months in ambient temperature (29-31 ºC) by packing with polythene or vacuum packing .

Keywords: low-salted, dried fish, water phase salt, protein

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Total lipid content and fatty acid composition of *Lutjanus rivulatus* from Sri Lanka

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This study investigated the fatty acid profile of 18 blubber lip snapper (BLS), badawa (*Lutjanus rivulatus*) collected from Peliyagoda Central Fish Market, Sri Lanka. BLS is a commercially important reef associated marine fish species, which has a maximum length of 80 cm with 11 kg of maximum body weight. The total lipid content and fatty acid profile were analysed by Bligh and Dyer and gas chromatography method respectively. The results showed that average length and weight of the male and female were significantly different ($p<0.05$). The female BLS have higher fat content (4.23±0.39%) compared to the male (3.97±0.49%). The total saturated fatty acid (SFA) in male and female were 50.44% and 48.67% respectively. The Palmitic acid (C16:0) was abundantly (SFA) found in muscle tissue at the level of 30%. The omega-3 (n-3) and omega-6 (n-6) polyunsaturated fatty acids (PUFA) in female fish was 12.20±1.66% and 11.61±1.20% respectively while male fish contained 11.23±1.23% and 12.95±0.56% respectively for the same. The ratio of the n-6: n-3 indicated as 1.15 for male and 0.95 for female. BLS fish showed very low PUFA content when compared to the common fish species: skipjack tuna. BLS has much similar n-6: n-3 ratio compare with white muscle of skipjack tuna but lower to the red muscle (1.79). The PUFA/SFA ratio of the BLS was 0.48 for male and 0.49 for female. BLS has high SFA, and it might be increasing the risk of cardiovascular disease.

Keywords: badawa (*Lutjanus rivulatus)*, fatty acid composition, n-6:n-3 ratio

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Determination of proximate and mineral composition of *Ulva reticulata, Caulerpa racemosa* and *Sargassum Wightii* in Southern Coast of Sri Lanka

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There has been little application of seaweeds in Sri Lanka contrary to the countries like Japan, China and some Western countries. Climate, habitat, maturity and environmental conditions may cause differences in nutrient composition of seaweeds. In this backdrop three seaweeds *(Ulva reticulata, Caulerpa racemosa* and *Sargassum wightti)* were collected from Koggala and Dondra and investigated for nutritional composition. The fresh seaweed samples were cleaned, dried (50°C, 48 hrs) and ground into fine powder and analyzed for proximate composition viz moisture, total ash, protein, fat, crude fibre, macro minerals (Na, K, Ca, Mg) and micro minerals (Fe, Cu, Zn, Se). The results revealed that moisture, total ash, protein, fat and crude fibre contents of *U. reticulata* were 12.98±0.18%, 20.35±0.61%, 28.63±0.63%, 0.91±0.04% and 7.19±0.32% respectively. *C. racemosa* contained the moisture, total ash, protein, fat and crude fibre in amounts of 10.88±0.49%, 26.09±0.63%, 25.84±0.49%, 1.31±0.03% and 15.36±1.00% respectively. In *S. wightii* the moisture, total ash, protein, fat and crude fibre the contents were as 12.73±0.21%, 15.36±0.71%, 14.40±0.51%, 0.46±0.05%, 12.06±0.23% respectively. Concentration of minerals of all three species increased in the order: Se< Zn< Fe< Cu< Mg< Na< K<Ca. Macro mineral level and micro mineral level in *U. reticulata* were found in the range of 14.156 - 147.733 ppm and 0.006 – 0.059 ppm respectively. *C. racemosa* contained macro elements in the range of 6.451 – 95.490 ppm level and micro elements in the range of 0.006 – 0.037 ppm. *S. wightti* showed the 12.716 – 48.229 ppm level of macro minerals and 0.004 – 0.017 ppm of micro mineral level. Among these 3 species, the highest mineral content 147.733±0.895 ppm was resulted in *U. reticulate* for Ca which is more or less two times as much Ca in *C. racemosa.* The results of this study revealed that the Chlorophyta species *U. reticulata* and *C. racemosa* good source of calcium,protein and crude fiber and could be used as good source of supplements for conventional leafy greens.

Keywords: proximate composition, mineral profile, seaweeds

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Socio Economic and Marketing

Economic efficiency of small scale coastal fishing fleets in Sri Lanka

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This paper explored the economic efficiency of small scale coastal fishing fleets in Sri Lanka. Different size of fishing fleets representing Outboard Motor Fiber Glass Reinforced Boats (OFRP), Non-motorized Traditional Boats (NTRB) and Motorized Traditional Boats (MTRB) are operated in the coastal fisheries. Questionnaire survey was conducted from January to December in 2016 with representative sample of 304 fleets. Data were collected on catch quantity and value, variable and recurrent costs incurred in fishery operations. Data analysis was done using SPSS software package. Results concluded that fuel, labour, water and ice were major cost factors in coastal fishing operations and all fishing crafts, irrespective of category, were operated with profits in small scale coastal fisheries in Sri Lanka.

Keywords: OFRP, MTRB, NTRB, operational cost, profit

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A bibliometric analysis of research trends towards the objectives, opportunities and challenges for a Sustainable Blue Economy

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This paper assesses the contribution of local conference/symposia publications towards achieving a sustainable blue economy in Sri Lanka. The principles, opportunities and challenges of "Blue Economy" were recognized by reviewing current publications (from 2015-2017) such as policy briefs, reports and articles (n=25). Abstracts published in conferences/symposia proceedings by three main national institutes with the themes related to blue economy/economic development/ blue-green economy (n=289, published from 2015-2017) were evaluated. The keywords or objectives of each article were matched with the identified objectives, opportunities and challenges of blue economy. The terms of "poverty alleviation", "food security", "sustainable livelihoods" and "environmental conservation" were the core objectives of blue economy, while "governance", "science based" and "holistic" approaches further complimenting the concept. Focused research areas were identified as categories of commercial fisheries (10%), aquaculture (7%), marine and freshwater ecology (13%), ports and shipping (1%), safety (3%), toxicology (2), anthropogenic impacts (2%), innovation (5%), livelihoods (5%), conservation (2%), ocean prediction and monitoring (5%), mineral resources (0.02%) and other (2%). According to those results, it is evident that researches were mostly interested on topics related to marine and freshwater ecological research, followed by topics on commercial fisheries and aquaculture. Most blue economic researches tend to address the trending opportunities such as commercial fisheries and aquaculture with little emphasis on other opportunities such as shipping, marine tourism, mineral, oil and gas exploration. Plenty of researches have been done in terms of understanding the ecology while little work has been done in order to understand the anthropogenic impacts and conservation measures. The concept of blue economy has to be identified in a broad way through research rather than confining in to few common areas of interests. The holistic anticipations of blue economy have to be interpreted through research and shall be brought in to policy level in order to achieve the expected long-term sustainable development.

Keywords: Blue Economy, research trends, bibliometric study

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Application of the Box-Jenkins model to forecast monthly average retail price of spotted sardinella fish in Colombo and suburbs

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This study aimed to investigate an appropriate model to forecast and examine the behaviour of the monthly average retail price of spotted sardinella (*Ambligaster sirm*) fish in Colombo and suburbs. Monthly average retail price of spotted sardinella at Colombo and suburbs markets from January 2010 to December 2017 collected by Hector Kobbekaduwa Agrarian Research and Training Institute were utilized to find out the appropriate model to forecast the price using the Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) procedure. Nominal time series prices were converted into real prices by using the Colombo Consumer Price Indices (CCPI 2013=100). Both nominal and real price series had shown a seasonal pattern. But properties of two price series were different and therefore two different seasonal ARIMA models were identified as the best fitted models to forecast nominal and real prices of spotted sardinella. ARIMA $(1,1,0)$ $(0,1,1)^{12}$ was the best model to forecast and explain the behaviour of nominal price while $(1,0,0)$ $(1,1,0)^{12}$ was the best model for real price series. Nominal retail prices have been increasing gradually over the years while no noticeable increment in real value forecasts. Even though the nominal price increment over the years did not reflect the real price series prototype of the price changes within a year was more or less similar in both series. By comparing the behaviour of observed and forecasts of real and nominal prices, it can be concluded that the inflation rate will have a higher weight in determining the nominal retail price of Spotted Sardinella than the changes of fishery itself.

Keywords: ARIMA, nominal price, real price, spotted sardinella, time series

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Determinants of per capita fresh fish demand in Sri Lanka

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This research explores the determinants of annual per capita fresh fish demand in Sri Lanka and estimate the elasticity of them by using the Autoregressive Lag model based on Linear-Log functional form. The time-series data (1987-2016) for thirty years were gathered from the statistical reports of fisheries ministry of Sri Lanka, the data base of EDB, the statistical abstracts of Department of Census and Statistics, annual reports of Central Bank and economic and social statistics books of Central Bank. The annual per capita fish demand is a function of the consumers' income; own price (fresh fish price), price of substitutes (dried fish and chicken price) and one year lag value of per capita fish consumption. The prices of beef, pork, mutton, Maldive fish, canned fish, egg and milk have not shown significant impact on fresh fish demand. The estimated long run elasticity are as follows own price = -0.57, chicken = 0.70, dried fish = 0.42, income = 0.81. The fresh fish demand was inelastic for all the determinants in the model. That emphasizes fresh fish is a very important food item for Sri Lankans and they try to consume a relatively constant amount of fish disregarding in changes of the demand determinants. The income has the highest positive elasticity value and that implied continuous growth of income is the major determinant to increase per capita fish consumption. For long term income elasticity is decreasing from 0.83 to 0.73 during last decade that means income became more inelastic for fish demand over time. The fish has not close substitute hence all cross price elasticity values were less than one. During the last decade dried fish elasticity value has been gradually decreased while elasticity of chicken increased. That means substitutability of chicken for fresh fish increase over dried fish. The consumer has switched from dried fish to chicken as close substitute of fresh fish.

Keyword: demand for fresh fish, elasticity, income, cross price

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Socio-economic status of resident communities in the islands of Kalpitiya Peninsula in Sri Lanka

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Kalpitiya Peninsula is located in the North-west coast of Sri Lanka and it is bordered by the Indian Ocean from the west, and Puttalam Lagoon from the east. There are 14 islands in Kalpitiya covering a total landmass of about 1672 hectares and Islands of Baththalangunduwa, Uchchimune, Palliyawatte and Rodapaduwa are human habitations. This paper examines the socio- economic and livelihood status of the fishing communities in the Islands. A socio- economic survey was conducted using a semi-structured questionnaire from 134 fishing households. Simple random sampling technique was applied to select the sample from the 4 Islands of Baththalangunduwa, Uchchimune, Rodapaduwa and Palliyawatte. Field data were analysed using SPSS statistical package. The majority of residents (72%) of Baththalangunduwa were migratory fishers from Negombo, Chilaw and Kalpitiya areas but all residents of Palliyawatte were permanent dwellers followed by Uchchimune (94.7%) and Rodapaduwa (83.3%). All respondents (100%) of Baththalangunduwa and Rodapaduwa were married followed by Uchchimune (95.5%) and Palliyawatte (71.4%). Rodapaduwa and Palliyawatte Islands communities were Catholics and that of Baththalangunduwa and Uchchimune were (96.8%) and (95.5%) respectively. The average monthly income of the household was 39,000 rupees while the average value of the household expenditure was about 31,000 rupees. Results revealed that among the fishing communities, there was a severe deprivation of basic human needs such as housing, safe drinking water, sanitary facilities, education opportunities, health facilities and infrastructure facilities. Geographical remoteness and occupational based migration are critical factors for deciding their living conditions. The role of social work is very important and necessary social policy options should be prepared to improve the socio- economic and livelihood status of the fishing communities in the islands of Kalpitiya Peninsula in Sri Lanka.

Keywords: socio-economic status, islands fishing communities, occupational based migration, social work

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The commercial post-harvest loss of deep sea fisheries in Sri Lanka

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Post-harvest loss of fish identifies as fish that are either discarded or sold at relatively lower prices because of differences in quality due to quality deterioration. The post-harvest loss of fish causes economic and social implications such as loss of revenue to the fishers, food wastage, negative impact on food security of the people, and reduce export earnings of the country. In Sri Lanka post-harvest loss of fisheries is a serious concern that needs to be addressed immediately. This study aimed at assessing the commercial post-harvest loss (economic loss): one of the major components of post-harvest loss, of deep sea fisheries in Sri Lanka. Data were collected from IMUL boats (Multi day fishing boats) that unloaded fish at 10 main fishery harbours through the coastal belt of the country. The total samples were 140 IMUL boats. The commercial post-harvest loss (CPHL) was estimated for three fish quality grades that have been commonly practiced by the fishers and traders, such as Grade 1(Q_1) -good, Grade 2(Q_2) - moderate, Grade 3(Q_3) – poor. Estimations were done according to the gear type, such as long line, drift gill net and ring net. Results revealed that the highest average catch, 2,978 kg per trip was recorded in ring netting fisheries. Results further revealed that commercial post-harvest loss was higher in ring net fishing. In ring nets, the commercial post-harvest losses were 24% for skipjack tuna (SJT) and 22% for scads. It was 14% for SJT and 4% for small yellowfin tuna (YFT) in gill net fishing. The commercial post-harvest loss of YFT fish and marlin in long line fishing were 8 and 4% respectively. This study confirmed that a significant amount of fish is lost both in quality and quantity due to the post-harvest losses. Further, commercial post-harvest losses vary by fishing gear and fish variety. It is needed strong measures to improve fish storing facilities and on-board handling practices in deep sea fisheries in Sri Lanka to reduce post-harvest losses and in turn reduce the commercial post-harvest loss in fisheries.

Keywords: IMUL boats, long lines, gill nets, ring net

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