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2021

AQUATIC RESEARCH FOR PROSPERITY OF THE NATION
17th November 2021

ABSTRACT BOOK

Ocean University of Sri Lanka and China-Sri Lanka Joint Center
for Education and Research, CAS
State Ministry of Skills Development, Vocational Education, Research & Innovations

State Ministry of Skills Development, Vocational Education, Research & Innovations

This is the book of abstracts of the 3rd Research Symposium of the Ocean University of Sri Lanka with names of all authors, and emails of corresponding authors.

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MESSAGE FROM THE VICE CHANCELLOR

It is with immense pleasure that I write this message as the Vice Chancellor of the Ocean University of Sri Lanka on the occasion of the Third Research Symposium of the Ocean University of Sri Lanka. The Ocean University of Sri Lanka (OCUSL) is a special purpose government University established with an aim of developing the human resources requirement to achieve the economic benefits of Marine, Maritime, Fisheries and allied technology sectors. Ocean University, unlike other conventional universities in the island is conducting courses both at Undergraduate and Vocational levels. The two academic pathways have been designed to cater the requirement of highly specialized human resources capital both in academic and skilled sectors with an aim of contributing to the Blue Economy.

Innovative findings of multidisciplinary research in Marine, Maritime, Fisheries and allied technology sectors will be presented on this extremely important occasion. The Research Symposium provides an excellent opportunity to academics, professionals and scholars to share their knowledge and research experiences. This research forum will provide an excellent discussion platform on future academic and research activities.

The purpose of research is to form action. Thus, your study should seek to contextualize its findings within the larger body of research. Research must always be high quality in order to produce knowledge that is applicable to national and international audience.

I wish that the deliberations of the research sessions will prove productive and intellectually stimulating findings and the outcomes will be extremely useful to national and international development.

Finally, my warm wishes are extended to all the speakers and poster presenters individually and to the research community of Ocean University of Sri Lanka as a whole, to enlighten this event as well as to make greater efforts in 2021 with the prevailing COVID 19 pandemic situation to enhance our research productivity.

Prof. Wasantha Rathnayake
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The role of Scientific Committee for Oceanic Research (SCOR) and its activities to support blue economy

Sinjae Yoo[1] and Patricia Miloslavich[2]

[1]*President, Scientific Committee on Oceanic Research (SCOR)*
[2]*Executive Director, Scientific Committee on Oceanic Research (SCOR)*

Blue economy can be loosely defined as the sustainable economic growth supported by marine ecosystem services, although various definitions have been proposed. The concept of blue economy is consistent with the UN Sustainable Development Goals (SDGs) with more emphasis on certain SDGs related to economic growth and ocean. Because of the relationship with the SDGs, the goal of blue economy partially overlaps with that of the UN Decade of Ocean Science for Sustainable Development (Ocean Decade). The Ocean Decade implementation plan clearly states that science plays a vital role in this by providing knowledge and solution for each of the challenges of the Ocean Decade. However, these are largely uncharted territory, and it is not clear enough what kind of scientific knowledge is required or how it can be obtained. Likewise, scientific path to blue economy is not adequately explored yet although scientific guidance is imperative to achieve the delicate balance between economic growth and ocean health preservation. The Scientific Committee on Oceanic Research (SCOR) has upheld cutting edge science since its inception in 1957. One of the missions of SCOR is advancing ocean science by solving standing conceptual and methodological issues. Also, SCOR tackles global interdisciplinary issues through its large-scale projects. In this talk, we will introduce the SCOR's activities that are directly relevant to the blue economy by showcasing the works of its working groups and large-scale projects.

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Keynote Speech - II

Discovery and biosynthesis of marine actinobacterial natural products

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Marine-derived actinomycetes are emerging as important new sources for novel natural product possessing excellent bioactivities. Chemical investigations on South China Sea (SCS)-derived actinomycetes led to the discovery of a number of novel polycyclic natural products, for example, bisindole alkaloids spiroindimicins with unprecedented spiro-rings, and cyanogramide that contains a unique spirooxindole system. Genetic and biochemical experiments demonstrated that different biosynthetic strategies were involved in the formation of these polycyclic natural products. Herein we report our recent progress in the discovery and biosynthesis of marine actinomycete-derived spiro-ring containing natural products.

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OCEANOGRAPHY, HYDROGRAPHY, REMOTE SENSING & GIS AND MARINE ENGINEERING

Small Scale Ocean Dynamics in the Strongly Stratified Pynocline around Sri Lanka

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Department of Marine Engineering, the Ocean University of Sri Lanka, Crow Island, Colombo 15

Quantification of mixing in the Bay of Bengal (BoB), is a vital factor for understanding and predicting the vertical exchanges of heat, mass and momentum which are leading to turbulence and mixing in the BoB. The oceanographic measurements were carried out in the coastal waters around Sri Lanka under the Air-Sea Interaction in the Northern Indian Ocean (ASIRI) programme to understand the small scale dynamics. Two main transects, perpendicular to east and south coasts were carried out with a short distance drift station at the southern shelf break of the country. The micro structure profiling results shows the depth of relatively well-mixed surface layer in the deep water appears to be about 30–40 m across the entire southern branch of the current, deepening slightly toward the open sea during the inter-monsoon season. The drift-station results indicated the mixed layer depth of ~60 m, signifying the possibility of substantial convective cooling and/or strong wind mixing in the upper layer at south of Sri Lanka. Fresher and cooler water lenses near the sea surface did not affect the near-surface density structure very much, as evidenced by the almost uniformly mixed upper layer and the sharp, but not very narrow, pycnocline. The pycnocline deepens toward the south, suggesting predominantly eastward geostrophic transport at the end of intermonsoon. In September, along the Trincomalee transect exhibits a sharp thermohalocline in the depth range (30–40m) near the shelf break. However, ~80–90 km offshore, the pycnocline bends toward the sea surface, forming a striking baroclinic front which separates the fresher BoB surface water (S ~35.2–35.4 psu at z ≈ 40–50 m), corresponding to the specific density range.

Keywords: Ocean Dynamics, Bay of Bengal, Pycnocline

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Assessing Shoreline Variation in the Sand Spit of Calido Beach Using High-Resolution Satellite Images

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Sand spit is a special type of geomorphological feature in coastal regions, subjecting to short-term and long-term variations due to natural and anthropogenic impacts. However, proper investigation of sand spit dynamism with regard to spatial and temporal variations is a tricky task only from field surveys. Using of high-resolution time-series data has been recognized as more effective and efficient solution in this regard. Therefore, this study attempts to understand the dynamism of sand spits using high-resolution satellite images from Google Earth Pro with special reference to the Calido Beach in Kalutara, Sri Lanka. Primarily, seaward land-water boundary was delineated as the shoreline on Google Earth Pro platform from 2004 to 2021 under 300 m eye-altitude. Extracted shorelines were further processed and analyzed using ArcGIS 10.5.1 software. Digital Shoreline Analysis System (DSAS) tool was used to detect the shoreline change by casting 2383 transacts at 1m interval with reference to a manually created baseline. Shoreline change statistics were calculated to understand three different scenarios namely tsunami impact, natural variation and anthropogenic impact. Area of the sand spit in each year was also calculated by creating polygons in the Google Earth Pro. Results showed that there was no any considerable change in the shoreline due to the tsunami. But area of the sand spit reduced about 1.5% because of the damage caused to the sand spit at the Kalu Ganga river outlet. It was further found that the natural variation under the normal sea condition was an erosion in the rate of 2.2 m/year between 2005 and 2017. The study revealed that, after 2017, the sand spit was gradually diminishing and by 2021 it was completely destroyed while changing the geomorphology at the river outlet unprecedentedly. This happened because of an anthropogenic impact and subsequently shoreline position of the sand spit has rapidly moved towards the land in the rate of 36.29 m/year. As a result of this, it was observed that there is a very high possibility to create a new lagoon adjacent to the environment. Uncertainty of the shoreline positions of this study is approximately 5± 5.33 m.

Keywords: Google Earth, DSAS, Coastal dynamics, Remote Sensing, GIS

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Seasonal Variations of Sea Surface Chlorophyll-a and Sea Surface Temperature in the South of Sri Lanka Using MODIS Satellite Data

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This study was carried out to fill the knowledge gap in spatial and temporal variation of chlorophyll-a concentration and SST during both monsoon seasons in southern part of Sri Lanka (latitudes: 5° 44' N to 6° 32' N and longitudes: 80° 43' E to 81° 53' E). Chlorophyll-a and SST were collected from MODIS data for a period from 2016 to 2020. Once the downloaded data were visualized and reprojected from SeaDAS software, respective bands for each parameter were extracted using Arc GIS 10.5.1 software to calculate average Chlorophyll-a (mgm^{-3}) and SST (°C). Within monsoon variation and inter monsoon variation of Chlorophyll-a and SST were analyzed using paired t tests and the relationship between average Chlorophyll-a concentration and SST values were analyzed for each year using regression test. Chlorophyll-a concentration was significantly varied between northeast and southwest monsoon (Paired-t:$p<0.05$) in 2018,2019 and 2020. Higher values were recorded in southwest monsoon than northeast monsoon. SST was not significantly varied between northeast and southwest monsoon in 2016,2017,2018 and 2019 (Paired-t: p 0.05). There was no a significant relationship betweenchlorophyll-a concentration andSST in northeast monsoon (Regression test: R^2= 0.012, $p > 0.05$) while there was a negative relationship (Regression test: R^2= 0.1944, $p< 0.05$) in southwest monsoon. These changesappeared tohave been caused by upwelling phenomenon. According to results, this area hashigher potential for goodfishery production. Paired t-test result between years showed significant difference ($p<0.05$) among several years in chlorophyll-a concentration and SST. This research needs to be continueed with more time period and seasonal rain fall patterns to identify the dynamics of chlorophyll-a concentration and SST according to monsoon seasonal pattern.

Keywords: Oceanography, Image analysis, GIS mapping, Remote sensing, Monsoon

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Remote Sensing and GIS Based Approach to Assess the Coastal Inundation Vulnerability in Matara, Sri Lanka.

H.M.T Pushpamali[*], N.K. Narasinghe and T.W.S. Warnasuriya

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Coastal inundation is a hazard that can happen due to tsunami, storm surge and intense rainfall. This causes devastating effects on coastal communities in terms of social, economic and environmental aspects. Last few decades, it was identified that the Matara region is highly vulnerable to coastal inundation from intense rainfall and 2004 tsunami. Therefore, main objectives of this study are to understand the coastal vulnerability in Matara with regard to different water-depth scenarios during inundations and to identify the most suitable evacuation location for a possible coastal inundation scenario from the study area. SRTM - DEM data downloaded from the USGS EarthExplorer website were reclassified for 58 different inundation depth scenarios in ArcGIS 10.5.1 software. Areas covered under each scenario were estimated and convert these values into percentages. Then a vulnerability curve was developed for the study area with regard to the percent inundation area and different inundation depth scenarios. Human population data and flow accumulation derived from the DEM were incorporated to the vulnerability described in aforesaid curve to interpret the most vulnerable areas. According to the vulnerability curve, all the inundation scenarios were categorized into three coastal inundation scenarios as least case (1m inundation depth) scenario, moderate case (10m inundation depth) scenario and worst case (20m inundation depth) scenario. According to the results, 1.94%, 35.75% and 91.75% of the total study area could be vulnerable under 1m, 10m and 20m inundation depth scenarios respectively. The area on both sides of Nilwala river estuary was found as vulnerable under 1m inundation depth scenario. Kadaweediya West was found as the most vulnerable GN division under 10m inundation depth scenario. The land located at 5˚56′40″N 80˚33′39″E could be used as a rapid evacuation place in the case of huge tsunami waves as that area is not vulnerable even under the worst-case scenario (20m inundation depth). Further studies on this vulnerability assessment should be carried out to develop a disaster risk model incorporating coastal dynamics and hydrodynamic modelling for wave height estimations and other aspects of physical, social, economic and environmental vulnerabilities.

Keywords: Coastal inundation, DEM, Flood hazard, Vulnerability, Disaster risk.

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Design and Performance Investigation of a Helical Bladed Vertical Axis Wind Turbine

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It is a well-known truth that power generation from renewable energies such as wind and solar has been significantly growing around the world to meet the rising energy demand with the focus of moving towards a sustainable and green energy concept. Being an island nation, Sri Lanka can focus on marine renewable energy resources for electrical power generation, but no efforts have still been made in this regard. This research study is focused with a main aim to design a vertical axis turbine (VAWT) to generate electricity using the wind generated at roads, highways, coastal areas, and rooftops where considerable wind speed is available. The helical bladed VAWT, an improved version of Darrieus VAWT, which is found to be the most efficient architecture, is employed in this study. Moreover, some operational and geometric parameters that significantly affect the performance of the VAWT, and aero foils, solidity, number of blades, Reynolds number, pitch angle, tip speed ratio (TSR), and turbine shaft are vital among them. From the first phase of the research study, The National Advisory Committee for Aeronautics (NACA) 4415 airfoil was used to design the twisted helical wind blades and the 03 bladed turbine was Computer Aided Design (CAD) modeled using AUTOCAD package. The CAD model was then meshed using ANSYS ICEM CFD package. For numerical analysis the CFD package ANSYS CFX v17.2 used, while the simulations were carried out for steady state and time averaged conditions. The turbulence model was K-Omega SST (Shear Stress Transport) and time step at 0.1 used. For the given 7.0 m/s wind speed, turbine was simulated for different RPM values, and the maximum power output of 141.2 W at 300 RPM was achieved.

Keywords: Marine renewable energy sources, Wind energy, Vertical axis wind turbine, Aerofoil performance, CFD.

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A Remotely Operated Robot for measuring Hull Thickness

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Currently, the thickness of a marine vessel's hull is measured manually by the installation of scaffolding or semi autonomous equipment, which is always seen as dangerous for humans because it requires highly risk operators. Also this method is time-consuming as it need to get data visually or using an ultrasonic thickness gauge. The shipping industries have now started robotic solutions in order to reduce these risks and operation time. However, most such robot systems cannot be operated fully autonomously due to the fact that they require humans in the loop. Here we develop a robot which is capable of operating remotely to vertical line wall climbing for getting metal thicknesses and inspections. The proposed project is most suitable in dry-docking periods in marine industries. We perform this robot as a wireless light-weight robot that can be remotely accessed through Wi-Fi Micro Controller Unit (MCU), using a metal tracked type locomotion system set with wheels and permanent magnets to avoid slipping. The adhesion system is one of the important functions for climbing robots because it helps to stick the robot on the wall. Also, this robot was equipped with (a) an ESP32 camera having an ESP32 Wi-Fi module for observing thickness gauge, and (b) a "SmartElex 15S" powerful motor driver with reducer motors. Furthermore, we hope to access data , to store and monitor them in order to identify its advantages in a comfortable place or area. Such findings will be helpful to produce a robot that can be controlled by one person or with lower attention of the person where the app with control and video feed.

Keywords: Hull Thickness, Wall climbing, Robots, Remote controlling, MCU

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Interannual Variability of Subsurface High Salinity Water in the Eastern Indian Ocean

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Based on ten-year in situ measurements from the "Eastern Indian Ocean Comprehensive Experiment Cruises", the interannual variability of subsurface high salinity water (SHSW) along the equator in the eastern Indian Ocean is investigated. The cruises were operated in the eastern Indian Ocean during spring each year since 2010. The in-situ salinity profiles along the equator reveal that the spring SHSW has significant interannual variability during 2010-2019, in which the salinity is weaker in 2012 and slowly increasing afterward. The interannual variability of other seasons are examined using monthly Simple Ocean Data Assimilation. It is found that the salinity variability from October to February is similar with that in spring but with lower salinity in 2013. Whereas the summer from May to September has more significant variability of salinity than other seasons, showing the lowest value in 2017. The subsurface zonal current within 70m-130m depth, playing a role in salinity exchange between western and eastern basins, is a dominant factor. Nevertheless, the correlation between subsurface zonal transport and different seasons varies implying complex relative contributions from different factors.

Keywords: interannual variability, Salinity, Subsurface zonal currents, Eastern Indian Ocean

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Simultaneous Measurement and Evaluation of Potential Novel Halogenated Transient Tracers in The Ocean

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Ocean ventilation is defined as the process that transports perturbations such as the concentration of trace gases from the surface mixed layer into the ocean interior. Ocean ventilation and mixing processes play significant roles in climate. They largely control the accumulated uptake of anthropogenic carbon at middle and high latitudes as well as the deep ocean's oxygen supply. One possible method to quantitatively describe these processes is based on multiple transient tracer measurements. For this purpose, CFC-12 has been widely used as an oceanic transient tracer since the 1980s, SF6 since the 1990s. However, since the atmospheric concentration of CFC-12 is declining, novel transient tracers are needed to characterize ventilation, in particular for recently ventilated waters. Here we evaluated a selection of potential alternative tracers (HCFCs, HFCs and PFCs) based on four aspects: atmospheric history, seawater solubility, stability and feasibility of measurement, and found the most promising transient tracers HCFC-142b, HCFC-141b, and HFC-134a currently.

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The Geological Disaster Assessment and Long-term Monitoring Network in Coastal Cities of Sri Lanka

Minghui Zhao[1, 2*], Min Xu[1, 2], Lingmin Cao[1, 2], Yong Zhou[1, 2] and Yayun Zhang[1, 2]

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Sri Lanka is characterized by complex geological structure, heavy rainfall, and severe tectonic relief. Meanwhile, with the development of economy and the increase of urban construction, the risks are rapidly increasing from geological disasters and major construction projects. Therefore, it is very urgent to explore the urban shallow structure and evaluate its potential geological disasters, especially for the coastal cities. In this project, Colombo, Galle, and Matara, are key research areas. A dense array of 150 short-period seismographs will be deployed for continuous data recording. The effective signals extracted from ambient noise will be used to detect the shallow structure and evaluate the potential geological disasters. These results will provide an important scientific basis for the classification of geological disasters and engineering construction plan in the future. This cooperated scientific project will potentially solve the livelihood problems during the process of Sri Lanka's urban construction under the strong support from CAS China-Sri Lanka Joint Center for Education and Research. More importantly, we train the young scientist for Sri Lanka to realize the long-term observation experiment in Sri Lanka, which could play an important role in the "one belt and one road" marine strategy.

Keywords: Shallow structure; Geological disasters; Ambient noise; One belt and one road; monitoring network.

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Designing and Manufacturing a Floating Oil Separation System for Harbours

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The economic and environmental damages due to the accidental oil-spills in marine environment seem to increase gradually around Sri Lanka during past few years. Oil spills make up about 12% of the oil that enters the ocean. The rest come from shipping travel, drains and dumping. An oil spill from a tanker is a severe problem because it emits large quantity of oil spill into one place. Oil spills cause very localized problems and can exhibit severe damage to local marine life and ecosystems. Therefore, more efficient engineering design should be developed to segregate oil from sea water. An innovative upstream solution for cleaner and more sustainable marinas, harbours, rivers, public water ways and ultimately oceans is discussed under this current study. In this regard, a new design of oil and water separation system is proposed. The effect of geometrical features, such as the location of the baffle plates and the projected horizontal area of the coalescing surfaces on the oil-recovery rate are investigated. The working mechanism of this separator is to utilize the density difference between the oil and sea water, by passing through coalescing media to help the coagulation of emulsified oil particles. Along the flow passage, additional parts such a curved baffle to regulate the contaminants location, and flat baffles, a flow path to regulate the influent rate were located. Coalescent media was used to provide a suitable surface for oil droplets to meet and grow into large droplets, as oil droplet grow in size the buoyancy of the droplet increases. Based on the Stokes's Law, the separator has a dimension of 6m length and 1m width along with 0.5m height to meet the required minimum volume to provide sufficient resident time for oil droplet size larger than 60 microns to rise to the surface of water before reaching the separator outlet for sea water. Two flat baffle plates were used to increase the oil removal efficiency. The removal efficiency of the separator was inversely proportional to inlet flow rate and effluent concentration while it was directly proportional to the retention time.

Keywords: Oil spills, Oil water separators, Gravity separation, Baffles, Coalescing media

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Studying the Methods of Improving the Efficiencies of Internal Combustion Engines

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The Traditional Internal Combustion Engines (ICE), particularly Spark Ignition (SI) engines have a maximum thermal efficiency which does not usually exceed the 35% mark. That indicates that 65% energy will loss as heat .Therefore wasting of these heat has been reduced as much as possible to increase the thermal efficiency of an engine. In IC engines, burning of fuel produces heat. Part of the produced heat will be converted to useful energy to run the engine. The excess of the produced heat will exit as exhaust gas and will be absorbed to the engine through the cooling system. The methodology of the current research is to analys the wasting heat recovery and to mitigate the friction losses of IC engines. The objective of the research is to find out the methods to improve the efficiencies of internal combustion engine and to test its benefit to the environment. The results indicated high compression ratio, supercharging, lean operation and high combustion temperature which lead to increase the efficiency of IC engines. Exhaust gas recirculation helped to protect the environment by reducing the harmful gases and the efficiency also was increased to a certain amount. Engine valves control the intake of fresh air, fuel, and the exhaust of combustion gases. Variable Valve Timing (VVT) and lift systems adjust the timing of the valves to match the operating conditions of the engine in order to improves the efficiency over a wide range of engine operating speeds. The use of appropriate oils reduces friction, increases fuel efficiency and at the same time it maintains low wear. The research can be concluded that there are several numbers of methods to achieve improvements of the engine efficiencies, lower emission and better engine performance. Those include use of turbochargers and superchargers, direct fuel injection, variable valve timing, variable compression ratio, exhaust gas recirculation, water injection, low temperature combustion, homogeneous charge compression ignition, etc.

Keywords: Internal combustion engine, Improvement method, Efficiency

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Designing and Manufacturing a Low-Cost Tommel Sand Nurdles Separator with High Accuracy and High Efficiency

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The purpose of the study is to design and manufacture low cost, high accuracy, and high-efficient Tommel to filter sand and to remove pellets as solutions for low efficiency and labor wastage. This device designing was focused because of pellet pollution prevails in the coastal areas. In this pollution, we considered about two scenarios: manual cleaning and cleaning using devices. However, in the manual cleaning the nurdle filtering process was harder because of the size of the nurdles. on the other hand, filtering using devices could able to reduce labor wastage and to increase efficiency than the traditional filtering method. As an advantage, even one person is able to handle the filtering process using this developed device. With trial and error method, we improved traditional Tommel to ergonomic design to operate easier, by using "Solidworks" software which is used in 3D modeling. in this case, designing dimensions was mainly focused to improve the accuracy and efficiency. The angle of the barrel, length of the barrel, and radius of the barrel were the dimensions focused during the study. In the final design, we were able to improve the accuracy with changing dimensions and using a simple design and thereby to increase the portability of the device. After modifying the first design, the length increased to 4.5ft. Also, 1.5ft diameter was used for the final design the same as the first design. The proposed sand nurdles separator would be beneficial for efficient coastal environment rehabilitation from sand pellets in the future.

Keywords: Nurdle remover, Tommel, Sand Sieve machine, Portable Tommel

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FISHERIES & AQUACULTURE

Tracing the Composition of Pacific Oyster (*Crassostrea gigas*) Microbiome: Impact of Sampling and DNA Extraction

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Accurate identification of Pacific oyster microbiome is crucial for understanding the polymicrobial aetiology of Pacific oyster mortality. Sequencing of the bacterial 16S rRNA gene is a common approach in this regard, which requires bacterial DNA extraction from oyster tissues. The objective of this study was to identify preferred tissue types, sampling and DNA extraction methods to extract DNA from Pacific oysters, and storage methods to store DNA extracts, to accurately determine its microbiome. Samples were collected from haemolymph, gill, gut and adductor-muscle. DNA was extracted using three different commercial nucleic acid purification kits. The bacterial DNA yields were quantified using an optimized real-time PCR assay while the bacterial community compositions were identified by high-throughput sequencing of the hypervariable V1-V3 region of the 16S rRNA gene. The bacterial DNA yields in different extracts were compared using a generalized linear mixed model. The bacterial community compositions were analysed using the software suite, Quantitative Insights into Microbial Ecology 2 (QIIME2). The bacterial DNA yield varied between different tissues ($p < 0.05$) and each tissue type harboured a unique microbiota, except for gill and muscle. Phylum *Proteobacteria* (69%) dominated in all tissue types except gut tissue where phylum *Fusobacteria* (39%) was most abundant. Despite the higher bacterial DNA yields with QIAamp® DNA microbiome kit, the EZNA® Mollusc DNA kit identified twice as many operational taxonomic units (OTUs) and eliminated PCR inhibition from gut tissues. Higher bacterial DNA yields were obtained by swabbing compared to tissue homogenates and from fresh tissues compared to frozen tissues, without impacting the bacterial community composition. While the tissue type and DNA extraction method substantially affected the quantity and diversity of bacteria, the sampling and storage methods only affected the quantity of bacterial DNA.

Keywords: Pacific oyster, Microbiome, *Crassostrea gigas*, DNA extraction, Tissue sampling

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Bioelectrochemical Hydrogenotrophic Denitrification in a Rotating Biological Contactor for Recirculating Aquaculture Systems

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Nitrite accumulation is a common issue in recirculating aquaculture systems. Hydrogenotrophic denitrification is a viable solution for aquaculture water with low biological oxygen demand. However, its application is limited due to low hydrogen solubility and safety concerns associated with conventional treatment systems. A bioelectrochemical rotating biological contactor (BE-RBC) was suggested as a safe and efficient method for hydrogenotrophic denitrification by combining a rotating biological contactor (RBC) and electrostatic field-based bioelectrochemical system. Performance of the BE-RBC was investigated under different influent quality, hydrogen supply and operational conditions. The BE-RBC reactor achieved a denitrification rate of 1.37 gNO_3^- -N/L.d and efficiency of 96.8% with the optimum pH, HRT, influent NO_3^--N, and bicarbonate concentration of 7, 20 min, 20 mg/L and 100 mg/L, respectively. Reactor assured sufficient hydrogen supply even at low hydrogen partial pressure (0.5 atm) and eliminated nitrogen gas accumulation in the continuous operation. *Thauera spp.* (47.8%) and *Sulfuricurvum spp.* (36.5%) were the dominant bacterial communities which tolerate high pH (up to 10) and oxygen concentration (6-7 PPM). *Thauera spp.* is considered as electroactive microorganisms enhance denitrification rate by 25.3% under the electrostatic field of 2 V/cm. Hence, the proposed BE-RBC reactor utilized H_2 gas efficiently and safely for hydrogenotrophic denitrification to meet the acceptable water quality requirement for aquaculture.

Keywords: Recirculating aquaculture systems, Hydrogenotrophic denitrification, Rotating biological contactor, Electrostatic field

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Bactericidal Activity of Marine Brown Algae Extract Against Biofilm-Forming Pathogenic Bacteria

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Antibiotic-resistant microorganisms are becoming more common in hospitals and communities, necessitating the development of new control methods. Marine species are thought to be a source of a variety of bioactive chemicals that can be used to treat a wide range of biological activities. As a result, algae, particularly marine brown algae, were selected to test their antibacterial activity against biofilm-forming human pathogenic bacteria. We searched for the relevant bioactive components in the extract of *Sargassum aquifolium* (Turner) C. Agardh (Phyophyceae) to inhibit pathogenic bacteria's drug-resistant capability. Disk diffusion and broth microdilution assays were used to assess antibacterial activity against Gram-positive and Gram-negative microorganisms. Furthermore, using gas chromatography-mass spectroscopy (GC-MS), the active component present in the extracts was discovered. A total of 21 bioactive compounds were identified using GC-MS analysis with different chemical natures. From less to more polar, the crude ethanolic extraction was fractionated according to the eluotropic series. The largest zone of inhibition was 38.0±0.17 mm for ethanolic extract on *Listeria monocytogenes*, while the lowest was 10.67±0.06 mm for ethyl acetate fraction on *Pseudomonas aeruginosa*. *Staphylococcus aureus* and *L. monocytogenes* had a MIC of 256 μg/mL, whereas *Escherichia coli* and *Pseudomonas aeruginosa* had a MIC of 512 μg/mL. The antibacterial efficacy of *S. aquifolium* (Turner) C. Agardh extracts against human pathogenic bacteria was investigated in this study.

Keywords: Antibacterial, extraction, Fractionations, *Sargassum aquifolium*.

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Antioxidant Capacity of the Bioactive Compounds Recovered from Sea Urchin (*Stomopneustes variolaris*) Viscera Using Subcritical Water Hydrolysis

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Subcritical water hydrolysis is an economical, effective, and overall green technique of recovering nonpolar and polar bioactive compounds such as phenols, flavonoids, polysaccharides, and proteins in contrast to conventional extraction methods. Therefore, in the present study, we utilized subcritical water hydrolysis (SWH) to recover bioactive compounds from sea urchin (*Stomopneustes variolaris)* viscera. SWH was used at four extraction temperatures (110°C, 150°C, 190°C, and 230°C), and Soxhlet extraction (SE) with 70% ethanol was used for comparison. Total phenolic (TPC), total flavonoid (TFC), total protein (TPrC) and total sugar (TSC) contents of the SWH and SE extracts were analysed using spectrophotometric methods. Also,*in-vitro* antioxidant capacity was analysed using 2,2-azinobis- 3ethylben zothiazoline -6-sulphonic acid (ABTS+), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assays. Data were analysed using one-way analysis of variance along with Tukey's Post Hoc test at a 95% confidence level from SPSS software (version 18.00, SPSS Inc., IL, USA). Highest TPC (9.38 ± 0.15 mg GAE /g), TFC (3.33 ± 0.02 mg RE /g), TPrC (19.68 ± 0.56 mg BSA /g) and TSC (23.38 ± 1.30 mg glucose /g) were recorded from the SWH at 150°C. Also the highest ABTS+ (98.92 ± 1.27 %) and DPPH (68.84 ± 7.91%) radical scavenging activities were observed from SWH at 150°C. In contrast to the SE, the SWH showed superior results ($p < 0.05$). The finding suggested that SWE could be useful for the extraction of antioxidant compounds from sea urchin, *S. variolaris* for advanced applications such as an animal extract-based food additive or a nutrition supplement including phenolics, flavonoids, polysaccharides and proteins.

Keywords: Subcritical water hydrolysis, Green extraction, Antioxidants, Sea urchin

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Growth and Mortality of *Decapterus macrosoma* (Bleeker, 1851) Off Cochin Coast, India

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Carangids are ecologically and economically diverse groups of marine fish species. They are a part of pelagic fishery and constitute the fourth important rank among the Indian fishery. They inhabit in various ecosystems such as coastal, estuarine, marine waters of tropical, subtropical, and temperate regions etc. *Decapterus* species of carangids have significant economic value because they are used as both food fish and bait. *Decapterus macrosoma* (Bleeker, 1851) is one of the abundant pelagic fish species. Heavy exploitation by the uncontrolled purse seine operations may leads to gradual decline of its stocks. Despite its fisheries importance in Kerala state, not much information is available on the aspect of growth and mortality. The objective of the study was to determine the growth and mortality parameters of short fin scad-, *Decapterus macrosoma* using length-based stock assessment from the length frequency data collected from the Cochin coast between April 2016 to November 2016. A total of 500 specimens ranging in size from 10.3 cm to 25 cm in total length (TL) and 10.24 gm to 114.42 gm were used in this study. The von Bertalanffy growth formula was used to describe growth of fish based on ELEFAN method. The von Bertalanffy's growth equation for *Decapterus macrosoma* was $L_t = 33 (1-e^{-0.320 (t + 0.5053)})$, where L_t is the length at age t The total mortality rate was 2.68 yr^{-1}, the natural mortality and fishing mortality were 0.80 yr^{-1} and 1.88 yr^{-1} respectively. The exploitation rate (E) was 0.70 indicating that this fish stock is heavily exploited. *Decapterus macrosoma* showed High mortality rates may be due to the reason that these small pelagic fishes are likely to be prayed on by other fishes.

Keywords: Age, Growth, *Decapterus macrosoma*, von Bertalanffy's growth equation;, Cochin coast

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Proximate Compositions of Four Different Jellyfish Species Collected from Sri Lanka

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Jellyfishes are the members of phylum Cnidaria. They are known for painful stinging that may arise negative impacts on the socioeconomic well-being of coastal populations. This study focused on the analysis of the proximate compositions of four different jellyfish species found in the Southern and the Western coasts of Sri Lanka, with the aim of assessing their applicability in food industry. The fresh samples of jellyfishes *Acromitus flagellatus* and *Acromitus maculosus* species were collected from Negombo. In addition, jellyfishes *Chiropsalmus* sp. and *Cyanea capillata* species were collected from Galle and Tangalle, respectively, during 2020. The jellyfish species were identified through morphological observations. The moisture content of the fresh jellyfish samples and the ash, crude protein and total fat contents of the freeze-dried samples were analyzed according to the methods of AOAC, 2005 with slight modifications. The moisture, ash, crude protein and total fat contents were significantly different ($p < 0.05$) in different jellyfish species. More than 95% of the bodies of all four jellyfish species were consisted of moisture. The highest and the lowest moisture contents were reported in *Chiropsalmus* sp. (98.11±0.07%) and *C. capillata* (96.07±0.23%), respectively. Of the dry matter, ash content was the highest followed by crude proteins, except for *Chiropsalmus* sp. The ash content of jellyfish *A. flagellatus* (58.98±0.86%) was the highest, while the lowest ash content was reported in *Chiropsalmus* sp. (37.21±2.02%). The crude protein content of *Chiropsalmus* species was higher than the ash content, which reported the highest crude protein content (39.08±1.01%) of the four jellyfish species. The lowest crude protein content was found in *A. maculosus* (11.49±0.38%). The total fat contents of all four jellyfish species were much lower, and significantly different among different species ($p < 0.05$), except for the two *Acromitus* species ($p > 0.05$). The highest and the lowest total fat contents were recorded in jellyfish *C. capillata* (2.23±0.18%) and *A. maculosus* (0.80±0.06%), respectively. Higher protein and mineral contents, along with lower fat contents of jellyfish species revealed from this study suggest their potential applications in the food industry, as an ingredient for the development of functional foods and nutraceuticals.

Keywords: Jellyfish, Proximate composition,; Nutritional value, Crude proteins

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Fishermen's Attitudes about the Impact of Opening of Paalameenmadu and Kallar Barmouths on the Fishery of Batticaloa District, Sri Lanka

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Batticaloa lagoon is one of the productive estuaries on the east coast of Sri Lanka and is connected to the sea at two points, Paalameenmadu and Kallar barmouths. The seasonal opening and closing of the above barmouths influences the fish catch composition in nearby fishing areas. In this study, information was gathered on current fishing practices, species composition of the catch, and seasonal catch species composition using semi-structured questionnaire, and responses were obtained after a pre-test and were analysed with descriptive statistics method using SPSS. The level of awareness among stakeholders was studied using five points Likert scale questionnaire. Fisheries data were collected from 10 major barmouth fishery landing sites from January to April 2021. Two hundred and ten respondents were selected using a stratified random sampling technique. The study revealed that Paalameenmadu barmouth was opened annually and Kallar barmouth has been closed for the last five years. The most practiced crafts in Paalameenmadu were outboard Fiber Reinforced Plastic boats (OFRP) by 35.3% of fishers and small lagoon canoes by 87.0% fishers in Kallar. Seven types of fishing gears were used, and among them hook and line, cast net and dragnet were identified as major fishing gears operated. Thirty species representing 17 families were recorded in the catch. Among them, dominant fish families were Scombridae (17.1%) and Penaeidae (14.8%) in Paalameenmadu. In the Kallar, families Penaeidae (18.8%) and Gerreidae (16.3%) were recorded. Barmouth opening appeared to be favourable for fishing and Penaeid species representing 38.6% were caught during barmouth opening period. Fishermen have "good" awareness level on the impact of anthropogenic activities on the fishery resources and fishery regulations. As such, fishermen's participation might be possible to reduce anthropogenic activities and to implement strategies for sustainability of fishery resources. COVID-19 pandemic has decreased the income of fishermen. Irregular and early barmouth opening have caused a reduction in fish production. Further research and stakeholder awareness programmes are needed for sustainable management of the lagoon fishery.

Keywords: Lagoon fishery, COVID-19 impacts, Fishery regulations, Sustainable fishing, Seasonal changes

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Demonstrating the Cultivability of Marine Bacteria Using Pacific Oyster (*Crassostrea gigas*) Microbiome

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Marine microbiome is diverse and dynamic. More than 99% of the bacteria have not been cultured under laboratory conditions. Microscopic examination of oyster tissue homogenates indicated that the number of bacteria growing on agar was < 0.001% of the total bacteria that were present in oysters. The current study aimed at assessing the difference between: (1) the total bacterial counts obtained from conventional bacteriology with that from molecular quantifications; (2) *Vibrio* counts obtained by conventional methods with that from molecular quantifications, using Pacific oyster microbiome. The research was carried out by using secondary data on Pacific oyster microbiome obtained by culturing oyster tissue homogenates and from real-time quantitative PCR assays. Culturing was done on marine salt agar-blood (MSA-B) and thiosulphate-citrate-bile salts-sucrose (TCBS) agar and the resulting number of colony-forming units (CFU)/g of oyster tissue, were used in this study. *Vibrio* counts and total bacteria counts of the same oysters had also been quantified using real-time quantitative PCR assays. All data were log-transformed and total bacteria were statistically compared with total cultivable bacterial counts (TCBC). Total *Vibrio* counts were compared with total cultivable *Vibrio* counts (TCVC). Total cultivable bacterial count was lower than the total bacterial count in the Pacific oyster microbiome and the total cultivable *Vibrio* count is lower than the total *Vibrio* count in Pacific oysters

Keywords: Pacific oyster, Marine bacteria, Cultivability, Microbiome, *Vibrio*

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Assessing the Efficiency of a Conventional Water Treatment Process in Improving the Quality of Water

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Many water treatment plants use a combination of processes including coagulation, sedimentation and disinfection to ensure the safety of drinking water before distribution to the public. Water quality parameters including pH, turbidity, coliform count and *Escherichia coli* (*E. coli*) count, are some crucial indicators of efficiency of the treatment process. The objective of this study was: (1) to assess the efficiency of a conventional water treatment process using physical, chemical and bacteriological water quality parameters; (2) to investigate the relationship between physical quality and the microbiological quality of water. The study was carried out at the Kandy South Regional Laboratory of National Water Supply and Drainage Board. Membrane filtration method coupled with Chromogenic Coliform Agar (CCA), was carried out for testing *E. coli* and other coliforms while pH and turbidity were also measured. Coliform and *E. coli* counts, pH and turbidity of water were compared between different stages of the water treatment process, using Generalized Linear Models. Potential relationship between the *E. coli* count and turbidity was also evaluated statistically. Both the *Escherichia coli* and coliform counts dropped after the water treatment process ($p < 0.05$) where the disinfection stage showed the highest effect on the elimination of coliforms and *E. coli*. There were no any significant reductions after aeration, coagulation, flocculation and sedimentation, in the elimination of pathogenic coliforms. A positive correlation was observed between the *E. coli* count and the turbidity during the water treatment process ($r = 0.65$; $p < 0.01$) In conclusion, the conventional water treatment process is efficient in enhancing the bacteriological and physio-chemical quality of water for drinking and domestic purposes. It was also noted that the *Escherichia coli* and coliforms were higher in water when the amounts of suspended particles were higher in water.

Keywords: Conventional water treatment process, *Escherichia coli*, Coliforms, pH, Turbidity

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COASTAL & MARINE ENVIRONMENT

Sample-Size Requirements for Evaluating Length-Frequency Distributions of Reef Fishes from Stereo-Bruvs

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Precisely describing the size structure of reef fish populations is vital for their management and conservation. This study, recently published in Ecological Indicators, assessed the number of length measurements required from baited remote underwater stereo videos (stereo BRUVs) to accurately describe the size structure of mesophotic demersal fish populations using a resampling approach from an empirical length dataset collected using stereo BRUVs across the continental shelf of eastern and southern Tasmania, Australia. The exact number of length measurements differs across species, with some less abundant species requiring substantial sampling effort. However, results suggest that, on average, between 60 and 120 individual length measurements were needed from at least 20 to 2000 independent deployments to be 95% confident that samples reflected the "real" size structure of fishes captured using stereo BRUVs. It is important to note that the "real" size structure of each fish species here is unknown but was parameterized by pooling all measurements across the stereo BRUV dataset. This study helps to initially inform sample size requirements for length measurements for monitoring using stereo BRUVs and provides a methodology that can aid researchers to further refine the overall sampling effort for future fisheries and marine park monitoring applications.

Keywords: Fisheries management, Fish monitoring, No-take marine reserve monitoring, size structure, Stereo BRUV

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Understanding the Natural Variability of the Beach Stretch from Mount Lavinia to Wellawatte for Long Term Management of Local Coastlines

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Sri Lanka is an island situated in the Northern Indian Ocean having a coastline that spans approximately 1600 km. Four monsoon seasons influence Sri Lanka's coastline, the northeast monsoon, southwest monsoon and 2 inter monsoonal seasons. The study was set out to assess how monitoring of a local shoreline can provide baseline data for bettering long term planning and management. The purpose of this study was to capture the natural variability of a 5km public beach stretch on the west coast of Sri Lanka between 18th June 2020 and 16th August 2021. Measurements of the beach width were conducted fortnightly at 14 predetermined sites along the stretch between Mount Lavinia and Wellawatte. The average width at each of the 14 sites was calculated and compared seasonally to analyse the variations. Limited variation of beach width was observed, with the highest average recorded after the northeast monsoon during the first inter-monsoonal season 2021 (40.39 m) and lowest record was during the Southwest monsoon 2020 (29.10 m) which could be attributed to the direction of sand transportation expected with the changing wind and wave circulation during the SW and NE monsoons. The findings can be used to assess the necessity of structural responses if an eroding coastline is observed.

Keywords: Natural variability, Local coastline, Coastal management, Dynamic coastlines

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Optimizing Ecosystem Restoration and Mangrove Conservation with Phytosociology-Ecology Synergy

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Increased coastal degradation and anthropogenic activities have posed potential threats on the vulnerable coastal ecosystems, especially mangroves. Hence, mangrove restoration is becoming an increasingly important strategy for combating mangrove loss and improving ecosystem services. Effective mangrove restoration depends on understanding the complexity, dynamics, and spatial connectivity of the selected landscapes. In the present study, we aim to address this issue by understanding the forest structure and ecological factors that influence mangrove distribution in eight mangrove forests across three climatic zones in Sri Lanka. We studied mangrove diversity and vegetation structure with 10m wide belt transects laid of different lengths (n=96) across the land-water gradient. Mangroves along the transect were identified, enumerated, together with measured tree Diameter at Breast Height (DBH). Subsurface water samples were taken from the adjoining lagoon/estuary to assess the environmental parameters (n=144). Site-dependent spatial changes in the mangrove community structure were depicted through Cluster Analysis (CA). The forest survey revealed a heterogeneous mixture of 20 true mangrove species across the sites dominated by *Avicennia* sp, *Rhizophora* sp, and *Sonneratia* sp. Among the several environmental parameters analyzed by the distance-based Redundancy Ordination Analysis (dbRDA), salinity, dissolved oxygen, and precipitation were found to be controlling factors in mangrove community structure. In addition, discriminant analysis confirmed the presence of ecological-phytosociological influence on mangrove assemblages identified through CA. When tested using the Canonical Analysis of Principal coordinates (CAP), two structural parameters (tree density, and taxonomic diversity) altered the species abundance significantly across the sites surveyed. The study discovered site-specific phytosociology-ecology linkages as important theoretical implications for future mangrove restorations. As aquaculture expansion, urbanization, pollution, and other land-use have already caused obvious anthropogenic disturbances to mangroves, ecosystem restorations are needed for the above study sites. The key outcomes from the present study will also facilitate restoration ecology and offer a way forward to the restoration practitioners concerning strategic site selection and planning for effective mangrove restoration on regional and national scales.

Keywords: Mangroves, Phytosociology, Ecology, Restoration, Ecosystem service

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Home for Marine Species: Seagrass Leaves as Vital Spawning Grounds and Food Source

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Seagrass beds provide nursery habitats for marine species. Seagrass leaves, in particular, are used as spawning grounds and as a food source for fish and invertebrates, but direct evidence of spawning in seagrass leaves is rare. It is also very challenging to identify eggs through morphological analysis, since the eggs of many marine species appear similar. To accurately identify the eggs on the leaves of the dominant seagrass species in the South China Sea, and evaluate seasonal contribution of seagrass leaves as a food source, DNA barcoding and stable isotope technique were conducted. Interestingly, *Monetaria annulus* was found to spawn on the leaf sheath of *Thalassia hemprichii* in Li'an gang, Hainan Island. This choice of oviposition site might increase embryo survival compared to the other parts of the seagrass leaves. Meanwhile, the eggs of *Stethojulis trilineata* were deposited on the entire leaf of *Halophila ovalis* in Liusha Bay, Guangdong Province. The small fingernail-shaped leaves of *H. ovalis* might be beneficial for *S. trilineata* to lay eggs as they are closer to the sediment surface than other seagrass leaves. Based on the stable carbon and nitrogen isotope analyses, the primary food source of *M. annulus* in summer and in winter were particulate organic matter and seagrass, respectively. The results suggest that seagrass leaves are not only important for fish and invertebrates as a spawning site, but also as a food source. The findings of the present study may support the urgent requirement of the conservation of seagrass beds for sustaining the productivity of marine fisheries.

Keywords: Seagrass, Eggs, DNA barcoding, Spawning grounds, Food source

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Contamination of Microplastics in Cultured *Kappaphycus Alvarezii* seaweed, North and Northwest Coasts of Sri Lanka

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Microplastics (MPs) contamination in marine biota has negative impacts to the human health. It has been linked to marine macroalgae, which serve as a vector for the movement of microplastics through the marine food web. This study was conducted to quantify and characterize the MPs in the edible dry seaweed of *Kappaphycus alvarezii* at eight cultivated sites. Dry seaweed samples were collected in each sampling site during 17th September and 22nd of December 2020 in North and Northwest coasts of Sri Lanka. Seaweed samples were analyzed for two size classes (300 μm - 1mm and <300 μm) of MPs in triplicate at each site. The particles belong to two size classes of MPs were counted and identified using light microscope. Total of 24 seaweed samples were analyzed and found that mean (±SE) total MP abundance is 12.33±1.095 items/50g and abundance varied significantly among the study sites (One-way ANOVA; $p<0.05$). Significantly higher abundance of total MPs and large MPs was reported in Pallikuda, Kiranchi, Walaipadu 1 and Silawathurai sites than that of other sites. However, abundance of small MPs was not varied significantly among the sampling sites ($p<0.05$). Composition analysis of shape categories showed that fibre in size class of 300μm – 1 mm was dominated in seaweed sampling site with 71.6% followed by film (5.35%), foam (11.93%), fragments (10.7%) and sphere (0.41%). In size class of < 300 μm , fibre were dominated in study sites with 62.26% followed by fragments (28.3%), form (3.77%) and film (5.66%). Composition analysis of five types of shape categories in total MPs revealed that studied culture sites are dominated by fibre (69.93%) followed by foam (10.47%). The lowest composition was spheres (0.34%) within the studied sites. This study provides accumulation of MPs in cultured seaweed including possible sources of MPs such as fishery, culture and handing practices and transfer pathway.

Keywords: Abundance, Composition, Fibre, *Kappaphycus alvarezii,* Microplastics, Seaweed

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Application of Photo-Quadrat Method for Determination of Benthic Coverage in Coral Reef Located in Weligama Bay Southern, Sri Lanka.

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Coral reefs are complex and productive ecosystems that provide habitat to ocean life. The interaction between coral organisms and the macroalgae was highly observed during the last decade and called as phase shift in recent literature. The mechanisms behind taking up the space available by the algae over the coral were explained by the global microbialization. The high-resolution photographs supported this descriptive study to show the status of benthic life forms related to the microbial process and sea water temperature. Therefore, it was recognized that applying the photo-quadrate technique to look at the benthic life forms in a coral reef is more precise and helps compare the changes over time. The objective of the current study was to determine the percentage cover of live coral, dead coral, and macro algae. The present study uses the photo-quadrate captured from 1m² area from reef lagoon located at Weligama bay, along a permanent transact line (400m). Photographs captured (n=40) were analyzed using Photoquad® software. A total number of 50 stratified random points were spawned on the selected image at a time. The percentage cover per image was calculated by selecting the number of points that fall to representing the life form category considered to calculate the mean percentage cover. The live coral, dead coral, and algae cover represented as 31.1% , 21.9%, and 31.4 %, respectively in the reef area. The other benthic category covered 15.7%, These photographs and the results will be incorporated into future monitoring to compare and contrast the status of the coral reef at Weligama bay.

Keywords: Coral, Algae cover, Photo quadrat method, Weligama bay, Underwater photography

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Morphological Response of the Sand Barriers to Human Interventions in the Nakdong River Estuary, Busan, South Korea

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The barrier island system is an important coastal landform. The barriers play a major role in mitigating catastrophic invasions particularly in the shoreline as a natural coast guard. However, natural and human-induced processes alter the morphology of the barrier system. The Nakdong river barrier system in Busan, South Korea is an excellent example of morphologically changing barrier system during last multi-decades. Over the last half of century, morphological changes in the barrier island system in Nakdong river estuary were documented by anthropogenic impacts. In this study we analyzed the morphological changes of the barrier island system induced by human, and evaluated the human forcing contributing to change physical regime from delta to wave-dominated barrier system. To investigate the morphological change over the last few decades in time and space, historical maps were closely examined. Ten nautical maps from 1972 to 2016 were digitized using by ArcGIS 10.1. The tidal prism decreased from $5.9 \times 10^9 m^3$ to $2 \times 10^9 \ m^3$ during 1972 to 2016. In response to the reduction of the tidal prism the east tidal inlet width decreased from 1,437m to 419m, i.e. 29% with 0.5% annual rate of its size. The west tidal inlet width was increased 34% with 0.7% annual rate. The area of the barrier islands was gradually increased with time. The barrier islands of Sinjado and Doyodeung were formed in 1988 and 2008 respectively. Older maps revealed that the barrier islands formed before human intervention. The facts signify the energy regime shift from delta to wave-dominated barrier system. Significant changes in tidal prism, variations of tidal channel inlet versus depth with time, and development and morphological alterations of the barrier island system all contributed to the energy regime shift. The barrier island formation and expansion were accelerated by anthropogenic intervention. The source of barrier sands remains obscure yet and requires clarification.

Keywords: Barrier system, Morphological changes, Tidal prism, Anthropogenic impacts

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Faunal Diversity Assessment of the Crow Island Beach Park and Associated Area.

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Colombo Crow Island Coastal wetland is coming under Ramsar wetland city (6˚58'24.1"N, 79˚52'09.9"E) which covers 7 ha. This coastal wetland consists of rich fauna and flora diversity and is among the least studied wetland in the capital. The objectives of the present study were to investigate the faunal diversity of the Beach Park and the associated area, and to assess the distribution and abundance of the mangrove associated crab species. The study was carried out from 24th of August 2020 to 23rd of September 2020 and it is the first detailed faunal diversity assessment in the Crow Island beach park ecosystem. A Total of 95 faunal species belonging to 53 families were recorded within the Crow Island Beach Park and it`s associated area. During the study, six species of amphibians, thirty-one species of birds, nine species of reptiles, twelve species of mammals, twenty species of butterflies, seven species of dragonflies and damselflies, and ten species of crabs were recorded. Among the recorded fauna, two species, namely Junglefowl (*Gallus lafayettii*) and Sri Lanka wood frog (*Haylarana gracilis*) are endemic to Sri Lanka. Four species are nearly threatened including one dragonfly, spine–legged redbolt (*Rhodothemis rufa*), two butterfly species known as mime (*Papilio clytia*) and brown king crow (*Euploea klugii*) and one mammal species identified as brown mongoose (*Herpestes brachyurus*). One species of vulnerable fishing cat (*Prionailurus viverrinus*) was also found. Birds were the most abundant faunal group and the amphibians were the least abundant in Crow Island Beach Park. Species evenness, species richness and Shannon Weiner diversity indices were calculated for mangrove associated crab species in selected four areas of the study site. Species richness was equal (9) in the lower and middle areas while the beach area had the lowest (1). Shannon Weiner Diversity indices were 0, 1.97, 1.92 and 1.83 for the Beach area, Lower area, Middle area and Upper area respectively.

Keywords: Coastal Wetland, Diversity, Fauna species, Species richness

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Preliminary study on the impact of South-West monsoon on the abundance and diversity of seaweeds in Dikwella algal bed, Southern Sri Lanka

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Marine macroalgae (seaweeds) are macroscopic, multicellular benthic marine algae that are important natural resources found throughout the world, including Sri Lanka. This study reveals the diversity of seaweeds found at the Dikwella algae bed at the beginning of South-West monsoon (March -April) and the end (October-November) during 2019. The random quadrat method was used to collect the data from 30 sampling locations in the first and last weeks of each month. The Shannon wiener diversity index (H) was used to calculate the diversity of recorded algae species, while the abundance of each species was calculated based on the total algal percentage coverage in all quadrates. Standard identification guides were used to identify the algal species. Results revealed that 42 algal species presented from 20 different families in the field. In March, the H values for the first and last weeks were 2.22 and 1.17, respectively, whereas in April, they were 2.37 and 2.39. H values were 2.38 and 1.88 in the first and last weeks of October (just after the monsoon), while they were 2.09 and 1.95 in November accordingly. The average total percentage cover of algae species on the bed prior to the monsoon and after the monsoon period was 68.06% and 98.66%, respectively. The increased coverage could be attributed to the wave actions and ambient environmental conditions received for algae growth during the monsoon season. Ulva lactuca had the highest abundance before the monsoon followed by Sargassum sp. and Chaetomorpha antennina had the lowest abundances followed by Cladophora herpestica. After the monsoon, the highest algal abundance was Sargassum sp. followed by U. lactuca while the lowest abundance was Padina minor followed by Hypnea pannosa. Regardless of the monsoon effect, Sargassum sp. was found to be the dominating species in the algae bed during both periods. However, after the monsoon season, the percentage coverage was higher. As a result, it can be suggested that the South-West monsoon showed a significant impact on the availability and diversity of seaweeds in the Dikwella algal bed in 2019.

Keywords: Algae, Dikwella, Abundance, Diversity, Monsoon

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Status of the Floral Diversity in the Crow Island Beach Park, Colombo 15.

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Crow Island Beach Park and associated coastal area is considered as a Colombo urban coastal wetland ecosystems. This wetland provides a diversity of habitats for numerous flora and fauna species. The present study was conducted to assess the status of floral diversity in the Crow Island beach park and it`s associated coastal ecosystem. Study area was divided in to three sites (site A, B and C). and line transect method and field observation were used to obtain data. Recommended guide books and plant identification applications were used for identification and nomenclature of flora species. Seaweeds were collected using a scraper and a stout knife. Crow Island coastal wetland consists of mosaic of five major vegetation types: herbaceous, tree, shrub, creeper and grass. In addition, marine algae species were also present in the site. A total number of 102 flora species belonging to 50 families were recorded from the study area which included 63 native species, 23 exotics species and 16 naturalized exotic species. There were two true mangrove species and sixteen mangrove associated species in the study sites. Out of the flora species, 46 species were recognized as medicinal plants. Apart from that four seaweed species namely *Chaetomorpha antennina, Rhizoclonium africanum, Ulva compressa* belonging to Chlorophyta (green algae) and *Grateloupia lithophila* belonging to Rhodophyta (red algae) were found in the study area. Simpson's, , Shannon-Weiner, and Menhinick᾿s indices were used to assess the species diversity and richness of mangroves and mangrove associted species. Shannon-Wiener index for mangrove and mangrove associated species were high in all sites shown as 2.378, 2.304 and 1.676 in A, B and C sites respectively. Simpson's diversity index for mangroves and mangrove associated species of the A, B, C sites indicated relatively high values given as 0.889, 0.874 and 0.735 respectively. Moreover, Jaccard index of similarity between the three study sites showed high values ranging from 41% to 69% for mangroves and mangrove associated species.

Keywords: Crow Island, Coastal ecosystem, Diversity Indices, Floral diversity, Mangroves.

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Assessment of Pollution Status with Reference to Physicochemical Characteristics in Panama Lagoon, Sri Lanka

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The lagoon ecosystems of Sri Lanka have come under pressure from agricultural, fisheries and other development activities in recent decades. The Panama Lagoon (6° 45' - 6° 46' N and 81° 48' - 81° 49' E) has been identified as a relatively pristine, shallow coastal lagoon in the Eastern coast of Sri Lanka. It is of high ecological importance due to its dense and healthy mangrove vegetation and associated biodiversity. This study focused on assessing the pollution status of the lagoon by analyzing selected physicochemical properties of the water. The physicochemical parameters of 14 sampling stations were measured during the wet season (February and May) and dry season (August and September) of 2017. Standard methods were used for determining of physicochemical parameters of water samples. The lagoon recorded mean pH and Dissolved Oxygen values of 7.7±0.7 and 5.8±1.7 mg/l respectively. Mean conductivity of the lagoon was 29.55±16.9 mS/cm. Conductivity, salinity and Total dissolved solids are correlated parameters and showed marked variation between dry and wet period. Ammoniacal Nitrogen, Nitrate, Nitrite and orthophosphate concentrations were recorded as 0.069±0.07 mg/l, 0.016±0.02 mg/l, 0.005±0.0008 mg/l and 0.076±0.01 mg/l respectively. Mean values of BOD and COD were 3.1±2.3 mg/l and 272.7±152.3 mg/l respectively and higher values were recorded in the dry period. Relatively low nutrient and organic matter levels in the Panama Lagoon indicate low pollution. The primary productivity of the lagoon was measured using the oxygen measurement method during dry months and the mean was 1.2±0.7 mg.C/l/d. Pesticide residues tested at selected locations were below the limit of detection (0.005 mg/l). Heavy metals; As, Hg, Cd (<0.001 mg/l), Cr, Pb (<0.01 mg/l) were also not detected. According to the findings of the present study, the health of the lagoon is at a satisfactory level in terms of water quality. Therefore, future development activities should be carefully managed to ensure the sustainability of the lagoon ecosystem.

Keywords: Panama Lagoon, Water quality, Physicochemical properties, Coastal lagoon

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Assessment of Public Perception on Marine Environment In Relation To X-Press Pearl Ship Disaster, Off Colombo Port, Sri Lanka

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The Singapore registered X-Press Pearl cargo ship was caught fire on 20th May 2021 in coastal waters of Sri Lanka (7° 4' 50.0694"/ 79° 46' 18.6234"), causing the biggest marine disaster in Sri Lanka in recent history. Pollution from the ship includes millions of plastic pellets, chemicals and other substances. On 7th July 2021 Sri Lanka's Attorney General's Department informed the Colombo Magistrate's Court that over 200 marine animals died (176 sea turtles, 20 dolphins, and 04 whales) following the ship accident due to marine pollution caused by the chemicals. This incident awakens the interest of the general public about the marine environment, pollution and related disasters. The objective of this research is to assess the public knowledge and knowledge gaps regarding the marine environment and marine pollution. Further, it aims to identify the types of information sources and recognize the opportunities to increase the public awareness regarding the marine environment. A survey was carried out using structured questionnaire which includes 25 questions through social media. The survey was communicated by 150 respondents through social media representing all age groups and education ranging from primary level to post graduate level. The results revealed that all the respondents were aware about the ship accident. The 83% and 81% of respondents were known about this incident from mainstream media and social media respectively. The 51% of respondents think they are moderately familiar about marine environmental issues and 3% claims that they are not at all familiar with issues related to the ship accident. The 84% of respondents believe that the ship accident motivated them to learn more about marine environment, while 16% think it was not. Out of the different consequences from the ship accident, the most known issue is the chemical and oil pollution and 70% were aware about it. Even though the plastic pollution considered as the most severe and long-lasting impact, public awareness on that is relatively low (58%). According to the study people are enthusiastic in learning more about marine ecosystems and marine pollution via television programs and newspaper articles.

Keywords: Marine disasters, Pollution, Sri Lanka, X-Press Pearl ship

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Preliminary Study on the Status of Micro Plastic Abundance and Distribution in the Shore Line of Batticaloa District of Sri Lanka in March 2021

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Plastic production is increasing year by year, for example the 1.7 million tons plastic production in 1950 became as high as 360 million tons by 2018.. Commonly used plastics do not perish. Instead they are exposed to ultraviolet (UV) light and temperature after being released into the environment and then break into small pieces. Broken pieces of plastic less than 5mm in this way are called as micro plastics. These are found in a wide range of ecosystems such as shorelines, seabed, beaches, frozen ice and surface waters. Marine organisms such as zooplankton, mussels, fishes, shrimps, bivalves, oysters, copepods, and whales are known to ingest micro plastic with their food. These are carried to other organisms through the food chain and impact on even human health. Monitoring the distribution and abundance of micro plastics in the east coastline of Sri Lanka is essential and very little microplastic information exists for this region. This study was aimed to provide information on the present status of micro plastic distribution found in the shore line at nine selected locations of Batticaloa district Sri Lanka. This preliminary study plan will be continued forat least for a calendar year to support future safety, management efforts and global comparisons. Sample collection was completed between 22th to24[th] February 2021 where two samples were collected as replicates using a 50 cm × 50 cm quadrat perpendicular to the shoreline. The soil inside the quadrate was then excavated to a depth of 5 cm and were placed in a clean container. During the analysis, the floating materials were separated by density separation method. Finally, the larger plastic particles less than 5 mm were dried and separated as micro plastics and their weigh were recorded. Results showed that micro plastics are found in a certain proportion in all the sites within the Batticaloa coast line. The grand mean value for all the sites was 3.89 ±SD gwhile the district mean value was 432.22 mg. Out of all the sites, Kalladi reported the highest percentage of micro plastics (15.17%). The lowest percentage of micro plastics was recorded from Punnakkudah site (2.06%). The reason for higher microplastic pollution in Kalladi could be higher usage and disposal of plastics than at the punnakkudah site. Future studies will investigate the sources and their relationships to the micro plastic pollution in the Batticaloa District.

Keywords: Micro plastics, Abundance, Distribution, Shore line

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Carbon Dynamics in Planted Mangroves - A Global Review

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Mangrove plantings are aimed for various economic and ecological benefits. Growing planted mangroves also capture atmospheric carbon in to their carbon components called Above Ground Carbon (AGC), Below Ground Carbon (BGC), Soil/Sediment Carbon (SC), Litter Carbon (LC) and Downed Wood`s Carbon (DWC)/litter. This is an additional service of all mangrove plantations against global warming however, studies on such carbon capturing in planted mangroves are scantly. This has limited out knowledge on climate mitigating function done by planted mangroves. Therefore, the current study was aimed for a global review on carbon capturing done by planted mangroves. A systematic, up to date literature review reviled that, carbon of planted mangroves have been researched in fourteen countries for total of thirty-three mangrove species. Out of the 22 studies about planted mangrove carbon, only four studies provided direct information on the planting density (3356 to 26400 trees ha^{-1}) while the plantation age (12 to 55 years) are mentioned only in seven studies. As the parameters needed for calculating carbon, tree height, the Diameter at Brest Height (DBH) or basal area have been mentioned only in twelve studies. There are fourteen studies about AGC and BGC of mangrove plantations while only few studies have covered the SC, LC, and DWC carbon components. The measured carbon values are given only in nine studies (AGC= 60.36MgCha^{-1} to 21790.7274MgCha^{-1}, BGC= 21.42MgCha^{-1} to 780.11MgCha^{-1}, Soil= 111MgCha^{-1}, Sediment= 243.54MgCha^{-1} to 31597.25MgCha^{-1}, DWC= 1.9473MgCha^{-1} to 26562.37MgCha^{-1}) while the total carbon pool given by all the five components have not been assessed for any single research. Absence of DBH and planting density are major barriers for calculating the AGC and BGC while lack of age information of the plantations have limited our understanding about the rate of carbon accumulation over the age of mangrove plantations. Due to these deficiencies, the carbon pool in planted mangroves is largely underestimated. Completing the carbon values of all the five carbon components of the already published 22 studies as well as for any future studies are essential for understanding the total carbon capturing by planted mangroves against the global warming.

Key words: Carbon, Planted Mangroves, Global warming

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Sri Lanka's Vulnerability to Ship Based Oil and Chemical Pollution: A PESTLE Analysis

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Oil and chemical spills are some of the most drastic marine pollution incidents, generally caused by shipping activities and offshore oil and chemical production. The toxic effects generated by spilt chemicals result serious issues in the physical and biological environments. PESTLE analysis is an effective tool, used to analyze and monitor the macro environment of a country that may have greatly affected by ship accidents with oil and chemical pollution. Shipping is an effective way to transport significant amount of chemicals and oil around the world to meet the demand of day today lives. As long as shipping is concerned, major ways for oil and chemical spills might be either through operational releases or in the cases of ship accidents. Several times Sri Lanka has experienced oil/chemical spills since 1994. The first reported ship-based oil spill incident was by the MV Komsomolets Azarbaydzhana and the most recent incident of a chemical spill is due to the MV X-press Pearl incident. . Hence the vulnerability to ship-based oil and chemical pollution in Sri Lanka has become an important marine pollution source that needs to be addressed to management and conservation of marine life. This study was carried out to assess Sri Lanka's vulnerability to ship based oil and chemical pollution within in terms of Political, Economic, Social, Technological, Legal and Environmental (PESTLE) aspects. The study was carried out as an "on desk" research, approximately referring to 38 published scholarly papers, articles, and other digital and printed sources. The objective of this research is to provide preliminary data on some major insights about the prevailing status of the country's vulnerability to ship based oil and chemical pollution and suggest some internal and external contents that might be of helpful to be better prepared for similar incidents in future.

Key words: Chemical Spill, Oil spill, PESTLE Analysis, Ship-based, Sri Lanka

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Spatiotemporal Variation of Physicochemical Parameters in Rekawa Lagoon in Different Rainfall Seasons of Sri Lanka

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Rekawa Lagoon (2.58 km²) is a shallow brackish water body with unique natural resources located in Hambantota District. Fishing is the main livelihood of the communities living near the lagoon and the beach. Physicochemical and biological parameters of lagoon water can directly affect fish production and ecosystem dynamics. The study aimed to determine spatial and temporal variation of physicochemical parameters in South West monsoon (SW) and North East monsoon (NE) in 2017. Eleven (11) sampling locations were selected representing the entire lagoon. All physicochemical parameters and heavy metals were measured in accordance with the APHA standard method. Pesticide residues in water were analysed using GCMS. Spatial and temporal data analyses were performed using Minitab 17 and Arc GIS. One-way ANOVA resulted that the mean values of Water Temperature (SW- 30.6±1.5°C, NE −28.4±0.9°C), pH (SW- 7.3±0.1, NE- 7.7±0.2), Salinity (SW- 18.1±2.4 ppt, NE- 14.8±0.9 ppt), Electrical Conductivity (SW- 35.8±2.9 mS/cm, NE- 23.1±1.2 mS/cm), Turbidity (SW- 18.8±10.2 NTU, NE- 10.6±3.9 NTU), Total Suspended Solids (SW- 54.3±12.7 mg/L, NE- 23.6±8.9 mg/L), Ammoniacal nitrogen (SW- 0.04±0.01 mg/L, NE- 0.15±0.08 mg/L), Orthophosphate (SW- 0.03±0.00 mg/L, NE- 0.02±0.01 mg/L) of SW and NE monsoons were significantly different (p<0.05). However, average values of Dissolved Oxygen (DO), Nitrite nitrogen, Nitrate nitrogen (NO_3^-N) and BOD in the above two seasons were not statistically significant. In addition, all physicochemical parameters in both seasons were within the limits of National Environmental (Ambient Water Quality) Regulations (Aquatic Life), No. 01 of 2019 excluding mean TSS during SW monsoon period. Mean water quality results together with GIS maps clearly showed the spatial variation of above parameters which was mainly based on the physical characteristics of the lagoon. As, Cd and Hg concentrations were below the limit of detection (0.001mg/L) and within the standard limits. Cr, Cu, Pb were also not detected (< 0.01 mg/L). Pesticide residue content was below the limits of detection (5.0 µg/L). In conclusion, physicochemical parameters of Rekawa lagoon had variations spatially and temporally with rainfall seasons providing favourable conditions to fish and aquatic life. The results are important in understanding the pattern of variation of water quality parameters of the lagoon and can be used as baseline data in future research and scholarly works.

Keywords: Rekawa Lagoon, Water quality, Physicochemical parameters, Seasonal variations

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MARITIME TRANSPORTATION
&
LOGISTICS

Exploring the Challenges in Implementing Green Port Concept for Ro-Ro Operation: A Case Study of Hambantota International Port

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Maritime transportation covers about ninety percent of the world's trade, and it is considered as the most cost-efficient way of transporting raw materials and goods. Sustainable development and environmental protection are the most pressing issues confronting today's society and economy. In today's world, environmental concerns are becoming increasingly important in seaports and port-led operations. As a result, the green port concept is founded on the idea of making port and its' operations more environmentally friendly in order to reduce pollution. In the today's competitive world, achieving "Green" status is one of the utmost goals for seaports all over the world. When considering the local scenario, the Hambantota International Port (HIP) is already established with Automobile transshipments hub port which would enable growing Hambantota up to be the 2nd commercial city in Sri Lanka after Colombo. In the environmental aspect, Hambantota can be defined as one of the major biodiversity hotspots located in the southern part of Sri Lanka. Due to the rapid increase of the handling Automobile cargo handling caused to generate high GHGs emission and noise pollution generate from the port operation. Therefore, there is an important necessity to implement green port practices for terminals in the Hambantota International port. In order to address this need, the objective of this study was set to investigate the problems of implementing green port concept for RO-RO operations at HIP. Data was gathered through a semi-structured interview with ten managers and the gathered data were analyzed using thematic analysis. According to the findings, lack of awareness among the employees, lack of finance to implying that the latest technologies for reducing emissions and lack of technological guidance were the major challenges to implement RO-RO operation. Employees' resistance to change current working processes and procedures into new methods, Lack of investors, level of education among the employees and lack of technical experts were sub challenges identified through study. However, a successful application of the green port concept would result in a number of benefits, including a reduction in nonrenewable energy consumption and emissions, as well as ensuring the safety of port employees and the port's surrounding

Keywords: Green Port, Sustainability, RO-RO Operation

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Optimizing Truck Turnaround Time of Container Terminals – A Case Study of Colombo International Container Terminal.

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The Truck Turnaround Time (TTT) is considered as one of important Key Performance Indicators (KPI) in port logistics. Shorter turnaround times facilitate in improving efficiency in the port terminal. Therefore, port terminals always attempt to optimize the TTT. The Colombo International Container Terminal (CICT) is one of the deep draft terminals governed by the China Merchants Port Holdings Company Ltd based on a BOT (Build, Operate & Transfer) agreement with Sri Lanka Ports Authority from the year 2013. CICT also attempts to optimize its TTT because its current TTT exceeds the world standard TTT and average TTT in Sri Lankan port terminals. Therefore, the main research objective of this study is to identify how to optimize the TTT in CICT. In order to achieve this research objective, the factors which influence the TTT were identified and their effect on TTT in CICT was studied. According to previous studies, there are number of factors which influence for TTT of a container terminal directly or indirectly. Among these factors, the yard capacity, quay crane operations timing, outsourced yard operations, yard traffic, yard infrastructure, yard labor, gatehouse operations and documentations are identified in this research as factors which influence TTT in CICT. The effects of these factors were closely analyzed and possible solutions for optimizing the TTT were identified. Both the inductive approach and descriptive survey design were used. The main methodology used in this study can be expressed as the mixed method. The main tool utilized to collect primary data from respondents was a questionnaire, while secondary data was gathered from existing data sources relevant to the study. The study's target population was around 2000 people, including employees of the CICT, inter terminal truck drivers, and local (import/export) truck drivers. The selected sample size is 400 respondents. The data was analyzed using Statistical Package for Social Science (SPSS) and Microsoft Excel. According to the findings of the study, it was concluded that enhancing the yard's infrastructure, introducing a new "Truck Appointment System" for local truck operations (imports/ exports), automating gate house documentation and implementing cycle operations will be highly contributed to optimize the TTT in CICT.

Keywords: Truck turnaround time, Port terminal

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Exploring Barriers for Implementing Green Transportation Practices in Logistics Companies in Sri Lanka

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Transportation is a crucial activity in the logistic process and is often referred to as the backbone of the logistics industry. It is a major economic contributor and a competitive commercial force and connects a company to its supply chain partners by moving commodities from where they are sourced to where they are demanded and has a significant impact on a customer's satisfaction with a company. On the other hand, the logistics industry is under increasing pressure due to the impact of the natural environment. The negative externalities of transportation have long been recognized. Globally, transportation accounted for one-fourth of total emissions in 2016, and it is expected to increase to 60 percent by 2050. Hence, countries have been practicing different environmental efficiencies in transportation and the recent trend is towards green transportation. Though numerous countries are practicing green transportation, the adoption of these practices is limited within the Sri Lankan context due to some barriers which hinder the successful implementation of green transportation practices. Understanding the issues that may impede the implementation of green transportation practices will help managers to create more effective corporate excellence initiatives. Accordingly, this study was a qualitative induction study which focused on exploring barriers to implementing green transportation practices in logistics companies in Sri Lanka. In-depth interviews with managerial level employees of eight logistics companies were carried out to collect data for the study and the data were analyzed using coding techniques. Findings revealed that lack of advanced technology, limited fund allocation, focus on short-term returns, lack of concern for environmental protection, resistance to change, lack of knowledge on green transportation practices and its benefits and are the vital barriers which impede the implementation of green transportation practices in Sri Lankan logistics organizations. These barriers can be mitigated through effective government intervention and proper education of the long-term benefits which could be gained through the implementation of green transportation practices.

Keywords: Transportation, Green transportation, Practices, Logistics

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Impact of Service Quality on Customer Satisfaction in Sri Lankan Freight Forwarding Industry

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The rising demand for imports and exports over international boundaries creates freight forwarding a key player in the world of commerce. In the broad sense, a freight forwarder is a person or a corporation that aids to rearrange shipments for people or firms to urge cargoes or products from the producer or manufacturer to a client or customers, a market, or final purpose distribution for end users. Customer satisfaction can be experienced in a variety of situations and connected to both goods and services. Satisfaction also is based on the customer's experience of both contacts with the organization and personal outcomes. The primary objective of the current study was to explore the impact of service quality on customer satisfaction in the Sri Lankan freight forwarding industry. No researchers have conducted researches to identify service quality on customer satisfaction in freight forwarding companies in the Sri Lankan context. Therefore, this gap was adressed by this study. This study was limited to the Biyagama Export Processing Zone and data were collected through structured questionnaire using five point Likert scale from the 164 employees in the Export and Import companies who are engaging with freight forwarders.. The random sampling method was used as the data collection method. The collected data were analyzed through SPSS statistical software and regression analysis were used as analytical method. According to the findings, service quality and all its dimensions have a significant impact on customer satisfaction.

Keywords: Freight forwarding, Customer satisfaction, Service quality

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Study of Post Harvest Losses During Logistics in Cut Flower Supply Chain

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Floriculture industry has been playing a prominent role in many economies with its potential to generate higher income and more employment opportunities in local communities. As per the Export Development Board in 2019 the floriculture sectors has contributed USD 17.5 million to the Sri Lankan economy. Further, due to its rich biodiversity and varying climate regions, Sri Lanka is recognized as one of the best quality floriculture production centers in the world. However, compared to the global floriculture production, the supply of floriculture products in general and cut flower in particular from the country is still in its infancy as most of the local exporters represent the small and medium scale enterprises. In order to be complied with the requirements of the international market, maintaining the quality throughout the supply chain is important. One of the major challenges that the industry is facing is ensuring the quality and the freshness of cut-flowers during handling and transportation. Main purpose of this research is to identify the reasons for losses takes place during cut flower transportation and handling. Accordingly, variables were identified and hypotheses were developed to identify the impact of transportation and handling method, packing, storing methods, employee skill level and new technology on post-harvest losses of cut-flowers. The population of the study was floriculture farmers, intermediaries, businessmen, agricultural officers, sellers and transport service providers were selected using stratified sampling method. The study adopted the mixed method for collecting data for the qualitative method, five industry experts were selected using the purposive sampling method and for the quantitative analysis thirty respondents were selected. Structured interview and a questionnaire were respectively used to collect the data for above approaches. Linear regression method was used to analyze the quantitative data while thematic approach was used to analyze the qualitative data. Findings from both quantitative and qualitative analysis reveal that transportation and handling methods, storing methods, packing methods, employee skill level and technology have negative impact on post- harvest losses of cut flowers and will provide implications for the supply chain partners to improve the quality and freshness with logistics practices and technology.

Keywords: Cut-flowers, Floriculture, Logistics, Transportation, Post-harvest.

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Impact of Total Quality Management on the Operational Performance of Apparel Exporters in Sri Lanka

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Globalization has created challenges and opportunities for commercial organizations. Business firms are attempting to maintain the quality standard to gain competitive advantages. The quality of products and services plays a vital role in stabilizing any business today. Therefore, most apparel manufacturing organizations adhere to the concept of Total Quality Management (TQM) to improve the efficiency and effectiveness of the organization. The developed countries often reject exports from developing countries due to poor quality standards. As a result, Sri Lanka as well as other developing countries are trying to gain business opportunities in the international market by implementing TQM. The study is mainly focused on identifying the impact of TQM on the Operational Performance (OP) of apparel exporters in Sri Lanka. The researchers have selected five main TQM practices: leadership, customer focus, process management, supplier quality management to measure TQM. The OP was measured by four dimensions: product quality, product cost, operational flexibility, and delivery time. The primary data was collected using a five-point Likert scale questionnaire with structured closed-ended questions. The sample includes 159 managerial level employees in the apparel organizations who are registered in the Export Development Board (EDB) of Sri Lanka. Data analysis was carried out by the Multiple Linear Regression Analysis through IBM SPSS Statistics. It was identified that all the dimensions of quality except leadership and training significantly impact OP. Customer focus, process management, and supplier quality management were found as the most influenced TQM practices on OP in the apparel exporters in Sri Lanka. Further, the results revealed the level of implementation of TQM and the OP in the apparel exporters in Sri Lanka is at a high level.

Keywords: Total Quality Management, Operational Performance, Apparel Exports, Export Development Board

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SOCIO-ECONOMIC & MARKETING

Changes in Fish Consumption Pattern and Consumer Perception: A Case Study of the MV X-Press Pearl Ship Disaster, Sri Lanka

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The MV X-Press Pearl cargo ship, which was carrying many noxious chemicals, substances, and low-density polyethylene pellets, caught fire when it arrived off the coast of Colombo on May 19, 2021, creating numerous negative impacts on both environment and humans. Understanding the key factors that influence consumer behavior in the aftermath of such environmental disasters can assist fishery industries in becoming more resilient in the face of such catastrophic events. The purpose of this study is to evaluate perceptions and behaviors regarding fish consumption patterns among Sri Lankans following this disaster. This study was carried out using a pretested and structured online questionnaire using Google Forms from May to July 2021. Data were collected from 546 households across Sri Lanka and analyzed using Microsoft Excel and SPSS. Prior to the incident, 53.7% of respondents rely on marine fish as their primary protein source. Eighty-five point three percent (85.3%) of them had stopped or reduced their fish consumption as a result of the incident. Among those who stopped eating fish, the majority (22.4%) indicated that they would avoid eating marine fish for at least a year, and 4.4% said they would never eat fish again. 44.8 % of them indicated that they would move to eggs as their primary protein source, 27.6% to chicken, 17.6% to fresh water fish, and 12% to vegetable protein sources. The Wilcoxon Signed Rank Test of pre and post fish consumption amount was significant (Z= - 17.0, p = 0.000), showing a significant reduction in marine fish consumption as a primary protein source. Our key findings indicate that, regardless of socio-demographic variables, there is a significant decline in fish consumption patterns as a result of the incident. Untrustworthy information about this incident has also harmed people's perceptions of consuming marine fish. To reduce the spread of false news, 38.5% ranked awareness through reputable organizations as the most important, followed by long-term research on fish and disseminating findings to the general public (30.4%), and immediate dissemination of research-based findings to the general public (29%). Accordingly, careful and efficient response to the incident in disseminating research-based findings is crucial to minimize the negative impacts on consumers and people engaged in the marine fish supply chain.

Keywords: Fish consumption, Behaviors, Perceptions, Environmental disaster

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Export Performances of the Ornamental Fish Trade of Sri Lanka

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Ornamental fish trade has become a considerable foreign exchange earner and contribute to the GDP of Sri Lanka with total export earnings of more than 2000 US $ Millions in 2019. Recent Trade Statistics of the United Nations Commodity Trade (UNCOMTRADE) indicate that Sri Lanka can be considered as a major competitor among regional rivals. The present study aims to understand the development and competitiveness of export oriented ornamental fish trade of Sri Lanka using widely available economic indexes, such as Annual Growth Rate (AGR), Compound Annual Growth Rate (CAGR), and Revealed Comparative Advantage (RCA) and Revealed Trade Advantage (RTA) for the period of 2000-2017. Further, study wishes to recommend the priority areas that needed to be addressed to sustain the industry while keeping competitive status among the competitors. Secondary data on total world trade and total trade of Sri Lanka were retrieved from the World Trade Organization's (WTO) (http://stat.wto.org/) statistical data base and the trade data of ornamental fish were extracted from the United Nations Commodity Trade (UNCOMTRADE) (https://comtrade.un.org) database under the HS Code of 03011. Study results showed that, AGR was highly fluctuated over the study period with lowest annual growth rate in 2011 (-0.35) while highest in 2014 (0.51). CAGR was low during the study period and showed slow growth rate with highest value in 2015 (0.05). RCA was maintained at higher level (36 – 77) with the highest value (77.44) in 2015. RTA value of ornamental fish was fluctuated and maintained above 34 during the period with the lowest value in 2003 (34.93) and the peak value in 2015 (74.34). Higher RCA and RTA values highlighted that Sri Lanka has strong competitiveness of exporting ornamental fish with the rest of the world. As a developing country with higher competitive advantage in export market, public and private partners need to carefully support to the export oriented ornamental industry to obtain a higher market share in the world export ornamental fish market. Moreover, study results highlighted the importance of empowering local breeders and growers with the skills, and knowledge of the area; allocation of the resources to develop new varieties and make availability of quality brooders among breeders; financial support to expand the industry and strengthening the supply chain linkages in export oriented industry.

Keywords: Ornamental Fish Trade, Sri Lanka, Exports, Revealed Comparative Advantage

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The Effectiveness of Online Learning in Undergraduates of Ocean University of Sri Lanka During the Covid-19 Pandemic

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The establishment of online classes during the Covid-19 pandemic as an alternative to traditional face-to-face physical classes is a considerable structural change in higher education at Ocean University of Sri Lanka (OCUSL). This is a new experience for both academics and students. Therefore, it is important to understand the effectiveness of online learning while studying the emerging issues and challenges in online learning, and taking remedial measures to improve this e-learning platform. We randomly selected 70 undergraduates of the Fisheries and Marine Science department attached to the OCUSL out of 87, using an online survey. Results of the binary logistic regression model show that students who have the interest to join online classes compared to students who are lack interest in joining online classes are more likely to feel online learning is effective. None of the other variables i.e. gender, living area, home environment, undergraduate batch, depend on lecturer, and lecture hours used in the statistical model did not significantly influence the effectiveness of online learning. Sixty percent of the respondents stated their overall attendance to the online lectures was above 76%. However, over half of the respondents stated that they were not satisfied with the coverage of signal in attending the online lectures due to the disturbances arising from break down of network connections. Our findings revealed that more than one-third of the undergraduates were not well familiar with the Microsoft Teams app and did not satisfy with their technical knowledge in computers to proceed with online learning. Wilcoxon signed-rank test results reveal that there is no significant difference in physical classes and online classes in time management and overall cost-effectiveness. However, a physical classroom environment is better than online learning in conducting group activities, maintaining teacher-student interactions, student-student interaction, use of multiple-teaching devices, and achieving learning objectives. Therefore, the use of Microsoft Teams break room facility to conduct group activities in the virtual platform, keep video-on time to time by the lecturer during the online lecture, and use whiteboard while teaching are suggested to enhance the effectiveness of online learning of OCUSL undergraduates. Future research should examine the perceptions of OCUSL academic staff addressing the challenges confronted during online classes, to receive a better picture about the effectiveness of online learning.

Keywords: online survey, E-learning, Teacher-student interactions, Traditional face-to-face physical classes.

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The Impacts of Covid-19 Pandemic on Fish Trade in Badulla District of Sri Lanka

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Fisheries sector plays a significant role in the economic growth of Sri Lanka. The coronavirus has severely affected to all sectors in the economy including fisheries. Objectives of the study were to examine the impacts on Covid-19 pandemic on fish trade in Badulla district, Sri Lanka compared to pre-pandemic and investigate the potential mitigation measures for the adverse impacts. The study was conducted in nine major electorates in Badulla District from 01st of April to 31st May 2021. A total of nine wholesale fish vendors representing nine electorates in Badulla district were interviewed using a pre-tested and structured questionnaire. Results showed that majority (78%) of the respondents had temporarily closed their business for one to four months during the early stage of complete lockdown period of the country and resumed their business with special permits even under the complete lockdown. According to the paired t-test, the total sales and gross profit of the wholesalers under new normal condition were significantly reduced than pre-pandemic (p< 0.05). Although the marine and freshwater fish sales dropped, the sales of the dried fish remained unchanged during the two tested periods. Most of the traders (67%) were highly dissatisfied about their business with ongoing pandemic while 22%were neutral, and 11% were somewhat satisfied. In conclusion, it is clear that Covid-19 has negatively affected the supply chain and livelihoods of wholesale fish vendors. Therefore, all the respondents demanded a financial assistance from the public and private sector to repay their loans and other liabilities during the pandemic. Further, all traders highlighted the importance of awareness raising in the general public using reliable health information relevant to the pandemic and fish consumption to minimize the negative consequences on fish supply value chain.

Keywords: COVID-19, Economic downturn, Fish trade, Lockdown, Sri Lanka

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Preliminary Study of the Daily Fish Consumption of Sri Lankan Children- A Comparison Among Ethnic Groups.

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Fish are rich in protein and other essential nutrients, thus they are helpful in improving human health particularly children. However, there is a research gap on the fish consumption pattern of Sri Lankan children. Therefore the objectives of this study were to 1) examine the daily fish consumption amount in different age groups, 2) compare the amount of fish consumed among different ethnic groups, 3) evaluate the preference for fish based on fish size, and 4) examine any fish allergies for Sri Lankan children. The data were collected from a convenient sample of 180 households using Google Forms in March 2021, covering the majority of the country (10 districts) and representing different ethnic groups. Parents in families were requested to answer the questionnaire on behalf of the children who are up to 10 years old. Minitab 14 was used for statistical analysis. The frequency of occurrence of fish consumption among different age groups of children (n=180) was; 5g-7.5g (31.6%) for below one year age group, 7.5g-10g (28.8%) for 1-2 years age group, 10g-12.5g (23.3%) for 2-3 years age group, 15g-17.5g (20.5%) for 3-4 years age group, 20g-22.5g (23.3%) for 4-5 years age group, 27g-30g and 30g-32.5g (20.5%) for 5-6 year age group, and 35g-45g (22.2%) for 6-10 years age group. This study found that the amount of fish fed to children increases with their growth. The amount of fish consumed by the children in different ethnic groups was significantly different in 3-4 year age group (Kruskal Wallis: H = 10.28, DF =2, p = 0.006) whereas other age groups did not show any significant differences. Results showed that there was a strong preference for consuming small fish (75.7%) than large fish (24.3%) and most of the children have no fish allergies (54.3%). Different ethnic groups did not show any particular preference for fish species to feed their children. The current study provides useful information of fish-eating patterns of Sri Lankan children which can be used for preparing dietary guidelines in the future.

Keywords: Preferences for fish, Age groups, Fish allergies, Dietary guidelines.

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The Impact of COVID - 19 Pandemic on Tuna Export Industry in Sri Lanka

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The COVID - 19 pandemic is severely affected all over the world. It is still going on around the world and was affected many industries mainly for trade and export industry. The tuna export market is a significant part of the fish and fishery products export industry that gives foreign income to the country. The main objective of this study was to calculate the export earnings and quantity differences before and during COVID period. Export quantities and values from 2019 and 2020 were used as secondary data that was collected from the Department of Fisheries and Aquatic Resources. Independent t-test was used for analyzing collected data, while SPSS software was used to analyze data. It was found that there is a significant deduction of export quantities and values of tuna fish during the COVID period. Considering the changes in tuna export values and quantities in two periods (2019 and 2020) the p-value of t statistics recorded as 0.010 and 0.003 gradually. It was found that, the demanded quantities for tuna in the USA, UK, Italy and Taiwan was declined while the value of tuna in Italy, Taiwan and USA was reduced. It is clear that there was a significant mean difference of exported quantities and values of tuna fish during the periods of before and during the COVID. Most countries were imported small quantities at low prices. So there was no acquisition during the pandemic period to the tuna export industry. Tax concessions and subsidies for stakeholders of export oriented tuna fishery, investment for fish storages and frozen fish sector, and dropdown freight charges are recommended to minimize the impact for tuna export industry.

Keywords: COVID - 19, Tuna, Wilcoxon test, Export, Value

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Identifying the factors of "Customer Based Brand Equity" of TVET: a case study of Regional Centre Galle, Ocean University of Sri Lanka.

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Technical and Vocational Education and Training (TVET) plays major role in economic and social development of a country as it provides competent human resource to the workforce of a country. Although, there is well developed structure and pathways to TVET, student enrolment to the TVET courses not in a sufficient level in Sri Lanka when compared to other developing countries. Therefore, proper marketing strategies should be formulated and customer based brand equity is an effective measure for that purpose. This survey has been conducted to identify factors of Customer based brand equity. All students studied in Ocean University Galle Regional Centre from February 9th to November 8th 2019 were the respondents of this study. Therefore, Quantitative data were collected from 168 students. Brand awareness, brand image, brand loyalty and perceived quality were the independent variables while customer-based brand equity was the dependent variable. Statistical analysis was done using SPSS version 20. Reliability of items and Validity of the items in the questionnaire were tested initially. Relationships of variables and impact on model variables were measured using correlation and multiple linear regression analysis respectively. The correlation values between brand awareness, brand loyalty, perceived quality, brand image and customer based brand equity were 0.215, 0.397, 0.539 and 0.485 respectively. Regression coefficient of brand awareness, brand loyalty, perceived quality and brand image, were 0.040, 0.047, 0.460 and 0.351. It was resulted that four variables namely brand awareness, brand image, brand loyalty and perceived quality have positive relationship with customer based brand equity and the four independent variables were predictors of the Customer based brand equity. It can be recommended to identify the ways of enhance brand awareness, brand image, brand loyalty and perceived quality among prospective students. Finally, it is recommended to carry out comprehensive qualitative study to identifying how to enhance brand awareness, brand image, brand loyalty and perceived quality of TVET institutions.

Keywords: Brand Awareness; Brand Image; Brand Loyalty; Customer Based Brand Equity; Perceived Quality.

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Assessment of Impact of Covid-19 Pandemic to the Ornamental Fish Industry in Sri Lanka

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Corona virus disease is severely affected to all over the world. Sri Lanka is one of the middle income country that affects in many ways from this pandemic. COVID-19 has affected for fisheries, agriculture and external trade in Sri Lanka. The main objective of this study was to assess the impact of COVID-19 on the Sri Lankan ornamental fish trade. The primary data was gathered from ornamental fish exporters, intermediaries, and fish collectors (divers) using structured questionnaires. 40 respondents were subjected to telephone interviews for primary data collection. While export quantities and values from 2019 to 2020 were collected from the Department of Fisheries and Aquatic Resources (DFAR) and Export Development Board (EDB) as secondary data. Microsoft Excel and SPSS software were used to analyze the data. The result taken from likert scale indicated that the COVID pandemic was negatively affected to collectors, and intermediaries and their fishery related activities. However, according the fish exporters, both negative impacts and positive impacts were experienced. All actors of the ornamental fish supply chain mentioned that the government involvement during the pandemic was poor. The ornamental fish exports earned USD 16.23 million in 2019 and it declined to USD 13.02 million in 2020. Similarly the quantities of ornamental fish exports declined by 17% in 2020 compared to 2019. The active involvements of the government, trade analysis, stakeholder's discussion could be undertaken to mitigate the economic slowdown in Sri Lanka's ornamental fish industry.

Keywords: COVID-19, Ornamental fish, Impacts, Quantity and values, Sri Lankan fish export

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Socio - Economic Status of Sea Cucumber Fishery in Point Pedro, Sri Lanka.

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Sea cucumber fisheries in Sri Lanka play an important role in the country's economy through improving the livelihoods and earning foreign exchange. Point Pedro in the Northern Province of Sri Lanka was selected as the study site considering the lack of recently published research work in this regard. A self-administrated pre-tested questionnaire survey using the convenience sampling method was carried out from January to May 2021 to collect details of sixty fishermen. Primary and secondary data were collected through personal interviews, field observations, and published research findings respectively. The data were analyzed using descriptive statistics. According to variables of fishermen information, about 52% were middle-aged fishermen between 35-50 years old, and 84% of them were married. Around 40% of fishers have studied up to grade 10. Job-related variables revealed that 48% of fishermen had 16-32 years of fishing experience, and 42% of fishermen had a monthly income range between LKR 2,000-LKR 30,000. According to the family background of fishermen, 45% of fishermen had medium-size families of 4-5 members. Constraints related to livelihood were lack of fishing equipment and facilities, lack of knowledge regarding the preservation and value addition, involvement of middlemen in selling, lack of support from the government, adverse climatic conditions, and recently the COVID 19 pandemic situation. Based on the study and findings, there is an urgent need for managing the sustainability of sea cucumber fishery while enhancing fishermen's livelihood. Therefore, it is necessary to implement optimum management strategies addressing the aforementioned constraints immediately. Furthermore, the awareness of sea cucumber fishery among associated government, and non-government authorities should be further enhanced.

Keywords: Sea cucumber fisherman, Pointpedro, Socio economic

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