BOOK OF ABSTRACTS

AQUABE 2019

INTERNATIONAL CONFERENCE ON
AQUATIC RESOURCES & BLUE ECONOMY

NOVEMBER 28-30, 2019
KOCHI, KERALA, INDIA

KERALA UNIVERSITY OF FISHERIES & OCEAN STUDIES
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AQUABE 2019
International Conference on Aquatic Resources and Blue Economy

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Foreword

The concept of Blue Economy (or otherwise known as Blue Growth Initiatives) is founded on the principles of sustainable use and conservation of aquatic ecosystems, and based on the United Nations Sustainable Development Goals (UN SDGs), in particular SDG 6 to “Ensure availability and sustainable management of water and sanitation for all” and Goal 14 to “Conserve and sustainably use the oceans, seas and marine resources for sustainable development” respectively. The notion of “blue economy” seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods synergistically ensuring environmental sustainability of aquatic ecosystems - from freshwater to coastal and marine.

Blue economy encompasses the complete spectrum of economic activities which has a direct dependence on aquatic ecosystems and their resources (both living and non-living), including fisheries and aquaculture, offshore oil, gas and other energy resources, inland and maritime transportation, maritime trade, inland, coastal and marine tourism, fisheries and maritime education and research, and coastal protection and maritime defense.

Worldwide, economic activities from the ocean and its resources is valued at approximately US$3-6 trillion/year, and a whopping 350 million jobs around the world are linked to fisheries and allied activities. Similarly, by 2025 it is estimated that one third of the crude oil production will originate from offshore areas. As the concept of Blue Economy is multidisciplinary and cuts across various ecosystems, sectors and industries, there is a need for developing and implementing an integrated legal and regulatory framework. Currently, there exists a suite of institutional and governance challenges to blue economy including insufficient commitments to the provisions of UNCLOS and other legal regimes and frameworks, lack of adequate capacities, inefficient and inadequate governance institutions. Addressing these challenges of Blue Economy must therefore be multi-country, transformative, holistic and sustainable.

In this background, the Kerala University of Fisheries and Ocean Studies is organizing an International Conference on ‘Aquatic Resources and Blue Economy’ (AQUABE2019) to review the status, challenges and opportunities of Blue Economy in India and the Indian Ocean rim countries, and discuss, deliberate and develop recommendations for ensuring sustainable growth in this sector towards 2025 and beyond.

Spread over three days (28th to 30th November), ‘AQUABE 2019’ will include keynote, invited and contributed talks, and posters by scientists, academicians, researchers, policy makers, corporate managers and graduate and postgraduate students, in nine technical sessions including Aquatic Resources (Living), Aquatic Resources (Non-Living), Climate Change Impacts, Aquatic Production Systems, Aquatic Production Systems (Biotechnology), Ocean Health and Global Warming, Aquatic Production Technologies, Ocean Processes and Environmental Impacts, Marketing and Trade, Education and Capacity Building, Legal Regimes, Policies and Governance. This book contains the compilation of over 200 abstracts of presentations made by the scientists/researcher and experts in various sessions of AQUABE 2019. I am sure that the outcome of the conference will contribute significantly to the knowledge base on the present and future of Blue Economy in India and beyond.

Prof. Dr. A. Ramachandran
Vice Chancellor KUFOS
Chairman, Organizing Committee AQUABE 2019
**AQUABE 2019 follows Green Protocol**

We wish to keep the plastic waste produced at the end of this conference to the minimum. Therefore, we do not plan to provide bottled drinking water during the conference. Water will be provided by dispensers and glasses will be provided. You are encouraged to bring your own water bottle. Thanks in advance for your understanding and co-operation.
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ARL-OR-01

Spatial fisheries management in a tropical estuary: development of a spatio-temporal ecosystem model for Zuari estuary, west coast of India

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²ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra

The Zuari estuary, located in the southwest coast of India is one of the most productive estuaries along the Indian coast. The fishery in Zuari estuary (a tropical monsoonal estuary along the west coast of India) has been overexploited and the estuary is subjected to anthropogenic impacts, which has depleted the fisheries resources. In this study, an Ecospace model was developed for the period from 2016-2025 based on the previously constructed Ecopath model of the estuary in 2016 to investigate the reaction of the ecosystem to different spatial management settings. The ecosystem indicators were analyzed for each management setting how the coastal fishing practices influence different functional groups in the estuary. Spatial simulations were also carried out to distinguish the regions with ecological significance proposed for rigorous spatial management. The indicators were used to provide the fisheries authorities with a set of guidelines to report the potential impacts and to ensure fisheries and ecosystem conservation objectives in the ecosystem-based fisheries management.

ARL-OR-02

Decline in genetic diversity of the Scalloped Hammerhead shark (Sphyrna lewini) calls for urgent management and conservation measures in Indian waters

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ICAR-Central Marine Fisheries Research Institute, Kochi

The scalloped hammerhead shark, Sphyrna lewini has been categorized as “endangered” in the latest IUCN Red List assessment and considering their high-risk status we assessed its intra-specific diversity and population genetic structure along the Indian coast so as to devise conservation measures. We analysed the genetic diversity patterns using mitochondrial cytochrome C oxidase 1 and control region sequences on samples collected from Arabian Sea and Bay of Bengal. The data generated from the present study was further compared with the sequences deposited in NCBI, GenBank of S. lewini from Indian, Indo-Pacific, Atlantic and Pacific regions. Presence of 3 haplogroups corresponding to Indian/Indo-Pacific, Atlantic and Pacific lineages was detected in haplotype network diagram. Genetic differentiation was not significant within the Indian coast, whilst significant sub-population structuring was evident between ocean basins (FST; 0.80; p<0.001). This indicates that S. lewini is capable of migrations across continental margins but not across regions divided by deep expanses of oceans. A recent reduction in genetic diversity and effective population size as indicated in Bayesian skyline plot calls for urgent management measures like complete ban of the fishery till the populations are sufficiently replenished.
Prey-predator interactions in Mettur reservoir in Tamil Nadu

Preetha Panikkar ¹, S Sibina Mol¹, VL Ramya¹, PK Jesna¹, UK Sarkar² and BK Das²

¹Research Centre, ICAR-Central Inland Fisheries Research Centre, Bangalore
²ICAR-Central Inland Fisheries Research Centre, Kolkata

The prey predator interaction of Mettur reservoir was assessed by developing an ecosystem model of the reservoir. Mettur reservoir (11°48'00"N 77°48'00"E) built in 1934 over River Cauvery in Tamil Nadu, has a water-spread area of 15,345 ha. Morphometric indicators such as high shoreline development index (6.7) and a volume development index more than unity (1.4) point towards productive nature of the reservoir. The ecosystem model of the reservoir structured around fifteen functional groups including a non-living group, the detritus. All these components are connected in a complex food web by evolving interactions. Network analysis was carried out using Ecopath with Ecosim software to determine the holistic ecosystem properties and low indices. The results of the aggregation of energy lows among trophic levels (TLs) showed the presence of five TLs. The trophic lows primarily occurred in the first four TLs. The food web structure in this reservoir ecosystem was characterized by the dominance of low-level trophic organisms. The highest effective trophic level (ETL) of 3.74 for the top predator, fish eating birds was followed by an ETL of 3.51 for the dominant predatory fish, the eels. The predation pressure was highest for minnows (Pseudambassis ranga and Chanda nama) and lowest for the most dominant fish.
India is one of the richest countries in terms of riverine fish gene pools with a network of hundreds of rivers. Currently, these rivers are facing multiple problems due to severe water pollution, over exploitation, encroachment, dams and barrages which cut off the connectivity of the river with its associated ecosystems, climate change, deforestation in catchment areas and invasive species introduction. Changes in ecosystems can be best understood from the status of fish fauna inhabiting the system. Precision in identification of fish species is necessary for reporting and taxonomy provides the basic knowledge on the components required for effective decision making as well as formulating policies on conservation and management of the resources. River Cauvery originates in the Western Ghats, one of the premier hotspots of biological diversity in the world. Fishes of the genus Labeo are a major contributor to the commercial catch from the river. The present study reports the occurrence of $L. \text{porcellus}$ for the first time and the taxonomy of seven $Labeo$ spp. viz. $L. \text{bata}$, $L. \text{calbasu}$, $L. \text{dyocheilus}$, $L. \text{fimbriatus}$, $L. \text{nigrescens}$, $L. \text{porcellus}$ and $L. \text{rohita}$ from the river. Discriminant analysis based on the eight morphometric traits of the species loaded in factor analysis successfully classified 94.2% of the specimens to its respective species. The Mahalanobis distance indicated highest similarity in morphometric traits of $L. \text{dyocheilus}$ and $L. \text{porcellus}$ as well as $L. \text{calbasu}$ and $L. \text{nigrescens}$. This study put forth the key morphological characters that differentiate the $Labeo$ spp. in the river.
Indian white shrimp (*Penaeus indicus*) is one of the important commercial penaeid species. Seven microsatellite loci were employed to study the genetic diversity of 202 individuals of *P. indicus* collected across Indian coast (Chennai, Kanyakumari, Quilon, Mangalore and Goa). The average number of alleles among the populations was 8.5 with a range from 5.4 (Kanyakumari) to 11.4 (Quilon). The mean observed heterozygosity ranged at sampled loci were high, ranging from 0.67 (Kanyakumari) to 0.76 (Puri). The analysis of molecular variance (AMOVA) revealed that 97% of the genetic variation was maintained within individual component, rather than shaped according to geographical regions. Pairwise FST (ranged from 0.009 to 0.053) estimates revealed Chennai and Quilon stocks differed significantly (*P* < 0.01) with all other stocks. However, Quilon did not differ from Mangalore stock. Bottleneck tests revealed all populations displayed a normal L shaped distribution in the mode-shift curve. None of the populations revealed significant excess of heterozygosity for Wilcoxon’s signed-rank test under the TPM model, suggesting no recent population size reduction. Mantel test indicated there was no significant correlation between genetic dissimilarity and geographic distance among populations (*R* = 0.0491; *P* = 0.49). The above stock structure findings would be helpful in conservation and stock management.
Fishing trap losses from Enayam coast of Tamil Nadu: Fishers’ perception

Saly N Thomas, KM Sandhya and K Harsha
ICAR - Central Institute of Fisheries Technology, Kochi

Abandoned, lost or otherwise discarded fishing gear (ALDFG), a growing issue of concern due to their potential to continue catch fishes and other aquatic organisms for many years, a phenomenon known as ghost fishing. Ghost fishing is largely confined to passive gears like gillnets, trammel nets, and traps. Knowledge concerning causes and quantum of ALDFG is significant for developing effective measures to reduce ALDFG. Present study attempts to assess level and causes of trap loss, reasons for trap discards and lost trap retrieval attempts based on fishers’ perception at Enayam fishing village, Kanyakumari, Tamil Nadu where there is an organized trap fishery for lobsters and fishes. Each fisher owns an average of 8 fish traps and 25 lobster traps. Based on structured questionnaire survey among a cross section of trap fishers (n=25) revealed an average of two fish traps and five lobster traps viz. 28% and 19% respectively were lost/year/person. Major reasons for trap loss were bad weather conditions followed by currents/tides. Other reasons were damage/corrosion of gear parts, collision with other vessels and snagging on bottom obstructions and vandalism. Fishers (30%) agreed they discard gear deliberately at sea when it is difficult to retrieve lost traps and when traps are in unusable condition. More than half of respondents indicated that sometimes or rarely they encounter with abandoned/lost/discarded traps while fishing and try to retrieve them to shore and either return to owner or sell as scrap. Information from present work will assist in improving fishing methods and/or to design fishing gear that become ineffective once lost and reduce possibilities of ghost fishing.
ARL-OR-07

**Eco-efficiency analysis of small pelagic fishery of south west coast of India**

Rithin Joseph, Dhiju Das, VS Yasmi, Sreejith S Kumar, Leela Edwin  
*ICAR-Central Institute of Fisheries Technology, Kochi*

Currently world marine landing reached at 79.3 million tonnes in 2016 with many ups and downs in last two decades. Studies conducted worldwide to improve the fishery management for sustainability and factors affecting fishery environment, including studies towards the direct environmental impact of fishing activity like impact towards harvested organism, discards, sea bottom damage, etc. Other than the direct impact, impact of fishing gear, craft, fuel usage, antifouling paint, production of ice, transportation, discharge of wastes, loss of fishing gear at sea affect fisheries negatively. Life Cycle Assessment (LCA) is a useful impact assessment methodology and its suitability for quantifying the impact associated with fisheries are proven. Observations in fisheries related to climate change foresee with intensified climate change as a consequence of increased greenhouse gases (GHGs) in the atmosphere because of human activities. The major part of the Indian marine fish production (55%) is contributed by pelagic fishes along the west coast of India. Ring seines are the major contributors to the pelagic fishery followed by gillnets. The present study was conducted during the January 2019 to September 2019 period in the selected ring seine and gillnet landing centres of Kerala. Study including field level data collection, group discussion etc. analysis was done using standard statistical analytical tools and life cycle assessment studies using SimaPro software. Material wise quantitative data on craft gear and operation frame works were collected. The results of the analysis show that fuel expended in the motorised sector is a matter of prime concern.

ARL-OR-08

**Decline in oil sardine landings and impacts on the marine fish economy in Kerala**

Aswathy Natarajan, Ramani Narayanakumar, Shyam S Salim, and TM Najmudeen  
*ICAR-Central Marine Fisheries Research Institute, Kochi*

The Indian oil sardine, *Sardinella longiceps* Valenciennes is a significant contributor to the marine fisheries economy of Kerala. The decline in oil sardine landings in the state is a critical issue of concern for the sustainable exploitation of the resource in the context of persistent ocean atmospheric changes associated with global warming. The catch decline will have serious implications on the marine fisheries economy as well as livelihood security of small-scale fishers. The paper analysed the economic impacts of the decline in oil sardine landings on gross value realized at landing centre and retail levels, inflation in domestic markets, livelihood security of traditional fishers and fish meal industry in the state during 2000-2018 period. The oil sardine catch declined from 2.41 lakh t in 2000 to 77,093 t in 2018 and the retail price increased from ₹25/kg to ₹120/kg during this period. The annual average decline in oil sardine landings in Kerala was 19.82% whereas the decline in gross value at retail market level was 12.18% during 2010-18 period. The inflationary pressure on domestic consumers was very high during 2010-2018 period. The fluctuations in gross value was more at landing centres (point of first sales) when compared to retail level which indicated the prevalence of unstable prices to the fisherfolk.
ARL-OR-09

**Report on endoparasitism in the bullseye fish *Priacanthus hamrur*, by the nematode, *Philometra sp.* from the Southeast Arabian Sea**

Livi Wilson, PU Zacharia, TM Najmudeen, PK Seetha, Archana Chandran, NK Sanil  
ICAR-Central Marine Fisheries Research Institute, Kochi

The present study describes the occurrence of nematode parasites in the gonads of bullseye fish *Priacanthus hamrur* caught off the coast of Kochi, India. The moontail bullseye, *Priacanthus hamrur* (Forsskål, 1775), is a circumtropical marine percoid fish occurring primarily in rocky or coral habitats at a depth range of 5 to 400 m. A 2-year study in *Priacanthus hamrur* showed that each year there is a high prevalence of philometrid infestation during the spawning season of the host. Samples were collected from the commercial catch during May 2017 to April 2019. Both male and female fishes were found to be infested by the nematodes, which were later identified as *Philometra spp.* using morphological and molecular analysis. Infestation of *P. hamrur* by this nematode had the following values: prevalence, 20.06 %; mean intensity, 2.20; mean abundance, 0.44; and range of infection, 1–7 specimens. High prevalence of parasites in the ovaries is a cause of great concern as it will destroy the eggs and harm the fish stock. This is the first record of endoparasite *Philometra* sp. in the bullseye fish *Priacanthus hamrur* from the southeast Arabian Sea.

ARL-PO-01

**Morphological plasticity in Indian oil sardine, *Sardinella longiceps* – Does it imply adaptive variation?**

ICAR-Central Marine Fisheries Research Institute, Kochi

The Indian oil sardine, *Sardinella longiceps*, is an important pelagic species in Indian waters, and shows divergent morphology while in sympathy. The reasons behind this divergent morphology were investigated using morphometric, genetic and nutritional analyses. Twenty-one morphometric characters (as percentage of standard length) and eight meristic characters were studied in the three variants to assess whether they are significantly diverged. Distinct clustering of morphotypes was evident in the principal component analysis on log-transformed ratios of morphological characters with PC1 and PC2, explaining 50.7% and 17.6% of the total morphological variation, respectively. PC1 was highly correlated with the distance from snout to anal origin, depth at dorsal, distance from snout to pelvic and distance from snout to first dorsal. PC2 was highly correlated with head length, caudal width and anal depth. Investigations based on mitochondrial cytochrome c oxidase I (cox1) or control region sequences indicated that genetic divergence is not significant between the 3 variants. Proximate composition analyses showed significantly high fat content in variants 1&3 and significantly high protein content in variant 2, probably due to dissimilar dietary preferences. The study shows that morphotypes of the Indian oil sardine may be the result of divergent selection and adaptive variation, which need further investigation using a long-term sampling design.
ARL-PO-02


Radhika Balachandran  
*Kerala University of Fisheries and Ocean Studies, Kochi*

The first information on the biology of the smooth dwarf monocle bream, *Parascolopsis aspinosa* (Rao and Rao, 1981) reveals that the species follows a Negative allometric growth pattern with \( b < 3 \) and follow a seven-stage maturity, and that females dominate the population. It attains maturity at 11.4cm and 12.5cm for male and females. GSI values suggest that *P. aspinosa* breed throughout the year with a peak during August to September and January. A progressive increase in size of the ova observed in advanced stages of maturity. Fecundity of *P. aspinosa* ranged from 45,823 to 1, 56,308 with an average 84,367 eggs.

ARL-PO-03

Towards responsible blue economy in the Western Ghats Biodiversity Hotspot

Rajeev Raghavan  
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‘Blue economy’ or ‘blue growth’ is built on the concept of, and emphasizes the three pillars of sustainable development, i.e. economic growth, environmental conservation and social inclusion. Much of the discourse on ‘blue economy’ is centred on marine ecosystems and their resources, and the role of inland waters (which comprise less than 0.1% of the earth’s surface but harbour 10% of all known species) has received scant attention. The Western Ghats Biodiversity Hotspot (WG) covering an area of 160,000 km² is one of the three main watersheds of India, draining 40% of the country, and harbouring exceptional freshwater biodiversity. It is also a densely populated region (50 persons/km²) where several thousands of riverine and forest-dwelling communities derive food security and livelihoods from inland waters. To successfully achieve and fulfil the 2030 Agenda for Sustainable Development (Sustainable Development Goals - SDG) and the Post 2020 Biodiversity Framework, a strategic approach to improving the use of aquatic resources is required. In the wake of irresponsible fisheries and farming practices in the WG region, particularly through the use of alien species, there is an urgent need to implement the ecosystem approach to fisheries and aquaculture so as to ensure responsibility and sustainability. Development of integrated water management policies by involving various stakeholders connected to freshwater ecosystems and biodiversity, improving quality control in the value chain from harvest to trade and initiating incentives for both investment and innovation can help foster blue growth in the WG region. Finally, fishers and other riverine and forest-dwelling communities in the WG should be empowered into ‘blue communities’ by enhancing their skills while safeguarding the aquatic environment so as to enhance food security, livelihoods, social protection and resilience to shocks including extreme climatic events. This contribution discusses about the key requirements and a road map for achieving blue growth in the freshwater fisheries sector in the Western Ghats.
ARL-PO-04

Distribution and bioprospecting of litter bacteria isolated from Ayiramthengu mangrove ecosystem of Kerala coast

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¹Post Graduate and Research Department of Zoology, Catholicate College, Pathanamthitta
²Department of Zoology, Baselius College, Kottayam

The present study deals with the distribution and bioprospecting of cultivable bacteria which is isolated from the leaf litter surface, collected from Ayiramthengu mangrove ecosystem. The study was conducted at three different sampling stations before and after the major riverine flood of Kerala, occurred during July and August, 2018. The different bacterial genera isolated were Bacillus sp., Micrococcus sp., Staphylococcus sp., Enterobacter sp., Pseudomonas sp., Halomonas sp. and Moraxella sp. The study revealed that the Station 1 showed highest Total Heterotrophic Bacteria count (THB), before flood (65x10⁴ cfu/ml) and it again increased after the flood (79x10⁴ cfu/ml). Extracellular enzymes such as amylase, protease, cellulase, lipase and phosphatise were screened with different bacteria, showed that phosphatase (78%) was predominant, followed by lipase (70%), cellulase (66%), amylase (60%) and protease (39%). In addition to this, the study revealed the fact that, mangroves are good source of potentially active bacteria which can find industrial and medicinal use with sustainable eco-friendly application. The high microbial diversity is responsible for organic matter decomposition and nutrient recycling in the most productive and economically important mangrove ecosystem.

ARL-PO-05

Benthic Macroinvertebrates as biological indicator of water quality status of Pampa River at Perunad Area

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The present study focused on the biological monitoring of Pampa river in the Perunad region using Biological Monitoring Working Party (BMWP). Benthic macroinvertebrates were sampled for one year from February 2016 to January 2017. Three sampling stations were selected and out of this one station was a disturbed sand mined area. Composition and abundance of benthic macroinvertebrates were evaluated by using GIS techniques. Based on the abundance and tolerance values, BMWP index of the invertebrates was determined to evaluate the water quality of Perunad area. A total of 505 individuals of benthic macroinvertebrates belonging to 25 families and 10 orders were collected from the locality during the study period. Among them, order Diptera (76.43%) was the most dominant group followed by Coleoptera (5.74%). BMWP score of the study area varied from 30-67 which shows that water quality of the stations was clean but slightly impacted (Station 1 and 2) and impacted (Station 3). The present study revealed that pollution tolerant benthic macroinvertebrates are dominantly inhabited in the study area.
ARL-PO-06

**Distribution and substrate specificity of Lecanid rotifers from middle and lower stretches of River Periyar, Kerala**

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The occurrence, diversity, substrate specificity and distribution of Lecanid rotifers were studied for a period of one year from five selected sites of river Periyar. The results showed the occurrence of twenty-five species of lecanids of which *Lecane clara* and *L. clastrocerca* were the most dominant species. Most of the lecanids found to colonize on leaf substratum than log and wall. Shannon diversity index was high in the pre-monsoon period along the lower reaches and the maximum dominance was observed during this period. Cannoical Correlation analysis supported the influence of nitrate and phosphate concentration on abundance of lecanids on site 4 Aluva. The overall results indicate the role of lecanids in water quality monitoring of freshwater rivers.

ARL-PO-07

**Biodiversity, a boon indeed!!!**

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From unicellular amoeba to multi-cellular species, the transition is rendering an awesome effect on the ecological balance. We all know that Biodiversity implies the whole of Mother Earth and the varied living things. There is a rhythm in the co-relation between one another and among themselves. When the tune is shattered due to unexpected ways and means, the balance is tilted causing the threat to Mother Nature and thus sets alarm to the forthcoming days. A yell is not sufficient at odd hours rather pay heed to the intuition which reverberates. i.e., when there is flood, we think of Nature, in another instance when Earth shakes by quakes we form forums to mitigate the gravity of suffering. Aren't we duty-bound to preserve and conserve the ecosphere in a form which it deserves to be to have a blissful living? Albert Einstein invites saying, “Look deep into nature, and then you will understand everything better.” His calibre connotes to beware, as is quite often found with the profound value behind the story of the goose that laid golden eggs.
Present study was conducted along the Vembanad backwaters with an aim to investigate the diversity, distribution and abundance of bivalves. Monthly sampling was carried out at 12 stations from northern, middle and southern regions. A total of 20 species of bivalves, belonging to 17 genera under 9 families were recorded during the study. Based on which a taxonomic checklist with updated IUCN status was compiled and compared with the previous records. Venerida, the dominant Order (30%) comprising 2 families and 6 species followed by Ostreida (15%), Arcida (15%), Mytilidae (10%), Cardiida (10%) and Pectinida (10%). Order Myida and Unionoida together contributed only <5% with a single species represented from each order viz., Martesia striata and Lamellidens marginalis respectively. Observation on the region wise diversity indices revealed that highest number of species (16-19 species) recorded from middle estuarine region. The relative abundance of Villoritta cyprinoides was noticeably higher in Southern (99%) region than the northern region. Results of present study indicate that the V. cyprinoides occupied in all the parts of Vembanad backwaters during all the seasons except in the estuarine region. Mytilaster lineatus which is a fouling invasive bivalve species recorded from middle and northern regions of Vembanad backwaters; its abundance was relatively high in middle region i.e. 51% during monsoon followed northern region i.e. 35% during monsoon. The study suggests the prominent spatial variability in the distribution pattern of bivalves in the Vembanad backwaters and is based on the prevailing environmental conditions.
Feeding habits of flood introduced catfish, *Pangasianodon hypophthalmus* (Sauvage, 1878) from Chalakudy river system of Kerala, India

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Introduced alien species are regarded as the second largest threat to biodiversity worldwide after habitat degradation and their economic loss nearly US$300 billion per year worldwide. The invading species may affect the native species populations in various ways: constitute a serious competitor for food and habitat (space), be a new potential prey, or be a predator. The catastrophic floods in Kerala during August 2018 has introduced may predatory exotic fishes from aquaculture ponds in to natural waters including striped cat fish, *Pangasianodon hypophthalmus* (Sauvage, 1878). Study of dietary components is an important tool to depict the ecological function of a species introduced in to novel ecosystem and study their possible ecological impacts. In the present study, we observe the diet pattern of a non-native fish *P. hypophthalmus*, introduced in to the Chalakudy river system (Western Ghats biodiversity hotspot) of Kerala, India during the 2018 floods. The study indicated that *P. hypophthalmus* is an omnivorous feeder consuming predominantly fish remains, crustaceans, insects, algae, higher plants and soil particles. These findings show that the introduced *P. hypophthalmus* shared a common feeding characteristic like indigenous catfishes viz., *Horabagrus brachysoma*, *H. nigricollaris*, *Heteropneustes fossilis* and *Ompok malabaricus* in Chalakudy river system which may result in an undoubtful dietary partitioning and competition causing potential threats to these native fishes.
ARL-PO-10

**Comparative assessment of phytoplankton distribution in the lagoons of Minicoy and Kavaratti islands, Lakshadweep Archipelago**

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Investigation on the distribution and abundance of phytoplankton in relation to physico-chemical characteristics were carried out during premonsoon season in the lagoon waters of Minicoy and Kavaratti Island, Lakshadweep archipelago. A total of eight stations were selected in the lagoon of Kavaratti Island and eight stations in Minicoy Island. Water quality parameters such as temperature, salinity, pH, dissolved oxygen and nutrients (Nitrite, Phosphate, Silicate and Ammonia) along with phytoplankton biomass (Chlorophyll a) were assessed. The quantitative and qualitative assessment of phytoplankton was carried out separately for all the stations. Phytoplankton community was mainly dominated by diatoms, dinoflagellates and blue green algae in Minicoy Island whereas in Kavaratti Island dinoflagellates are dominated followed by diatoms and blue green algae. Chlorophyll a ranged between 0.06 - 0.19 mg.m⁻³ and 0.07-0.14 mg.m⁻³ among stations in Kavaratti and Minicoy Islands respectively. The present study is an attempt to understand the spatial differences of phytoplankton properties in the lagoon ecosystems of the Kavaratti and Minicoy Island, Lakshadweep Archipelago.

ARL-PO-11

**Catch composition of migratory fishes in Winter migratory coastal set bagnets of Hooghly-Matlah estuary**

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Set bagnets (Behundi jal) in Hooghly – Matlah Estuary are the dominating fishing gear in the entire coastal and estuarine belt of West Bengal, accounting for 74.7% of the total catch. The study was to determine the catch composition of migratory fishes in indigenous coastal set bagnet (CSBN) operated during Kutty fisheries by the migratory fishermen in the lower stretches of Hooghly – Matlah estuary. Experiments were carried out for a period of four months during the winter migratory fishing season from November to February. The total of forty-eight (48) hauls was made in twelve (12) day of fishing trials. The soaking period was fixed to six (6) hours for every day of the experiment including the time of setting and hauling. *Setipinna phasa*, *Setipinna taty*, *Harpodon nehereus*, *Coilia* spp., *Osteogeneiosus militaris*, *Otolithoides pama*, *Cynoglossus* spp., *Ilisha megaloptera*, *Polynemus paradiseus*, and *Chirocentrus dorab* were the common migratory fishes reported during the study. Bombay duck contributing around 25.34% of the total catch is found as the dominating migratory fish in kutty fishery followed by *Trichiurus* spp.
Near reef abundance and on-off shore distribution of four different Tuna larvae in Lakshadweep Sea

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The near reef abundance and on-off shore distribution of fish larvae around Minicoy Island were studied in cruises onboard FORV Sagar-Sampada during 2014-15. The samples were collected by oblique tows using Hydrobios bongo twin nets (mesh size 300 µ) for three seasons (Fall inter-monsoon (FIM), Spring Inter-Monsoon (SIM) and Summer Monsoon (SM)) in six on-off shore stations ranging 1-20 km off shore of the Minicoy. Spring Inter-Monsoon season is the peak spawning season of major fish families. Distribution of total 28 different families were identified, the larvae are distributed near to the reef area, especially in the wind-ward side of the Minicoy Island. Major Tuna families are *K. pelamis*, *E. affinis* and *Auxis spp.*, *Thunnus spp.*, were the most abundant over the entire sampling period. Different environmental patterns and season are influenced the larval distribution (such as water temperature or current speed) (Nathania 2015). Presence of reef abundance affected the larval distribution. Larvae shows the behaviours of diel vertical migration and possibly selective tidal stream transport (Nathania 2015). Lakshadweep is a least studied area and this attempt to explore the influence of environmental variables on the larval fish association during three season.
Lobster trap fishery along Enayam-Kadiapattanam coast of Tamil Nadu

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Lobsters are low volume high value crustacean resources which have been exploited commercially since early 1950s. The major lobster fishing grounds in south-east coast region include, Enayam – Kadiyapattanam belt of Kanyakumari district and Thoothukudi- Rameswaram coast of Tamilnadu. Total crustaceans landing in Tamilnadu (2016-2017) is estimated as 6% of the total marine production of which, lobster production contributes to 0.7 % and it is contributed by gillnets, bottom trawls and traps (locally known as ‘koodu’). However, in Enayam-Kadiapattanam coast bottom trawling is not possible due to the coral and rocky substratum. Besides, bottom set gillnets are also banned in this area. Hence the traps are a prominent fishing gear and the study depicts the lobster trap fishery in this region. There are around 600 trap fishers from seven fishing villages (Enayam, Enayam Puthenthurai, Kurumanai, Vaniyamkudi, Kodimunai, Kadiapattanam and Colachel) of Enayam-Kadiapattanam coast. The traditional traps were made with palm materials whereas modern traps are made of iron rods and HDPE webbing which lasts for 3 – 4 years. Fishing season lasts for seven months from October- May and peak season is October- December (20-30 kg lobster/day). Generally, 10-50 traps were operated per person in their ancestral fishing location, the rights of which are passed through generations. Traps are set at a depth ranging from 10-30 m and it is operated by skin diving. Overall it is a selective, eco- friendly and responsible fishing method provides the traps are not lost which may lead to ghost fishing related problems.
An account on CO$_2$ emission by the mechanised fishing trawlers of Kerala - issues and threats

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Marine fisheries sector of India has been witnessed with unwieldy increase of fishing efficiency and fishing effort during the last five decades resulting in substantial enhance in diesel consumption equivalent to emission of CO$_2$ of 0.3 MT (metric tonne) in the year 1961 to 3.6 MT in 2010 (Vivekanandan et al., 2013). The present study covered three important fishing harbours of Kerala namely Beyapore, Kalamukku and Munambam to reveal an estimation of CO$_2$ footprint (in t of CO$_2$/t of catch per fishing trip and considering the emission of CO$_2$ only during the fishing operation) by the mechanised fishing trawlers which showed a considerable higher values, i.e. 2.64, 1.95 and 2.62 respectively than the previous studies. The study also significantly reported that a considerable number of fishing trawlers operated in these harbours had been unscientifically overpowered (according to the standard table recommended by Baiju & Boopendranath, 2014). In the present context of overexploitation of commercially valuable fish stocks, the menace of overpowering of fishing vessels caused a tremendous elevation of fishing expenditure thereby making the fishing operation uneconomical and non-environment friendly (from GHG emission and global warming point of view). This study calls for an urgent requirement to scientifically down-size the craft in terms of number, size and engine power in various categories of fishing vessels in order to make this sector economically viable and sustainable.
Energy and Ecological Sustainability of Wular Lake Fisheries

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Inland fisheries contributed 68% of India’s total fish production of 11.41 million tons in 2016-2017. Inland capture fisheries share is relatively less but have inestimable value in terms of biodiversity and other ecological services. A study was conducted in Wular Lake, one of largest fresh water lakes in Asia with 11,277 ha area, on ecology and ecological sustainability of fisheries. Wular contributes about 54% of total fish yield from lakes of the Kashmir Valley and supports about 2914 families. Secondary as well as primary data was collected from nine representative villages through detailed KII, FGD and participant observation methods during October 2018 to February 2019. Ecological sustainability of Wular Lake fisheries was assessed using 5 attributes viz., fish production, trophic status, environmental degradation, species composition and recruitment variability. RAPFISH-Ecological dimension score was found to be 58% which is considered a ‘moderate’ / ‘quite’ category of sustainable development status. Leverage analysis revealed that ‘recruitment variability’ is the most influential attribute influencing ecological sustainability. Trophic status of Wular Lake was found in medium to high category, species composition of omnivores, herbivores and detritivores forming about 90% of total catch, fish production from last 30 years was found fluctuating, low (25%) of recruitment variability and high level of environmental degradation. The study suggests intervention plans namely implementation of seasonal ban in Wular Lake, treatment of sewage flowing into Wular Lake, reorientation and capacity building of DoF and diversifying livelihood options to sustain the ecology of lake fisheries as well as the fishers livelihoods.
Taxonomy of *Ellipsomyxa ariusi* infecting the marine catfish, *Arius arius* Hamilton, 1822 - a holistic approach

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Intensive aquaculture practices always invite higher incidence of pathogens/parasites. Identification of pathogens forms the first step in any disease control programme. Traditionally, taxonomy of most parasites is carried out based on morphology and morphometry. However, in some groups, especially myxosporeans, limited number of morphological features and their overlapping, and existence of cryptic species and species complexes creates confusion for taxonomists. A typical example is genus *Ellipsomyxa*, a myxosporean belonging to the Phylum Cnidaria. Many of the morphological features of this genus overlap with those of *Myxidium*, *Zschokkella* and *Sigmomyxa* leading to misidentifications. A holistic approach involving molecular and phylogenetic analyses along with biological and geographical data will help in resolving such taxonomical ambiguities. The present study was aimed to identify a species of myxosporean recovered from the gall bladder of *Arius arius*. Morphologically, spores of the parasite were ellipsoid, smooth, bivalvular with a prominent, curved sutural line, measured 10.05±0.78 x 6.59±0.81 x 7.65±0.74 μm. Polar capsules equal, at opposite ends, measured 2.66±0.42 x 2.46±0.38 μm. Morphologic and morphometric features indicate that it belongs to the genus *Ellipsomyxa*. For confirming the taxonomic identity, molecular analysis was performed by partial SSU rRNA (MK561978 & MK561979). In phylogenetic analysis the parasite was placed clearly under *Ellipsomyxa* clade, well separated from other *Ellipsomyxa* species with high bootstrap support (100%). Further, information on the site/organ infected and geographic location were also considered for taxonomic delineation. Accordingly, the parasite appears to be a new one and the name *Ellipsomyxa ariusi* is proposed.
Otolith trace element profile in *Tenualosa ilisha* from Brahmaputra River, Assam, India

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Sagittal otolith was extracted from *Tenualosa ilisha* specimens from Guwahati and Dhubri landing centre of River Brahmaputra in Assam during October 2017 and October 2018. Total length of otolith ranged from 4.10-6.12 mm with mean of 5.18±0.09 mm. Mean concentration of 14 trace elements in otolith of *T. ilisha* from four populations were analysed using ICPMS. Among the trace elements, Chromium (Cr) was found to be most dominant in Guwahati 2017 and Guwahati 2018 population, while it was Copper (Cu) in Dhubri 2018 and Zinc (Zn) in Dhubri 2017 population. Factor loadings based on principal component of concentration of trace elements (log transformed) shows that 10 elements namely, Lithium (Li), Beryllium (Be), Chromium (Cr), Cobalt (Co), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Cadmium (Cd) and Lead (Pb) were loaded in Factor 1 (>0.70), while Manganese (Mn) showed significant loadings in Factor 2. Discriminant function analysis showed that out of the 11 trace elements, 10 trace elements showed good fitting to the model, except Beryllium (Be) and hence excluded. Mahalanobis distance was found to be on the lower side between Guwahati 2017 and Guwahati 2018 and between Dhubri 2017 and Dhubri 2018 populations, while it was found to be on the higher side across stations. Classification matrix of four populations showed that 93.33% of the total samples were correctly classified. Bivariate plot shows that in general the differences in otolith micro-chemistry of *T. ilisha* are more pronounced on a spatial scale as compared to the temporal differences.
ARL-PO-18

Observations on length composition of major finfishes caught using stake net in Cochin backwaters

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The Cochin backwaters is one of the primary openings of the Vembanad Lake into the Arabian Sea. The estuarine region closer to the sea are known for its traditional prawn fishery by traditional set nets viz., Chinese dipnet and the Stake net. Stake net is a conical bag net set against the tidal currents by means of wooden stakes. Even though shrimps are the target resources for stake nets, a significant component of the catch is various finfish species including juveniles and undersized individuals. The study was conducted for a period of nine months from June 2018 to March 2019, during which fortnightly samples of fishes were collected from stake net operated across two sampling stations. The mean, minimum and, maximum lengths of the major finfish species caught in the stake nets were compared with their respective size at first maturity obtained from the secondary sources. Z test was used for testing the occurrence of undersized individuals of five species of commercially important fish in the catches. Results showed that there were significant differences (p<0.05) between the length caught and the recorded size at first maturity in the case of four species such as Arius subrostratus, Anodontostoma chacunda, Collectichthys dussumieri, Caranx ignobilis and Daysiaena albida. The mean length of Cynoglossus macrostomus had no significant difference from its recorded size at first maturity. These findings indicate the negative impact of stake nets on finfish resources and confirms the magnitude of exploitation of undersized individuals.

ARL-PO-19

Composition of epibenthic macrofaunal community in the Kuttanad region of Vembanad Lake

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Study deals with the composition and relative abundance of macrofaunal epibenthic community in Kuttanad region of Vembanad Lake. Extensive surveys were carried out along the region by using biological bottom dredge. Fauna composed of 12 groups dominated by Gastropod (51%) and bivalves (35%); both are represented by single species viz., Nassodonta insignis and Villorita cyprinooides respectively. Other groups were observed from this region were shrimps, polychaetes, fishes, tanaids, amphipods, isopod, crabs etc. Distribution pattern of the groups showed variation with respect to bottom depth and sediment composition. Occurrence of Gastropods was observed all along the region, whereas bivalves showed more or less patchy distribution. Aponegeton appendiculatus, a submerged macrophytes were distributed along the eastern side proximate to shallow (~2m) region with sandy substratum. In such areas, the community structure was dominated by polychaetes, gastropods, invertebrates and other microscopic organisms.
First record of the leopard jellyfish, *Acromitus maculosus* from Indian waters

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*Acromitus maculosus* reported by Light, 1914 from the coastal waters of Palawan, Philippines is recognized as a valid species in the World Register of Marine species under the Order- Rhizostomeae; Class-Scyphozoa and Phylum-Cnidaria, the only other recognized species in this genus being *A. flagellates*. We report the rediscovery of the species from Indian waters after a gap of 100 years and re-describe the species on the basis of detailed analysis of 8 specimens collected in 2019 from the stake Net fishery of Kumbalam, Cochin backwaters. The specimens had umbrella diameters varying from 102mm to 205 mm and weighed between 81 gm. to 545 gm. The umbrella of *A. maculosus* is dome-shaped with prominent leopard spots on the exumbrella, the spot size ranging from 0.52 mm to 5.64 mm. The umbrella has a tetra radial symmetry with 8 perradial canals of which four originate from the lobes and the remaining four from the groove portion of the oral disk. All the perradial or Rhopalar canals terminate in Rhopaliums which are sensory organ arranged on the rim of the umbrella. The rhopalar canals give off several tiny canals which anastomose to form a network which is more prominent in the muscular area between the circular canal and the rim of the umbrella. In these 8 lobed patterns, each octant has one rhopalar canal lodged between 2 adradial canals. The rim of the umbrella has around 80 lappets with each octant having 8 more or less semi-circular lappets arranged in 2 pairs of 4 lappets.

Diversity and distribution of freshwater fishes of Peechi and Chimmony Wildlife Sanctuaries in the Western Ghats of Kerala

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The status, diversity and distribution of fresh water fishes of Peechi and Chimmony wildlife sanctuaries in the western Ghats of Kerala, was studied for a period of one year (October 2018-October 2019). A total of 45 species belonging to 10 orders, 16 families and 35 genera were recorded. Cypriniformes was the most species rich order followed by Siluriformes, while Cyprlnidae was the most predominant family. 19 freshwater fish species were found to be endemic to the Western Ghats and five species are in threatened category. Apart from the native forms, four species recorded were inter-basin transplants within India and three species were exotic invasive. Uncontrolled fishing practices, water impediment due to dams, invasive introduced species etc. causes major threats to the native fishes of the area.
Length-weight relationship, condition factor and morphometric characteristics of Slender pinjalo (*Pinjalo lewisi* Randall, Allen & Anderson, 1987) from the southeast Arabian Sea

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Length-weight relationships of fishes are significant as they estimate the average weight of the fish of a given length group by forming a mathematical relation between the two. It is also an effective tool for understanding the biological changes in fish stocks and for developing fishery management measures. The present study describes the length-weight relationship (LWR), condition factor and morphometric relationships of Slender pinjalo, *Pinjalo lewisi* Randall, Allen & Anderson 1987 (Perciformes: Lutjanidae), a new recruit into the commercial fishery among snappers landed along the southwest coast of India. A total of 90 fishes (34-79.5 cm TL) were sampled from the commercial catches during May 2017 to April 2019. The length-weight relationship was calculated as $W = 0.065288 L^{2.597383}$. It showed a slight negative allometric growth with b value of 2.59 indicating that the fish becomes slenderer as it increases in length. LWR was highly significant ($p < .001$) with coefficient of determination ($r^2$) values greater than 0.93. Meristic and morphometric proportions were compared. The average Fulton’s condition factor (K) was 1.396. This is the first report on LWR, condition factor and morphometric characteristics for *Pinjalo lewisi* from the southeast Arabian Sea.
Fish assemblage structure of a temporarily closed sandbar estuary, from west coast of India

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Temporarily closed estuaries are one of the fragile and disturbed coastal ecosystems in the global context. The fish and shellfish assemblages of Poonthura estuary, a temporarily closed sandbar estuary along west coast of India was analysed from June 2016 to May 2017 from three designated stations covering outer, middle and upper stretches of the estuarine gradient. The fish and shellfish samples were collected every month with different types of nets bottom and surface gill nets and cast net during the study period. A total of 46 fish and 5 shellfish species were recorded from 30 families distributed in eight different orders. Among the finfishes, the order Perciformes with 8 suborders and 33 species dominated the fish assemblages. Carangidae was the dominant family represented by five number of species. The results indicated spatial and seasonal variations in diversity indices and the functional fish guilds. The guild composition also indicated that marine seasonal migrants (MM) (estuarine use) and miscellaneous opportunist (OP) (feeding mode) were the dominant guilds in the estuary. The diversity indices such as species richness, evenness, Shannon diversity, Simpson diversity and dominance ranged from 2.30 to 4.51, 0.79 to 0.92, 2.52 to 3.42, 0.76 to 0.91 and 0.11 to 0.23 respectively. In temporarily closed estuaries from tropical waters, such as Poonthura estuary, the fish assemblages are not uniformly distributed, and there is an immense pressure from anthropogenic activities and fishing. Proper management inputs are necessary to sustain the resources along with pollution abatement measures for improving the livelihood support from this estuary.
Present status of Trichiuroid fishery of India

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Trichiurid fishes, includes 24 species of snake mackerels, snoeks, gemfishes, sackfishes, escolars, the oilfish and the domine (Gempylidae) and 45 species of cutlass fishes, hairtails, scabbardfishes and frostfishes (Trichiuridae). Out of 24 species belonging to the Family Gempylidae, only ten species were reported from the Indian coast. Similarly, number of Trichiurids species reported from Indian coast is nine only. During 2014, a major Trichiurid Largehead hairtail *Trichiurus lepturus* alone contributed 1.26 million tones towards world marine fish landings. In India, Ribbon fishes landing during 2016 was 1.77 lakh tones. Trichiurids are benthopelagic fishes, typically live close to the bottom on the continental shelf and the upper slope, reaching the depths of 50–1500 m. They are widely distributed in tropical to warm temperate waters. Considering the wide spatiotemporal distribution pattern and diurnal migration habit, number of species reported from Indian water is very low. Moreover, in India except two coastal species Viz, *Trichiurus lepturus* and *Lepturacanthus savala* other species were rarely exploited. Most of the Gempylidae species reported from Indian waters are good candidate species as future conventional fishery resource. However, lack of information on the Systematics, distribution and abundance of Trichiurid resources is a major hurdle for the utilization of this major fishery resource. Present study reviews the present status and prospectus of Trichiuroid fishery of India.

Taxonomic validation of *Tentoriceps cristatus* (Klunzinger, 1884) (Perciformes: Trichiuridae) from Indian waters using morphological and molecular analysis

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Crested hairtail, *Tentoriceps cristatus* (Klunzinger, 1884) species belonging to the family Trichiuridae specimens were collected from the trawlers operated off Natika at a depth of 70-90 m. Specimens were identified following standard methods. Morphological, Morphometric measurements and meristic counts of the specimen showed significant similarities to the type specimen. In molecular analysis, collected sequences barcoded with the sequences of the species available from the Gene bank and made Maximum-likelihood tree based on K2P model of available CO1 sequences for members of the species *Tentoriceps cristatus* and output as Gempylus serpens of Gempylidae family. The current study extends the distribution range of the species to Indian waters. Full description of the species is provided.
ARL-PO-26

**Prospectus of Gempylid fishery of India**

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Deep sea fishes are considered to be non-conventional fishery resource. Among the deep-sea fishes Gempylids have more potential to be the conventional fishery resource. All over the world there are 25 species of Gempylids present. In India total of 10 species have been reported from 9 genera. Except *Lepidocybium flavobrunneum* and *Ruvettus pretiosus* all other species are being used as food in different regions of the world. There are incidents of selling *L. flavobrunneum* as seer fish in some local fish markets. *Neoepinnula orientalis* has a good ratio of nutrients for human consumption. As the pace of exploitation is changing, it is highly recommended to use the fishery as our future food. Present study reviews the distribution and abundance of Gempylid fishes occurring in Indian waters in the backdrop of utilization of this immense resource.

ARL-PO-27

**Finfish Biodiversity of Kole wetlands of Kerala**

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Kole wetlands of Kerala come under Vembanad-kole wetland, a Ramsar site. Kole wetlands are well known for its rich floral and faunal biodiversity. A study to understand the biodiversity of fishes was carried out by collecting fish specimens from the selected sites. Present study recorded 44 species of fin fishes belonging to 10 Orders, 20 Families and 34 Genera. Fishes belonging to Family Cyprinidae dominated in number with fourteen species. Ten species recorded during the study are endemic to the Western Ghats region of which four are endemic to Kerala. Five exotic species also reported from the Kole wetlands. Presence of exotic species in the Kole wetlands is an indication of the vulnerability of the ecosystem due to the intruder species. The diversity indices of fin fishes in Kole wetlands were estimated. Shannon diversity (H'), Margalef richness (d) and Pielou's evenness index (J') were estimated as 3.904, 3.690 and 0.889 respectively. Simpson dominance was estimated at 0.0872 and simpson dominance Index(1-λ) was 0.913. Month-wise diversity indices were calculated and highest species richness was recorded during August 2016 (d=4.494, J'=0.910, H'=4.314, λ=0.060) and lowest during month of May 2017 (d=2.843, J'=0.876, H'=3.361, λ=0.120). According to IUCN category, out of 44 finfish species recorded during the study period 3 species are Vulnerable and 2 species are Near Threatened. This indicates the importance of conservation of native fishes of Kole wetlands.
Freshwater fish diversity of Achankovil River with special reference to endemism, threats and conservation

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The Western Ghats (WG) is one of the world’s eight ‘hottest hotspots’ of biological diversity. Also referred to as the “Great Escarpment of India” WG harbours exceptionally rich freshwater fish fauna (>300 species) with a high level of endemism (65%). As part of a project to document the fish diversity of the rivers draining the Vembanad Lake, preliminary surveys were carried out understand the diversity, threats and conservation strategies of fishes of the Achankovil River. Fishes were collected from various tributaries and the main river using variety of gears including cast nets, dip nets, gill nets and drag nets. Fifty-eight fish species belonging to nine orders, 24 families and 44 genera were recorded of which Cyprinidae, Channidae and Bagridae were the dominant families. Of the 58 species, six were endemic to the Western Ghats. As per the IUCN Red List of Threatened Species, six species of fish occurring in the Achenkovil River are threatened (listed as Vulnerable) and an additional three are assessed as ‘Near Threatened’. Though preliminary in nature, our results indicate the rich ichthyofaunal diversity of this river system. Major threats to fish diversity in the Achenkovil River are from pollution, sand mining, over exploitation for food and the aquarium trade, and alien invasive species (both introduced and escapees). Hence, awareness on the diversity and threats of the fish fauna in this river system is lacking and targeted campaigns need to be carried out to improve the profile of freshwater biodiversity conservation in the Achenkovil River.
Mahseer group shows phenotypic plasticity and often difficult to discriminate on the basis of morphological characters alone. Prioritization of mahseer species for conservation would be difficult due to the taxonomic ambiguity. An evolutionary study with mitogenome would resolve the species complex more accurately than morphological characters alone. Thus, the present study was carried out to sequence the complete mitochondrial genome of threatened mahseer, *Neolissochilus hexastichus*. The mitogenome was found to be 16,535bp in length and consisted of 22 tRNAs, 2 rRNAs, 13 protein-coding genes as well as a putative non-coding control region. All protein-coding genes were encoded on H-strand (Heavy strand) except ND6 protein-coding gene and eight tRNA were encoded on the L-strand (Light strand) while most of the other tRNA genes were present on H strand. Except for cytochrome c oxidase subunit I (start codon: GTG), all other protein-coding genes share the start codon ATG. Seven of 13 protein-coding genes are terminated with incomplete codons of T– – (CytB, ND2, ND3, ND4, COII, and COIII) or TA– (ATPase 6). Remaining six protein-coding genes (ND1, COI, ATP8, ND4L, ND5, and ND6) have TAA termination codon. The overall base composition was A: 31.9%, C: 27.3%, G: 15.6 % and T: 25%. Reconstructing the phylogenetic trees using Neighbour-joining, Maximum parsimony and Maximum Likelihood methods and Bayesian inference revealed that *N. hexastichus* is closely related to *N. hexagonolepis*. 
Identifying challenges and need for improved knowledge in octocoral research in India

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The tropical Indo-West Pacific, known for its remarkably high diversity and endemism of corals is, however, a region (especially Eastern Pacific and Indian Ocean) of data-deficiency in the case of octocorals. Though India is known for its distinctive tectonic history, paleogeographic position and unique biodiversity; there exists a huge knowledge gap in case of octocorals. Of the 205 online primary publications relating to octocorals from Indian waters, a considerable magnitude of work has been focused on diversity and bioactivity studies. Despite several publications on diversity and distribution, the taxonomic ambiguities and probable misidentifications have obliterated the actual octocoral diversity data. The lacuna in studies related to ecology, threats and conservation are also evident. There is also a regional inclination in the representation of octocoral studies where several regions, especially on the northern coasts, have been ignored. A significant number of non-peer reviewed publications (including predatory journals), inaccessible types, and national legislations (e.g. Indian Wildlife Protection Act) has challenged the progress of octocoral research in India. Integrative taxonomy involving morphology, molecular biology, ecology and biogeography serves to be the best way to overcome prevailing diversity and taxonomic ambiguities in this context. Besides improved publications, comprehensive and collaborative research projects, standardized museum facilities and access to genuine researchers would help to improve the quality of Indian octocoral research to global-standards. Future research should also focus on ‘deep-sea octocorals’ of the Central Indian Ocean and other diversity rich areas in this region (e.g. Lakshadweep and Gulf of Kutch).
Food availability counter balances seawater pH effect in *Gafrarium divaricatum*

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Coastal and marine ecosystems are under extreme stress due to the changing climatic factors of which ocean acidification is believed to be a primary concern. The increasing CO$_2$ levels in the atmosphere are reduced by the oceans, which have absorbed about 29 percent of global CO$_2$ emissions. Most ocean acidification studies reveal the potential of organisms to physiologically acclimatize to ocean acidification conditions where food availability may play a crucial part in counterbalancing the decreased seawater pH effect on bivalves. A laboratory experiment was conducted to study the effect of food availability on response of clam species, *Gafrarium divaricatum*, in different seawater pH conditions. The study species, which are ecologically and economically significant marine intertidal clams, were collected from the Juhu-Koliwada coastal area on Mumbai coast. The clams were exposed to the combined effect of two factors, such as two variations of feeding density of Isochrysis algal cells (low: 2500 cells mL$^{-1}$ and high: 10000 cells mL$^{-1}$) and four different seawater pH levels (8, 7.7, 7.4 and 7.1) for 60 days. We found out that low feeding density and low pH level combination significantly led to decreased growth rate and high mortality rate. The result of the present study concludes that *Gafrarium divaricatum* tolerates pH 8 and 7.7 when feeding density is high which may compensate energy for the vital processes and shell maintenance. Besides, data reveals that ocean acidification impairs the calcification process at pH 7.1 and 7.4 causing the inner shell surface dissolution by stereomicroscopy and SEM imaging.
Distribution of Sea anemones in the Intertidal regions of Malabar coast

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Malabar coast is one of the richest areas of sea anemone diversity contains a vast number of species yet to be identified. The study conducted in 4 stations - Thikkodi, Puthiyappa, Dharmadam, and Muzhpilangad. Sea anemones were collected using handpicking and with the hammer and chisel. Photographs of anemones in depth were taken. About 3 families and 5 genera were identified. Size range from 1 to 6cm in general. *Anthopleura handi* (Dunn 1978) in the rocky areas, *Aiptasia* sp. attached to bivalves, *Calliactis* sp. associated with polychaete, *Paracondylactis sinensis* in the sand, and *Heteractis* sp. Sand anemones were larger with 6cm length while the size of the other groups ranges from 1 to 3cm. Some of the anemones and *Corynactis* sp. were found in 10 to 18m depth. Sea anemones are the predators waiting for the prey by submerging in the water and often foraging for their survival.
Biogeography of Chitons (Class: Polyplacophora) from the Indian Ocean

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Chitons (class: Polyplacophora) are marine molluscs that dominate the intertidal and shallow subtidal zones with some records from the deep-sea. As prolific grazers of rocky intertidal regions, chitons are important bioindicators. Further, their evolutionary history of chiton makes them an ideal group for understanding species diversification and biogeographic patterns. Compared to the Atlantic and Pacific waters, research focussed on taxonomy has only recently begun in the Indian Ocean region. To understand the biogeography of chitons from the Indian Ocean fringing countries, data were collected from published literature including records from GBIF (Global Biodiversity Information Facility), and analysed using multivariate techniques. Of 173 species recorded from the region, four species (Acanthopleura brevispinosa, Acanthopleura Gemmata, Chiton hululensis, Craspedochiton laqueatus) were distributed throughout the Indian Ocean, while some species showed restricted distribution and endemism. Hierarchical clustering of species revealed four significant clusters in the Indian Ocean region with a clear differentiation of the western Indian Ocean region. Clustering patterns were compared with existing biogeographic research. Extensive and systematic data collection will help elucidate detailed biogeographic patterns of chitons in the Indian ocean region and help improve the understanding of these coastal regions.
ARL-PO-34

Survey and inventorisation of brachyuran crabs from the mangrove patches in and around Cochin backwaters

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Brachyuran crabs form a principal group in mangrove ecosystems that aids a significant role in nutrient recycling because of their burrowing nature that ensures aeration and irrigation of the mangrove soil. An investigation on the density and diversity of brachyuran crabs from three selected mangrove patches of Cochin backwaters, namely Puthuvyppu, Panangad and Mulavukad were carried out for a period of one year. A total of 14 species of brachyuran crabs were recorded that belongs to 10 genera and 5 families were recorded and the maximum species diversity was recorded in Puthuvyppu; whereas Panangad and Mulavukad recorded 12 species each. The qualitative and quantitative estimation of brachyuran crabs and their relation to water quality and sediment characteristics were evaluated so as to identify the most influencing water and sediments characteristics that influence on crab diversity. The percentage wise species composition of brachyuran crabs during various seasons and stations were worked out separately. The univariate methods of biodiversity indices and multivariate analysis such as cluster and MDS were worked out season wise for the three stations.

ARL-PO-35

Comparative assessment of teeth and gills of three species of genus *Mobula* from Kerala Coast: a taxonomic tool for species identification

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Comparative analysis of teeth and gill plate morphology of three species from the genus *Mobula* of Kerala coast were analysed. The present study depicts the remarkable difference found in teeth and gill morphology of three species, namely *Mobula birostris*, *Mobula mobular* and *Mobula thurstoni* of the genus *Mobula*. Based on the analysis, two dental morphologies such as peg like teeth and comb like teeth were identified. Peg like teeth is encompasses in the species *M. birostris* and *M. mobular*, whereas *M. thurstoni* have comb like teeth. *M. birostris* is characterized by lack of upper teeth. The structure of branchial filter also exhibits pronounced difference between the species. The branchial filter in *M. birostris* is uniformly black having large gill plates with fused lateral lobes and rounded terminal lobe. *M. mobular* bears medium sized gill plates with separated bristled and pointed lateral lobe edging, with leaf shaped terminal lobe. Lobes are black with pinkish white terminal lobe. *M. thurstoni* have medium sized gill plates with leaf shaped terminal lobe twice as long as wide. Plate black with grey terminal lobes and some light white shading near the base.
Composition and diversity of periphytic algae in Achankovil River, Kerala during the monsoon season

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Achankovil River with a total length of 128 km emerges from Western Ghats and drains to Vembanad lake in Alappuzha district. The periphytic algal species composition and diversity in the upstream, mid-stream and downstream of Achankovil River was studied during the monsoon season of 2019. Qualitative as well as quantitative estimates were carried out using standard references to identify systematic position of periphytons. High variability in periphytic algal community structure was observed in different sites. More taxa and low density were observed in upstream while the reverse was the case in downstream. A total of 48 periphyton taxa were identified and categorized into 4 divisions, 9 orders, 9 families and 32 genera. Chlorophycea (25 species) forms the dominant group followed by Bacillariophycea (10), Cyanophyceae (7) and Eugenophyceae (6). Desmids (56%) represent major forms among Chlorophycea. The present study provides information on variation in periphytic algal composition and abundance in Achankovil river ecosystem. Observed variations in distribution can represent the ecological health of the system.

Phenotypic variations in Anchovies off the south and central Kerala Coast

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This paper presents the morphometric and meristic features of Anchovy species, Stolephorus commersonnii, Stolephorus indicus, Stolephorus waitei, Encrasicholina devisi, and Encrasicholina punctifer off the South and Central Kerala coasts. In the meristic characters studied, number of dorsal fin rays varied from 11(range 11-12) in E. punctifer; 12 (11-14) in E. devis; 13 in S. indicus (range 12-13) and S. commersonnii (12-14). Maximum number of dorsal fin rays (14) was found in S. waitei (range 12-15). Other meristic counts of Anal fin rays, Pectoral fin rays, Pre-pelvic scutes, Lateral Line scale count, and Gill Rackers of the 1st Gill arch show significant variation among the species except for the Pelvic fin rays which was consistent (7) in all the species studied. Morphometric characters show good correlation with standard length and reflect strong inter species and intra species variations which are characterised through truss morphometry.
ARL-PO-38

Meiofaunal diversity and abundance in bottom sediments along the southern sector of Vembanad Lake

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Meiofauna, which constitutes an important component of benthos facilitates biomineralization of organic matter and enhances nutrient regeneration. Meiobenthos are highly diverse and several phyla are only known to occur as meiofauna. The present paper reveals the diversity and abundance of meiofauna in the southern sector of Vembanad lake (latitude $9^\circ35'16.47'' - 9^\circ40'0.26''N$ and longitude $76^\circ23'37.20'' - 76^\circ23'51.52''E$) from south of Kavunkal to Thanneermukkom bund in the north. The data presented in the paper is based on grab samples collected during two consecutive seasons (pre-monsoon and monsoon, 2019) from 25 selected stations representing the southern sector of Vembanad Lake. Meiobdunal composition in the lake was constituted by different taxa in varying proportions. Nematodes, foraminifers (Trilobatus sacculifer), copepods (Harpacticoid copepods), polychaetes and oligocheates were the abundant and most widely distributed groups. Nematodes, foraminifers and polychaetes were found to be abundant in silty sediments with bottom temperature of 29$^\circ$C and salinity 1ppt while copepods preferred sandy habitats and Tardigrada species were found in muddy sediment. The well-known interstitial genus Halammohydra was found only in sandy sediments. Meiobdunal abundance and distribution was prominent during the pre-monsoon season (March) as compared to the monsoon season (July). In both the seasons nematodes were the dominant group with occurrence in all the stations during the pre-monsoon whereas thus occurrence was restricted mostly to the western sector of the lake during the monsoon.
Performance evaluation of multifilament and monofilament cast net fishing in Wular lake, Kashmir

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Wular lake is the largest freshwater lake of Kashmir within the river Jhelum basin. It is a major source of fish in the valley supporting a large population living along its fringes. Fishermen of Wular lake operate stringless polyamide multifilament cast nets. Experimental monofilament cast net (stringless and stringed) and multifilament cast net (stringless and stringed) were fabricated and operated in the Wular lake of Kashmir to analyze the catching efficiency, catch composition and size range of fish caught in multi and monofilament netting material. The mesh size of both types of experimental nets was 30 mm and 50 operations each were conducted. Stringless and stringed monofilament cast net caught nine species and the total number of fish was 237. The highest percentage catch was of *Cyprinus carpio communis* (30.8%) in terms of number. Multifilament stringless and stringed cast net caught 145 fishes. The highest percentage catch was of *Ctenopharyngodon idella* (27.5%). The monofilament cast nets showed better catching efficiency than the multifilament nets as per the results of the study. The introduction of the monofilament cast nets in the Wular lake can improve the catch rate and the income of fishermen and can be a means of alternate livelihood for those engaged in agriculture also.
ICAR-CIFT Collapsible fish trap : a smart technology for the traditional fishermen of India

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Traps are passive fishing gear where fish is lured for food or shelter. Different types of traditional fish traps are operated in India, mostly made of bamboo/palmyra with short life span and difficult to handle due to huge size. ICAR-CIFT improved the design of traditional trap as collapsible fish trap with two rectangular and square frames with stainless steel. Side frames are covered with HDPE (80 mm mesh size, 1.25 mm diameter). Entrance funnels are made of polymesh with tapering rates. Polypropylene rope (4 mm diameter) is attached at the center of the upper frame with a float attached at the other end for locating and retrieving the trap. Chicken, fish and prawn waste are used as bait. *Etroplus suratensis*, *Lutjanus argentimaculatus*, *Lates calcarifer*, Epinephelus sp., *Scylla serrata* are the common target species and the trap can be set and hauled after 2-3 days of soaking. Average catch/haul is 1.5 kg. Design of the trap is simple and any fishermen can adopt the technology and is 40% lighter in weight & durability is 3-4 times more than the conventional traps. Several collapsible traps can be transported and operated using a small canoe due to its foldability. These traps can be made ecofriendly by using biodegradable materials like cotton in selected portion can contribute in reducing ghost fishing. Cost of ICAR-CIFT collapsible fish trap is only 50% of the conventional bamboo traps with same dimension. ICAR-CIFT collapsible fish trap will be a better option for the traditional fishermen to improve the livelihood.
BRDs for exclusion of Squilla from shrimp trawls – preliminary studies along Cochin coast, Kerala

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Globally, shrimp trawling generates highest quantity of bycatch and discards, contributing 46% of the total annual discards of 9.1 MMT estimated by Food and Agricultural Organisation (FAO). In India, 35,228 trawlers of various sizes and engine powers, contributing more than 50% of the total marine catches of the country, is very significant. Indian fisheries accounts for about 58,000 tonnes of bycatch and about 57% of the total catch of Indian shrimp trawlers is bycatch. Though squilla forms a major bycatch in most shrimp trawls operated along Kerala coast, it has no commercial value and substantially increases drag, sorting time and limits space for target catch in codend, which is an issue. Keeping this in view, a hard Bycatch Reduction Device (BRD) was developed to exclude squilla from shrimp trawls, by adjusting the spacing of the horizontal bars of the grid. Three different designs of squilla bycatch reduction device (S-BRD) were developed and field tested off Cochin. Out of three designs, two designs (grid distance; 2.6 and 3.4 cm respectively), were found to significantly exclude squilla, with average separation of 56% and 61% respectively. The average length of squilla in the upper and lower codends of the BRD was 11.5±2.4 & 8.6±2.1 cm in the first design and 11.7±0.19 & 8.8±0.13 cm in second design. The result indicated that though physical separation was occurring, the grids needs to be further optimized by evolving modified designs, by taking cues from underwater behaviour of squilla. The results and implications are discussed in manuscript.
Marine pollution is one among the major issues in the ocean system and wide use of synthetic fishing gears further magnifies this issue. Studies reported that nearly 10 percent of the marine debris is contributed by the fishing systems in the world. The fishing gears or its parts accumulated in the sea as marine debris are categorized as Abandoned, Lost or Discarded Fishing Gears (ALDFG) by the UN-FAO. In this background a study on lost fishing gears was carried out through scuba diving in the trap fishing ground of Enayam coast of Tamil Nadu during March 2019. From repeated dive studies in four different locations at a depth range of 16-20 m lost traps and parts of gillnets, floats, long line, trawl cod end and head rope were retrieved from the bottom of the sea. Examination of these fishing gears showed colonisation by marine organisms such as sea spiders, gastropods, crabs, sea stars, sponges, juvenile lobsters, barnacles, clams etc. But the retrieved fishing gear have not shown skeleton/ remnants of fish/other organisms as proof for ghost fishing at the time of retrieval. Hence the study depicts that the lost fishing gears after a while might have turned to fish aggregating device. This lost gear may or may not be a ghost fishing gear in the early stage but, becomes an ecological niche in the later stage.
The leap! Natural riverine barriers and the molecular ecology of hillstream loaches in the Western Ghats Biodiversity Hotspot

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Natural riverine barriers such as cascades and waterfalls are habitat discontinuities resulting in strong structuring of genetic diversity and divergence between fish populations. Using a monotypic hillstream loach species, *Bhavania australis*, endemic to the Western Ghats Biodiversity Hotspot of peninsular India, we investigate how natural riverine barriers influence gene flow, genetic diversity and phylogeography in habitat specialist species with low mobility, and how this data can inform their conservation. Mitochondrial genetic data (cytb sequences) of *B. australis* specimens collected from various locations above and below the 25m high and 100m wide (120m ASL) Athirapally waterfalls in the 146km long Chalakudy River, were analysed to understand haplotypic diversity and population structure. Though populations upstream of the waterfall get washed downstream either due to natural flow, or heavy rains, the barrier (i.e. waterfall) makes it difficult for downstream populations to migrate upstream. Five distinct haplotypes were found on either side of the barrier which are separated by four polymorphic sites. All upstream populations share haplotypes with downstream populations except two haplotypes which are exclusive to downstream. In addition to throwing light on the potential role of natural riverine barriers on the genetic diversity of restricted range hillstream fishes, our study also provides preliminary insights into the evolution and historical drainage patterns of the small westward flowing river systems in the Western Ghats Hotspot.
Biological invasions in a microhotspot of biodiversity: the Kabini catchment of Wayanad hills, Western Ghats, India

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Invasive alien species have caused major impacts on biodiversity at a global scale, with 39% of the species extinctions in the past 400 years attributed to biological invasions. In this study, we investigated fish diversity and abundance in the River Kabini, draining the Wayanad hills of the Western Ghats Biodiversity Hotspot to inform future conservation and management plans. A combination of methods including extensive field surveys, local ecological knowledge and geospatial threat mapping was done during a five-year period from 2013 to 2018. Kabini harbours an exceptional level of fish diversity with 76 species represented by 10 orders, 23 families and 54 genera. Twelve species (~16%) of the total diversity are contributed by exotics, while 64 are native (of which 35 are endemic to the Western Ghats, 6 endemic to the political boundary of Kerala and three endemic to the Wayanad hills). Of the 76 species, 10 are listed under various threatened categories of the IUCN Red List including four each which are Critically Endangered and Endangered, and two of which are Vulnerable. An additional two species are assessed as Data Deficient. Aquaculture often using banned species is the major pathway for introduction of alien species in the region. Based on the global invasive database, three species Oreochromis mossambicus, Cyprinus carpio and Gambusia affinis are listed as 100 world’s worst invasive species. Seven alien species are used for food, three are used for the aquarium trade, while two species are used for both these purposes.
Assessment on the incursion of marine litter in Kanjiracode Kayal, a part of Ashtamudi Lake

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The sources of litter enter the marine environment from different and diffuse areas. Generally, the litters are originating from human activities and can also get transported over long distances before being settling onto beaches or deposited to the seafloor. The study was evaluated the composition, abundance, distribution, and impact of marine litter on the three different zones of Kanjiracode Kayal. The litter was collected and categorized as per the UNEP system of classification of marine litter and sorted into different classes by weight, size, and material type. The samples were classified into 42 different kinds of litter materials recorded from the study areas. Plastic items were contributed more than 90% by weight and 94% by number of the total litter gathered include plastic covers, pet bottles, damaged electronic gadgets, textile materials, and abandoned fishing gears forms its lion share. The observation was indicated that the average assemblage of marine debris per month is more than 40.5 kg in all the sampling areas. However, there is no significant variation was noticed among the sampling areas. The fishing activities are also found to be responsible for the generation of marine litter, primarily consist of abandoned or discarded fishing gears. It was also noticed that single-use plastics forms a major share in litter assemblage. The study also showed that the intrusion of marine litter increases during the monsoonal month along with river discharge.
An incidence of diet shift in Snapper

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Snappers are active predators feeding mainly on a variety of food items including fishes, crabs, shrimps, gastropods, cephalopods and also planktonic organisms. Generally, fishes are dominant in the diet of most of the larger, deep-bodied snappers. They are usually equipped with large canine teeth, adapted for seizing and holding their prey. Our recent investigation during September-December of 2018, on the feeding biology of *Lutjanus gibbus* revealed the presence of Red-toothed triggerfish *Odonus niger* as a major component in the diet of the fish. Before the advent of *Odonus niger* into the scenario, the diet was mainly composed of squids, crabs, anchovies, carangids, and the Indian scad. The year 2018 was noted for remarkably huge landing of *Odonus niger* in all the landing centres throughout the west coast of India and its annual landing in Kerala during 2018 was 8917.34 tonnes. *Odonus niger* is a reef-associated species of the family Balistidae occurring at a depth range of 5-40 m. It is considered as a trash fish due to its low market value amounting to Rs. 15-20/kg. Gut content analysis of *L. gibbus* exposed the occurrence of undigested as well as semi-digested forms of *Odonus niger* in the stomach of snappers. In some cases, *Odonus niger* with a hook attached was obtained from the gut which evidences that it is also used as an effective live bait for catching snappers. A significant diet shift is noticed in snappers with *Odonus niger* as a predominant prey species.
Whole mitogenome analysis of endangered freshwater catfish
*Horabagrus nigricollaris*

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The genus *Horabagrus* is comprised of two species of freshwater catfishes endemic to peninsular India, *H. brachysoma* and *H. nigricollaris*. Compared to that of *H. brachysoma*, *H. nigricollaris* (black collared catfish) distribution is very much limited and the species is under the threat of extinction. In the present study we have sequenced and analyzed the complete mitochondrial genome of *H. nigricollaris*. The mitochondrial genome, 16561 bp in length, consist of 13 protein-coding genes, 22 tRNAs and 2 rRNA genes with a control region (D-loop). The mitogenome has a base composition of A: 31.3%, T: 25.4%, G: 15.2% and C: 28%. The base composition of protein coding genes in *H. nigricollaris* is A: 29.1%, T: 27.4%, G: 15.6% and C: 27.9% while that of *H. brachysoma* is A: 29%, T: 27.2%, G: 15.6% and C: 28.2%. Both species are A+T (56.6%) rich with least G content. The protein coding regions of the two mitogenomes covered 68.3% of the total genome with 0.5% intergenic spacer and 0.06% overlaps. The overall AT skew and GC skew of *H. nigricollaris* and *H. brachysoma* mitogenomes were 0.1027, 0.1045 and -0.2943, -0.2955, respectively. Most frequently used codon was CUA which codes for the amino acid leucine. Comparative analysis of *H. nigricollaris* mitogenome demonstrated a close similarity with its sister species *H. brachysoma* in composition, gene order and orientation. The mitogenome characterised in this study can serve as a primary genomic resource for further research on this endangered catfish.
Species diversity and abundance of mangroves in fisheries station, Puduveypu

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²University of Kerala

Puduveypu is one of the mangrove rich areas of Cochin, which faced massive destruction in the recent past. The Government of Kerala introduced many schemes for mangrove conservation. Kerala University of Fisheries and Ocean Studies (KUFOS) established a Mangrove Research Centre at Fisheries Station, Puduveypu to promote mangrove conservation. As part of the project entitled “Mangroves for Fisheries and Environmental Enhancement in Cochin- a comprehensive intervention through participatory approach” implemented by KUFOS in association with SERB, a biodiversity study was carried out in the mangrove ecosystem of Fisheries Station, Puduveypu. Data reveals that there are 8 true indigenous mangrove species are present in the area. *Avicennia officinalis* is the highest abundant species with a density index of (0.080 nos /500 m²). *Rhizophora mucronata, Bruguiera cylindrica* and *Bruguiera gymnorrhiza* are also recorded with a density of 0.072, 0.070 and 0.051 nos/ 500 m² respectively. The Simpson Index of Diversity (1-D) value ranges between 0 and 1. The study on species richness revealed that Station 1 shows the highest species richness and repetition index and Station 5 recorded the highest diversity. Station 1 is dominated by *Avicennia officinalis* which appeared in all 30 quadrants. *Bruguiera cylindrica* is also present in that area which appeared in 10 quadrants. *Acanthus ilicifolius, Clerodendrum inerme* and *Derris trifoliata* are the mangrove associates which recorded highest species richness and repetition index. Study on the abundance and distribution parameters indicates that the mangrove forest of Fisheries Station, Puduveypu is rich in species diversity.
Present status of Crinoidian diversity along Vizhinjam coast vis-à-vis construction of International Seaport

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²Department of Aquatic Environment Management, Kerala University of Fisheries and Ocean Studies, Kochi

The present study reveals the current state of feather star diversity along the margins of the proposed Vizhinjam International Seaport. Crinoids belonging to the class Crinoidea of order Comatulida are one among the key ecological groups. As sessile rheophilic suspension feeders, crinoids are sensitive to fluctuations of several environmental parameters. Vizhinjam the southern west coast of Kerala, has traditionally been a productive zone for comatulid feather stars. With the onset of construction of an International Seaport at Vizhinjam in 2015 there has been mass dredging in the region. The area has been undergoing increasing anthropogenic stress due to the removal of rocks, underwater dredging, reclamation of the sea, sand mining, construction of breakwater and quay walls for the port etc. This has resulted in huge sedimentation in regions near to the construction site. Sedimentation is a detrimental process that affects the distribution of crinoids in their coastal habitats. The study conducted during 2018-19 showed that there were three species in three genera and three families. The present study is the current state of Comatulid feather stars from the Vizhinjam coast.
ARL-PO-50

Impact of invasive mussel, *Mytella strigata* on estuarine macrobenthic community structure in the Kanjiracode Kayal water labyrinth of Ashtamudi Lake

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¹School of Ocean Science and Technology, Kerala University of Fisheries and Ocean Studies, Kochi
²Fisheries Station, Kerala University of Fisheries and Ocean Studies, Kochi

Estimates of the benthic macrobenthic community are often used to indicate environmental health because of their relatively sedentary nature, will not avoid deteriorating water and sediment qualities. The present study was focused on the macrobenthic community structure of Kanjiracode Kayal was recorded in the 3 different zones dominated by a seagrass, seaweed and invasive mussel species. The basic community structure of these zones varied based on the type of substrata existing in the respective zones. The study revealed that the mussel, *Mytella strigata* forms a dominated organism and it contributed its maximum at zone III (99.23%) followed by a seagrass dominated area, zone I with 63.59% of total biomass. The lowest density was recorded in the seagrass meadow (zone III) with a density of 17.26%. Among the three zones, the percentage of community biomass composed of equilibrium species was greater in the zone I less in zone III. The percentage of community biomass composed of opportunistic species was alarmingly greater in zone III with other zones. It is also evident from the study, the density of invasive species is more determinant on the nature of substratum which has adversely affect the species diversity of zones than that of any other parameter.

ARL-PO-51

New distributional record of Golden catfish, *Horabagrus brachysoma* from Kavvayi backwaters

VM Sachin, CP Binesh, Ashwini Gopi, TA Keerthana and B Manoj Kumar

Kerala University of Fisheries and Ocean Studies, Regional Centre, Kannur, Payyanur

Kavvayi backwater is an extensive water body located in the northern Kerala. It is one of the least studied backwaters in Kerala in terms of faunal diversity and fisheries. In a preliminary investigation on the ichthyofaunal diversity, the golden catfish *Horabagrus brachysoma* was discovered for the first time in this water body using taxonomic keys on the morphological features. The fish is listed under the category ‘vulnerable’ by the IUCN. So far, the fish was reported only from the Chalakudy, Periyar, Meenachil, Manimala, Pampa, Moovatupuzha, Achankovil Rivers and Vembanad Lake in Kerala. As per the IUCN, in the geographic region, the fish was recorded from Mangalore and Calicut; the present study area lying in between. Thus this study reports another water body in which the golden catfish is distributed in Kerala. In Kavvayi area, the fish is being fished for consumption for want of awareness on the need and importance of conservation of this fish species. The observation warrants creation of awareness among the fishers and formulation of conservation strategies of this fish in this water body.
ARL-PO-52

First report on distribution and DNA Barcoding of a cambrian brachiopod, *Lingula anatina* from the Kavvayi backwaters.

CP Binesh, Ashwini Gopi, VM Sachin, TA Keerthana and B Manoj Kumar
*Kerala University of Fisheries and Ocean Studies, Regional Centre, Kannur, Payyanur*

Kavvayi backwaters is an extensive wet land system in the northern Kerala. This is one of the least studied water body in Kerala in terms of hydrobiology and diversity of flora and fauna. In a preliminary investigation, specimens of lamp shell were obtained from the Padanna region. Based on the morphological and anatomical characters, the specimen was identified as *Lingula anatina* which is often considered to be a living fossil due to its existence since cambrian period. The identity of the specimen was further confirmed at the molecular level by amplification of the cytochrome c oxidase gene by PCR and subsequent DNA sequencing. The nucleotide sequence of the gene was compared with available information in the GenBank database and a phylogenetic tree was constructed. This is the first record on the distribution of *Lingula anatina* in Kerala and Kavvayi backwaters. The findings opens up avenues for research especially with regard to the prevailing hydrobiology conditions in the water body as a cambrian fauna still survives well in the system.

ARL-PO-53

New distributional record of *Colletteichthys flavipinnis* in the Kavvayi backwaters

Ashwini Gopi, CP Binesh, VM Sachin, TA Keerthana and Manoj Kumar
*Kerala University of Fisheries and Ocean Studies, Regional Centre – Kannur, Payyanur*

A toad fish, locally known as “kooman” was collected from the Kavvayi backwaters in the Northern Kerala. The specimen was identified as *Colletteichthys flavipinnis* based on the morphological features. At the molecular level, cytochrome c oxidase gene was amplified by PCR and sequenced subsequently. The nucleotide sequence of the gene was compared with available information in the GenBank database. The generated sequence belonged to *Colletteichthys flavipinnis* confirming its genetic identity. In a constructed phylogenetic tree, the present specimen clustered within the *Colletteichthys flavipinnis* branch. However, the fish differed from its original description in its geographical distribution and recorded body size. So far, the fish was reported only from the South East and North East coasts of India and Sri Lanka respectively. Thus, the present study forms the first report on its presence in the South West coast of India. Secondly, total length of the present specimen far exceeded that of the original description. More research is needed to ascertain whether this difference could be attributed to a distinct population cohort.
Impact Assessment on collapse of marine fisheries: case studies and root cause analyses for remedial measures

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Marine fisheries collapse occurs for various reasons. Apart from causing serious dent on socio-economics of dependent population mainly fishers in particular regions or country, often leads to serious consequences to whole region. In this focus is on Somalia as case study wherein the fisheries collapse resulted in far reaching consequences forcing the countries to incur expenditure to the tune of 7 to 10 billion USD due to piracy.

For instance the losses due to Somalia piracy included:

<table>
<thead>
<tr>
<th>Country</th>
<th>Main Cost Factor</th>
<th>Loss Per Year</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Revenue losses to Egypt from Suez Canal fees</td>
<td>$642 million</td>
</tr>
<tr>
<td></td>
<td>(re-routing of ships away from the Gulf of Aden)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trade impact on Kenya:</td>
<td>$414 million</td>
</tr>
<tr>
<td></td>
<td>$414 million</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trade impact on Yemen:</td>
<td>$150 million</td>
</tr>
<tr>
<td></td>
<td>$150 million</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nigeria losses to oil and fishing industry</td>
<td>$42 million</td>
</tr>
<tr>
<td></td>
<td>$42 million</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Losses to fishing and tourism industries of Seychelles</td>
<td>$6 million</td>
</tr>
<tr>
<td></td>
<td>$6 million</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Macroeconomic Costs in total:</td>
<td>$1.25 billion</td>
</tr>
</tbody>
</table>

The statement on gravity of this situation by then Secretary General of the United Nations, Ban Ki Moon in November 2010 is self-explanatory: “Piracy… has had an immense impact on the economies of East Africa and also the wider world….International trade routes are threatened and goods in the region as well as Somalia are becoming more expensive”. We made analyses of this problem and also similar conditions elsewhere in the world that are in budding state and overlooking the same can possible lead to the serious repercussions. We have suggested remedial measures so as to avoid recurrence of these conditions.
**ARL-PO-55**

**Otolith shape analysis as a tool for discrimination of stock of *Upeneus vittatus* from Indian water**

*Suman Nama*

*ICAR-Central Institute of Fishery Education, Mumbai*

The use of otolith shape analysis for stock identification is proven as a precise, objective and efficient method. To check this hypothesis, in this study otolith shape of *Upeneus vittatus* was studied by using shape software (shape v1.3) and Elliptical Fourier analysis with combined measures of otolith size parameters, i.e., perimeter, area, length, and width and otolith shape indices. Principal component analysis (PCA) of shape variables and cross-validation classification were carried for 192 otolith samples and out of seven PCs, the first four PCs showed 91.87% of total shape variation with a overall correct cross-validation classification of 70.55%, which indicate the good classification of individuals. The well classified group was Kakinada population (79.99% correct classification) and maximum misclassification was observed in Mumbai population with 45.24%. An MNOVA showed the mean values of the EFDs vary significantly between areas (P < 0.05). These findings indicated that otolith shape analysis based on EFDs could be an efficient tool to discriminate the stocks from both the coast of India.

**ARL-PO-56**

**Investigation on the fishery of Indian oil sardine, *Sardinella longiceps*, Valenciennes, 1847: An INCOIS-KUFOS initiative aiming at Single Species Fishery Forecast**

*S Athul, P Anjaneyan, GR Rahul Raj and SM Raffi*

*Kerala University of Fisheries and Ocean Studies, Kochi*

Indian Oil Sardine, *Sardinella longiceps* constitutes the largest single species fishery of India, that exhibits wide fluctuations inter-annually and between decades. *S.longiceps* serves as a cheap protein source for the populace of maritime states of India in general and; in particular to Kerala where it stands as the major income source for the traditional and motorised fishers. Hence, a comprehensive and detailed study aiming at the short term and long term prediction of sardine schools and its fishery is very imperative and is the need of the hour. In this prelude, a joint research initiative commenced by Indian National Centre for Ocean Information Services (INCOIS) and Kerala University of Fisheries and Ocean Studies (KUFOS) aiming to achieve this goal is its initial phase. Information on sardine fishery landings were procured for the landing centres of Kollam, Kochi and Kozhikode on a regular basis. Geo-referenced sardine fishing were carried out in locations were sardines schools are actually fished in abundance. Along with the fished sardines, various water quality parameters and information related to phyto and zooplankton density and diversity were also assessed so as to generate the possible links with various physico-chemical and biological parameters with that that of sardine fishery. The data generated on sardines pertain to biology and stock assessment based on landing centres were correlated with the data generated out of geo-referenced data collected on sardine stock and fishery.
This session comprises of only invited talks.
Climate Change, Ocean Health & Global Warming (CCO)
Climate change and role of e-commerce as a socio-economic resilience strategy for fishermen communities

Rojith Girindran, PU Zacharia, Sharon Benny, Sajna V Hussain, Liya V Benjamin, Roshen G Ninan, Dhanya Joseph, Akash Somasekharan and Grinson George
ICAR – Central Marine Fisheries Research Institute, Kochi

Indian coasts witness increase in frequency of extreme climatic events such as cyclones and heavy rainfalls, which damages coastal infrastructures and fishing equipment, thereby elevating the vulnerabilities of coastal communities. Stock fluctuations, loss of fishing days, low valued catch compositions and increased scouting are evidenced changes of national marine fisheries sector, which cumulatively leads to livelihood insecurities for coastal communities. Many of the fishermen are on the verge of exit path from fisheries sector as they have no options to avail better price on their much-stressed catch, than to depend on the conventional supply chain. The perplexing challenge of resilience through income improvement for coastal communities is addressed through the development of multivendor e-commerce platform as a parallel supply chain, which could directly connect the producers and consumers. As a first national initiative by a fisheries institute, a multivendor e-commerce website www.marinefishsales.com and associated mobile app with fisher self-help groups as vendors has been launched and experimented, which function for exploration of new geographical avenues for direct sales and strengthening of market linkages. Field Surveys on 15 SHGs and 25 fishermen at Kalamukku and Chellanam harbours of Kerala reveals motivation of fisher folks to associate with the e-venture. Lack of training, minimum assured order and financial bondages with money lenders are the challenges to be resolved prior to scale up. Fisheries related e-commerce technologies could facilitate and replicate resilience of fishermen communities and thereby negate the livelihood insecurities, in the context of mounting climatic pressures.
CCO-OR-02

Transitional changes in hydrography of Cochin backwaters associated with the August 2018 floods

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Kerala University of Fisheries & Ocean Studies, Kochi

The August 2018, severe floods that hit Kerala caused tremendous physical, chemical and biological changes in both upland and coastal waters. The present study focuses on the variation of hydrographic parameters and nutrients during the pre and post-flood period by the analysis of the surface water samples from 21 stations of the Cochin backwaters. The water samples exhibited variation in average value for pre and post flood surface temperature; 31.5°C and 29.5°C, Dissolved Oxygen; 6.7 ppm and 4.8 ppm, Salinity; 1.42 psu and 12 ps and, total hardness; 170.95 ppm and 2142 ppm respectively. Nutrients like nitrite and phosphate had an average value of 0.1893 µM and 1.8 µM in pre-flood and 1.068 µM and 2.936 µM during post-flood respectively, but for silicate it was 86.49 µM and 8.0582 µM. In pre-flood, ammonia and nitrate showed a value of 4.3µM and 3.355µM respectively, however, in post-flood, its value elevated up to 4.971 µM and 15.087 µM respectively. General hydrographic characters during pre-flood showed more resemblance to freshwater and during the post flood periods the resemblance was more towards seawater due to flood tide ingression. After the flood, all nutrients load raised in Cochin backwaters, except silicate which could be due to the spreading of more nutrient-rich upwelled water from the Arabian Sea to the lake.
Impact of climate change on the feeding habits of Indian oil sardine (Sardinella longiceps) along Kerala coast

Sajna V Hussain, PU Zacharia, Liya V Benjamin, Akash Somasekharan, Dhanya Joseph, Rojith Girindran, Sharon Benny and Roshen G Ninan
ICAR-Central Marine Fisheries Research Institute, Cochin

Climate induced decline in phytoplankton growth and primary production of the oceans is expected to modify the food webs in marine ecosystem with alternations in the flow of energy and nutrients. As assessment of the prey composition and feeding habitats of fishes in relation to climate change needs scientific attention, a study was conducted on the feeding habits and diet composition of Sardinella longiceps, the Indian oil sardine (IOS) along the Kerala coast. The current study uses Generalized Additive Models (GAMs) to evaluate the causal linkage of climate change on the feeding habits and diet composition of Indian oil sardine. Major Prey Index was developed for a period of 48 months from January 2012 to December 2016 to evaluate relative Importance (Index of Relative Importance) of dominant prey items (diatoms, dinoflagellates and copepods) in the diet. GAM models were fitted with monthly IRI (Index of Relative Importance) of the major prey items in the diet and Sea Surface Temperature, Precipitation, Chlorophyll a, Salinity and Ekman transport. Trophic level indices and Amundsen plot exposed the ontogenetic variation in the diet composition whereas CLUSTER analysis revealed the seasonal diet patterns of IOS. The results strongly suggest that the occurrence of prey items in the diet of fish has strong relationship with the selected climatic variables. GAMs provide a better assessment of the nonlinear relationship between climatic variables and the occurrence of the major prey items in the diet of Indian oil sardine.
Assessment of perception and vulnerability of fishers’ livelihood to climate variability

Shakir Ahmad Mir
ICAR-Central Institute of Fisheries Education, Mumbai

Climate change is expected to impact fishery dependent communities especially in small scale artisanal fisheries in various ways and keeping the same thing in mind the present study was conducted in the state of Jammu and Kashmir to assess the perception of fishers to climate variability and assessment of subsequent vulnerability of fishers’ livelihood. Information was collected from 90 fisher households through interview schedule from three fishing villages of Dal Lake. Most of the fishers perceived that there is increase in temperature, frequency, intensity of floods and rainfall over last 10 years. Most of the fishers also perceived the cause of climate variability to be natural factors and they were not taking any adaptive measures because of lack of necessary money and other facilities. The aggregated vulnerability score was found to be 0.02 suggesting that fishers are vulnerable (moderately) to climate change. Among the 3 villages, the Kruskal- Wallis test shows that there is significant difference in sensitivity and adaptive capacity. The vulnerability score also shows the significant difference and is highest for Tailbal village while it is low for Habak Colony indicating their low vulnerability. The study has shown evidence that fishers of Dal lake are vulnerable to climate change and there is a need to adopt target-specific approach in climate change related policy formulation and implementation.
CCO-OR-05

Fuel use and Greenhouse gas emission (GHG) implications in fishing: a study on gillnet cum longline fishery of Tamil Nadu

VS Yasmi, Sreejith S Kumar, Rithin Joseph, PH Dhiju Das, Paras Nath Jha and Leela Edwin
ICAR-Central Institute of Fisheries Technology, Kochi

Gillnet cum longline fishing is one of the most popular combination fishing method in mechanised fisheries sector of Tamil Nadu. Gillnetter cum longliners are mainly based at Thoothoor fishing village of Kanyakumari district and it mainly targets commercially important high value large pelagic fishes like tuna, marlin, sail fish, seer fish and shark. A study on gillnet cum longline fishing was conducted at Thoothoor, Tamil Nadu to understand the fuel consumption of multiday gillnetter cum longliner and to estimate the Greenhouse gas emission (GHG). Structured questionnaires were prepared for collecting quantitative data on fishing vessel (steel, FRP, wood, marine plywood, surface primer, paint etc.), gear (weight of webbing, rope, floats, hooks etc.) and its operational inputs. Twenty gillnetter cum longliners were selected from Thoothoor for the data collection. Based on general classification recommended by CIFT, the selected gillnetter cum longliners are classified into medium (LOA of 14-16 m, Engine- 98-140 hp) and large (LOA of 16-20 m, Engine- 104-167 hp) gillnetter cum longliners. The average endurance of medium and large gillnetter cum longliners is 10-15 days and 15-25 days, respectively. The fuel consumption of medium and large gillnetter cum longliners fall in the range of 4.0-5.8 lh-1 and 4.1 -7.2 lh-1. The present study deals with the comparison of fuel use and GHG emission of medium and large gillnetter cum longliners operated along the South coast of India.

CCO-OR-06

An exploration on flood forecasting techniques and their applications

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School of Ocean Engineering & Underwater Technology (SOEUT), Kochi

Among all observed natural hazards, water-related disasters are the most frequent and pose major threats to people and socio-economic development. Flood forecasting is one of the most important problems because it has critical contribution in reducing economic and life losses. In many parts of the world, flood forecasting is one among the few viable options to manage floods. In the recent years, there has been a remarkable improvement in the reliability of forecasts due to the integration of meteorological and hydrological modeling capabilities, improvements in data collection through satellite observations, and advancements in knowledge and algorithms for analysis and communication of uncertainties. The purpose of a flood forecasting and warning system is to alert the general public and concerned authorities of an impending flood as much in advance, and with as much reliability, as possible. This includes data collection and transmission, forecasting, analyzing the observation, predicting future rainfall, water elevations and discharge for periods varying from a few hours to a few days ahead and broadcasting information to user agencies and communities. In this paper, we are analyzing the different methodologies used for the prediction and analysis of flood forecasting techniques across various parts of the world as well as analyze the pros and cons of each.
Monsoonal variability of zooplankton standing stock in the Cochin estuary

PM Hani Mohandas¹ and KJ Jayalakshmi²

¹School of Ocean Science & Technology, Kerala University of Fisheries and Ocean Studies, Kochi
²Fisheries Resource Management, Kerala University of Fisheries and Ocean Studies, Kochi

Zooplankton standing stock in Indian estuaries highly influenced by the variability of monsoonal rainfall and subsequent fluctuations in the salinity pattern. The present study investigates the monsoonal variability of zooplankton standing stock during summer monsoon in the Cochin estuary. Sampling were carried out during the monsoon months of 2016, 2018 and 2019. A total of 19 groups of zooplankton was observed during the study period. Copepods were the dominant taxa throughout the study period. High biovolume was observed during 2018 (0.91 ml/m³) followed by 2019 (0.17 ml/m³) and 2016 (0.05 ml/m³). Zooplankton standing stock was high during 2018 (44142 No./m³), 2019 (1800 No./m³) and 2016 (1677 No./m³) respectively. Abundance of larval forms such as polychaete (1603 No./m³), bivalves (438 No./m³) and gastropod (214 No./m³) were also high in the 2018 monsoon season and polychaete larvae become the second largest group in the estuary. Comparing to previous studies the zooplankton standing stock, distribution and abundance is almost similar in 2016 and 2019 but 2018 season showed extreme variation due to the highly impacted flood hit. Higher abundance of larval population suggests that heavy rain and river/land runoff associated with flood supplied surplus detritus and organic matter to the bottom fauna. This may provide more conducive environment for breeding and survival of benthic organisms in the Cochin estuary. This study suggests that monsoonal variation of zooplankton standing stock is only marginal except during the extreme conditions like 2018 severe floods.
Aquatic Production Systems (APS)
Genetic analysis of Nile Tilapia *Oreochromis niloticus* reared in two input production systems

Kassaye Balkew Workagegn and P Natarajan

*Department of Biology, College of Natural and Computational Sciences, Hawassa University (HwU), Hawassa, Ethiopia*

The Nile tilapia is a globally important fish species for freshwater aquaculture. However, in many African countries it is not well developed. One of the main reasons is lack of better-quality strains that can grow well in different production systems. The aim of this study was to evaluate performance of different strain combinations and determine level of GxE for HBW of fish measured from two production systems. For this, HBW of 2,409 fish from 81 fullsib groups reared in the two production systems were recorded. The results shown that Chamo and Koka strains preform significantly better than Ziway strain across production system. The heritabilities estimated from bivariate model were 0.23 and 0.20 for high and low input production systems, respectively. The estimated common fullsibs effect was higher for HBW of the fish reared in the high input production system (0.03) than that of in the low input production system (0.002. The least square of HBW of the nine-strain combination within the two production systems showed that re-ranking of the different strain combinations in the two production systems. However, as strain GxE was not less important as genetic correlation (0.96) is high. Thus, the higher genetic correlation with low GxE between the HBW measured from the two production systems indicated that environment specific breeding program could not be required to achieve optimum genetic gain.
Developing a simple outdoor breeding system for Pearlspot, *Etroplus suratensis* for continuous seed production and facilitate selective breeding programme

Binu Varghese, Grace George and S Thiruvarasu
Kerala University of Fisheries and Ocean Studies, Kochi

Seeds of pearlspot were generally collected from traditional earthen ponds or natural water bodies. The availability of seeds from nature is rapidly declining due to increased water pollution and heavy siltation of breeding grounds. Meanwhile, there is an ever-increasing demand for seeds and is typically met by the farmer- cum- seed suppliers. This led to inbreeding and resulted in a declined growth rate and is hampering the commercial aquaculture. Generally, under normal farm conditions, these seeds take about a year to reach 200 to 250 g. However, cage and pen farming where in wild-caught seeds of larger sizes were usually stocked grows much better. In the present study, an attempt was made in captive breeding and seed production in outdoor cement tanks of 50 m² area with an average water depth of about 1 ½ foot were used. Forty adult fishes of about 180 - 200g size were released into the tank provided with clay pots as spawning substratum. Unlike the natural system, substratum was completely avoided to maintain water quality. After about a month of introduction, fishes started pairing and spawning. The tanks were checked on alternate days and eggs were collected and incubated in the hatchery. On average, about 10-15 spawning per month from a tank was observed. This system can be effectively used for commercial seed production as well as in the selective breeding of pearlspot.
Effects of dietary blend of fish oil with corn oil on growth, digestive enzyme activity and fatty acid composition of milkfish (Chanos chanos) larvae

T Sivaramakrishnan, K Ambasankar, KP Sandeep, J Syama Dayal, KP Kumaraguru Vasagam, Aritra Bera and KK Vijayan

ICAR-Central Institute of Brackishwater Aquaculture, Chennai

A growth trial was conducted to investigate the effects of fish oil and corn oil on the growth and survival of milkfish, Chanos chanos larvae. Five micro extruded and marumerized (MeM) diets supplemented with 40 g kg⁻¹ of either fish oil (F4), corn oil (C4) or blend of the both at ratio of 3:1 (F3C1); 1:1 (F2C2) and 1:3 (F1C3) respectively. Each diet was fed to triplicate groups of milkfish larvae (45 ± 0.08 mg) in a flow through rearing system for 6 weeks. Final weight, weight gain and specific growth rate of fish fed the F3C1, F2C2 and F4 diets were highest (P < 0.05) followed by fish fed diet F1C3, and the lowest in fish fed diet C4. Larvae fed the F2C2 and F3C1 dietary groups were significantly better (P < 0.05) in terms of FCR, FER and PER. Fish fed diet C4 had a lowest survival (%) among the five dietary treatments. These results suggest that milkfish larvae fed diets with 3:1 or 1:1 of fish oil to corn oil ratio had significantly (P < 0.05) higher growth to the fish fed diet which only had fish oil. Diet which had blended fish oil and corn oil shown significantly higher growth and survival of milkfish larvae than the larvae fed diet which contained either fish oil or corn oil shown significantly higher growth and survival of milkfish larvae than the larvae fed diet which contained either fish oil or corn oil as the dietary lipid source.
Quantitative taurine requirement for *Pangasius hypophthalmus* fed casein based diet

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*Pangasius hypophthalmus* is an important catfish widely cultured in our country in which essentiality of taurine in terms of quantitative requirement has not been studied yet. Dietary taurine requirement of fingerling *Pangasius hypophthalmus* (Avg initial weight, 0.8g ± 0.07g) was quantified by feeding six isonitrogenous (370 g/kg crude protein) and isolipidic (10g/kg crude lipid) casein based purified diets with graded levels taurine at 0 (basal diet), 0.5, 1, 1.5, 2 and 2.5 g/100g feed for six weeks. Fish were randomly stocked in triplicate groups in 100 L plastic tubs and fed to apparent satiation over two feedings at 10.00 and 16.00 hrs daily during the experimental period. Final weight gain (5.5g y = -1.956x2 +21.36x+20.13, R² = 0.998 ), weight gain % (587.5%, y = 2.008x2 + 83.79x + 13.75, R² = 0.999), specific growth rate (4.28%, y = -0.054x2 + 0.922x + 0.694, R² = 0.998), protein efficiency ratio (1.10, y = -0.1393x2 + 0.6014x + 0.4125, R² = 0.9517), protein retention efficiency (62.16%, y = -1.7357x2 + 7.7387x + 53.759, R² = 0.9847) improved significantly with increasing dietary taurine up to 1.5g/100g feed and plateaued thereafter. The significantly lower (P<0.05) FCR was also recorded at 1.5% taurine level. There was a linear increase in activity of antioxidant enzyme such as SOD, catalase and GST with increase in taurine levels in the feed. Digestive enzyme activity such as protease (y = -0.5259x2 + 5.2401x - 0.311, R² = 0.9602) and amylase (y = -0.3029x2 + 3.1397x - 1.184, R² = 0.9506) activity also showed higher and significant difference at 1.5% level among treatments. Dose response curve analysis based on final weight gain; weight gain %; FCR, SGR, PER, PRE against dietary taurine indicated the optimal taurine requirement of fingerling Pangasius hypophthalmus at 2.090, 2.090, 2.178, 1.965, 2.158, 2.22g/100g diet, respectively.
Mariculture of spiny lobsters *Panulirus homarus* in sea cages at Thoothukudi district, Tamil Nadu

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Mariculture of spiny lobsters (*Panulirus homarus*) is being practised since 2016 with the wild caught undersized *P. homarus* with an individual weight of 60±12g at Sippikulam and Keelavaipar sea in Thoothukudi district, Tamil Nadu. The spiny lobsters were stocked in 18 nos of net-cages, fabricated with Galvanized Iron (GI) frames of 7 m dia and 2.5 m depth of inner net. The stocking density maintained were 28 nos per m2 in the above installed net-cages. The scientific guidance and technical aspects of sustainable sea cage culture are firmly established and they constitute the necessary basis for its economic development to the sea cage farmers in the selected coastal villages. This study elaborates the production performance of sea cage culture of spiny lobster as sustainable mariculture practice adopted by the trained fisher groups under the scientific guidance of ICAR-Tuticorin Research Centre of CMFRI. Spiny lobsters culture in sea net-cages are highly profitable and serve as an alternative livelihood option for the traditional fisher folks at Thoothukudi district, whose lives were in financial crisis due to high operational cost and decline in marine capture fisheries. The success of this productive farming method proved to be an evidence for the proper liaison of fisher folks and research institute for successful adoption of technologies developed. It also proved the skill, ability, and interest of the fisher folk in adoption of scientific farming in their respective coastal villages.
Fishmeal replacement with cottonseed meal on growth, feed utilization and hemato-immunological response of snubnose pompano

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An experiment was conducted to evaluate the effect of fishmeal replacement with cottonseed meal (CSM) on growth, feed utilization and hemato-immunological response of snubnose pompano, Trachinotus blochii. After acclimation, the fishes with the average weight of 12 ±1 g were stocked in five different treatments such as control diet (C), 25% FM replaced with CSM (25CSM), 50% FM replaced with CSM (50CSM), 75% FM replaced with CSM (75CSM) and 100% FM replaced with CSM (100CSM) fed groups each with triplicates. The experiment was conducted for 10 weeks. The growth, feed utilization, metabolism and haemato-immunological parameters were studied among the treatments. Better growth in terms of weight gain percentage and specific growth rate was noticed in control diet fed groups (385.68% and 2.25%) followed by 100 CSM group (368.3% and 2.20%). Better FCR was witnessed in 1:1.26 was found in 100CSM group. The histological observation of liver samples indicates that 100% CSM replacement showed some vacuoles in the hepatocytes while comparing with 0% CSM diet. Higher hemoglobin content, WBC and RBC count was witnessed in 50 CSM group. Higher MCV was observed in control group and higher MCH and MCHC values were noticed in 25 CSM group. The whole body proximate composition of experimental animals revealed that total ash content was increasing as the CSM inclusion increased and reverse trend was observed for gross energy content of the tissue samples. This study reveals that fishmeal can be replaced completely with CSM without any adverse effect on growth and general well-being of snubnose pompano.
Growth performance, osmolality and histological changes in hepatopancreas of Indian white shrimp, *Penaeus indicus* juveniles reared at different salinity regimes

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Osmoregulatory and physiology of hepatopancreas helps in characterizing the adaptive capacity and growth performance of penaeid shrimp at various salinity regimes. In order to evaluate the growth physiology of Indian white shrimp (*Penaeus indicus*) at different salinity regimes shrimp juveniles (0.4 g) were reared at different salinity (3, 25 and 48‰) at 200 shrimps/m3 using low protein feed (CIBA feed-30%). At the end of the 50-day experiment, shrimps attained highest growth and survival at 25‰ (ABW 3.19±0.25 and 79.16±2%). Although lower salinity recorded better growth (2.99±0.6g) compared to higher salinity (1.93±0.07g), no significant difference in survival noticed among high and low salinity (57-60%). Serum osmolality showed the rising trend with increase in salinity and ranged between 480 to 1408 milli/mol/Kg. Furthermore, histology of hepatopancreas tubules at lower and higher salinity had higher number and enlarged size of B cells indicating a high rate of synthesis and release of digestive enzymes in hepatopancreas tubules to meet energy demand for better osmoregulation. Moreover, the number of R cells in the hepatopancreas tubules differed between salinity treatments with maximum R cells recorded in 25‰ salinity while higher and lower salinity had lowest R cells. As R cell is considered the main site for nutrient reserve, decrease of R cell number at low salinity might be due to the enhanced energy demand for osmoregulation. The study reveals that Indian white shrimp spend high energy expenditure to cope up with the osmolality stress at high and low salinity through various functional adaptations.
Shrimp shell meal as an active nutritional ingredient for growth and coloration in the high value ornamental fish, Discus (*Symphysodon aequifaciatus*)

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A 90 days trial has been conducted to evaluate the effect of Shrimp shell meal (SSM), a processed by-product of shrimp shell waste, in enhancing growth and coloration of high value ornamental fish, Discus (*Symphysodon aequifaciatus*). Four isonitrogenous and isolipidic diets viz., 0% SSM (Control), 15% SSM (T<sub>1</sub>), 20% SSM (T<sub>2</sub>) and 25% (T<sub>3</sub>) were formulated, prepared and fed to the respective groups twice daily. Growth parameters like Specific Growth Rate (SGR), FCR, PER, Weight gain (%) and color parameters like lightness (L*), redness (a*), yellowness (b*), chroma, hue angle and whiteness were calculated for each of the treatments. The results showed that highest final body weight (FBW), weight gain (WG) and specific growth rate (SGR) recorded for 25% SSM incorporated diet (T<sub>3</sub>) as compared to control (0% SSM), T<sub>1</sub> (15% SSM), T<sub>2</sub> (20% SSM). Moreover, the colour in terms of redness and chroma was found to be higher in T<sub>3</sub> as compared to T<sub>2</sub>, T<sub>1</sub> and Control. Hence T<sub>3</sub> has been recommended to be the most effective and economic inclusion level of SSM from a cheap crustacean waste source which can be used as an active dietary ingredient in the feed of high value ornamental fish, Discus.
Seahorses, *Hippocampus* spp., are charismatic marine livebearers that can be easily identifiable with its individual morphological features such as horse-shaped head, large eyes, curvaceous trunk, and monkey-like prehensile tail from other sea-living creatures. They are present in shallow inshore habitats of seagrass beds, coral reefs, mangroves and estuaries of tropical and temperate waters of about 6-35 ppt salinity, and are widely distributed from 50°N to 50°S, mostly in Indo-pacific regions. Despite its quirky characters, these species are overfished for aquarium trade and medicinal purposes. Hence, farming of seahorses is necessary and most of the commercial aquaculture practices were mainly on intensive monoculture. Therefore, alternative methods of seahorse farming are essential and such systems are Integrated multi-trophic aquaculture and integrated eco-aquaculture which can be a way for energy efficient and sustainable farming of seahorse species. Due to the decline of the wild population through trade-off of about 20 million, CITES has listed seahorses as the first marine species in Appendix II. In India, there should be integrated management practices for the conservation of seahorses, which is still in the infant stage. Hence by solving the issues related to market and trade, sustainable fisheries and aquaculture of seahorses form the key to enhance the wild seahorse population.
Ontogenic development of digestive tract in Indian walking catfish, *Clarias magur*, larvae

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Indian walking catfish, *Clarias magur* (Family: Clariidae) is an economically important freshwater fish having high consumer preference in the North Eastern, Eastern, and mainland states of India. The ontogenetic development of the gastrointestinal tract of *C. magur* larvae was studied histologically from hatching to 35 days post hatch (dph). Digestive tract of *Clarias magur* during hatching appeared as an undifferentiated straight tube lying dorsally to a large yolk sac. Appearance of intestine and stomach with incipient gastric gland were clearly evident at 3 dph. Most of the yolk appears digested at 3 dph and pigmented remnants of yolk material can be observed in between liver and pancreas at 4 days post hatch. During the time of endogenous feeding until 3 dph, hepatocytes appear fatty indicated by vacuolar appearances which disappear almost completely at 6 dph. Minimal zymogen granule in pancreas can be seen at 0 dph which appear to increase gradually until 3 dph and decreases thereafter. At 6 dph, widening of oesophageal tube, anteriorly placed liver followed by discrete pancreas, intestine with prominent fold, presence of supranuclear vesicles in posterior intestine, stomach with well-developed gastric glands, epithelial folds with gastric pits can be clearly observed. From this study it can be concluded that development of digestive tract is very rapid in this species and it has a morphologically complete digestive track by 7 dph and weaning could be initiated at early stage. The study about the digestive track development of *C. magur* larvae will contribute to better larval-rearing techniques of this premium aquaculture species.
Significance of organic aquaculture in Kerala: current status and way forward

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The food safety is an important concern in the food production and marketing sector and antimicrobial resistance has been discussed extensively during these days. So, a specific demand is being emerged for the organic food products all over the world. This can be used as a potential area for producing sea food and improving livelihood of farmers using indigenous shrimps cultured in coastal areas. The sector is still in infancy not only in Kerala but also in most parts of the world. Kerala, being a State endowed with rich aquatic resources including coastal waters suitable for organic shrimp farming, attempts are in progress to promote this sector with the help of global expertise in the area. Though the State has a long history of traditional shrimp farming integrating with tall rice varieties, the sector could not flourish much due to many reasons. Kerala University of Fisheries and Ocean Studies is taking initiative to bring the glory of organic shrimp production back to the State for helping the marginalized farming community. Adhering to organic protocols in all steps of shrimp farming and getting the system certified by a competent authority are the basic requirements for an organic shrimp farming. Broodstock development, seed production, rearing protocols, culture environment, co-existence of the various biotic and abiotic components and conservation of biodiversity are the essential entities of organic shrimp farming. The efforts of KUFOS to establish such system towards supporting the farming community are explained in the paper.
Utilisation of extracted lemongrass as potential source of feed ingredient for *Labeo rohita* fingerlings supplemented with exogenous enzyme

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Aquafeed industry is heavily dependent on de-oiled rice bran as a source for feed ingredient. As the competition for rice bran from other sectors as a feed ingredient is rising day by day, thus alternative resources are required for meeting the future requirement. Extracted (Spent) lemongrass is an agro-industrial waste product abundantly available after oil extraction. Supplementation of cellulose hydrolysing enzyme to plant-based feed can improve nutrient utilisation and reduce faecal wastage. Thus an experiment was conducted on *Labeo rohita* fingerlings with an average weight of 1.5 to 2 g were fed with six isonitrogenous (30%) feed with different levels of spent lemongrass leaf, control (30% DORB), L15 (15% lemongrass), L30 (30% lemongrass), CE (control+enzyme), L15E (15% lemongrass+enzyme) and L30E (30% lemongrass+enzyme). The highest WG% and SGR was found in the CE as compared to other treatments. The WG% and SGR of the exogenous enzyme supplemented treatments were higher to that of the extracted lemon grass diets. The L15E fed group showed comparable WG% and SGR to that of control (DORB) diet. The results of the current research indicated the extracted lemongrass meal can replace 50% of DORB in *L. rohita* diets along with exogenous enzyme.
Effect of stocking density on growth and survival of silver barb, \textit{Barbonymus gonionotus} (Bleeker, 1850) fry reared in concrete tanks

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A 90-day growth trial was undertaken to assess the effect of different stocking densities on growth performance of fry of silver barb, \textit{Barbonymus gonionotus} under controlled condition. Fry of size range 2.6 to 2.7 cm length and 0.75 to 0.87 g weight were selected for the experiment. The experiment was conducted in triplicates using concrete tanks (7×3×1 m) at 3 different stocking densities i.e. 40 (T$_1$), 50 (T$_2$) and 60 (T$_3$) fry m$^{-2}$, and 20 fry m$^{-2}$ (T$_0$) served as control. The fish were fed with powdered feed (a mixture of groundnut oil cake, de-oiled rice bran and vitamin-mineral mixture) containing 32% dietary protein at 10% feeding rate which was adjusted at 15 days interval after each sampling. The results showed significant difference between the treatments with respect to growth response in terms of length, length gain, weight, weight gain, and specific growth rate. Among the treatments, the fish in T$_0$ exhibited maximum growth values. However, no significant difference was observed between the treatments T$_2$ and T$_3$. The highest survival rate was observed in T$_1$ (80%) followed by T$_0$ (70%), T$_2$ (70%) and T$_3$ (62%). Overall, it can be concluded that the stocking density at the rate of 20 – 40 fry m$^{-2}$ is optimum for rearing of silver barb in concrete tanks pertaining to the efficient culture performance.
Feeding of *Chromolaena ordata* leaf meal as a replacer of de-oiled rice bran: effect on α-amylase activity, mRNA expression and digestibility of *Labeo rohita*

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A feeding trial of 60 days was conducted to evaluate dry matter digestibility, amylase enzyme activity and mRNA expression in *Labeo rohita* fingerling fed with *Chromolaena ordata* (siam weed / communist pacha) leaf meal (COLM). Fingerlings of average weight 3 ± 0.13g were randomly distributed in the four distinct experimental groups in triplicates. Four purified iso-nitrogenous diets (330gKg⁻¹ CP) with gradual replacement of DORB by including COLM such as control (300gKg⁻¹ DORB + 0gKg⁻¹ COLM), T₁ (200gKg⁻¹ DORB + 100gKg⁻¹ COLM), T₂ (100gKg⁻¹ DORB + 200gKg⁻¹ COLM) and T₃ (0gKg⁻¹ + 300gKg⁻¹ COLM) were prepared and the fishes were fed to satiation level. Among the various groups T₃ group exhibited higher (P<0.05) dry matter digestibility, amylase activity and amylase mRNA expression compared to the control group. However, these parameters did not vary significantly in the T₄ group from the control. Also, there was a direct relationship between dry matter digestibility and amylase activity \( y = 0.0305x^2 - 1.9945x + 55.165, R^2 = 0.96 \), where \( x = \) dry matter digestibility, \( y = \) amylase activity), revealing the increase in digestibility and amylase activity with the inclusion level of COLM. Overall results revealed that COLM can be effectively included up to 300gKg⁻¹ and it could be used as a replacer of DORB in the diet of *Labeo rohita* fingerlings.
Molecular characterisation of Peptidoglycan recognition protein gene in *Cirrhinus mrigala* (Hamilton, 1822)

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Peptidoglycan recognition proteins belong to a family of pattern recognition receptors and members of this family play important roles in the innate immune responses by mediating the recognition of and elimination of pathogens. *Cirrhinus mrigala* (Mrigal), a carp endemic to Indo-Gangetic riverine systems is one of the most preferred species for aquaculture in India. The disease poses one of the most significant threats to successful aquaculture and is now responsible for severely impending economic and socio-economic development in many countries of the world. The aim of the current study was to undertake the molecular characterization of *Cirrhinus mrigala* peptidoglycan recognition receptor-5 (cmPGRP-5). Total RNA was extracted from gill tissue and converted into the first-strand cDNA for the amplification of the desired gene using specific primers. The amplified product was cloned into pTZ57R/T vector and sent for sequencing. A total of 400 bp of the cmPGRP-5 fragment was amplified for the first in the Indian major Carp *Cirrhinus mrigala* and further work in going on in our laboratory to elucidate the full gene sequence and to determine the functional characterization of the cmPGRP-5 gene. Further insights into the components of the innate immune system would be the route of choice for the generation of higher disease resistance in *Cirrhinus mrigala* that most likely can be extended to other Indian Major Carps.
Use of fish waste hydrolysate as plankton booster and its potential to reduce feed requirement in *Chanos chanos*

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Study was undertaken to transform the fish waste into its hydrolysate and to unravel the potential of the fish waste hydrolysate (FWH) on promoting phytoplankton production and reducing feed requirement in milk fish (*Chanos chanos*) culture. Milk fish fry (ABW 0.137±0.004 g) were randomly distributed in 27 FRP tanks with 20 fry per tank. The experiment was in 3×3 factorial design where, factor 1 was level of FWH supplementation (0, 20 and 40 ppm) and factor 2 was level of feed supplementation (0, 50 and 100%). Experiment revealed that in FWH fed treatments, *Isochrysis* sp., *Chlorella* sp., *Tetraselmis* sp., *Nitzschia* sp. etc. were the dominant microalgae with negligible percentage of chain blue green algae (BGA). The abundance of BGA is exceptionally higher in the non FWH fed treatments. It was found that FWH supplementation @ 40 ppm significantly (p<0.01) influenced average daily gain (ADG), total biomass gain and survival (%) of *C. chanos*. At both 20 and 40 ppm FWH supplementation with 50% feed supplementation showed similar ADG, SGR, biomass gain in *C. chanos* when compared with group received 100% feed but without FWH supplementation. From the results of the experiment, it is evident that the effect of FWH on microalgae diversity and abundance has positive correlation with the enhanced growth performances shown by the fishes fed with FWH. Therefore, it can be concluded that FWH supplementation either @ 20 or 40 ppm can save 50 % of required feed without affecting growth performance and survival of *C. chanos*. 
Dietary gamma amino butyric acid potentiates growth and the expression of growth and appetite regulating genes in *Labeo rohita* fingerlings

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A 60-days feeding trial with *Labeo rohita* fingerlings (6.05 ± 0.20 g) was conducted to evaluate the effects of dietary gamma aminobutyric acid (GABA) on the growth, haemato-immunological status, ghrelin and IGF-I gene expression in the *Labeo rohita* fingerlings. Five isonitrogenous (crude protein, 35%), isolipidic (crude lipid 6%) and isoenergetic (383 Kcal/100g) experimental diets were prepared with different inclusion level of GABA viz., Control (0.0 mg/kg), T₁ (25 mg/kg), T₂ (50 mg/kg), T₃ (75 mg/kg) and T₄ (100 mg/kg of diet) respectively. The weight gain % (WG %), specific growth rate (SGR) and protein efficiency ratio (PER) increased significantly with the increase in dietary GABA with highest values in T₃ group and then decreased in the T₄ group (p < 0.05). The haemato-immunological parameters such as serum protein, albumin, globulin, Hb (Haemoglobin), RBC (Red blood cell) and Packed cell volume (PCV) were significantly (p < 0.05) higher in T₃ group as compared to control. No significant differences were observed in the WBC (White blood cell), serum A/G ratio, glucose, cortisol and whole-body composition among the different treatments. The activities of catalase and superoxide dismutase (SOD) in the liver and gill were significantly reduced up to the T₃ group, but in the higher inclusion level (T₄) the activity increased significantly. The mRNA expression of both ghrelin and IGF-I liver were found to be highest in T3 group. Thus, it is concluded that the diet containing 75 mg/kg GABA is optimum for growth, appetite regulation and endocrine modulation of growth.
Behavioral response towards different colors of LED light in *(Macrobrachium rosenbergii*, De Man, 1879) in Y-maze tank

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Fisheries sector plays an important role in the economy of the country. India is the second largest fish production country. The total production was 13.7 million metric tons in 2018–19, the inland production was 65% and out of 50% contributed from culture fisheries since 2016, the global production peaked 171 million tones and 43% contributed from aquaculture. As in the marine and freshwater fishes, the estuarine water are the diversified nursing pool for some fishes and crustaceans. In fresh water fisheries tropical Giant freshwater prawn (*M. rosenbergii*) has a considerable attention and have been a good commodity to enhance countries economy. The data availing from the inland production was very complex due to intrinsic and extrinsic factors and the use of illegal fishing methods and non targeted species specific gear affect the juveniles and badly affect the fishery also. The study focused on using standard species specific gear and try to know the color preference, behavioral response towards the specified gear to avoid the non targeted species and help the sector more sustainable. Generally vision is one of the most important component to detect the prey, predator, habitat, feed, mates with its color in both marine and aquatic habitat. The study evaluated the behavioral response towards different colors of LED light (Blue, Red, Green, and White) in *M. rosenbergii*, under controlled conditions in a Y-maze tank of specifications 97 × 40 × 27 cm. Individuals in the size range of 1.77+/−0.5 cm and body weight of 2.19+/−0.7 g used for the experiments. Thirty observations with three frequent intervals were taken using each LED light on each sides and choice frequency were of the organisms were measured. The animal showed maximum peak response towards white > green > red > blue correspondingly. The paper discusses the implication of the results for scaling up to field conditions.
Role of Earthworms for sustainable fish culture in attaining Better Food Security

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Fisheries are an important sector in India-it provides employment to millions of people and contributes to food security of the country. Massive fish mortalities have been observed in different countries due to bacterial, fungal, viral and protozoan diseases and resulting in heavy economic losses have been reported. Bacteria, the major group of pathogens, pose one of the most significant threats to successful fish production throughout the world. Diseases and pollution play an important role in aquaculture. Attendant to the increased production of food fish under intensive culture conditions, there has been an increased loss of production potential through infectious and non-infectious disease processes due to bacterial, fungal, viral and protozoan diseases and resulting in heavy economic losses have been reported. Bacteria, the major group of pathogens, pose one of the most significant threats to successful fish production throughout the world.

Extracting and using biologically active compounds from earthworms has traditionally been practiced by indigenous people throughout the world. In the present investigation, extract of earthworm, *Eudrillus eugeinea* was prepared and antimicrobial activity of the extract was determined by well diffusion method. Firstly, tissue and organs were aseptically collected from diseased common carp and bacterial diversity was identified by gram staining method. The different bacteria were isolated i.e. *Aeromonas hydrophila*, *Micrococcus luteus*, *Staphylococcus aureus*, *P. aeruginosa*, *Enterobacter aerogens*, *Escherichia coli*. All these are pathogenic bacteria but gram –ve bacteria dominated the population. The earthworm extract showed zone of inhibition against pathogenic bacteria in well diffusion method. After 24 hrs of incubation period, it was observed that earthworm extract showed antibacterial activity against all the pathogenic bacteria. It was also found that maximum zone of inhibition shown against *Aeromonas hydrophila* by earthworm extract of *Eudrillus eugeinea*. Hence, the study conclusively proved that the earthworm extract has strong antibacterial properties which would be effective in treating bacterial infections in fishes.
APS-PO-09

**Culture performance of Black Tiger Shrimp *Penaeus monodon* (Fabricius, 1798) in improved traditional and semi-intensive culture systems in central Kerala, India**

**AT Anna and K Dinesh**
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A comparative study on the culture performance of black tiger shrimp, *Penaeus monodon* from two improved traditional and semi-intensive culture systems was conducted in the Village of Chellanam under Ernakulam District, Kerala. Water temperature ranged from 27.5 to 32°C throughout the experimental period in all the trial ponds. The pH ranged from 8.25 to 8.84 in improved traditional ponds and 7.34 to 8.45 in semi-intensive ponds. During the culture, the DO concentrations ranged from 3.5 to 4.38 mg/l and 4.2 to 5.6 mg/l in improved traditional and semi-intensive system respectively. The salinity in both the systems ranged from 5 to 26 ppt. At the end of the trial, the mean average weights recorded for the shrimp at harvest were 28, 40, 30, and 33g; %survival were 18.6, 16.7, 72, and 42%; ADG was 0.23, 0.33, 0.26, and 0.36 g; the average production was 520, 800, 1740 and 750 kg/ crop for P_1, P_2, P_3 and P_4 respectively. FCR in semi-intensive ponds were 0.95 and 0.5 in P_3 and P_4 respectively. The total cost of production was Rs.3,63,000, Rs.2,21,000, Rs.6,85,000 and 2,94,600; the gross income was Rs.4,56,000, Rs.2,60,000, Rs.8,60,000 and Rs.4,12,500; the net profit was Rs.93,000, Rs.38,900, Rs.1,75,000 and Rs.1,1,9000 for P_1, P_2, P_3 and P_4 respectively. It is understood that there are farmers in some parts of Kerala who still practice the farming of *P. monodon* on organic mode for reaping the better margins with less disease issues even amidst the high density of pathogens in open waters.

APS-PO-10

**The impact of floods on yield and water quality parameters in traditional shrimp filtration fields: a case study from Chellanam, Cochin, Kerala**

**AT Anna and K Dinesh**
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The present study was carried out to evaluate the impact of recent floods on the shrimp yield, soil and water quality parameters in the selected ponds at Chellanam area. The pre floods water pH ranged from 7.35 to 7.83, 7.42 to 7.72, 7.25 to 7.52 and 7.32 to 7.50, while post floods water pH recorded were as high as 8.24 to 8.50, 8.46 to 8.58, 8.39 to 8.55 and 8.43 to 8.53 in Pond 1, Pond 2, Pond 3 and Pond 4 respectively. The water temperature ranged from 26°C to 32°C throughout the period in all the trial ponds irrespective of floods. The anoxic condition in many parts of the field was clearly visible after the floods may be due to the disruption of photosynthesis. The reduced salinity in the fields has affected the shrimp growth adversely after the floods. The values of pre floods-soil pH were 5.57 to 6.31, 6.03 to 6.79, 5.92 to 6.62 and 6.11 to 6.73 and post floods-soil pH were 7.20 to 7.55, 7.06 to 7.41, 7.15 to 7.46 and 7.27 to 7.59 in P_1, P_2, P_3 and P_4 respectively. The organic carbon (OC) and oxygen reduction potential (Eh) of soil were also recorded high after the floods. The post flood production from the ponds were 740 kg, 520 kg, 580 kg and 410 kg/crop in P_1, P_2, P_3 and P_4 against the pre flood values of 945 kg, 640 kg, 735 kg and 540 kg/ crop respectively.
APS-PO-11

Effect of dietary methionine supplementation on survival and immune response of Rohu fingerlings, *Labeo rohita*

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Protein is the major constituent of animal body and an adequate level of protein is required throughout the life for the function and development of tissues/ organs. The primary aim of fish culture is the efficient transformation of dietary protein into tissue protein. The amount of dietary protein required by fishes is directly influenced by the indispensable amino acid pattern in the diet. A well-balanced feed not only results in the higher fish production, but also provides the nutrients that are necessary to prevent the occurrence of disease and to resist any kind of environmental stress. Accordingly, the present study primarily aims on the role of methionine as a feed additive and its influence on survival where the health of rohu fingerlings was investigated for 90 days in cement cisterns of 25 m³ size with soil base at College of Fisheries, Mangalore. Uniformed sized fingerlings of rohu with an average weight of 10.68±0.5 g was stocked at the rate of 20 numbers/cistern. The basal diet in all five replications contained 30% protein with different doses of methionine at 0% (control), 0.08% (T₁) and 0.48% (T₂) diet. A significant difference was observed between treatment groups (P<0.05) in the survival rate and the NBT- test. Among all the tested doses, 0.48% methionine showed better results than 0.08% methionine inclusion in the fish diet. Results of this study indicate that the best overall survival rate and disease resistance of rohu fingerlings were obtained with 0.48% methionine supplementation.

APS-PO-12

Rohu (*Labeo rohita*) seed rearing: an Experiential Learning Program initiative in KUFOS

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As a part of the final year curriculum activity, the seed rearing of rohu (*Labeo rohita*) was carried in the concrete pond of Kerala University of Fisheries and Ocean Studies. The objective behind this initiative was to provide good quality seeds to the farmers for the successful aquaculture. Twelve thousand number of hatchery-produced fry having a size of 1.5 -2.5 cm were stocked in a well cleaned, disinfected, algal enriched concrete pond after proper acclimatization. The seeds were obtained from National Fish Seed Farm, Malampuzha. Groundnut oil cake and rice bran in the ratio of 1:1 were given as feed at the rate of 5% of the body weight. The water quality parameters in the pond were maintained at the optimum level. Various measures were taken to prevent the occurrence of the disease. The dead fishes were immediately removed from the rearing pond. To prevent the attack of predators, nursery pond was protected with a bird net. After proper rearing of around 4 weeks, the seeds were sold according to the farmer’s demand. Survival was 83%. The specific growth rate, the average body weight and average body length showed a steady increase during this time. The profit obtained from the seed rearing was almost three times as that of the actual expense. Through this activity, we acquired a good idea about seed rearing and business potential of aquaculture for the sustainable development of the blue economy.
Potential of combination of \textit{Leucas aspera}, Oxycyclodextrin and Bentonite as feed additive in Nile tilapia (\textit{Oreochromis niloticus})

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Nile tilapia, one of the most important farmed fish species in the world contributes significantly to the development of aquaculture industry. Strategies to improve health of Nile tilapia has been implemented in the past years. Inclusion of functional feed additives either alone or in combination help improve immune system and induce physiological benefits. The present study aimed at evaluating the health effects of combination of Bentonite, a mineral clay along with \textit{L. aspera} and oxycyclodextrin as feed additive. 240 Nile tilapia were randomly distributed into 12 glass tanks with 20 fish per tank in triplicates. Fish were divided into three treatment groups $T_1$-300mg/Kg, $T_2$-600 mg/Kg, $T_3$- 900 mg/Kg and a control group and were fed for 90 days. At the end of the feeding trial, blood, mucus and tissues were collected for evaluating immune response, cytokine expression and expression of immune genes. Results revealed a significant increase ($P<0.05$) in the activities of lysozyme, myeloperoxidase, respiratory burst, antiprotease, alkaline phosphatase and acid phosphatase. Significantly ($P<0.05$) higher expression of cytokines (IL-4, IL-6, IL-10, IFN-gamma, IL-8, PGE2 and TNF-0) were also reported in the treatment groups. The results suggest that inclusion of combination of Bentonite, \textit{L. aspera} and oxy-cyclodextrin help improve the immune response of Nile tilapia.

A Geo-spatial study on the spatio-temporal growth of brackish water aquaculture using Geographical Information System for Varapuzha Village in Ernakulam District

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Varapuzha (10°75’8”N 76°27’14”E) is a small village located in the neighborhood of Ernakulam city, the coastal area of Kerala state, India. This is a traditional pokkali farming area. During monsoon period paddy is cultivated and during the high saline period the fields are used for prawn filtration which is locally known as “Kettu”. Devasompadam located in the western part of the village is the largest pokkali prawn filtration field of the area. The present study identifies change occurring in the land use due to the growth of brackish water aquaculture in the region through GIS techniques. High resolution temporal Google Earth images were used for detecting the spatial-temporal changes of Varapuzha village. Analysis of sequential imagery pertaining to 2009 to 2019 was done for detecting the land use/land cover changes of the area using GIS package (10.3 Version). Also, the area was surveyed using GPS and the digitized maps, and verified using the information collected from aquaculture farm owners. The sequential study indicated the increase in aquaculture during the ten-year period and reduction in cropland mainly due to the increase in the area used for aquaculture. It is evident from the change detected in the study that there is increase in aquaculture farms compared to decrease in the agriculture and also few numbers of pre-existing ponds have been converted for brackish water aquaculture.
Nursery rearing of *Penaeus monodon* (Fabricius) and *Litopenaeus vannamei* (Boone) in the recirculatory aquaculture system

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The present study was carried out to evaluate the efficacy of an indoor nursery rearing system on the growth performance and food conversion ratio (FCR) of post larvae of *Penaeus monodon* and *Litopenaeus vannamei*, in a specially designed recirculatory aquaculture system (RAS) for a period of 30 days. Post larvae of *P. monodon* (Avg. total length = 15.1 mm; Avg. total weight = 0.02 g) and *L. vannamei* (Avg. total length = 12.3 mm; Avg. total weight = 0.017 g) were stocked into RAS tanks of two-tonne capacity with a stocking density of 1 larva/L prior to stock them in grow-out culture in earthen ponds. After one month of nursery weaning, the avg. total weights obtained were 1.17 g and 0.77 g for *P. monodon* and *L. vannamei* respectively. The average daily gain (ADG), specific growth rate (SGR) and FCR attained for *P. monodon* at the end of the study were 0.04 g, 12.21% and 0.36 respectively. *L. vannamei* recorded an ADG of 0.03 gm. The SGR and FCR obtained for *L. vannamei* were 12.17% and 0.28 respectively. Significantly higher survival of 99% was recorded for both *P. monodon* and *L. vannamei* at the end of the study period. The study revealed that a nursery phase is ideal to achieve better survival and better feed utilization and recommend it prior to the grow-out culture.
Effects of modified Clinoptilolite (Minazel Plus®) feed additive on the immune response of Nile Tilapia (*Oreochromis niloticus*)

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Aquaculture is the fastest growing animal production sector globally. Tilapia is playing an increasingly important role in the growth of aquaculture, especially in lower income economies. Mycotoxins are an important human and animal health hazard, especially in the areas with inadequate storage and use of grains in aquatic animal production. The exploration of feed mycotoxin adsorbents to mitigate the adverse effects of mycotoxin on animals has received increasing attention over the last decade. Recently, a novel process of chemical modification of natural zeolite (clinoptilolite E567/568; Minazel Plus®) surface with addition of organic cations has been shown to increase selective adsorption of both polar and non-polar mycotoxins in contaminated feed. However, the safety and effects of this new additive on tilapia immune responses have not yet been studied. The feed samples were analysed as per EU guidelines. Mycotoxin results (µg/kg) or ppb relative to a feed with a moisture content of 12 % shows Aflatoxin (0.02), Ochratoxin A (0.25), Zearalenone (2), Deoxynivalenol (8), Fumonisin B1+B2 (60), HT-2 + T-2 (0.05) reduced level for mycotoxins in feed. This reveals the action of Minazel Plus® against mycotoxins. We here report the effects of Minazel Plus® used as feed additive in commercial diets fed to healthy tilapia fingerlings (Nile tilapia, *Oreochromis niloticus*) for 30-45 days. Total of 200 tilapia fingerlings were randomly distributed into the tanks (50/tank) and fed with commercial pelleted feed supplemented with 1g Kg⁻¹, 2g Kg⁻¹, and 4g Kg⁻¹ of Minazel Plus® and a control diet with no additive. Fishes were fed with the prepared diets for 30 days and Specific growth rate (SPR), Feed conversion ratio (FCR), immune parameters and growth performance were monitored. The fish were sampled on regular basis to collect biometric parameters, perform clinical health and histopathological exam, immune assays, and total and differential leukocyte counts. The results revealed a significant (P < 0.05) increase in weight, specific growth rate, lower feed conversion ratio and immune parameters in fish fed with 2 g Kg⁻¹ of Minazel Plus®. The RBC and WBC levels were significantly (P < 0.05) higher in all experimental groups. Clinical and pathological findings were not significantly different among treatment and control groups. We conclude that addition of Minazel Plus® not only reduced the chance of mycotoxin to commercial fish diets but also increased production parameters and in Nile tilapia without observable side effects.
APS-PO-17

Negative buoyancy disorder in a Flower Horn Fish

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A three-year-old flower horn fish (*Vieja synspilus*) weighing 0.6 kg was brought to Teaching Veterinary Clinical Complex Mannuthy with the complaint of unable to swim properly for the last three days with the fish lying on the bottom of the tank for considerable amount of time. In fish, buoyancy is controlled by the amount and distribution of gas within the swim bladder. Anamnesis revealed that fish was feeding normally and its body hit on the aquarium tank net, when it jumped up. Clinical examination showed a mild discolouration on body and minor ulcerations of the exposed skin due to disruption of the protective mucous barrier from rubbing on the base of tank. Radiograph was taken to determine causes of swim bladder disease and a partial fluid filled swim bladder could be seen in X-ray, which manifested as a faint area of radiolucency in the centre of the swim bladder chamber. The response of abnormal buoyancy cases to treatment is often poor due to the severity of the underlying disease. The case was managed medically with Enrofloxacin bath at 5 mg/L for 5-hour sid for 7 days. Since there was not much response to treatment, advised to add sodium chloride salt at a level of 5 grams/L for 3 days to provide physiological benefit to the fish and to maintain the water temperature of aquarium tank at 27°C. Negative buoyancy disorders may be a cause for immediate concern and can be associated with a guarded prognosis.
Evaluation of different substrates for raising *Moina macrocopa*

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Cladoceran crustaceans of the genus *Moina* are small freshwater organisms commonly called, water fleas. The freshwater cladoceran *Moina macrocopa*, has excellent potential as a live feed in larval rearing. They are small in size, with short, jerky hopping movement in water, which increases their visibility to larvae. Nutritionally superior, it grows rapidly on a variety of materials and under varying conditions. They are very tolerant of poor water quality conditions and are resistant to changes in oxygen concentration. *M. macrocopa* is resistant to extremes in temperature and withstands wide variations. This high temperature tolerance is of great advantage in their culture. They are also amenable for intensive culture. The nutritional quality of *Moina macrocopa* depends on the type of feed received. In the present study, the feasibility of using oilcakes as food substrate for *M. macrocopa* was assessed. The oilcakes evaluated were groundnut oilcake, sesame oilcake and coconut oilcake. Oilcake suspensions were fed once a day. Yeast substrate was used as the control. Each of the three substrates were tried in triplicate. Pure culture was used for inoculating. The biomass produced was assessed daily. Water quality parameters were monitored over the period of study. Maximum biomass was produced in the groundnut oilcake substrate, followed by yeast and sesame oilcake. The lowest biomass was recorded with coconut oilcake. *M. macrocopa* developed were brown red in colour, with full digestive tract, indicative of a healthy culture (except in the case of coconut oilcake).

Comparative assessment of the production of *Moina macrocopa* at different stocking densities

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Live feeds for larviculture should be acceptable to the larval fish in terms of size, shape and palatability. The cladoceran *Moina macrocopa* has considerable economic importance as cheap source of live feed for fish and shellfish. It is an important component of food chain in freshwater and brackishwater systems. Quality and quantity of feed are important factors determining biomass production of *Moina macrocopa*. Stocking density is also found to have a significant influence on the biomass developed. The influence of stocking density on the biomass production of Moina macrocopa was assessed at three different stocking densities $D_1$, $D_2$ and $D_3$ with 1 individual per 10, 20 and 30 ml respectively. Groundnut oilcake was used as the feed substrate; with oilcake suspension being used for feeding. In $D_1$, neonates peaked on day 5 and 13, juveniles on day 7 and 15 and adults on day 10 and 18. A cyclical up and down pattern was observed before the phase of decline was reached. Difference between two consecutive peaks of neonates juveniles and adults was 8. In $D_2$, neonate peaks were on day 7 and 14, juvenile on day 9 and 17, while in the case of adults it was on day 6 and 15. Difference between two consecutive peaks of neonates, juveniles and adults were 7,8 and 9 days respectively. In $D_3$, neonates peaked on day 2,11 and 19, juvenile on day 6 and 16; adults on day 9 and 17.
Life history parameters of *Moina macrocopa* raised in different media

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Successful hatchery production of fish and shellfish depends on the availability of suitable live feed organisms. The quality and quantity of live feeds is crucial in larviculture. The cladoceran *Moina macrocopa*, has high reproductive potential, short generation period, high nutritive value and capacity to live and grow at high densities. Moina has higher visibility to larvae due to their characteristic movement. They can also be mass cultured under controlled conditions. The adult cladoceran releases young ones @ 10-12 nos / day. Young ones become adult in 18 - 24 hours and start to reproduce. Stability and reliability is crucial in live feed production. Study of life history traits enables facilitating a steady supply of live feed. The life history parameters of *M. macrocopa* provided different nutrient sources were evaluated.

Finger millet, in the nonsprouted form and in the sprouted form was assessed as food substrates in culture of *M. macrocopa*, against a yeast control, to determine influence on the life history parameters. Inoculation was done with pure culture. The raw millet was used as suspension; sprouted millet suspension was also employed. Each substrate was tried in triplicate. Water quality parameters were monitored. Both sprouted and nonsprouted ragi suspension fared better than yeast. Maximum growth, lifespan and number of offsprings produced were high in sprouted suspension. The time to first reproduction of Moina was more in nonsprouted as compared to sprouted. Earlier as well as extended reproduction peak occurred in the sprouted suspension.
Farmer friendly technology for enhanced seed production of Pearlspot, *Etroplus suratensis* (Bloch)

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Culture of Pearlspot *Etroplus suratensis* (Bloch), the state fish of Kerala is largely depended on seed collected from wild and those produced from pond breeding. The limitations such as non-availability of sustainable seed production techniques, commercial hatcheries, complex breeding behaviour and slow nursery rearing phase have hampered its commercial aquaculture. The present study initially compared two different breeding and rearing techniques of pearl spot at farmers’ fields in its on-farm testing (OFT) programme and later refined it to come up with a farmer friendly technique with enhanced seed production. The study showed pond breeding of pearl spot with scientific management practice as farmer friendly compared to collecting eggs from ponds and rearing them separately. The refined technique involved trapping of spawns using 1mm mesh size enclosures on 7th day after hatching, when the spawn is still in pit and rearing them using commercial shrimp larval feed. Subsequently on 10th day the size of enclosure was doubled and later fry were reared in floating cages. This semi controlled rearing technique involves rearing of fry with commercial feed and also utilizing the plankton available in ponds naturally. This technique produced $580 \pm 92$ fingerlings (25-30 mm size) from a pair (Avg. wt $227.7g \pm 21.98g$) per spawning in comparison with pond based breeding technique which could produce only $47 \pm 27$ fingerlings. The study also revealed homing behaviour of pearl spot parents with fry to their pits at night up to 10 days after hatching. This technology is becoming popular among farmers.
Diversity in cage farming protocols with special reference to coastal environment of Central Kerala

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One of the most dependable food production systems is the cage culture farming and it needs to be financially viable and technically feasible to maintain sustainability. For ensuring this, the aspects of diversity in terms of various indicators are to be seriously taken into account. An extensive survey was conducted among the cage farmers of the coastal Districts of central Kerala, India viz. Ernakulam, Trichur and Alleppey to update the diversity indices influencing the growth and profitability followed in cage farming. The survey focused exclusively on the farmers who are the beneficiaries of brackish water cage farming projects supported by Department of Fisheries, Government of Kerala. The study revealed the extensive diversity with respect to culture protocols existing in the area. It was found that the variations were noticed in terms of technical, environmental and socio-economical factors. A comparative analysis on these diversity factors was undertaken using appropriate statistical tools. The study will throw light on the short falls of the current system followed by the farmers towards improving the productivity and profitability. The findings can be used by the policy makers in future while new projects and programmes are formulated. The famers need improved awareness on these aspects through concerted efforts by various stakeholder organizations. The concept of Best Management Practices (BMPs) and System of Procedures (SOPs) needs to be populaised among the farmers for ensuring sustainability.
Sour paste nematodes as live feeds

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Live feeds used in larviculture are limited to a relatively small number of organisms. *Artemia* nauplii and rotifers are commonly employed. *Artemia* nauplii are often too large for many fish larvae. Rotifers are suited for smaller larvae, but are laborious to produce. Nematodes are an extraordinarily diverse group of organisms found in all ecosystems. The sour paste nematode *Panagrellus redivivus* is a preferred live feed for small larvae. It is ovoviviparous with a very high reproductive rate. Potential of three oilcakes viz., coconut oilcake, groundnut oilcake and sesame oilcake, as such and in fermented form, in the production of *P. redivivus* was assessed. Culture trials were conducted in transparent plastic containers. Substrate was spread evenly, to cover the bottom of the container. Oilcake suspensions were filtered and used. The substratum was soaked thoroughly with the suspension initially. Inoculum of *P. redivivus* was added to the surface of the substratum. Substratum with added yeast served as the control. Each treatment was tried in triplicate. The oilcake suspension (s) was applied daily to the substratum. The biomass produced was the maximum in the groundnut oilcake treatment, followed by the sesame oilcake and coconut oilcake. In trials involving fermented oilcakes, interestingly, maximum production was in coconut oilcake, followed by sesame oilcake and groundnut oilcake. To sum up, large yields of sour paste nematodes can be obtained, within very short periods of time, cost effectively, using the above simple media. Long term cultures are also possible with minimal effort.
Captive breeding and embryonic development of an endemic ornamental cyprinid, *Rasbora dandia* (Valenciennes)

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Experimental breeding of the larvivorous, ornamental cyprinid, *Rasbora dandia* (Valenciennes) endemic to Kerala and Sri Lanka was attempted to understand the sexual dimorphism, nature of eggs and the embryonic development. Mature individuals collected from Chalakudy River, Kerala were acclimated and developed as brood stock under aquarium conditions. Sexes were distinguished based on much increased body depth of females compared to males of same size and age. Breeding was induced by administering Wova-FH @ 0.25 ml / g body weight for both the sexes; dry stripping was applied after 8 hours of injection for effecting fertilization and the microscopic observation along with documentation of developmental stages of embryo were carried out at periodic intervals. The fertilized eggs were non adhesive, sinking, golden yellow colored with an average diameter of 1.61 mm and a characteristic perivitelline space of 0.404 mm. First cleavage, morula and blastulation and gastrulation commenced respectively at 0.25 minutes; 2.30, 2.51 and 5.45 hours post fertilization. Somite formation and twitching movement started respectively at 10.32 and 14.5 hours; hatching occurred 21-24 hours post fertilization at 26-28°C. Characteristic lateral streak of the juvenile started appearing from 15 days post hatch. The results of the current experiment on reproductive guild and embryonic development was compared with the closest cyprinid genera viz. *Chela, Neochela, Esomus, Horadandia* and *Devario* and the findings will definitely aid as the basic information for standardization of captive breeding protocols for this endemic fish species.
Replacement of fishmeal with a mixture of fermented guar and copra meal in the diet of genetically improved farmed Tilapia (GIFT)

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Present study was conducted to assess the potential of fermented guar and copra meal (FGCM) mixture as an alternative to fishmeal in the diet of genetically improved farmed Tilapia (GIFT). Five iso-nitrogenous (30% CP) and iso-lipidic (6% CL) diets were formulated replacing fishmeal at 0% (FGCM0), 25% (FGCM25), 50% (FGCM50), 75% (FGCM75) and 100% (FGCM100) with fermented guar and copra meal mixture. The feeding experiment was conducted in 150 l FRP tubs with water recirculation facility for 75 days. Four hundred GIFT fry with an average initial weight of 1.07±0.26g were procured from MPEDA and twenty numbers stocked in triplicate tanks of each feeding treatment. The GIFT fed with FGCM25 showed better performance than the control group and other treatments with final weight (40.87±0.84g, Y= -1.3214x2 + 199x + 1053.8, R2=0.87), weight gain (39.87±23.47g, Y=-1.4414x2 + 198.69x + 1031, R2=0.87), specific growth rate (4.85±0.03, Y=-0.1621x2 + 0.1159x + 4.89, R2=0.97), protein efficiency ratio (3.43±0.78 y = -0.0893x2 + 0.1113x + 3.498, R2=0.90), protein retention efficiency (55.72±0.29, y = -1.0443x2 + 1.0897x + 54.684, R2=0.95), lipid retention efficiency (81.72±0.92, y = -3.5236x2 + 14.44x + 59.958, R2= 0.85) and significantly lower (P<0.05) feed conversion ratio ( 0.96±0.03, y = 0.137x2 - 0.380x + 1.278, R2=0.97). No mortality was observed during the experimental period among the treatments. The activity of digestive enzymes such as protease and amylase were significantly higher (P<0.05) in fish fed with FGCM25 and did not change (P>0.05) further with the replacement of fishmeal with FGCM. Hematological parameters did not change among the treatments. FGCM25 group GIFT showed similar carcass composition with control group which was significantly higher (P<0.05) than the rest of the groups. The result showed that fermented guar and copra meal mixture can replace 25% fishmeal in the feed of GIFT.
Evaluation of green pea, *Pisum sativum* leaf meal in the diet of *Labeo rohita* (Hamilton, 1822) fingerlings

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A 60-day feeding trial was conducted to evaluate the utilization of green pea, *Pisum sativum* leaf meal (PSLM) in the diet of rohu, *Labeo rohita* fingerlings in replacement of de-oiled rice bran (DORB). Six iso-nitrogenous (31% CP) and isocaloric (349 Kcal DE/100g) experimental diets viz., control (0% PSLM), LM15 (15% PSLM in replacement of 50% DORB), LM30 (30% PSLM in replacement of 100% DORB), CEE (0% PSLM + 0.1% exogenous xylanase and cellulase), LM15EE (15% PSLM in replacement of 50% DORB + 0.1% exogenous xylanase and cellulase) and LM30EE (30% PSLM in replacement of 100% DORB + 0.1% exogenous xylanase and cellulase) were fed to acclimated rohu fingerlings (5.06±0.08g) twice daily. Significantly (P<0.05) higher weight gain (WG %), specific growth rate (SGR) and protein efficiency ratio (PER) were found in LM15EE group, whereas no significant difference was observed in LM30EE and control groups. Significantly (P<0.05) lower Feed conversion ratio (FCR) was recorded in LM15EE group. Fish fed with LM15EE diet showed significantly (P<0.05) higher aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activities in liver and muscle. Meanwhile, Superoxide dismutase (SOD) and catalase activities were significantly (P<0.05) highest in LM30 and LM30EE groups. Thus, it can be concluded that PSLM can be included at 15% with level of supplementation of 0.1% exogenous enzyme in the diet of *L. rohita*. However, 30% PSLM with 0.1% exogenous enzyme could replace 100% DORB.
APS-PO-27

Production of monosex Pearlspot, *Etroplus suratensis* using synthetic hormone

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Rearing of pearl spot is an important aquaculture activity in the state of Kerala, where it enjoys the status of State Fish. Early fries for the present work was collected from the same brood reared at 15ppt salinity in the hatchery. Thirty-day old fries having 0.01±0 g weight and 0.96±0 cm length was used. They were fed with 170-Methyl Testosterone (MT) to assess the potential for all male production. Commercial feed having 38% protein and 9% lipid were used for incorporating the hormone. Hormone was thoroughly mixed with micro feed to achieve tested dosages of 0, 20, 40, and 60 mg/kg MT. Duration of the study was 60 days of which first 28 days hormone mixed feed was given 5-6 times a day. The results showed significant difference in masculinization (P<0.05). Hormone administration significantly increased the male population to 96.7% at 60mg dosage. This was followed by 40mg (80%). However, the control gave almost the 1:1 ratio with 46% males. So, this study reveals the potential of producing all male pearlspot seed and thereby increased growth and productivity.

APS-PO-28

Lethal concentration (*LC*$_{50}$) of cadmium for juvenile Pearlspot, *Etroplus suratensis* (Bloch, 1970)

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Industrialization results in the production of huge amounts of wastes, which find their way into the nearby water bodies, leading to the damage of these ecosystems and their biotic components. The present study aims to highlight the issue of pollution of aquatic ecosystems and fish health due to heavy metals. Acute toxicity due to the heavy metal, cadmium in juveniles of *Etroplus suratensis* (Bloch, 1970), an economically important finfish species was evaluated. For this, pearl spot juveniles of average size 3-4 cm were exposed to different concentrations (0.2, 0.4, 0.6, 0.8, 0.10 and 0.12 ppm) of cadmium, with three replicates for each concentration along with control for 96 hours. The test solutions were replaced regularly and behavioural changes were monitored. Following exposure, survival and growth were evaluated for a period of 96 hours. Exposed fish showed abnormal behavioural changes. 96-h median lethal concentration (*LC*$_{50}$) value (with 50% confidence limit) was calculated by probit analysis as 4 ppm. Survival time for the exposed fish decreases with increasing concentration of cadmium. Considering the health risks for consumers including humans, potential use of *Etroplus suratensis* as a bioindicator of heavy metal pollution need to be investigated.
Dietary methionine requirement of juvenile Silver pompano, *Trachinotus blochii* (Lacepede, 1801)

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A 90-day feeding trial was conducted to optimize the dietary methionine requirement of juvenile silver pompano (average initial weight of 5.47 g) reared in an indoor recirculatory system. Six isonitrogenous and isolipidic diets (42 % CP and 6 % lipid) were formulated with graded levels of methionine (0.51, 0.69, 0.90, 1.07, 1.31 and 1.52 g100g⁻¹, dry diet) at a constant level of cysteine (0.53 g100g⁻¹). Equal amount of amino nitrogen was maintained by replacing methionine with nonessential amino acid mixture. Fish were randomly stocked, in triplicates of six treatment groups. After the feeding trial, significant differences (P< 0.05) were observed with respect to growth parameters such as weight gain (WG), specific growth rate (SGR), thermal growth coefficient (TGC) and feed utilization indices such as feed conversion ratio (FCR) and protein efficiency ratio (PER) among the treatments. No significant differences (P>0.05) were observed with respect to hepatosomatic index (HSI), viscerosomatic index (VSI), muscle ratio (MR), condition factor (k), serum glucose, triglycerides and erythrocyte count of fish among the treatments. The optimization of fitted quadratic regression of WG, SGR, TGC, FCR and PER on dietary methionine revealed that the optimum methionine requirement of silver pompano lies in the range of 1.16 – 1.18 % of dry diet (2.76 – 2.81 % of dietary crude protein) corresponding to a dietary cysteine level of 0.53 %.
Bioremediation has proved to be an environmentally friendly and economically feasible approach for the treatment of aquaculture wastewater. Considering the necessity to remediate nitrogenous waste in the effluents, the present study attempted to develop a bioaugmentation agent to remediate ammonia and nitrite in aquaculture wastewater. The bacterial isolates obtained through enrichment were screened thoroughly for enzyme activities and ammonia and nitrite degradation efficiencies. A consortium of six isolates identified as *Bacillus amyloliquefaciens*, *Bacillus cereus*, *Pseudomonas sp.*, *Aeromonas sp.*, *Paenibacillus timonensis* and *Pseudomonas stutzeri* was assembled and employed as a bio-augmentation agent in tanks stocked with *Oreochromis mossambicus* fingerlings. The results showed that the isolates possessed the amylase, cellulose and proteases enzyme activities and the consortium has more efficiency in the removal of ammonia and nitrite in effluent water than single cultures. During the 30 days indoor study, the values of ammonia was found to be increasing, its residual concentration was always lower in the treatment tanks compared to the control tanks. Increased values of nitrite and nitrate in the treatment tanks confirmed the effective conversion of ammonia to nitrate by the bacterial action which lacked in the control tanks. A survival rate of 65± 0.58 % recorded at the end of treatment whereas in the control tanks loss of fishes was observed (30 ± 0.25 %) due to ammonia toxicity. The study proved that the bacterial consortium was efficient in reducing ammonia and nitrite concentration in aquaculture wastewater, hence can be a good candidate favoring the cleaning of aquaculture wastewater.
Assessment of growth performance of mud crab, *Scylla serrata* on formulated feed

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A total 250 crablets were collected from hatchery and weaned in two type of floating enclosures with formulated feed in two different form, pellets and flakes with control after proper acclimatization in respective treatments. Crablets are fed @ 10% of body weight for period of 90 days and were measured for their morphometric parameters and biomass in 10 days of interval. Proximate composition of formulated feed with a crude protein content of 41.48%, crude lipid of 8.10%, Crude fibre of 4.06%, nitrogen free extract of 25.98% and ash content of 12.49% with almost 8% moisture was used in the experiment. Highest survival rate was observed in Treatment I (98.2%) and the lowest survival rate was in Control (92.0%). Carapace width-weight relationship showed with an isomeric growth and a high significant correlation in all the treatments and control. The percentage of weight gain was showed an increasing trend initially, then gradual decrease and the highest value was recorded in Treatment III and I. The specific growth rate values of all the parameters also showed similar trend. The daily growth rates of carapace width and carapace length showed an increasing trend. Whereas, in the case of total weight, it was showed an increasing trend with increase in DOC. Feed conversion ratio was calculated were showed a better performance in the all treatments and the best was recorded in Treatment I (2.2) than that of the control. Pellet feed is comparatively better than flakes as evident FCR values.
APS-PO-32

Embryonic and larval development of Malabar dwarf puffer, Carinotetraodon travancoricus

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Malabar dwarf puffer, Carinotetraodon travancoricus is one of the smallest puffer species known and is endemic to Western Ghats tributaries. Due to their miniature form, curious behavior and appearance they command premium position in ornamental fish trade and is the mainstay of Indian ornamental fish export. Malabar dwarf puffers were collected and conditioned in aquaria for breeding. They exhibited distinct courtship behaviour especially during late evening and male guards the eggs. Present study revealed that C. travancoricus is a batch spawner and releases 1 -12 eggs with an interval of one to three days. Eggs were spherical in shape and hatching takes place after 90 - 108 hours of incubation. Early larvae have significant yolk content and oil globules. They become free swimming and accept exogenous feeds after 4 days. The study reveals the potential of producing C. travancoricus under captivity and meets its demand for aquarium trade.

APS-PO-33

Winter fish: survival and adaptation strategies with respect to the tropical fishes in India in response to prolonged low temperature

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Future fisheries production may be at greater risk owing to anthropogenic climate change. Moreover, extreme temperature event are on the increase, where it has stated that high temperature can be beneficial in accordance with the fish growth but these can also have profound negative consequences for fisheries and aquaculture. One such impact can be a prolonged winter period or a state of extended low-temperature leading to a reduction in feed intake, which often results in metabolic and immunological disorders and stagnation of growth. It is, therefore, important to study how water temperature affects the metabolism and physiology of fish. Therefore a 30-day feeding trial was conducted with an aim to delineate the effect on feed intake and growth in common carp reared at low temperature. Six iso-nitrogenous and iso-caloric practical diets were prepared with varying levels of metabolic modifier viz, control, T_1, T_2, T_3, T_4 and T_5. The experiment was conducted in low temperature (12-14°C) Recirculatory aquaculture system (RAS). Feed intake and growth parameters viz; weight gain, weight gain%, SGR, FCR and PER; digestive enzymes; metabolic enzymes were studied. The result showed that with the inclusion of metabolic modifier in the diet there was an increase in feed intake in all the modifier fed groups and the highest feed intake was observed in the T_4 fed group and also a higher growth rate was recorded. From these results, it can be concluded that feeding of metabolic modifier had increased feed intake and metabolic activities in common carp reared in low temperature.
The effect of different C/N ratios on survival and growth performance of rohu, *Labeo rohita* spawn cultured in biofloc system was evaluated in the present study in order to optimize the C/N ratio for efficient rohu fry production. The experiment was performed using 5-day-old rohu spawn stocked at an intensive density of 2 spawn L⁻¹ in HDPE tanks having 100 L biofloc water for 20 days duration. The experimental treatments included maintaining three different C/N ratios, i.e., C/N 10, C/N 15 and C/N 20. A control was kept which involved biofloc inoculation but was devoid of carbon source input all over the culture period. The experiment was carried out in completely randomized design having seven replicates for each of the treatments. The spawn were fed slurry of groundnut oil cake and sugar was used as carbon source for maintaining the C/N ratio. After 20 days of the experiment, the mean survival percentage was significantly higher (p < 0.05) in C/N 15 and C/N 20 experimental groups than other groups. The fish reared at C/N 20 showed significantly better (p < 0.05) growth performance in terms of final length, final weight, specific growth rate, coefficient of variation in length and weight, and low apparent feed conversion ratio compared to other groups. The results evinced that the maintenance of C/N ratio 20 is optimum for the survival and growth of rohu spawn in biofloc technology-based culture system at intensive level.
Transcriptomics - a journey through the expressing part of the genome

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Transcriptome represents a small percentage of genetic code that is transcribed into RNA molecules in a cell. It is a dynamic and good representative of cellular state and offers valuable information on the significant biological processes behind the maintenance of the functionality of the cell. The analysis of transcriptome-transcriptomics, allows the identification of candidate genes and expressed markers associated with the traits of interest. Two key methods widely used for transcriptomics are microarrays, which quantify a set of predetermined sequences, and RNA sequencing (RNA-Seq), which uses high-throughput sequencing to capture all sequences. Transcriptomics has got application in both medical and research field. Its application in aquaculture include effective identification of candidate genes involved in growth, reproduction, development, immunity, disease, stress and toxicology and their expression analysis. However transcriptomics has been criticized as an inappropriate method to identify genes with large impacts on adaptive responses to the environment. mRNA abundance typically provides little information on protein activity and fitness and cannot substitute for detailed functional and ecological analyses of candidate genes. The present paper reviews the recent applications of transcriptomics in crustacean aquaculture with a view to increase production and yield characteristics in species that have inherent bottlenecks in terms of reduced survival rates, stunted growth, size disparity and disease outbreaks. The paper also brings out the significance of genetic expression studies to identify these biological impediments for ensuring better production for sustainable aquaculture.
Mussel farming in Kasaragode: a successful model for rural women empowerment and gender inclusiveness

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Mussel farming is a bread winning activity in the northern coastal districts of Kerala. With due supports from the governments and research institutes, local residents have been practicing mussel farming successfully in these districts for the past 25 years. Starting in mid-90, mussel farming in Kasaragode region grew enviously and at present the region is the “mussel hub” of the country. The production of farmed mussels from this region peaked to 15,000 tons in 2015. Here, the farming is more of a group activity and at present, around 500 groups are involved. Uniqueness to this region is that, except for some labor-intensive tasks, most of the farms are managed by women individually or in groups as women Self-Help Groups or Kudumbasree units. This is a self-emerged model of rural women empowerment and is highly successful with unparalleled gender inclusiveness.

Way forward in selective breeding of Pearlspot, *Etroplus suratensis*

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Pearlspot, *Etroplus suratensis* is the state fish of Kerala. It gained this status owing to its contribution to inland fisheries as well as its importance in local culinary. Unfortunately this fishery is losing its sheen to rapid environment degradation and destructive fishing practices. Potential of this species is yet to be properly explored, owing to severe apprehensions about the fish in many parts of the country. Aquaculture of pearlspot can easily compete with that of tilapia as it can be successfully reared in fresh and brackishwater areas. They easily tolerate wide variations in salinity and temperature and also command better market demand making it a superior climate resilient species. As a prelude to selective breeding several studies were successfully conducted to achieve year round spawning, external egg incubation and larval rearing. Absence of distinct sexual dimorphism at early life stages needs to be effectively sorted out for efficient selective breeding programmes. An average female *E. suratensis* has the potential to produce more than a thousand eggs at a time and this can be further improved by providing proper brooder diets. Proper record maintenance of different families by tagging the brooders and juveniles and data maintenance are essential for selection programmes. Production and promotion of selectively bred pearlspot can transform the aquaculture scenario and can boost rural economy.
Developmental stages of oocytes and ovary during oogenesis in the spiny lobster *Panulirus homarus* (Linnaeus, 1758)

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During oogenesis the female germinal cells undergo a series of transformation. In the present study the female reproductive system of the spiny lobster *Panulirus homarus* was investigated histomorphologically and ultrastructurally to know the process of oogenesis. The ovary of *P. homarus* is an H-shaped paired cylindrical lobe of tissue located beneath the heart dorsolateral to the alimentary canal. The ovarian wall consists of an outer epithelium, middle connective tissue and an inner most germinal epithelium. Based on the changes that occur in the cytoplasm and the nucleus, the oocytes are classified into secondary oogonial cells, primary vitellogenic oocytes, secondary early vitellogenic oocytes, secondary late vitellogenic oocytes and mature oocytes. Primary vitellogenic oocytes formed from the secondary oogonial cells are characterised by endogenous vitellogenesis. Secondary vitellogenic oocytes exhibited considerable increase in the size of cytoplasm. Early secondary vitellogenic oocytes are further classified into a cisternal phase and a platelet phase. The secondary late vitellogenic oocytes are characterised by the cortical body formation and the migration of nucleus. In the mature oocytes the nucleus moves towards the extreme periphery and becomes obscure. The ovary of *P. homarus* was classified based on the morphological characteristics like colour, texture, gonado somatic indices and the percentage composition of oocytes into stage V₁ (immature), stage V₂ (primary vitellogenic), stage V₃ (secondary vitellogenic), stage V₄ (mature) and stage V₅ (spent). The current study will be useful in developing a suitable hatchery technology for the spiny lobsters.
Aquatic Production Systems (Biotechnology) (APB)
Effect of varying dietary protein levels on physio-metabolic responses of *Penaeus vannamei* (Boone, 1931) juveniles reared in Inland saline water of 10 ppt

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A 60-day feeding trial was conducted to determine the effect of varying level of dietary protein on digestive, metabolic and antioxidant enzyme activities of pacific white shrimp, *Penaeus vannamei* juveniles in inland saline water (ISW) of 10 ppt. Seven iso-energetic (408kcal DE/100g) and hetero-nitrogenous semi-purified diets with varying levels of crude protein viz., 20% (T20), 25% (T25), 30% (T30), 35% (T35), 40% (T40), 45% (T45) and 50% (T50) were formulated for the study. Following the completely randomized design, a total of 315 acclimated shrimp juveniles (average bodyweight: 8.15±0.10g) were randomly distributed in 21 experimental tanks (300 L capacity) of seven experimental groups in triplicate with stocking density of 15 shrimp/tank and fed with respective experimental diet at satiation level. The results showed that the protease activity was increased significantly (P<0.05) with an increase in dietary protein levels up to 35% and decreased beyond that. Similarly, the lipase activity was increased significantly (P<0.05) with an increase in dietary protein levels, but the amylase activity was decreased significantly with an increment of dietary protein levels. A significantly lower (P<0.05) AST and ALT activity were observed in muscle and hepato-pancreas of T35 and T40 groups, but lower and higher dietary protein fed groups exhibited significantly the higher enzyme activity. Shrimp fed with protein levels beyond 40% showed significantly higher SOD and catalase enzyme activities in gill and hepatopancreas. It is concluded that feeding of 35 and 40% dietary crude protein could result better physio-metabolic responses in shrimp in in inland saline water of 10 ppt.
Identification of carbapenem and extended-spectrum β-lactamase resistance genes in *Klebsiella pneumoniae* and *Escherichia coli* in public water bodies in Kerala, India: evidence of horizontal spread of antimicrobial resistance

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Development and spread of antimicrobial resistance has become a global public health concern. Due to the excessive use of antibiotics in hospitals, not only the clinically important bacteria but also the bacterium in the aquatic environment has become resistant to various antibiotics. In the present study, we investigated the incidence of blaNDM-1 producing *Klebsiella pneumoniae* and other extended spectrum beta-lactamase producing *Escherichia coli* in public water bodies receiving hospital effluents and in adjoining aquaculture farms using the same water source for culture in Kerala, India. Carbapenemase producing NDM-1 positive *K. pneumoniae* and ESBL-positive *E. coli* was isolated from two districts of Kerala. A total of 312 isolates from areas where the hospital effluents were being discharged and 335 isolates from different aquaculture farms in their vicinity were collected. Antimicrobial susceptibility and minimum inhibitory concentration were determined by Kirby-Bauer disc diffusion method and E test strip method. Carbapenemase and ESBL production was phenotypically detected by Modified Hodge test and Double Disc Synergy test. 25 *E. coli* isolates were ESBL-positive. blaCTX-M, blaTEM and blaSHV genes were identified in 21,18 and 15 ESBL-positive isolates by PCR, respectively. A total of 22 carbapenemase producing *K. pneumoniae*, blaNDM-1 was detected in 8 isolates. Plasmid-mediated resistance gene was successfully transferred into *E. coli* DH5α cells. This study provides valuable evidence that hospital effluent water discharged into public water bodies contaminates not only the soil, water and aquatic animals in these waters but also, adjacent aquaculture farms leading to the emergence and spread of multi-drug resistant bacterial pathogens in the environment.
APB-OR-03

Synthesis and characterisation of carbon nanotubes (CNTS) and assessment of toxicity in Zebra fish model

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Carbon nanotubes are cylindrical, fabricated of rolled graphene sheet, wound around themselves in one or more layers. The diameter ranges from 0.4 - 100 nm and length varies from 1nm to few micrometres. CNTs are the most promising nanomaterials and used in different fields like nanomedicine, genetic engineering, biosensor and tissue engineering, etc. There is tremendous scope of its application in fisheries and aquaculture sector. However, it is reported that the metal catalysts used for CNTs growth harbour serious problem to living organisms. For this, various modifications in the synthesis like functionalization of CNTs and use of safe catalysts for synthesising CNTs are practiced. CNTs can be a promising tool in fisheries for various purposes provided its toxicity studies are conducted. In this study, the toxicity of different CNTs in vertebrate model organism Zebrafish (Danio rerio) was conducted. A pristine CNT as well as MWCNT (Multi walled carbon nanotubes) were synthesised and functionalised by three groups (BSA, COOH and OH). All the MWCNTs were characterised by HR-TEM and FT-IR spectroscopy. The acute toxicity of BSA-MWCNT, OH-MWCNT, COOH–MWCNT and P-MWCNT (dm 10-15nm, length 1-5µm, purity>99%) was assessed in zebrafish embryos and adult zebrafish. The LC₅₀ value at 96h was found to be 150.45, 228.62, 285.81 and 237.38 mg/ L, respectively. Survival analysis, genotoxicity studies using comet assay, histopathology and real time PCR of DNA damage related genes in embryos and adult zebrafish confirmed the toxicity of CNTs. The BSA MWCNT is the best functionalised MWCNT. Further studies with respect to tissue accumulation and vertical transmission of BSA-MWCNTs need to be undertaken.
Effects of $17\beta$-Estradiol on survival and growth performance of Giant Freshwater Prawn, *Macrobrachium rosenbergii* (De Man, 1879) larvae

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The effects of $17\beta$-estradiol were investigated on survival and growth of giant freshwater prawn, *Macrobrachium rosenbergii* larvae. The larvae were stocked in 12 Nos. of FRP tanks filled with 100 l of 12 ppt. saline water. The experiment was conducted in triplicates. Out of the 12 No. tanks, three were used for control and others were used for three different hormonal treatments. All the tanks were stocked with stage-I larvae at the rate of 80 Nos. / l. The *Artemia* nauplii were enriched with $17\beta$-estradiol at the rate of 25 ($T_1$), 50 ($T_2$) and 100 ($T_3$) µg/ liter separately in 12 ppt. saline water for a period of 24 hours. The larvae were fed enriched *Artemia* nauplii @ of 4-8 Nos. /ml of larval rearing medium from second day to till the larvae reached to post larvae. The larvae metamorphosed into post-larvae in 25-35, 24-32, 25-42 and 23-45 days with an average survival of 38.75, 27.25, 19.38 and 8.75 with an average weight of 435, 490, 515 and 570 mg in control and $T_1$, $T_2$ and $T_3$, respectively. Hence from the present study, it can be concluded that among treatment groups highest survival and growth of post-larvae were obtained at $T_1$ and $T_3$, respectively. The hormone enriched *Artemia* fed larvae grown faster due to efficient utilization of feed than control. The results indicated that administration of $17\beta$-estradiol at a concentration of 25 µg/liter helps in growth promotion without much effecting on survival as compared to control.
Isolation and characterization of vitellogenin and vitellin and the extraovarian synthesis of vitellogenin in the spiny lobster *Panulirus homarus* (Linnaeus, 1758)

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Information on egg formation with special reference to yolk biosynthesis and deposition is a prerequisite for getting good quality eggs from captive breeders. The present study was carried out to isolate and find out the immunological similarity of vitellogenin in the serum and vitellin in the ovary and the role of tissues other than ovary in the synthesis of vitellogenin in the spiny lobster *Panulirus homarus*. Albino rabbit was used for raising the antiserum. Immunoelectrophoresis of the separated proteins of haemolymph and ovary of the vitellogenic lobsters were carried out. The arc formation was found in the haemolymph and ovary. The arc formation by the vitellogenin band confirms that vitellin and vitellogenin are immunologically identical. SDS-PAGE of these fractions revealed that vitellogenin consists of 4 polypeptide units and vitellin consists of 5 subunits. The immunodiffusion test with the antiserum showed cross reactivity by forming precipitin arcs with haemolymph and extracts of ovary, hepatopancreas and adipose tissue of the vitellogenic female. Precipitin arcs further confirmed that the vitellogenin in these tissues and lipovitellin are immunologically identical. The haemolymph, hepatopancreas, and adipose tissue showed a colour change during secondary vitellogenesis. Electron micrographs showed cell organelles in the ooplasm and numerous micropinocytic vesicles in the perivitelline space during vitellogenesis. These observations and the results obtained in the immunodiffusion studies confirm an extra oocytic yolk synthesis in *Panulirus homarus* and adipose tissue and hepatopancreas could be the sites of vitellogenin synthesis.
APB-OR-06

**Optimized purification method for white spot syndrome virus from *Penaeus monodon* (Fabricius)**

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White Spot Syndrome Virus (WSSV), a bacilliform, non-occluded, enveloped rod-shaped virus, is one of the most virulent pathogens, causing high mortality in cultured shrimp. Using filtration (0.22 µm) and ultracentrifugation separately and in combination, a method for isolation of WSSV particles in high yield from infected *Penaeus monodon* hosts was developed. Gills, pleopods, carapace epithelium and muscle part of tail were homogenized suitably in STE buffer. Crude extract prepared had a yield of $4 \times 10^{10}$ virions from 10g of infected tissue. In the method involving ultracentrifugation only, the virus copy number was $1 \times 10^9$ per 10g tissue. However, the introduction of a filtration step using a 0.22 µm filter decreased the total yield to $5 \times 10^7$ virions per 10g tissue. Confirmation and quantification of virus copies were done using highly sensitive and reliable real-time PCR assay. Additionally, the virions in crude extract were biologically active and pathogenic as adults and juvenile shrimp showed proliferative signs by three days upon infection with crude WSSV extract @ 105 copies per 25g bodyweight. Further, studies of the concentrated virus using transmission electron microscopy (TEM) and confirmation of pathogenicity of pure virions are underway.

APB-OR-07

**dsRNA dependent protein kinase of *Schizothorax richardsonii* has three dsRNA binding motifs**

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Double stranded RNA (dsRNA) dependent protein kinase (PKR) is an interferon (IFN) stimulated antiviral protein. It phosphorylates the eukaryotic translation initiation factor 2-alpha (eIF2-α) by its serine/threonine kinase activity that prevents virus replication. dsRNA dependent protein kinase (PKR) from *Schizothorax richardsonii*, one of the several species of snow trout inhabiting sub-Himalayan fresh water bodies was studied. This is the first report of molecular characterization of PKR from any Coldwater fish. The complete nucleotide sequence of *Schizothorax richardsonii* PKR was obtained to be 2884 bp along with 5′ and 3′ untranslated regions (UTR) of 234 and 558 bases. The deduced open reading frame (ORF) of 2076 bases encoded a polypeptide of 691 amino-acids. Snow trout PKR protein contains three double stranded RNA binding motifs (dsRBM) at N terminal, besides possessing a serine/threonine protein kinase and a C terminal catalytic domain.
Identifying implications of marine bioactive compounds for therapeutics in Alzheimer's disease

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Alzheimer’s disease (AD) is the main cause of dementia in more than 80% of geriatric population and is prevailing as life threatening as well as economic and social burden to the health-care system. Until now, none of the treatment practice has been reported which really prevent or reverse the progression of AD. The present study focus in formulating neutraceuticals from selected species of marine sources which ameliorate Alzheimer’s disease and offer neuroprotection. Compounds from marine/herbal biota with different core moities such as alkaloids, heterocyclic structures, polyphenols, etc were chosen. Contemporary analytical tools like HPLC, FTIR, XRD, TEM etc. were performed for structural elucidation of the interested compounds. Annotation of functional attributes of purified bioactive compounds was performed with Drosophila melanogaster fly models. Protein expression system, GAL4-UAS (Upstream activation system) used in the fly models helps to assess the effect of drugs on protein expression as well as influence their phenotypes. Expression of human mutant Tau (hTau) in Drosophila shortens their life span and causes deficits in olfactory learning and climbing abilities. Adult h-Tau male flies were mated with virgin ELAV (Embryonic lethal abnormal visual system gene)-Gal4 and progenies were used for compound treatment. The study employs bioactive compounds from herbal and marine resources including the metabolites from Lichens. Flies were undergone behavioral analysis by locomotory (climbing) assay after treating with compounds in individual and in combination to assess their cumulative effect on each other. Toxicity of drug treatment in vivo was evaluated by analyzing mortality and behaviors using survival assay. Following behavioral screening, gene expression studies using RT-PCR was performed to identify and quantify the Tau protein expressed in the D. melanogaster fly models, using the homogenate from the whole flies corresponding to each group of treated compounds. The study provides a plausible approach for identification of potent neuroprotective compounds as well as to explore their possible mechanism of actions in ameliorating AD. This can be further utilized with better activity by rational modifications highlighting both clinical and pharmaceutical applications.
Anti-bacterial and anti-oxidant efficacy of macroporous bioscaffolds prepared with gelatin-chitosan and collagen of *Prionanthus hamrur* skin

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Novel porous bioscaffolds were fabricated using blends of collagen and gelatin extracted from the skins of Marine big eye snapper *Prionanthus hamrur* combined with chitosan. The scaffolds were evaluated for rheological properties – porosity, density, swelling capacity and tensile strength to assess their mechanical property. Morphology of the prepared scaffolds were analyzed by Scanning Electron Microscopy. FTIR analysis showed intense peaks ranging 1120 -11267 cm⁻¹ in the three different scaffolds that are denoted as CH groups. In-vitro antioxidant investigation through DPPH assay showed that the composite 3 1mg/ml concentration exhibited higher antioxidant potential 70%. In contrast, ABTS scavenging assay identified composite 1 in 1 mg/ml had good antioxidant activity (29.5%). The scaffolds were also evaluated for anti microbial properties through disc diffusion assay. The results showed maximum inhibition- 14mm, 12mm and 14mm for 200µg of the sample for collagen/ chitosan, gelatin/chitosan and collagen/gelatin/chitosan scaffolds respectively towards *E.coli* and 20mm, and 24mm towards *S. aureus*. The zone of inhibition against *E. coli* and *S. aureus* for the three scaffolds was comparatively lower and that could be due to the presence of chitosan. The findings of the study indicate that the bioscaffolds are expected to have wide application in tissue engineering.
TriButylTin (TBT) is an organotin compound employed in ships, boats and aquaculture nets as antifouling agents. The use of TBT has been progressively restricted in many countries owing to pollution affecting aquatic flora and fauna. The global ban on TBT use by IMO international Convention for the Control of Harmful Anti-fouling Systems on Ships came into effect on September 2008. However, in the Indian subcontinent high concentrations of TBT are still detected in marine and freshwater ecosystems varying between ~1.5 and 350 ng/L exceeding the allowed toxicity levels. Adverse effects of TBT on lipid metabolism is less studied. We have earlier shown that TBT exposure (100-300 ng/L) induces obesity and also exhibited increased lipid accumulation in liver of zebrafish. Here we sought to understand the adverse effects of TBT on lipid accumulation in liver and altered hepatic gene expression associated with lipid metabolism pathways. Exposure to TBT for more than 90-120 days resulted in inflammation of hepatocytes with increased accumulation of lipid droplets, a pathological feature of hepatosteatosis. Preliminary qRT PCR analysis revealed that TBT exposure altered expression of specific genes (SREBP1& 2, DGAT2, LDLR), associated with lipogenic enzymes, lipid transport and storage and other factors indicating steatosis and liver damage. TBT is well known to induce multiple and complex alterations in transcriptional activity of genes involved in lipid metabolism and steatosis. Advantages and disadvantages of using zebrafish larvae are discussed.
Study of leech infestation in freshwater pearl mussel, *Lamellidens marginalis*

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Freshwater mussels are benthic organisms live at the bottom of the pond surface. They are burrowing habit in sand or mud, keeping themselves half burrowing in the sand. They are filter feeders, feeds on planktons, organic matter, and tend to accumulate parasite in their mantle cavity because of their filter feeding nature. Mussel parasites include protozoans, flukes (trematodes), annelids, leeches, unionicoloid mites and insects. The parasitic epibionts inhabiting the external surface of mussels includes algal weeds, barnacle, limpets etc. They may negatively impact on the health and growth of mussels. Leech infestation is commonly found in freshwater mussels. Removal of leeches is very essential to obtain healthy mussels for breeding, growth and survival. Implantation of nuclear beads could only be possible in a healthy mussel in order to get good quality of cultured pearl. Leech infected freshwater mussels were collected from the ponds of ICAR-CIFA, Bhubaneswar, Odisha, India and they were brought into wet laboratory for treatment. An experiment was conducted in duplication to remove the leech infestation in freshwater mussel. It was carried out using malachite green, potassium permanganate, formalin and amitraz and hot water treatment at various concentrations. Effect of different treatment was observed in regular 12 hour interval for 10 days. During this experiment, the observations showed that the degree of parasite removal varies with different physico-chemical parameters. Further, the eggs were obtained from the treated brooders to check the survival and attachment of glochidia to the *Catla catla*. 
Broodstock age based embryonic development of common carp
(Cyprinus carpio var. communis)

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Embryonic development of Cyprinus carpio var. communis based on broodstock age has been recorded in the present study. The hatchery-raised brooders of two different age groups (virgin and 1+ year) bred naturally in the month of March in Tarai region of India. Fertilized eggs were adhesive, round and yellowish with average diameter 1.00±0.04 and 1.15±0.06 mm of virgin and 1+ year group respectively. About 8 hrs. post fertilization the gastrula disc began to protrude gradually and formed the germinal ring in eggs of 1+ age group while in virgin the development was comparatively slow. The development of the head and tail region became visible 16 hrs. post-fertilization in 1+ year group eggs. Head region becomes visible in virgin group embryo at 30 hrs post-fertilization while in 1+ year group optic primordium and somites developed prominently at this stage. Hatching took place 52 hrs. post-fertilization in 1+ year while in another group it occurred at 54 hrs. The yolk sac was also absorbed rapidly in 1+ year group hatchling as compared. While after yolk sac absorption the development was almost observed to be same in both group embryos. This study is advantageous in choosing better broodstock for aquaculture production.
Enhancement of antimicrobial activity of lectin conjugated with copper nanoparticles against aquatic pathogens

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Lectins are glycoproteins which are involved in innate immune response in invertebrates by helping in neutralizing pathogens by the recognition of Pathogen associated molecular patterns. However, it alone is insufficient to curtail severe infections. The over dose and unethical use of antibiotics led to the evolution of several dreadful antibiotic resistant bacteria. Hence, there is an increasing demand for an alternative strategy to treat bacterial infections with no or minimal side effects along with the lack of resistance development on the part of the pathogen. Developments in nanotechnology have revealed metal nanoparticles as promising new generation antibacterial agents. However, the mechanism of action of nanoparticles remains unclear. It is proposed that the NPs can disrupt bacterial membrane integrity, generate reactive oxygen species and result in bacterial cell damage. But the overdosage of nanoparticles may lead to bioaccumulation which is another serious issue. Thus lectins, having antibacterial property, which are isolated from shellfish when conjugated with nanoparticles will enhance its antibacterial activity and in turn can help in combating bacterial infections at a minimum concentration of nanoparticles which are safe. In the present study we have synthesized lectin coated nanoparticles and characterized their functional properties including, antibacterial activity by zone of inhibition assay, lipid peroxidase assay, membrane integrity study etc. Thus after proper further research and findings this conjugate can be used as a biological tool in aquaculture.
**Recent EUS outbreak in the flood affected fish farms of Kerala**

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Large scale fish mortality was observed recently in flood affected fish farms in several parts of Kerala following the very heavy rainfall, which was nearly 53% above the normal monsoon rain that the region receives. The affected fish had severe haemorrhages and ulcers, typical of the highly infectious disease Epizootic Ulcerative Syndrome (EUS). In the freshwater areas, snakeheads (*Channa* sp.) was severely affected, while in the brackishwater areas mullets and pearl spot were the worst affected. The cause of the mortality was confirmed to be EUS by histology and molecular diagnosis. The fungal hyphae in deeply ulcerated fish was also observed by lactophenol cotton blue staining. The severity of EUS outbreak is linked to the sudden change in water quality associated with the flood such as low water temperature, drop in pH, DO, alkalinity and hardness.

**Occurrence of fungal infection in fishes - case reports**

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In aquatic environment, fungal organisms serve an important ecological function in that they process or degrade dead organic matter. However, they can become pathogenic especially in conditions of stress by poor nutrition, injury and poor environmental conditions including low pH, environmental hypoxia and rise in temperature. The most common fungal infections in fishes include Saprolegniasis, Branchiomycosis and Icthyophonus disease. The present report describes the occurrence of fungal infection in fishes brought for post mortem examination to the Department of Veterinary Pathology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur during 2016-2018. Out of the fifteen cases brought during this period, in three cases, the owners reported lethargy, gasping air at the water surface and high mortality in fishes. On post mortem examination pale viscera and gills was seen in all the three cases. Whitish discoloration was seen in the gills in two cases, whereas whitish deposits was seen in the free borders of the gills in one case. Scraping of the material from gills and staining with lactophenol cotton blue demonstrated branched, non-septate fungal hyphae. Intestinal contents and heart blood smear were negative for any pathogenic organisms. Based on the clinical signs, gross lesions and laboratory test, the post mortem diagnosis was given as gill mycosis or branchiomycosis. Localised gill infection and respiratory failure was the immediate cause of death.
Diet induced obese Zebrafish model for identifying therapeutic targets in human obesity

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Obesity is a multifactorial metabolic disorder caused by chronic accumulation of excess body fat deposition in intra-abdominal, subcutaneous and in ectopic sites such as liver and muscle. Obesity a master disease leads to globally prevalent metabolic syndromes such as Type 2 Diabetes Mellitus (T2DM) and cardiovascular disorders. India has now a multitude of the paediatric and adolescent obese population mainly due to westernization of diets, sedentary lifestyle and altered activity patterns. Zebrafish have become an eminent vertebrate model in biomedical research owing to genetic characteristics such as external availability of gametes for genome manipulation, hundreds of embryos per spawn for studying siblings/generations in a short time, optically transparent embryonic development for efficient in vivo visualization of gene expression and a fully functional larvae in <5 days. The availability of complete genome sequence and structural similarity of organs to humans makes zebrafish an attractive model for studying human pathophysiological and genetic disorders including obesity. Here, we report the generation of diet-induced obesity (DIO) in zebrafish model by dietary supplementation of Cholesterol (5-15%). Dietary supplementation with cholesterol for 6 weeks resulted in the induction of obesity in zebrafish. Zebrafish fed cholesterol diet had increased body mass index (BMI) and hepatosteatosis compared to the control. Quantitative RT-PCR studies for gene expression profiling showed upregulation of key genes involved in lipid metabolism in humans. DIO zebrafish can help elucidate candidate molecular and physiological genes and pathways for identifying novel therapeutic targets for treating obesity.
Regeneration is a diverse and intense biological process involving controlled proliferation of adult stem cells and patterning of cells to form respective organs. Regeneration biology of lower organisms are well studied compared to vertebrates. Zebrafish has recently received considerable attention from biomedical researchers owing to their genetic homology (>80%), organ similarity to humans and their ability to regenerate several organs from fins, muscles, and nerves by epimorphic regeneration. Even major visceral organs like heart and pancreas also regenerate in zebrafish. However, our understanding of the molecular mechanism and signalling pathways involved in cardiac regeneration is at infancy. Human cardiomyocytes cannot regenerate after injury but zebrafish can. We have shown that adult zebrafish males regenerated their hearts within 57±6 dpi after ischemic injury. However, obese zebrafish showed delayed recovery but confirmed ventricular cardiomyocytes proliferation after 79±7 dpi. Semi qRT PCR analysis of key genes expressed during myocardial regeneration showed Gata4, IGF2 and Alpha2 macroglobulin (α2M) and miR-133a expression were significantly (P<0.05) upregulated immediately after cardiomyocyte proliferation. Relatively, selective miRNAs such as miR-99 and miR-100 were down-regulated following injury. Understanding zebrafish cardiomyocyte regeneration, adult stem cell differentiation and regulation by MicroRNAs (miRNAs) in zebrafish may reveal novel therapeutic targets useful in treating human myocardial infarction and for regenerative medicine.
N-acylhomoserine lactone-degrading Bacillus strains isolated from fish culture pond soil

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Many aquaculture pathogens regulate the expression of virulence genes through quorum sensing, bacterial cell-to-cell communication with small signal molecules. N-acyl homoserine lactones (AHLs) are the most extensively studied class of quorum sensing signals. Quorum quenching (QQ), the obstruction of quorum sensing, is the most attractive way to break down the N-acyl-homoserine lactones molecules. The present work was focused at isolating AHL degrading bacteria from fish culture pond soil. The presence of an autoinducer inactivation (aiiA) homologue gene and AHL-inactivation assay showed that five gram positive spore forming bacteria could rapidly degrade synthetic C6-HSL and C10-HSL in vitro and hampered violacein production by Chromobacterium violaceum. The selected isolates were confirmed to belong to the genus Bacillus by 16S rDNA sequencing and might be interesting novel biocontrol strains for use in aquaculture. AHL degradation potential of these five quorum quenching isolates was quantified using a microtiter plate assay by measuring the intensity of violacein production by C. violaceum CV026. The production of violacein was restored in the biosensor strain C. violaceum CV026 when challenged with the acidified AHL degradation media incubated with quorum quenching isolates, confirmed the production of lactonase enzyme by QQ isolates. Coculture of five QQ isolates with fish pathogen effectively reduced the amount of acyl-homoserine lactones (AHLs) and the extracellular proteases activity of Aeromonas hydrophila. They had excellent biodegrading ability of natural N-AHL produced by Aeromonas hydrophila, suggesting that they can be used as a potential quencher bacterium for disrupting the virulence of A. hydrophila in Aquaculture.
Screening of antifungal activity of freshwater fish species against selected microbes

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The issues of multi antibiotics resistant and continuous pressure on fish health welfare have shifted to the search of new effective natural based antimicrobial agents. In this context, an assessment of antifungal activity of integumentary extract of *Catla catla*, *Cirrhinus mrigala*, *Clarias batrachus* and *Heteropneustes fossilis* against the four selected fungal species viz., *Aspergillus fumigatus*, *Aspergillus flavus*, *Candida albicans* and *Fusarium solani* were conducted. The results revealed that different fish integumentary extracts produced significant variation of antifungal activity against the selected microbes. *Heteropneustes fossilis* integumentary extract achieved the highest (16±0.71 mm) antifungal activity against *Aspergillus fumigatus* as compared to other counterparts. The results also showed that integumentary extracts of all the fish species showed better inhibitory effect against *Aspergillus fumigatus* as compared to other fungal species. *Catla catla* antifungal activity was found to be lesser effective than the positive control Ketoconazole, however, the antifungal activity of *Cirrhinus mrigala*, *Clarias batrachus* and *Heteropneustes fossilis* have produced better result than positive control. Thus, the present study underlined the screening and understanding of antifungal activity of integumentary extract could provide the role of fish innate host defense mechanism. Moreover, it could help in preventing the use of antibiotics through by developing new drugs based on natural substances secreted from fish integumentary glands.
C-type lectin and its mechanisms of resistance to parasitic diseases in marine finfish and its role in antimicrobial defense

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The characterization of the immune response in the Finfishes with an emphasis on Lectins in innate immunity is important. The aim of this project is to study the biochemical, immunological and antimicrobial properties of the purified lectins from *Etroplus suratensis* against parasitic diseases in marine finfish. The blood was collected and allowed to clot for serum separation, centrifuged and the proteins were precipitated out, purified by affinity chromatography and molecular masses of the constituent proteins were compared by SDS-PAGE. The protein concentration was determined by Lowry's method. The biochemical characterization was done by sugar binding assay and by checking its activity at various temperatures and pH. In addition to haemagglutination assay, biofilm quantification assay and yeast agglutination assay, antibiofilm activity against different pathogens (Gram positive and Gram negative) were also examined at different concentrations of the crude extracts and observed under light microscopy and Confocal Laser Scanning Microscopy (CLSM). The pathogens examined proved to be sensitive against all the samples tested and exhibited significant haemagglutination and yeast agglutination activities. These investigations proved the antimicrobial and haemagglutination activity of the serum lectins and further studies are required for the identification of exact mechanisms of their activity and role in lectin pathway cascade. It will pave the way for future experiments of expression analysis of key immune molecules as well as study of the immune response to parasitic infections.
Dissipation kinetics of thiamethoxam and its major metabolite clothianidin in soil under chilli ecosystem using LC-ESI-MS

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An easy, simple and efficient single laboratory method was validated for the detection of thiamethoxam and its metabolite, clothianidin in soil under chilli ecosystem were evaluated using liquid chromatography–tandem mass spectrometry. The modified QuEChERS extraction method was validated in terms of linearity, specificity, limits of quantification (LOQ), limits of detection (LOD), accuracy and precision as per EU guidelines (SANTE 2017) prior to the real sample analysis. For validation studies, a series of homogenized control samples of soil was fortified with thiamethoxam and clothianidin at 0.01, 0.05 and 0.1 µg mL\(^{-1}\) levels with five replicates. The extraction of residues from soil matrix using acetonitrile followed by clean up through dispersive solid phase extraction (dSPE) technique. The residues were analysed by using Thermo-Dionnex Ultimate 3000 UHPLC equipped with TSQ Quantiva, tandem mass spectrometry (LC-MS/MS) with C18 column (100 x 2.1 mm, 2.6 micron particle size). LC-MS grade methanol and water with 0.1% formic acid and 5 mM ammonium formate was used as the mobile phase at a flow rate of 0.3 mL min\(^{-1}\). In this study, the recovery of thiamethoxam in soil matrix ranged from 83 to 92 % with RSDr of 6.48 to 12.05; whereas, clothianidin showed a range of 80 to 96 % having RSDr 4.88 to 10.24. The results obtained from recovery and precision were within the acceptance validation criteria 70 to 120 % with relative standard deviation below 20%. The method was linear with coefficient of determination, \(R^2\) value greater than 0.9981, in soil matrix standard solution for thiamethoxam and its metabolite (clothianidin). The analyte signal suppression was observed for thiamethoxam and metabolite in soil matrix. An ion suppression effect due to the matrix was found to be in a range of 6.88 to 17.68 %. The matrix matched calibration was used for the quantitation of the molecules, which helps to nullify the matrix effect. The method was successfully applied to the real samples. According to the residue definition, the total residue of thiamethoxam and its metabolite, clothianidin was estimated by the sum of the residues of parent compound and residues of metabolite multiplied with the correction factor, where the correction factor is the value obtained from the molecular weight of parent molecule by molecular weight of the metabolite molecule. The data on the persistence of total thiamethoxam residues in soil, revealed the persistence up to 15 and 10 days, when applied at 25 and 50 g. ai. ha\(^{-1}\), respectively. A plodding and continuous worsening of residues of total thiamethoxam in soil was found as a function of time after the second application in soil at both doses. For lower dose, the total residue of thiamethoxam in soil, initial deposit were 0.54 µg g\(^{-1}\) which dissipated to 0.36, 0.32, 0.26, 0.12, 0.03, 0.01 µg g\(^{-1}\) on the consecutive days and in the case of higher dose, the total residues present after two hours of spraying was found to be 1.26 µg g\(^{-1}\). The residue values declined to 0.51, 0.43, 0.34, 0.22 and 0.07 µg g\(^{-1}\) on 3, 5, 7 and 10\(^{th}\) days. The metabolite, clothianidin was first detected on 1\(^{st}\) day for both the doses, which was increased to a maximum on 5\(^{th}\) day which was declined substantially and reached below quantitation level after 15\(^{th}\) and 10\(^{th}\) day on lower and higher dosed, respectively. In the view of environmental safety, thiamethoxam can be incorporated as one of the best insecticides in integrated management of pest complex in chilli and also safe for the non-targeted systems.
Extraction and Isolation of PHNQ pigments from sea urchin *Stomopneustes variolaris* (Lamarck,1816) shell and its anticancer activity against human ovarian cancer cell lines

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Sea urchin shells are generally discarded as food waste after removal of edible gonads, although they possess significant amount of polyhydroxylated naphthoquinone pigments having potent antioxidant property. In this study, separation and quantification of polyhydroxylated naphthoquinone (PHNQ) pigments that is biologically active in the calcareous skeleton of sea urchin *Stomopneustes variolaris* (Lamarck,1816) were performed. The presence of the PHNQ pigments was confirmed using a UV-Vis spectrophotometer. FT-IR study shows the presence of functional groups such as alcohols, acids or aromatic ethers, methyl alkyl groups. The extracts of the sea urchin have remarkable anticancer activities against ovarian cell lines. The findings suggest that sea urchin shell and spines, most of which are discarded as waste, may serve as a new biologically active resource. Also, separation and quantification of the pigment mixtures from the sea urchin shells were performed using a Phenomenex ODS C18 reversed-phase HPLC with isocratic elution of 50% mixture of solvent (A) Phosphoric acid: water (0.1: 100, v/v) and solvent (B) MeOH: acetonitrile (10:90, v/v) at a flow rate of 1.2 mL/min. The results indicated that the HPLC method deployed in this study would be applicable for the separation and quantification of these major pigments in sea urchin shells.
Aquatic Products and Technologies (APT)
APT-OR-01

Effects of chitosan on retrogradation properties of corn starch in fish mince emulsion sausage

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Chitosan is a naturally derived polymer of biological origin which is a deacetylated form of chitin found in shellfish exoskeletons. It is having broad spectrum applications in food industry due to its diverse properties. As filler starch is added to the sausage samples during preparation. And this influences the texture and shelf life of the product. Retrogradation of gelatinized starch during storage is believed to be an important contributor for the product staleness. Chitosan is the only natural cationic polysaccharide which could inhibit starch retrogradation. In the current study, chitosan in the form of gel (hydrogel) with different concentrations of chitosan (0%, 0.125%, 0.25%, 0.375% and 0.5%) are incorporated into fish mince (*Pangasianodon hypophthalmus*) sausages. Results showed that both starch retrogradation and starch digestibility was found reduced in chitosan treated samples during entire storage period. Nominal change in water holding capacity was observed in chitosan treated samples. Textural parameters indicated that both hardness 1 and hardness 2 values increased significantly (p<0.05) in all the treatment groups including control throughout the storage period, however the increment was less in the control group (from 4.196 to 5.186) in compared to other groups. Elasticity change in chitosan added sausage samples were insignificant while control having significant difference. In case of cohesiveness also, there was significant (p<0.05) increase in all the treatment groups although the control group showed highest value at all-time points.

APT-OR-02

Assessment of in-vitro and in-vivo biocompatibility of fish scale derived hydroxyapatite for bone regeneration

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The study involved the assessment of in-vitro and in-vivo biocompatibility and possible cell interactions of fish scale derived hydroxyapatite intended for bone regeneration. The MTT assay of fish scale derived hydroxyapatite on fibroblast cells did not indicate any toxic effects at lower concentration of 0.05 g/ml, however indications of toxicity were evident at 0.1 g/ml concentration. The in-vivo analysis was carried out in rodent models (Spargue dawley male rats) and sample animals were drawn on 4, 8, 12 &16 days. The commercially available xenograft was kept as positive control. The histopathological evaluation of both commercially available xenograft and fish scale derived hydroxyapatite showed more or less similar results. Hence, it was concluded that fish scale derived hydroxyapatite could be used as an alternative to commercially available xenograft for tissue regeneration.
Cronobacter spp. in seafood of Mumbai, India and their antibiogram: a concern to food safety

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Cronobacter spp. (formerly Enterobacter spp.), a member of the Enterobacteriaceae family, are ubiquitous organisms, which are motile, non-spore forming, Gram-negative facultative anaerobes. These pathogens contaminate and survive in a diverse range of environments and foods. The present study investigated the presence of Cronobacter spp. in seafood and their antibiotic susceptibility pattern which collected from fish landing centres, fish markets and retail supermarkets from Mumbai, India. Among 50 screened samples 87.87% isolates were confirmed to be Cronobacter spp. by biochemical tests and 22.4% by PCR. The confirmed isolates of Cronobacter spp. were also studied for their antibiotic susceptibility pattern by testing them against 15 commonly used antibiotics using disc diffusion method. All the isolates were found to be resistant to the 3rd generation cephalosporins, cefpodoxime and ceftazidime, and 97.29% were sensitive to kanamycin and ciprofloxacin. Cronobacter isolates showed resistance to two or more antibiotics when analysed, with a less percentage of the isolates showing resistance to three or more than three antibiotics. The emergence of resistance to antimicrobials is a significant public health problem and justifies monitoring the antibiotic susceptibility of foodborne pathogens. Incidence of Cronobacter spp. in fresh and dried seafood and their antibiotic susceptibility pattern reported in this study is the first of its kind of attempt from India, which underlined the concern of potential public health concerns.
Identification of allergic proteins of Kiddi shrimp (*Parapeneaeopsis stylifera*) and characterization by mass spectrometry

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Allergy associated with consumption of seafood is increasing worldwide and shellfishes are major causative of food induced anaphylaxis. These reactions are mediated by immunoglobulin E (Ig E) antibody. Allergic reactions include gastrointestinal, dermatological, and respiratory symptoms. Kiddi shrimp (*Parapeneaeopsis stylifera*), locally known as ‘karikkadi chemmeen’ is a highly preferred variety. Muscle proteins of kiddi shrimp was profiled by SDS PAGE and evaluated IgE binding activity by raw and cooked protein extracts. IgE reactive proteins present in the protein extracts were identified by immunoblotting with sera from persons allergic to shrimp. Tropomyosin of 37 KD was identified as the major allergen with highest frequency of immunoreactivity. Mass spectrometry analysis of trypsin digested tropomyosin was carried out by MALDI TOF. The peptide mass fingerprint analysis showed strong similarity with tropomyosin from other crustacean species and also showed within sequence variation compared to others.
APT-OR-05

**Development of portable machine vision system for freshness assessment of Indian Mackerel (*Rastrelliger kanagurta*) during iced storage**

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Fish freshness is generally determined by sensory assessment which is highly subjective necessitating an objective instrumental method. Therefore, a rapid and non-destructive instrumental system to detect the freshness of Indian Mackerel (*Rastrelliger kanagurta*) was developed. Freshly caught Indian Mackerel was stored under ice for 15 days and the principle of colour change in fish eye during storage was studied. The miniscule changes that occur inside the pupil and iris region of the fish eye was measured objectively as pixel count by capturing fish eye image using image processing technique. The destructive fish freshness tests K-value and microbial analysis were carried out at 24h interval and correlated with pixel count values. It was observed that progression of spoilage was associated with increase in redness and opaqueness in pupil region of eye, accordingly increase in pixel count was observed. The K-value was within 20% on 3rd day implying that fish samples were extremely fresh and on 13th day the K-value increased to 57%, acceptable for consumption, and beyond 60% fish was spoiled. The psychrophilic count of less than 4 Log CFU/g on 3rd day implying that fish was extremely fresh and on 12th less than 6 Log CFU/g was fresh, thereafter fish was completely spoiled. The data correlation of the quality test results with pixel counts, two threshold levels (40000 and 140000) were fixed to categorize the fish sample into extremely fresh, fresh and spoiled and then sensor was developed. The results of validation study of sensor reported that sensor outputs were accurately matching with results of k-value, microbial and sensory analysis.

APT-OR-06

**Characterisation of surface-active protein hydrolysate from yellowfin tuna red meat**

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Tuna red meat, a major cannery waste in seafood industry requires effective addressal and attempts were made in the current investigation on utilization of this nutrient rich source in the form of protein hydrolysate. Protein hydrolysate from yellow fin tuna red meat, optimized for surface active properties was comprehensively characterized viz., nutritional profile, molecular weight, surface morphology, thermal characteristics, physical properties and in-vitro digestibility studies for exploring its application potential. Protein recovery of 39.64% was observed in the hydrolysate from its parent source, representing a protein content of 88.57±0.66%. Protein quality evaluation indicated its opulence in aminoacids like glutamic acid, aspartic acid, lysine and leucine while the limiting ones were tyrosine, phenyl alanine, methionine and cysteine. Molecular weight of the derived protein hydrolysate indicated divergency with major contribution by peptides above 10 kDa (60%). Storage stability studies conducted under ambient and chilled conditions indicated an uptake of moisture, increased oxidative indices as well as functionality variations. Present study explores the suitability of protein hydrolysate from tuna red meat in formulation of functional foods as well as nutraceutical products.
APT-OR-07

Extraction and characterization of gelatin from blubber lip (*Lutjanus rivulatus*) scales

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Gelatin is widely used biopolymer with extensive application in various sectors on account of its excellent biocompatibility, techno-functional properties and health benefits. Gelatin extracted from fish sources is one of the best alternatives to replace the porcine and bovine gelatin which has certain limitations including the religious concern and disease transferability. In the present study, gelatin was extracted by standard protocols using acid and alkali from blubber lip scales, one of the commercially available discards from seafood industry. Scales were initially characterized for physico-chemical properties including the major biochemical constituents. The extracted gelatin was characterized for nutritional, physico-chemical, functional, textural and bioactive properties for understanding its application potentials. The yield of gelatin obtained in the present study from the parent source is comparable with the value available in the literature indicating the potentiality of this species as a source for gelatin extraction. The finding of the study explores the suitability of blubber lip scales as a sustainable source of gelatin with desirable functionalities for use in food and other applications.

APT-OR-08

Biofunctional effects of protein and lipids from echinoides of east coast of India with reference to antimicrobial and antioxidant properties

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Lipids and protein samples were isolated from the roe of regular echinoides (sea urchins) *Stomopneustes variolaris* and *Salmacis bicolor* from east coast of India. Protein estimation was carried out by Bradford and Lowry whereas the molecular weight of proteins was determined by SDS PAGE and 2D Gel electrophoresis. GC-MS analysis showed presence of compounds Hexatriacontane, Tetratetracontane, Octacosane in the lipid extract. Various functional groups with wavenumber 3418.93 cm⁻¹ (Alcohol), 2921.08 cm⁻¹ (Alkane), 2660.69 cm⁻¹ (Carboxylic acid), 1596.11 cm⁻¹ (Amine), 1291.76 cm⁻¹ (Aromatic amine) was determined by FT-IR analysis of lipid extract. The antimicrobial activity was done by disc diffusion and broth dilution methods for different concentrations and fractions of lipid extract. The test microorganisms used for the antimicrobial activity includes two gram positive bacteria (*Streptococcus aureus*, *Pseudomonas aeruginosa*), three gram negative bacteria (*Escherichia coli*, *Klebsiella pneumoniae*, *Vibrio cholera*) and a fungal species (*Candida albicans*). The antioxidant activity of the crude lipid extract was assessed by 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and hydrogen peroxide free radical scavenging method which shown an LC₅₀ value 25 µg/ml for both the samples.
Physical, chemical and sensorial quality evaluation of phosphate treated and non-treated PUD shrimp (Litopenaeus vannamei) samples

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The present study was conducted to assess the effects of food grade sodium tripolyphosphate (STPP) (Na₅P₃O₁₀) or water dip (control) treatments on the physical, chemical and sensorial quality attributes of decapitated Pacific white shrimp (Litopenaeus vannamei) during frozen storage at -35°C for 10 days. Results indicated that control shrimp samples have been shown to lose texture, and gradual deterioration in quality attributes with frozen storage. The rate of these deteriorations are increased as the time of storage progressed. On the other hand, phosphate (STPP) treated shrimp samples exhibited significantly (p<0.05) higher moisture retention, tenderness and bound water at any given time of frozen storage as compared with control samples. The present work also demonstrated significantly (p<0.05) lower values of drip loss, TVB-N and TMA-N, recorded in STPP-treated samples. Results indicated that economic, physical, chemical and sensorial quality advantages have been resulted from soaking Pacific white shrimp in cold 5% Sodium tripolyphosphate solution for 5 minutes prior to freezing. With these results, we can suggest that 5% STPP treatment would be an alternative way to improve the quality of decapitated Pacific white shrimp during frozen storage.
Extraction of carotenoprotein from *Penaeus vannamei* shell waste using extreme halophilic archaea

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Shrimp shell waste from the processing industry constitute of high value carotenoproteins and bioactive components which are underutilized. Dumping of these waste without proper treatment leads to environmental pollution. Along with increasing demands on environment-friendly society, more eco-friendly processes using microbiological method for producing bioactive compounds have attracted great interest. Emphasising this, the present work has been conducted for utilisation of shrimp shell waste to produce carotenoprotein and chitin using two strains of halophilic archaea such as *Halobacterium salinarum* and *Halococcus dombrowski*. Shrimp shell waste is added to a medium containing archaea with 25% salt. Out of these two strains, *Halococcus dombrowski* showed maximum proteolytic activity with 98.99% protein recovery within 3 weeks of incubation period. Similarly, it also showed maximum carotenoid recovery of 94%. The recovered carotenoprotein liquor is having high DPPH (2, 2-diphenyl-1-picrylhydrazyle) scavenging and FRAP (Ferric Reducing Antioxidant power) activity. The residue obtained after carotenoprotein removal had higher mineral content. The pitfall of this method is that there is no acid production during the fermentation process, so shell residue obtained was treated with dilute HCl for chitin preparation. Final product obtained after demineralization is having 94.68% chitin. The present study reveals a new method of eco-friendly management of shrimp shell waste.
APT-PO-02

Comparative analysis of three strains of fermentative bacteria on recovery of nutritional components from Pangasius processing waste

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A study was conducted to compare the yield efficiency of protein and lipids using selected lactic acid bacterial strains in silage preparation which is an eco-friendly method in minimizing fish processing waste in fish markets. Basa fish waste was taken. Three types of silage were prepared using three lactic acid bacterial cultures i.e. Lactobacillus plantarum, Pediococcus acidilactici and Bacillus licheniformis. Proximate analysis of three types of silage was done. First Silage using Lactobacillus plantarum showed respectively Moisture 87.3%, Protein 1.34%, Lipid 4.01% and Ash 1.47%. Type two silage using Pediococcus acidilactici showed Moisture 84%, Protein 1.4%, Lipid 1.6% and Ash 2.1%. Type three silage using Bacillus licheniformis showed Moisture 83.3%, Protein 2.1%, Lipid 6.3%, and Ash 1.9%. The outcome of the studies confirms that Bacillus licheniformis have got better protein and lipid yield efficiency which can be used in silage to minimize the fish processing waste in fish markets.

APT-PO-03

Development and quality evaluation of fish protein concentrate incorporated value-added products

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The study was aimed to assess the quality of fish protein concentrate (FPC) incorporated value added products stored at room temperature for one month. The FPC was prepared from Tilapia (Oreochromis niloticus) by physical method and were incorporated in cookies and flakes by adding different proportions of FPC (3%, 6%, 10%). Cookies and flakes developed by incorporating 6% FPC were organoleptically selected using 9 point hedonic scale. The proximate constituents of FPC like moisture (15.98%), protein (75.02%), fat (0.018%), and ash (3.02%) were analysed by standard methods. The nutrient analysis revealed that the selected FPC incorporated products were found to meet more than half the RDA of protein and one third the RDA of energy, calcium and iron for a pre-schooler aged 7-9 years. The biochemical and microbiological quality of the products stored were analyzed by standard methods. The results indicated that peroxide value, free fatty acid, trimethyl amine, total volatile base nitrogen and total plate count values were within the accepted limits during the storage period. However, all the values were found to increase as storage proceeds and hence addition of preservatives can be adopted to improve the quality and shelf life of products. In brief, fish protein concentrate is considered
APT-PO-04

Determination of the quality and shelf life of sous vide cooked Cobia (*Rachycentron canadum*) fillets in chilled condition

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The changes in the chemical, physical, microbiological and sensory qualities of sous vide cooked processed Cobia (*Rachycentron canadum*) fillets in comparison with vacuum packed fillets were monitored during chilled storage (0-2°C). Physical-chemical (pH, TVB-N, TMA, TBA, FFATBARS, L*), Microbial (TPC), and sensory parameters were determined. The sous vide cook and chill method at 85 °C for 10 min resulted in being able to preserve the quality of Cobia fillets and extend their shelf-life to 28 storage days whereas vacuum packed fillets were having a shelf life of 13 days under chilled condition. Fillets processed by “sous vide cook and chill” method, marketed at refrigerated conditions, may be a promising addition to “ready to cook” food products with an extended shelf-life and high versatility as requested by the changes in consumer habits.

APT-PO-05

Extraction and characterization of fish protein hydrolysate from head of skipjack tuna (*Katsuwonus pelamis*)

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Tuna landing is one of the major landings of Indian subcontinent fetching high market price in international markets. The wastes generated from the tuna processing are the best source of protein hydrolysate having many nutritional factors. Skipjack tuna (*Katsuwonus pelamis*) was the species taken for the study. Tuna head protein hydrolysate (THPH) was prepared using papain enzyme and initial conditions of enzyme/substrate and time were optimized using response surface methodology (RSM) by Box Benkhen design. The predicted maximum response value for degree of hydrolysis was 14.20 % and the optimum values for E/S ratio and time were 0.78% and 58.02 minute respectively at 37°C. The quality characteristics and bioactive properties of the prepared hydrolysate were evaluated. THPH had total protein of 77.77% (dry weight basis) with yield of 3.1%. The study of functional properties of THPH revealed that the solubility and foaming capacity of hydrolysate increased with increasing concentration of hydrolysate. However, the foaming stability was higher (44.16%) at 2% THPH concentration. Similarly, best emulsifying properties were obtained with addition of higher concentration of THPH. Bioactive properties were estimated based on DPPH and FRAP assays. The highest DPPH radical scavenging activity of THPH was 79.02±0.00% at 10mg/mL. However, the highest FRAP activity was obtained at 8mg THPH/ml. Current study revealed that THPH can be used as functional and bioactive ingredients in food formulations.
Optical fiber bundle sensor and other conventional techniques for detection of formaldehyde concentration in fish: a review and comparative study

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Fish is an inevitable part of Kerala’s food style and around 3% of the State’s economy is attributed to Fisheries. Fish being an easily perishable commodity, unethical means of fish preservation methods are done in a large scale nowadays. The mixing of formalin (solution of formaldehyde in water) with fish is the current threat posed to Kerala. Formaldehyde is a noxious chemical extremely menacing to human life causing malicious diseases like cancer and leukemia. These factors attribute to evaluation of fish quality in an effective and well-timed manner. There are numerous conventional chemical methods for detecting formalin concentration in fish. The main drawback is that majority of these techniques are time-consuming, tedious and destructive that requires well-trained operators and cannot be applied for on-field detection. In the current review, principles and applications of the most recently developed technique- Optical Fiber Bundle Sensor is discussed, and a comparative study with other conventional methods is done. Here, the contaminated fish samples are shined with red laser light with about 630 nm wavelength. The intensity of reflected light from sample is collected and measured by optical detector that is connected to a voltmeter. The measure of voltage gives formaldehyde concentration. The sensor can detect formaldehyde concentrations from 3% to 21%. It has a simple architecture, exhibits good linearity, stability, sensitivity, low cost, non-invasive, non-destructive and has the potential to be developed as a portable device. Using this non-destructive technique, unethical means of food preservation can be monitored, thereby ensuring fish quality in Kerala.
Comparative study of carotenoprotein extracted from four different shell waste by enzymatic hydrolysis

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Carotenoproteins from four different shrimp shell wastes *Penaeus monodon*, *Parapenaeopsis stylifera*, *Metapenaeus affinis* and *Nematopalemon tenuipes* were extracted with the aid of papain enzyme and characterized by their protein, amino acid and carotenoid content of the shell wastes and the antioxidant activities like DPPH, FRAP, ABTS radical scavenging activity and reducing power assay of the carotenoprotein. Higher protein content of 9.8 g 100g⁻¹ and 9.2 g 100g⁻¹ was recovered from shell waste of *P. monodon* and *P. stylifera* respectively along with highest carotenoid content of 114 ± 0.02 µg g⁻¹ in *P. stylifera* followed by 100.6 ± 0.02 µg g⁻¹ from the shell waste of *M. affinis*. Highest antioxidant activity was found in the carotenoprotein extracted from the shell waste of *P. stylifera* which suggest that the antioxidant activity of carotenoids followed a concentration dependent pattern. The amino acid profile showed that carotenoprotein is a rich source of essential amino acids such as glutamic acid, aspartic acid, lysine and leucine. Among shell wastes, *P. stylifera* shell waste was calculated to be superior as it contained higher amount of essential amino acids and exhibited higher antioxidant activity in terms of protein, carotenoid as well as radical scavenging and reducing power and it could serve as a supplementary nutritive feed ingredient in animal diets.
APT-PO-08

Effect of Carbon/Nitrogen ratio on microbial ensilation of fish and vegetable waste

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In India problems concerning fish and vegetable waste management and disposal currently an issue in the organized waste management system. A study has been conducted to evaluate the variation in C/N ratio of waste material in the process of ensilation with three different combination of fish waste (FW)-to- vegetable waste (VW) ratios was prepared to achieve three different C/N ratio gradients during the ensilation process. In this experiment, T1 (25% FW +75% VW), T2 (50% FW +50% VW) and T3 (75% FW +25% VW), along with carbohydrate (15% molasses) supplement and starter culture Lactobacillus acidophilus (MTCC 10307) was used for the microbial ensilation. Proximate composition, variation in carbon/nitrogen ratio, chemical parameters (pH, TTA,) and microbiological (total plate count, LAB count) aspects were investigated on every alternative day during the ensilation process over a 3 weeks period of storage at room temperature (25°C). A significant decrease in carbon/nitrogen ratio was observed among different treatment groups during the ensilation process. In all the ensilage groups LAB showed a two-fold increase whereas, TPC value was decreased from 5.65 to 3.91 log cfu/g. The results indicated that T3 (75% FW +25% VW), was the best combination as per as carbon/nitrogen ratio is a concern for the effective utilization of fish and vegetable waste as bio-organic manure in the agro-cultivation system.

APT-PO-09

Determination of phenolic compounds and antioxidant activity of ethanolic potato peel extract in fish (Sardinella fimbriata) mince

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Potatoes are the widest available and commonly consumed vegetable in the world. Peels are found as the major wastes that creates disposal and environmental problems. To overcome this, these wastes has been used in fish processing sectors due to their much-known benefits. Peels are rich in phenolic acids which are a group of natural antioxidants such as chlorogenic acid, caffeic acid, gallic acid, protocatechuic acid, salicylic acid, ferulic acid etc. (Farvin et al., 2011). Phenolic compounds are secondary metabolites that constitute one of the most common and widespread group of substances in plants (Whitting, 2001). In the present study, the HPLC-MS analysis of the extract done in SAIF, IIT Bombay and the compounds present in it were determined qualitatively. Some of the major acids found were caffeic acid, gallic acid, vanillic acid, chlorogenic acid, ferulic acid, Quercetin, Melissic acid, Pilocarpine, Ceramide, Solanidine, Sulfamethazine, Dinopromazine etc. The antioxidant activity has several mechanisms like chelation of metals, scavenging of active oxygen species, biological activity etc. The antioxidant activity of the ethanolic potato peel extract analysed by radical scavenging activity has been found to be 32.42%. The recent technology of using these byproducts has been increasing the global consumption of aquatic products and giving a very good benefit to food processors and industries.
Nutritional quality of edible crab species from Kochi, Kerala

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Crab is a delicacy in certain pockets across the globe. The proximate analysis of the edible meat from the crabs collected from marine and brackish water ecosystems showed interesting nutritional benefits. The average moisture content in raw species ranged between 75-80%, with lowest in *Charybdis lucifera* (72%) and highest in *Portunus pelagicus* (80%) among the marine species. The water content among brackish water species remained more or less constant (75%). The average protein content ranged from 9.6%-14%, with lowest in *Charybdis lucifera* (9.6%) and highest in brackish water species (12-14%). The fat content ranged between 0.70% to 1.60%, with highest in *Scylla serrata* and the lowest in *Portunus pelagicus* (0.70%). The crab meat showed the monounsaturated acid (C16:1, C18:1 and C20:1) in appreciable quantities with C16:1 and C18:1 predominating. Other prominent acids include C18:2, C18:3, C20:5, C22:6, besides other n-3 acids in good proportions. The carbohydrate content in crabs are comparatively higher among the aquatic species and ranged between 1.74-6.88% across the six species studied. Upon cooking, the way in which crab is generally consumed, the parameters changed by 65-77%, 3-17%, 0.5-3%, 12-17%, 1-11%, 0.09-4% respectively for moisture, ash, fat, protein, carbohydrate and fiber. Significant loss of polyunsaturated fatty acids (PUFAs) also noticed during cooking. Generally, it is seen that the ash and fiber content of crab meat was higher compared to fish.
Preservation of mahseer (Tor khudree) steaks in natural extract

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Shelf-life extension of fish and fishery products are often improved by using the various food supplements during the processing cycle. But due to the prospective health risk caused by using the various synthetic antioxidants, additives of organic nature are being used because of increasing consumer preference. White Radish (Raphinus sativus) solvent free extract was used for the shelf-life enhancement of mahseer (Tor khudree) steaks due to the presence of phenolic compounds. Based on the in-vitro antioxidant activities viz., total phenolic content, 2, 2- azinobis (3-ethylbenzothiazoline-6-sulfonic acid) and DPPH activity; 20\% concentration of the extract was selected for the dip treatment of mahseer steaks stored under chill conditions (0-2°C) for 15 days. Based on the biochemical analysis (PV, FFA, TBA, TVB-N and TMA), microbiological parameters (TPC) and sensory analysis; it was concluded that the both the control (CT) samples and whole radish extract (WRE) treated sample showed the increasing trend for biochemical and other parameters with respect to the days of interval for taking sample. On the day of sensory rejection, trimethylamine and total volatile base nitrogen were within the acceptability limit 8.58 mg/100g and 22.47mg/100g in case of WRE treated sample whereas the control sample crossed the limit of acceptability on the 9th day. The results depicted that dip treatment of WRE increased the shelf-life of mahseer up to 6 days during chill storage. Therefore, it can be concluded that whole radish extract (WRE) can be used as a promising natural preservative and a substitute to the synthetic counterparts.
A practical proposal for utilization of water hyacinth as a potential raw material for sustainable construction materials: a review

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The main constituent of traditional and ordinary construction material is cement. Cement production emits a huge amount of CO₂ in the atmosphere. At the same time, invasive aquatic weeds like water hyacinth (WH) are posing serious economic and environmental issues in Kerala. The plant chokes the life out of the freshwater ecosystem by preventing penetration of sunlight, required for the survival of underwater fauna. Mass fish die-off in lakes appeared several times due to drop in oxygen level caused by WH infestation. Other impacts of WH are decline in water quality, enhanced evapotranspiration, and reduced biodiversity. This paper reviews a practical proposal for utilization of WH as supplementary cementitious material for sustainable construction materials. This provides a summary of the existing knowledge about the successful use of WH in the production of panel-boards, bricks and as a bio admixture in the concrete production. For panel-boards, an optimum mix of 80 % WH with 20% cement shows excellent thermal insulation properties. Hence it could be used as an alternative to thermal insulation material. An optimum mix of 10% WH with soil is appropriate for brick production using WH as a partial substitute to the soil. The incorporation of 10% WH leads to 7% net saving in the consumption of fuel required for firing the bricks. In the case of concrete production, the optimum chemical admixture replacement is 20%, at which concrete shows good workability and compressive strength. The use of WH in the construction industry would contribute to a cleaner environment.
Molecular characterization and antibiogram analysis of *Vibrio parahaemolyticus* isolated from the traditional penaeid shrimp rearing ponds of Cochin, Kerala

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This study was conducted to evaluate the presence, potential pathogenicity and antimicrobial resistance of *Vibrio parahaemolyticus* isolates from 30 penaeid shrimp samples obtained from 10 different traditional aquafarms in Ernakulam area. A total of 21 isolates of *V. parahaemolyticus* were obtained which was identified by conventional methods and further confirmed by PCR targeting the species-specific markers like toxR and tlh genes. None of these isolates were found positive for the virulence genes like tdh and trh gene. Antibiogram analysis of the isolates done against a set of 13 commonly used antibiotics revealed highest resistance towards Amoxyclav in over 66% of all the isolates. Almost 11 isolates (52.3%) showed resistance to majority of the antibiotics used in the study whereas all the isolates showed sensitivity to chloramphenicol (100%). Current work reveals that 9 among the 21 isolates were showing MAR index greater than 0.2 indicating the potential of these multidrug resistant isolates to serve as reservoir of antibiotic resistant genes in aquatic ecosystems. The presence of multidrug resistant *Vibrio parahaemolyticus* in the traditional culture ponds is therefore demanding the need for adopting ideal, ecofriendly alternative measures that could substitute the use of antibiotics for treating diseases in the shrimp culture ecosystems.
Thermal process standardization of Ready to Eat (RTE) fried Malabar short neck clam (*Marcia recens* Holten, 1802) in transparent retort pouches

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This study intends to standardize a Ready to Eat (RTE) product from Malabar short neck clam (*Marcia recens*) from Ashtamudi Lake, Kerala. It became India’s first Marine Stewardship Council (MSC) certified fisheries in 2014. The fried clam was packed in transparent retort pouches and processed at different F0 values such as 7, 8 and 9. The total process time was determined 43.97 min for F0 7, 26.97 min for F0 8 and 50.41 min for F0 9. The cook values recorded for F0 7 was 80.78 min, F0 8 was 68.1 min and F0 9 was 93.51 min. Significant variation in proximate composition of fresh clam (N) and marinated fried clam (M) samples were obtained (p < 0.05). Colour plays an important role in acceptability of fresh/processed food items. Highest colour values L* in F0 9 (39.03±1.28), a* in F0 8 (6.71±0.44) and b* in F0 7 (29.44±0.48) compared to the lowest L* in F0 8 (36.74±0.52), a* in F0 7 (6.57±0.47) and b* in F0 8 (26.22±1.11) (p < 0.05). All the F0 values were found commercially sterile but on the basis of sensory evaluation the clam meat processed at F0 9 was selected as the best commercially acceptable combination. The outcome of the study confirms the utilization of retort pouch processing as a promising technology for developing RTE products from a sustainability certified species, increasing further its marketing opportunities.
A study was conducted to standardize and to develop value added product from *Sardinella longiceps* (Valenciennes, 1847) using leaves of *Garcinia gummigutta* and also to investigate the combined effect of vacuum packaging and leaves on the quality changes of Indian oil sardine during storage at 3°C for 20 days. The leaves exhibited strong antioxidant activity as determined by DPPH assay. A ready to cook product was developed viz., ‘Meen puliyila’ by marinating fish with paste of leaves, coconut, bird’s eye chilly and salt using standardized recipe. The quality parameters of the developed product along with control (raw sardine) were analyzed during different storage periods. Fish treated with *Garcinia gummigutta* leaves showed significantly lower value for pH, peroxide value, free fatty acid, Total volatile base nitrogen, trimethyl amine and total viable count till the last day of storage when compared to control. Synergistic use of leaves and vacuum packaging has markedly controlled microbial proliferation and rancidity in the samples when compared to control. Based on sensory evaluation, a shelf life of 16 days can be assured for Indian oil sardine stored under vacuum at 3°C whereas more than 20 days for fish in combination with vacuum and leaves. The study conclusively indicates that development of value-added fish products from Indian oil sardine play an important role in improving the utilization of this fish in a more beneficial manner and also the possibility of utilizing *Garcinia gummigutta* in preventing free radical related diseases and to the current growing pharmaceutical and food industries.
Validation of multiplex PCR protocol for the identification of *Escherichia coli* O157 by spiking in seafood

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Increasing human demands for food, pharmaceutical, cosmetics and others products have imposed higher demand on agar production. In 2016, the world total agar production is 15,406 tonnes where India’s contribution estimated to be 300-400 tonnes. Agar production practices generate a large amount of by-product which is rich in organic and inorganic matters. In the present study, an attempt has been made to assess the changes in protein fraction during agar extraction. The red seaweed *Gelidiella acerosa* was collected from Agar processing industry, Madurai, Tamil Nadu, India. The agar extraction was carried out using 10% acetic acid and sodium hydroxide according to the method of Gunasekera (1963), separately with slight modification. In brief, the process followed the steps like soaking, boiling, filtering, freezing-thawing, bleaching and drying. The initial raw material and industrial waste were analyzed for proximate composition including moisture, protein, fat, ash and fibre (AOAC, 2006). The raw material found to have 14.73% moisture, 17.67% protein, 1% fat, 22.30% ash and 20.22% fibre on dry weight basis. The protein lost was found to be more in solid waste obtained at the end of agar processing in both acid and alkali process. The by-product of agar had 8.28% of protein, 30.23% of fiber and 24% of ash. It is concluded that the solid by-product generated from the agar processing industry has to be valorised for human as well as animal usage as a source of protein.
Changes in protein during agar processing from seaweed (*Gelidiella acerosa*): a comparison between acid and alkali method of agar extraction

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Increasing human demands for food, pharmaceutical, cosmetics and others products have imposed higher demand on agar production. In 2016, the world total agar production is 15,406 tonnes where India’s contribution estimated to be 300-400 tonnes. Agar production practices generate a large amount of by-product which is rich in organic and inorganic matters. In the present study, an attempt has been made to assess the changes in protein fraction during agar extraction. The red seaweed *Gelidiella acerosa* was collected from Agar processing industry, Madurai, Tamil Nadu, India. The agar extraction was carried out using 10% acetic acid and sodium hydroxide according to the method of Gunasekera (1963), separately with slight modification. In brief, the process followed the steps like soaking, boiling, filtering, freezing-thawing, bleaching and drying. The initial raw material and industrial waste were analyzed for proximate composition including moisture, protein, fat, ash and fibre (AOAC, 2006). The raw material found to have 14.73% moisture, 17.67% protein, 1% fat, 22.30% ash and 20.22% fibre on dry weight basis. The protein lost was found to be more in solid waste obtained at the end of agar processing in both acid and alkali process. The by-product of agar had 8.28% of protein, 30.23% of fiber and 24% of ash. It is concluded that the solid by-product generated from the agar processing industry has to be valorised for human as well as animal usage as a source of protein.
**APT-PO-18**

**Proximate body composition of commercial barbs of Malankara Reservoir, Kerala**

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The proximate composition of three small indigenous fish species namely *Dawkinsia filamentosa*, *Puntius mahecola* and *Systomus sarana* were analyzed to evaluate their nutritive value. The fresh fish samples were collected during period of August to October, 2019 and major nutrient composition was estimated using standard method AOAC, 2006. The moisture content was estimated in *P. mahecola* (76.62 ± 0.763%), *D. filamentosa* (73.505 ± 1.607%) and *S. sarana* (78.44%) respectively. Fat content was recorded as 2.65±0.75% in *P. mahecola*, 4.05± 0.374% in *D. filamentosa* and 4.01% in *S. sarana*. Likewise, ash content varied from 2.16% (S. sarana) to 2.64±0.247% (D. filamentosa). Protein content was estimated as (12.37±1.294)% in *P. mahecola* and (9.24±0.520)% in *D. filamentosa* whereas fibre content was ranged from 5.55±1.49% (*D. filamentosa*) to 4.335±0.813% (*P. mahecola*). The present findings revealed that protein content was highest in *P. mahecola* followed by *S. sarana* and *D. filamentosa*. Present study results indicated that these small indigenous fish species are playing important role by safeguarding both nutritional and livelihood security of population, additionally the pioneer reference to the proximate analysis of commercial barbs species from Malankara reservoir is provided.

**APT-PO-19**

**Evaluation of antibacterial potential of marine sponge *Fasciospongia* spp. against fish pathogens**

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The marine environment is the vital resource for pharmacologically active natural compounds. The importance of antimicrobial resistance led to the development of new antimicrobial compounds from various source especially from the marine sources. This work was designed to investigate the antibacterial activity of marine sponge *Fasciospongia* spp. Four different sponge extracts- methanol, ethyl acetate, chloroform and hexane were used for the study. Antibacterial activity was evaluated by well diffusion method, minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) assays against three fish pathogens (*Citrobacter freundii*, *Aeromonas hydrophila* and *Vibrio parahaemolyticus*). Methanolic extract of the sponge showed potent antibacterial against fish pathogens. The findings of this work suggest that marine sponges are huge reservoir of many bioactive compounds that can be exploited in pharmaceutical industry for the further development of potential drugs.
Effect of different storage conditions on viability of *Acartia tropica* eggs

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Copepods of genus *Acartia* are considered as efficient live feeds for marine fish larviculture and their egg storage for different periods with successful results has been reported in many temperate *Acartia* spp.. The present study evaluated the egg storage potential of tropical calanoid copepod, *A. tropica*. The different storage conditions used were high salinity storage (50-200ppt) at room temperature, Cold storage (4ºC) at different salinities (15-200ppt), cryoprotectant solutions (methanol, glycerol) and antibiotic solutions (kanamycin, oxytetracyclin). Results showed that high salinity (50-200ppt) storage did not have any effect on retaining egg viability under cold storage as well as room temperature conditions. Whereas eggs exposed to cold storage and lower salinities (15-40ppt) survived after 24h with highest egg hatching success recorded at 15ppt (69.44±4.69) followed by 30ppt (50.62±3.75) and 40ppt (30.41±2.77). No egg hatching was recorded after 48h storage. However addition of cryoprotectants and antibiotics to the storage media significantly improved the survival of *A. tropica* eggs. After 48h storage, highest egg hatching success was recorded at 100ppm kanamycin treatment (50.2±3.07) which was not significantly different from 50ppm kanamycin (46.94±4.89) and 1M glycerol treatments (49.46±2). But any of these conditions could not extend the egg viability beyond 48h storage. Hence the present study suggests that *A. tropica* eggs do not have long term storage potential and it recommends cold storage of *A. tropica* eggs in 15ppt salinity seawater and incorporation.
APT-PO-21

Effect of seaweed based bioactive edible coating on fish proteins and lipids during freezing and frozen storage

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A coating solution containing hydroethanolic extract of brown seaweed, Padina tetrastromatica as bioactive component (1.01%) and sodium alginate (2.02%) as matrix component was formulated using Response surface methodology and its preservative effect was evaluated. The fresh seer fish steaks (Scomberomorus guttatus) were given three treatments, namely coating before freezing (T1), coating after freezing (T2) and water glaze (C) and were frozen and stored at -20°C. The cryoprotective effect of edible coating on myofibrillar protein stability was measured in terms of drip loss, protein solubility, SDS- PAGE and microscopic imaging of muscle. T1 steaks exhibited a meagre amount of drip loss (4.35%), significantly (p≤ 0.05) lower expressible moisture and a higher solubility (71.51±1.00 %) compared to C and T2. The dense bands obtained in SDS PAGE with higher band intensity/mm2 showed resistance to denaturation and aggregation of myosin heavy chain in T1 compared to control and T2. TBARS value for both control and T2 crossed the limit of acceptability on the fifth month of storage itself, however, in T1 group; the value remained limit of 2 mg MDA/ Kg till the end of storage. A significant increase in b* in C and T2 indicated a shift in the flesh colour towards yellow due to rancidity. T1 exhibited an additional shelf life of three months in comparison to the control possibly due to the oxygen barrier mechanism of alginate coating and radical scavenging capacity of seaweed phenolic. Thus, the bioactive coating reduced the oxidation of lipids and proteins during frozen storage.
Potential of spices for value added sea food preparations

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Spices have been used since ancient times for their flavoring, coloring, especially as preservative and have wide applications both in the traditional food preparations and in the food industry. Spices have exhibited numerous health benefits in preventing and treating a wide variety of diseases such as cancer, aging, metabolic, neurological, cardiovascular, and inflammatory diseases. Spices play an important role in preventing food spoilage by exhibiting strong antioxidant property of scavenging free radicals, chelating transition metals, quenching of singlet oxygen, and enhancing the activities of antioxidant enzymes. Many spices—such as clove, oregano, thyme, cinnamon, and cumin—possess significant antibacterial and antifungal activities against food spoilage bacteria like *Bacillus subtilis* and *Pseudomonas fluorescens*, pathogens like *Staphylococcus aureus* and *Vibrio parahaemolyticus*, harmful fungi like *Aspergillus flavus*, even antibiotic resistant microorganisms such as methicillin resistant *Staphylococcus aureus*. Therefore, spices have a great potential to be developed as new and safe antimicrobial agents. The potential of spices in value addition of fish based products is extensive and presently Indian cuisine uses spices in all fish based preparation. There is also a potential possibility of entrepreneurship development for newer product development using spices for many sea food products.
Ocean Processes & Environmental Impact (OPE)
Seasonal variation of core sediment biogeochemistry in the selected mangrove regions of West Bengal and Kerala

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Sediments of mangrove ecosystem is a blue carbon resource in the form of geochemical composition, which is essential in influencing the climate change globally by sequestering carbon dioxide from the atmosphere and oceans at significantly high rates, per unit area than terrestrial forests. When these coastal ecosystems are degraded or converted to other land uses, these large stores of blue carbon resources are exposed and released as CO₂ into the atmosphere leading to green-house effect and hence, global warming (2-6% of degradation of coastal ecosystems generates 3-19% of carbon emissions). Thus, characterization of labile organic compounds (LOC) from mangrove surface and core sediments will help in source characterization of organic carbon compounds sequestration capacity of mangroves as a blue carbon resource. A case study in mangrove sediments in West Bengal and Kerala have been carried out in pre-monsoon, monsoon and post-monsoon seasons which reveals the changes in composition of various biogeochemical compounds (LOC) with respect to seasons. The relative distribution of labile organic compounds (LOC in mg/g) on an average in mangrove sediments in West Bengal and Kerala during pre-monsoon, the order is: total tannin and lignin (TT&L) (7.21;±4.60) > carbohydrate (CHO) (2.41;±1.91 ) > lipids (LPD) (0.79;±0.46) > proteins (PRT) (0.44;±0.25); in monsoon: TT&L (9.69;±6.05) > CHO (2.12;±1.73) > PRT (1.82;±2.80) > LPD (1.06;±0.72); and in post-monsoon: TT&L (8.92;±7.83) > CHO (2.91;±1.61) > LPD (0.54;±0.40) > PRT (0.35;±0.43). The selected areas are continuously degrading and emitting considerable fraction of free CO₂ and other GHGs in atmosphere, thus, leading mother earth to stress condition due to increase in the adverse effect of global warming.
Role of meteorological factors on the ocean bio-productivity in the coastal waters of Arabian Sea during the Indian summer monsoon

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During the Indian summer monsoon season, along shore wind prevails in the Arabian Sea (AS). It gives rise to Ekman mass transport away from the coast producing coastal upwelling. Upwelling causes transport of subsurface nutrient rich water to occupy the surface. In this study, meteorological factors responsible for high bio-productivity in the AS basin in general and coastal regions of Somalia (West), Oman (North) and Kerala (East) are brought out. Daily values of along shore wind, Ekman mass transport, wind stress curl and Ekman pumping are evaluated utilizing NCEP and QuikSCAT wind and OLR to assess the upwelling processes. The along shore wind in the coastal waters of Somalia and Oman is strong in monsoon season as indicated in the high chlorophyl-\(a\) concentration. Wind induced circulation features are favourable for upwelling in the AS away from the coast. Wind stress curl and subsequent Ekman pumping are examined to understand the upwelling features. Maximum upwelling is found in the northwest Arabian Sea. Further, coastal upwelling features in the Kerala coast is closely associated with the monsoon organised convection. When it locates near the equatorial region (break monsoon situation) the prominent wind in the southwest coast of India orients parallel to the coast causing high Ekman mass transport. Strong along shore wind triggers the coastal upwelling. Along shore wind and Ekman mass transport play vital role in the coastal upwelling whereas wind stress curl and Ekman pumping due to large scale circulation in the AS cause upwelling away from the coast.
Bathymetric steering induced sea surface cooling and the enhancement of biological productivity off the southwest coast of India

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Off the southwest coast of India, the distribution of observed sea surface temperature (SST) during the Indian summer monsoon season (June–September) shows the presence of a distinct cold pool (SST<27°C), located within the grid 8° N–10° N/74° E–76° E, with a diameter of about ~200 km, centred approximately at 9° N/75° E. This cold pool, forms during the end of June as a small cooling within the cold surface waters advected northward along the southwest coast of India. With the progress of the season the cooling intensifies, spread radially outwards and shows a westward spread during late July. Maximum intensity and radial spread are attained during July. By the end of August, the pool extends northward along the coast up to 13° N, and by September, it gets completely annihilated with the advection of southwest monsoon current. The intensity, duration, and spread of the pool showed annual variations in each summer monsoon and owes its origin to the upwelling induced through Taylor columns triggered by the interaction of elevated bathymetry (mounts) and the poleward undercurrent existing along the continental slope in the region during the period. During the formation of the pool the Chlorophyll-a (Chl-a) in the region is enhanced. This enhancement begins during the late June, intensifies during July to August and declines in September. During July the spatial spread forms as a westward surface bulge in surface Chl-a concentration and extends well offshore up to 74°E. The detailed estimation of the Chl-a concentration and SST shows an increase from June to July with a maximum of 1.8 mgcm⁻³ in July and a SST maximum of 28°C. The observations suggests that the upwelling associated with the cold pool induces the enhancement in Chl-a concentration and thereby the enhancement in biological productivity.
Nanobiocides as antifouling agent in aquaculture cage nets: bioaccumulation and toxicity studies in *Oreochromis mossambicus*

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Currently cage aquaculture is gaining more attention all around the world due to increasing consumption and declining stock of capture fishes. In cage aquaculture, biofouling is one of the major threats and causes huge economic loss and about 25% of the budget is being utilised only for the maintenance of cages. To overcome biofouling, several methods were developed by researchers and one of the effective methods is polyethylene webbings treated with nano copper oxide (0.02%) and polyaniline. Studies showed that this composite had a significant potential to reduce the biofouling on polyethylene nets in aquatic environment. In contrast, in the case of this composite its fate in the aquatic environment and organisms has not yet been evaluated. *Oreochromis mossambicus* was exposed to different concentrations (200, 30, 15, 7.5, 3.75, 1.5 mg/l) of nano copper oxide for a period of 21 days. During the study, it was found that dissolution of nano copper oxide is influenced by pH (pH below 4) in varying salinity. Bioaccumulation of nanocopperoxide in fish was maximum in the gut, which is primarily due to the consumption of flocculated nano particles in water even in alkaline pH. But the rate of accumulation of copper was much below the standard permissible limit in fish body parts (muscle, gill, brain, gut). This baseline study will be useful for the formulation of new antifouling composites for commercialisation, which may pave a way to prevent biofouling in aquatic environment, especially in cage nets.
In the present study, we demonstrate the sea surface thermal frontal analysis based on sea surface temperature gradient data for the southwest coast of India at seasonal cycles along with chlorophyll variability. Thermal fronts are regions of high horizontal sea surface temperature gradients. These thermal fronts can be detected from the SST data using edge detection algorithm. An edge detection algorithm is gradient based approach. Thus, to find out suitable SST gradient for the study region, a sensitivity analysis is carried out with different SST gradient values starting from $0.1^\circ C$ to $0.6^\circ C$/pixel for thermal fronts detection for different seasons. Daily SST data during 2014-2017 are downloaded and processed to detect thermal fronts and categorized according to summer monsoon (June-September), winter monsoon (October –January) and pre-monsoon (February –march) condition. The seasonal climatological mean, annual amplitude and semi-annual amplitude is calculated from the intensity of gradients data using least square harmonic method. The distribution and variability of thermal fronts depends on spatial variability in air-sea interaction and ocean dynamics. Since these mesoscale features are highly associated with enhanced chlorophyll-a values. Chlorophyll-a data is also downloaded for same time period and seasonal climatological mean, annual amplitude and semi-annual amplitude is computed for chlorophyll data. Both seasonal distributions have been analyzed together to identify the high amplitude regions and understand about their coherent relationship. The outcome of study can help us to demarcate the areas of high productive region in Southwest coast of India.
Hydroacoustic surveys were conducted at Krishnarajasagar reservoir, Mandya District, Karnataka using a portable Simrad EY60, split beam echo sounder with a frequency of 120 kHz. The transducer converts electrical energy to acoustical energy and then acoustical energy returned from objects in the water (echoes) back into electrical energy. By using a directional acoustic beam, conical in shape, acoustic surveys and depth profiling was done in lotic, intermediate and lentic zones of the reservoir. The fish concentration was found to be more in the lotic zone followed by intermediate and lentic zone. The acoustic survey recorded a greater number of fishes in transect selected near the cage culture site than any other transect selected in the reservoir. The Biomass analysis in each transect was done using Sonar X software. Fish biomass in the reservoir varied from 70 kg/ha to 820 kg/ha. Integration of acoustics transducers will advance the development of ecosystem approaches in resource conservation and management without affecting the fishes. This capability to acoustically survey, discriminate, track and estimate biomass in reservoirs will help in ecosystem-based fisheries management.
Wave characteristics of Kozhikode region, southwest coast of India during the passage of cyclone, Nilofar

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Ocean State Forecasts and its quality for a region are primarily dependent on the forcing mechanisms including cyclones, which is responsible for the high sea state conditions. The present study is focused on understanding the ocean state parameters such as (Significant wave height, Peak wave direction and wave period) particularly off Puthiyappa, Kozhikode, North Kerala coast during the Pre-cyclonic, Cyclonic and Post-Cyclonic periods of Nilofar cyclone for the month of October 2014. The analysis is performed on the wave rider Buoy data deployed by INCOIS at Puthiyappa harbour region at a depth of 22m (Latitude 11°1.575 N and longitude of 75°41.037 E), on the south west coast of India. Wavelet analysis is conducted for analyzing localized variations of power within a time series (Spectrum) of the buoy data. During the Pre-cyclonic and cyclonic period wavelet spectrum shows a good peak over a period of 16 seconds corresponding over the time and also the time series analysis for significant wave height with high significance of 0.5m to 0.75m, and also for 0.5 to 1.4m respectively. During the post cyclonic period wavelet spectrum shows weak projections when compared with Pre-cyclonic and Cyclonic over the time with significance of 0.6 to 1.1m. The wave characteristics were also analysed from wave rose for the available speed and direction during pre, post and during the passage of cyclone. During the Pre-cyclonic period 90% of the waves were approaching the coast between 215°-220°(south-westerly) whereas only 30% of the waves were approaching between 210°-225° (south-westerly). During the cyclonic period only 50% of the waves were approaching the coast between 210°-220°(south-westerly) whereas 30% of the waves were approaching the coast between 210°-255° (west of south-westerly) and during post cyclonic period the 30% of the waves were approaching the coast between 250°-255° (westerly), mostly swell waves. From the analysis we conclude that during the passage of cyclone the directionality of the waves approaching the coast were from a wide angle that can accentuate coastal erosion along this coast line as compared to the pre and post cyclonic periods.
OPE-OR-08

Synthesis and characterization of silver nano particles using mangrove humic acids and the role as catalyst in the degradation of organic dyes

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The present study focused on the synthesis of silver nano particles and the consequent formation of self-assembled humic-silver supra molecules. The silver nano particles (AgNPs) with higher stability were prepared in a completely green and cost-effective manner using aqueous extract of humic acids synthesized by using standard procedure IHSS 2010. The humic acid was extracted from mangrove sediments collected from Mangalavanam and Valapattanam during the year February 2018. Silver nano particles was synthesized by reduction of silver nitrate in the presence of humic acids (HA) which acted as capping agents. The characterization carried out by FT-IR, UV-Visible spectroscopy and HR-TEM. The high crystallinity of the biogenic AgNPs was confirmed from clear lattice fringes in the HR-TEM image, bright circular spots in the SAED pattern and tuning of dipole and quadrapole oscillation (silver nano particles size of 5 nm). The study also highlights the spectroscopic investigation on the catalytic efficacy of the biosynthesized AgNPs in the reduction reactions of hazardous organic dyes Congo red using sodium borohydride, which followed pseudo-first order kinetics.

OPE-OR-09

Contributary role of tides and sea level in prolonging the flood inundation period

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Floods are natural hazards usually accompanying heavy rainfall and high tide events. In this background, we analyze the role of heavy rain fall, tide and sea level rise in the recent floods occurred in Kerala during August 2018 and October 2019. Excess rain fall was recorded in the Kerala during June to August 2018 which was about 42% above normal. South and central sector of Vembanad Lake received a cumulative volume of 1.447 BCM flood water through the combined run off from 5 rivers during 15 to 17th August’18 as against the potential discharge volume from lake to Arabian Sea of 0.54 BCM. At the maximum volume discharge capacity (0.18BCM/day), the surplus water of 0.907 BCM would have been flushed out within 5 days. Instead the flood conditions persisted for 23 days making it a severe flood situation, unlike the October 2019 floods which receded in one day. Analysis of the August 2018 tide data from Kochi shows abnormally high MSL (10cm), much reduced tidal amplitude and flood dominant patterns in neap-tide phase coinciding with the flood period. This might have reduced the discharge rate to the sea and contributed to the persistence of the flood conditions for a considerably longer time.
Degree of chaos in surface-subsurface chlorophyll interlinkages in the North Eastern Arabian Sea (NEAS) during Spring Inter-Monsoon

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Subsurface Chlorophyll Maxima (SCM) are a ubiquitous feature of the ocean and it is strong (>1.2mg/m³) in the North Eastern Arabian Sea (NEAS) during Spring Inter-Monsoon (SIM). A numerical expression for the SCM (Chloromax) based on the regulatory role of water mass characteristics (regional density/stratification) has been developed. The present analysis explain the inter linkages between surface Chlorophyll (Chl-a) and SCM-chl-a derived from Chloromax for the 17 years from 2003 to 2019 for February and March. The degree of chaos in the association needs to be addressed, and the same is explained in the changing scenario of climate. The major processes considered to address the complexity in the regional ecosystem processes are mesoscale eddies and the process of convective mixing. Clear trend of warming and strengthening in Chl and SCM, enhanced stratification, altered duration and pattern of northeasterly winds were the major observations reflected in the analysis. The possible strengthening in primary production both at surface and SCM results in an altered production pattern which will be having cascading effect in the food web dynamics and production potential at the higher trophic levels. The temporal analysis on the Surface Chl-a, SCM Chl-a, SST, SSHA, Wind magnitude and direction and BioArgo profiles were attempted for the spatial domain of 60-70E 15-24N for the period 2003 to 2019 for February and March. The analysis also addresses Okubo-Weiss parameters, Empirical Orthogonal Teleconnections (EOT) and Granger causality (GC) analysis for explaining the threshold values and interlinkages.
Microplastics in Shrimps: a case study of Mumbai waters

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Plastic have wide applications in human life which is used in packaging industries, automobiles, cosmetic products, textile and clothing industries, agriculture and fisheries sectors etc. Globally, production of plastic products has increased from 1.5 million tons in 1950s to more than 335 million tons in 2016. It is reaching to sea in huge quantity through various sources; as a result, it has become a serious global concern due to its slow degradation. Further, microplastics are particles with a size lower than 5 mm and the aquatic animals, particularly fish and shellfish are susceptible to ingesting microplastics due to their attractive coloration and buoyancy that resembles to their food items. This issue is attracting global scientific concern due to their presence in gut and tissues of fishes and shrimps. Mumbai coast, is one of the most polluted coastlines in terms of plastic litters. Major sources for the plastics in the coastal water are sewage, recreational, religious and fishing activities. In this study, Shrimp samples were collected from different locations of Mumbai waters, by experimental fishing. The ingested microplastics were found to be dominantly fibres and fragments. Size and colour wise dominated by <250 µm and black colour respectively. In order to restrict the use of plastic items and to regulate the sources of plastic pollution, introduction of certain essential policies is required. The sustainability of ocean is dependent on the scientific management of plastics that are entering in marine ecosystems.
Studies on the bioaccumulation of microplastics in bivalves of urban beaches of Mumbai

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Plastic is a highly versatile, multi-utility substance which is used throughout the world and it became unavoidable in day to day life. These plastics are susceptible to disintegration into smaller particles and those particles of size less than 5 mm are termed as micro-plastics (MPs). These are ubiquitous in marine environment. Many aquatic organisms, including zooplankton, invertebrates, fish, bivalves, incidentally consume MPs from sediment or the water column, mistaking them as food and then biomagnified to animals at higher tropic levels which in turn feed on them. Among these organisms' bivalves are excellent filter feeders and approximately filter 24 liters per day and accumulate these micro-plastics in their gut and tissues and thus can be used as bio indicators for plastic pollution status of that region. Microplastics related observations, highlighting its implications to bivalves, are available globally, but in Indian context only very few studies have been conducted so far. In present investigation, most polluted urban beaches like Juhu, Bandra and Navi Mumbai industrial areas of Mumbai city with a population of 1.3 crores were selected and bivalve samples were collected. Chemical digestion and visual identification of bivalve tissues under microscope reveals lot of micro-plastic fibers and fragments of varying colors (red, black, transparent) and sizes (20-300 microns) indicating the extent of anthropogenic pollution in Mumbai beaches. The presence of microplastics in seafood pose a threat to sea food safety. This study implies the plastic pollution status of Mumbai and can guide the policymakers in framing rules for sustainable plastic usage.
Macroplastic load in the bottom sediments of the southern sector of Vembanad Lake

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The 76.5 km² southern sector of Vembanad Lake extends from Alappuzha in the south to Thannermukkom bundh in the north. Macroplastic load in the top two-meter sediments of this sector was quantified through swept area method using dredge and bottom trawl survey results from 24 representative stations. The total load of macroplastics in this sector is estimated as 4276 tons @ 55.89 ton/km² area. The floating and slow settling light macroplastics such as plastic sheets, plastic covers, carry bags, food packets etc. accounted for 615 tons @ 8.04 ton/km². Fast sinking heavy macroplastics such as fishing gear material, plastic chappels, rexin sheets etc. accounted for 3661 tons @ 47.85 ton/km² area. In general the macroplastic load in the bottom sediments was much higher along the relatively deep and fast flowing western segment of the lake, as compared to the shallow eastern segment where the flow velocity is weak.
OPE-PO-04

Isolation of tannins from the bark of mangrove plant *Rhizophora Mucronata* and evaluation of its antibacterial activity

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*Rhizophora mucronata* have been recognized as one of the most traditionally used mangrove species. In the present study, bark of the mangrove plant *Rhizophora mucronata* was used for the extraction of natural products. Bark of the mangrove plant was dried and extracted with ethanol, and then fatty components were removed using hexane. Then the extract was made basic by the addition of ammonia, which resulted in the formation of red precipitate. The precipitate was separated and analysed for various chemical reactions. The solubility of the precipitate was found to be very low in organic solvents such as hexane, ethyl acetate and chloroform and the solubility was comparatively higher in polar solvents such as methanol, ethanol and acetone. Chemical identification test such as reaction with ferric chloride solution and vanillin-HCl test were carried out. FT-IR spectroscopy was also used for the identification of the compound. From the solubility, chemical reactions and FT-IR spectrum the substance is identified as tannins. The antibacterial activity of the isolated tannin was also investigated against 4 strains (*Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*) using agar disc diffusion technique. Inhibition was slightly higher for *Escherichia coli* and *Klebsiella pneumonia*, but no inhibition was noticed for *Pseudomonas aeruginosa* strain.

OPE-PO-05

An exploration of noise mitigation techniques for superior pre-processing of image

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Underwater environment and the images taken in them are susceptible to many issues relating to the turbidity, poor visibility, scattering, blurring etc. It is always a concern to get underwater images with good quality, but with the advancement in Computer vision the computational difficulty of getting a smooth, clear, blur-free and high-quality image is reduced to a greater extent. Filtering techniques improves the visual quality and also gives us more information embedded in the image. Basically, there are four major filters low pass, high pass, band pass and band stop filter. All other filters are derived from these basic filters. This paper does a thorough investigation on different techniques of refining image for better pre-processing, color correction, image enhancement, contrast stretching, haze removal etc so that we get a distortion free image. Author after comparing the existing filtering techniques suggests the best method suitable for specific environment.
Ingestion of microplastics by brown mussel, *Perna perna* (Linnaeus, 1758)

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Marine organisms are vulnerable to microplastics pollution as these minute pollutants are bioavailable for ingestion. Filter feeders are more susceptible to microplastic ingestion due to their mode of feeding. The brown mussel *Perna perna* from the coasts of Kovalam in Kerala had been inspected for the evidence of the ingestion of microplastics in the wild as well as in the captive condition. The fate of microplastics in the digestive tract was also tracked by examining the faeces and pseudofaeces. The brown mussel was found to be contaminated with the presence of foreign particles. The microplastic particles ingested were characterized by Fourier transform infrared (FT-IR) spectroscopy as polypropylene and hence confirmed the exposure of organisms to the microplastics in the wild. To exclude the possibility of adhesion of microplastics to the tissue, mussels were fed with orange fluorescent polystyrene beads of 10micron size along with algal feed at a concentration of 200 particles per L and 600 particles per L. Feeding behavior of the animal was observed and substantial reduction in algal clearance rate after the exposure to microplastics proved the ingestion of the same. Accumulation and retention of microplastics in the digestive system of mussels were prevented by defense mechanisms such as egestion through faeces and pseudofaeces. Depuration was effective in eliminating the accumulated microplastics from the digestive tract. Retention of a few particles in the tissue even after 5 days of depuration, possibly indicating the threat of trophic transfer.
Coastal vulnerability analysis along Thiruvananthapuram coastline using remote sensing and GIS

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Thiruvananthapuram is one of the coastal districts of Kerala having a Coastline of 78 km. The total land area includes 214 km2 (83 sq mi). On geological basis we can see the area transforms from coastal area to hilly Western Ghats. Thiruvananthapuram is roughly divided into three climatically distinct regions. These include the eastern highlands (rugged and cool mountainous terrain), the central midlands (rolling hills), and the western lowlands (coastal plains). An attempt is made to estimate the relative vulnerability of any of the area is done by conducting coastal vulnerability analysis by calculating coastal vulnerability index. Remote sensing and GIS techniques are used to calculate coastal vulnerability index. CVI is an index that expresses the relative vulnerability of the coast to physical changes due to future sea-level rise. It highlights areas where the various effects of sea-level rise may be the greatest. Once each section of coastline is assigned a vulnerability value. The calculated CVI value is divided into quartile ranges to highlight different vulnerabilities within the area of interest. The purpose of this study is to determine the physical coastal vulnerability index using satellite imagery and GIS in coastal areas of Trivandrum. Such information is indispensable in order to anticipate and reduce the impact of environmental degradation and to be used as a reference in determining the vulnerable areas and invulnerable areas to natural physical factors.
Mangroves as natural defences against natural disasters

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The 2018 Kerala floods wreaked havoc throughout the state. While excess rainfall triggered the flood event, another factor which exacerbated the extent of the damage was related to the storage capacity of Vembanad Lake, which receives discharges from five rivers. The rapid conversion of the most precious wetlands for agriculture, urbanization and human settlements and the conversion of natural shorelines of estuaries by human factors and the sand mining carried out in the in-flowing rivers made the Vembanad region shallower. The carrying capacity of a wetland plays a significant role in controlling the severity of inundation caused by the monsoon river flows. When the floodwaters gushed downstream, the reduced water holding capacity of the Lake due to the anthropogenic encroachment of the natural ecosystem proved to be fatal. This turn of events reminds us of the depleting green cover in our State. Mangrove forests act as a filter trapping suspended mud and sand carried by rivers which leads to delta formations around estuaries. The restoration of mangroves, which is an important ecosystem, in terms of economic benefits, wave attenuation capability, storing carbon, protecting the shoreline, combating climate change, is the need of the hour. This paper presents the results of a study carried out to analyse the wave characteristics in terms of wave attenuation with and without the presence of mangrove forest using SWAN model in specific regions of the Vembanad Lake.
Weathering of plastic: an overview of physical, chemical and biological implications of its transformation in marine environment

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Microplastics are small fragments of plastic debris that have accumulated in the environment on a global scale. They represent a heterogeneous mixture of particles ranging in size from a few microns to several millimeters in diameter. Small microplastic particles can be formed by the weathering of plastics which may also cause for the release of chemical additives and production of nanoparticles. Weathering of plastics can be chemical, physical and biological with respect to different environmental conditions such as prolonged exposure to UV radiation, variation in temperature, salinity, microbial degradation, biofilm formation etc. It has been found that microplastics are ingested by zooplanktons, fish as well as several other higher level aquatic species and bio-accumulates in the food chain. There is a large uncertainty about the weathering of plastic in marine environment because most of the studies in microplastic are focused on surface water, shore lines and sub tidal sediments. There is lack of scientific data on experimental studies regarding the weathering of plastic at environmentally realistic concentrations and in combination with the mixture of organisms and sediment in aquatic environmental conditions. The present paper reviews the physical and chemical processes involved in the weathering of plastic particles over time including morphology, size and their degradation products in the marine environment. Information on the process is important in assessing its influence to the marine biodata especially unicellular algae and zooplankton, as they form the base of marine food web.
OPE–PO-10

Underwater Safety

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At present the underwater divers use communication modules which are being directly connected to data processing system through cables. This causes disadvantage in mobility for the divers. Our work proposes a wearable type of communication structure. The major challenges facing for wearable structures are the need for small, lightweight and power efficient models. By this we can propose a real time underwater monitoring system to avert natural disasters like cyclone ockhi. The human body parameters of the divers such as hear beat, body temperature etc will give us information about the diver’s survival. This proposal provides an innovative solution for the safety of underwater divers.

OPE–PO-11

An attempt to integrate environment and dol net fish catch of Maharashtra coast using GAM analysis

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Dol nets are conical, passive, non-selective traditional gears with rectangular mouth and tapering cod-end operated in areas of strong tidal currents along the coast of Maharashtra and Gujarat. An in-situ study was carried out to understand the influence of environmental variables on dol net catch of Maharashtra coast from 2016 to 2018. Sixteen major environmental variables viz., temperature, salinity, pH, DO, BOD, current speed, turbidity, TSS, ammonia, phosphate, nitrate, nitrite, silicate, chlorophyll-a, phytoplankton and zooplankton densities were analyzed together with dol net catch data to investigate the relation between catch and environmental conditions. A total of 156 species belonging to 63 families were recorded in the catch with an annual average catch rate of 45.75 kg/haul. Using GAM analysis, catch data of targeted species and the studied environmental parameters were integrated to understand the influence of environmental parameters on catch composition. The results showed that each target species has different sets of preferred environmental parameters with varying weightages. Among the studied environmental parameters; current speed, salinity, temperature, turbidity and plankton density showed more influence on the catch of major resources with significant F values. Deviance explained in the final model varied from 41.3% (penaeids) to 86.7% (H. nehereus). The plot of the best smoothing showed the range of most decisive environmental variables, where the probability of abundance of the target species is maximum. The information from the study could be used as baseline data for framing management measures for a sustainable dol net fishery along Maharashtra Coast.
Ergonomics on intelligent underwater communication

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There has been a growing demand for high speed wireless communication links for underwater applications, which include: oceanographic data collection which will require data exchange between underwater sensors. Underwater Wireless Sensor Networks (WSN) uses sensors to monitor environmental or physical phenomena in order to cooperatively collect the data through the network of sensors to a shore access point. WSN’s are deployed in unconventional environments for data collection which are stationed underwater, in order to monitor soil or sea properties respectively and then transmit the data. There are three established technologies through which underwater communications have been considered, they are; acoustics and ultrasonic signals, optical signals, and Electromagnetic (EM) signals. Each of these technologies has its merits and demerits in their usage for underwater communications. Acoustic technologies which are suitable for long range communications (in the order of several km), has several demerits which also includes potential impact on marine life. Similar is the case with Optical and RF systems. Hence for the development of a sensor network with high data transmission, better understanding of these technologies are inevitable. This paper provides a detailed evaluation of the performance of these three technologies, along with the focus on its merits and limitations under water are discussed.
Diversity, distribution and substrate specificity of fouling molluscs in the Cochin backwaters

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Biofouling, the attachment and subsequent growth of a community of visible plants and animals on structures and vessels exposed to water, is one of the key deterioration processes that affect all stationary and moving engineered structures irrespective of the nature and type of material employed. A study was carried out to analyze the diversity of fouling molluscs in the Cochin backwaters to understand its seasonal distribution and to investigate the physicochemical factors facilitating fouling with emphasis to their substrate specificity. Results showed that predominance of seven species of molluscan biofoulers in the region. Among them, the invasive mussel Mytella strigata was profoundly found in some of the stations. Shannon’s diversity index \(H'(\log 2)\) for the stations varied from 0.67 – 0.85. Better values for Shannon diversity and Margelef species richness (d) was seen in Vypin. While the Simpsons diversity index (1-Lambda) and Pielou’s evenness index (J’) was highest for Puduvype. Results of MDS plot clearly defined the variation in the species assemblage molluscan foulers during different seasons. While comparing the stations, Station 4 showed a marked difference in the molluscan diversity compared to the other four stations. While comparing the substrate specificity of these biofoulers it was seen that fouling communities is highest on substrates which are physically and biologically inert; substrates like wood, plastic and rock shows highest fouling diversity. Substrates like coir, tyre and concrete showed least fouling diversity. The present study, therefore, provides benchmark data on the fouling molluscs diversity of Cochin backwater.
The use of *Oryza sativa* in sediment toxicity test of the River Periyar  
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A survey on sediment toxicity data shows that vascular plants have rarely been used in sediment toxicity tests. The present study reports sediment toxicity test – a scenario which is hardly observed in sediment risk assessments from the Indian subcontinent. Whole sediment bioassay with *Oryza sativa* (var. Jyothi) was performed on sediment samples collected from the lower reaches of the river Periyar – Manappuram (S1), Binanipuram (S2), and Kuzhikkandam Thodu (S3) – from monsoon to pre-monsoon during 2013 - 14. Physicochemical analyses showed that S2 and S3 were characterised by significantly higher pH and electrical conductivity (EC). S3 demonstrated significantly higher total organic carbon (TOC) and lower oxidation reduction potential (ORP). Significantly lower values for total ammonia nitrogen (TAN) and TOC were observed at S2. A significant growth reduction was observed for root, shoot, and seedling at S2 and S3 (Eloor-Edayar industrial belt) compared to S1 indicating the pollution. EC at S3 was the only variable which showed a strong negative correlation with the toxicity, indicating dissolved solids as toxicants. Further bioassay with a salinity tolerant rice variety ruled out salinity as the toxicant at S2 and S3, which stresses the involvement of factors other than salinity in sediment toxicity. The results call for further investigations in this regard. The study signifies the integration of toxicity tests with the traditional chemistry-based risk assessment practice. This is the first study of its kind from this region. It also demonstrates that *O. sativa* can be used as a valuable risk assessment tool.

**Screening of plastic degrading microorganism isolated from different environmental sources**

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Plastics are synthetic polymers with varied properties which led to its use in agriculture and industrial sectors. There durability has changed it to a non-biodegradable threat to the producer and nature itself. The biological way of degradation by the use of microorganism isolated from different contaminated and environmental sources has been successful in a wide number of studies. In this study, we have isolates from different environmental sources that has been screened for their plastic degrading capability. The present work has focused to bring to the notice, the different criteria for the isolation and screening of plastic degrading microorganisms.
Marketing, Trade, Education and Capacity Building (MTE)
MTE-OR-01

Market linkages and benefit sharing in the Indian mackerel value chain in Karnataka: a policy analysis

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The Indian mackerel (\textit{Rastrelliger kanagurta}) is the national fish of India and a significant contributor to the marine fish landings of the country. Even though the production of mackerel showed an increasing trend, there has been a consistent rise in the price of mackerel in the domestic markets in the country indicating a supply-demand gap. The present study analysed the market linkages and benefit sharing by different stakeholders in the value chain of Indian mackerel in Karnataka state. Sector wise analysis of net benefits to various intermediaries in the value chain indicated that the boat owners received the maximum share of aggregate profits (65\%) followed by processing plants (14.61\%) and local traders (12.27\%). However, in terms of economic benefits to individual units, the export processing firms and canning sectors grabbed a sizable share in the value chain. The increased export demand poses a serious threat to sustainability of the resources by way of overexploitation driven by market demand and it affects the domestic consumers by way of reduced supply and rise in prices. The study suggests a revisit into the policy on export incentives to Indian mackerel to ensure equitable distribution of benefits among the stakeholders as well as to protect the interests of domestic consumers.

MTE-OR-02

A study of fish purchase behaviour of consumers over online portals in Kerala

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Most Keralites keep a positive attitude towards seafood and maintain fish as an important part of their diet. However, consumers have been buying fish mostly from unhygienic markets and roadside vendors. Recently, issues of fish adulteration have been widely discussed by media and have created an increased health, safety and quality consciousness among consumers. The changing purchase behaviour and market choice is evident with emergence of large number of online fish vendors in a short span of time in Kerala. Media reports also validate that online fish marketing has emerged in a big way in urban areas with their customer base increasing day by day. This paper studies purchase behaviour of consumers over 15 online fish vending portals operating in Kerala and presents results on frequency of online fish purchase by consumers, choice of fish varieties made over various portals and consumer preference for different online fish vending portals. Availability of fish varieties, quantum of purchase and choice behaviour over online portals were also studied and presented along with consumers’ willingness to pay and affordability of common and high value fish species over online portals. The paper also identifies constraints faced by customers in buying fish online. The findings assume great importance since online fish marketing is an emerging business in Kerala and its sustainability counts mostly on consumer satisfaction and continued patronage.
An Introduction to Blockchain Technology (BCT)

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Many companies and research institutes have shown interest in Blockchain Technology. Blockchain proposed by Nakamoto in 2008, is supposed to be a public ledger. Features such as decentralization, continuity, anonymity, accountability etc. make it cost-effective and efficient technology. Numerous authors proposed the application of blockchain technology in agrifood transactions which can address several problems such as food certification authenticity. Applications of blockchain technology rely on an online third party to authenticate and protect digital transactions. Smart Contacts by Nick Szabo (1994), found application with the introduction of cryptocurrencies. The blockchain technology that is supposed to revolutionize the world is applied in financial as well as non-financial transactions. NASDAQ Private Equity, Medici, Blockstream, Coinsetter, Augur, Bitshares etc. are examples of usage of blockchain technology in private securities. Everledger certifies diamond sales employing blockchain technology. Stampery, Viacoin, Block Notary, Crypto Public Notary, Proof of Existence, Ascribe etc. provide notary service. It also helps to maintain the rights of music ownership. It helps to store proof of the existence of any document. Storj employs blockchain technology to maintain peer to peer distributed cloud storage platform. Blockchain technology along with its many applications provides anti-counterfeiting mechanisms. This can also be applied in the supply chain of fish products with a very short shelf life. Fishcoin is a software platform built on the blockchain developed specifically for the global seafood industry. Many believe blockchain to be disruptive technology but in fact, it is having capabilities to create new foundations to our economic and social systems.
Fish consumption pattern among students of SKUAST-Kashmir

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The study focuses on the factors affecting fish consumption pattern among youth in Kashmir. The spirit of a consumer is directly affected by the society he lives in as well as the knowledge he has. The data was collected upon a specific group of final year students of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, with a total sample size of 120 students from different faculties including Horticulture, Agriculture, Fisheries and Veterinary with 30 students from each faculty. The results suggest that majority i.e. 56% of the students prefer to eat fish and chicken respectively followed by mutton 54%, beef 42% and egg 38%. The indigenous *Schizothorax* species (Kashir gad) was most preferred fish (91%), followed by trout (27%) among the investigated sample. The students prefer it because of its nutritive value (74%), freshness (68%) and taste (61%). 45% of the students eat fish once monthly, followed by 41% which eat fortnightly, 21% eat weekly. However, the major problems faced are lack of freshness (57%) and non-availability of desired fish (56%). It was found that the high price fluctuations do not affect the fish consumption. The amount and frequency of consumption can be increased by improving the marketing strategies, product diversification, identifying different marketing niches and more importantly equal distribution of the fish throughout the year.
MTE-PO-03

Seafood export from Kerala: trends and future prospects

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Fisheries play a pivotal role in the economy of Kerala State. The state has always been contributing more than 20% of the foreign exchange earnings of India through seafood trade. The current study evaluates the recent trends and growth in the fish export of Kerala. The marine product export from Kerala has achieved remarkable progress over the last few decades. The quantity of marine product export from Kerala increased from a meagre 9561 tonnes in 1965-66 to 178646 tonnes in 2017-18. The compound annual growth rate was 5.79% during the period. The value of marine product export during the same period has increased from Rs 6.01 crores to 5919.02 crores which imply a compound annual growth rate of 16.7%. The state’s share in all India exports has been declining over the years. The share declined from 26.63 percent in quantity terms in 1995-96 to 12.97 percent in 2017-18 and the share in value declined to 13.12 from 24.48. Pragmatic strategy with strong policy measures is required for achieving the sustainable growth of both marine and inland resources export and to regain the glory of the State in fish production of India.

MTE-PO-04

Seafood exports – key concerns and opportunities

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Among the blue economy’s emerging and vibrant sectors, fisheries and aquaculture have emerged as an essential commercial enterprise, as it has the ability to provide food, livelihood and wealth generation among the coastal communities. India is the second-largest fish producing country in the world, next to China, with an annual production of about 12.6 MMT and is aimed to increase to 15.00 MMT in 2020. Indian shrimps and fish products are of great demand in the global markets - US is the largest market, followed by South-East Asia, EU, and Japan. In 2017-18, India’s seafood exports have seen a growth of 13.7% in quantity and 10.1% in value. Due to the perishable nature of the products it is important to have efficient logistics to reduce transportation time and transit cost. Availability of port infrastructure and hinterland connectivity, cold chain, warehouses, power, quality control and testing infrastructure are extremely important for promoting export and reduce wastage. The Government of India understand the importance of this sector and ‘Sagarmala Project’ - microcosm of Indian blue economy - suggests opportunities such as logistics optimisation to reduce overall logistics costs thereby improve overall efficiency of the economy and increase competitiveness of exports. A Community Development Fund is envisaged to fund projects related to value addition in fisheries, aquaculture, cold chain and skill developments. Indian products have the potential to cater to the global platter and hence can leverage this sector to open new avenues for investments and exports.
Commoditization of seafood: analysis in the perspective of Indian seafood industry

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Globally, the seafood market is dramatically changing from the last few decades. The landing of wild fish is getting stagnated whereas the increment in the aquaculture production is gaining momentum. Globally, aquaculture provides 53 percent of fish for human consumption and has an annual growth rate of 5.8 percent during the period of 2001-2016 and it is going to continue to grow faster than other major food production sectors in the world. The numbers of species are also getting added into the list of culture species worldwide. The two factors, increasing global trade of seafood and the potential of growth of the aquaculture sector to increase per capita seafood consumption of the world have allowed scale, modern logistics and marketing practices to be used for the seafood, this has resulted to the commoditization of some main species groups. India is one of the largest producer as well as exporter of seafood in the world. The seafood sector contributes 1.1% of India’s GDP and 5.23% of the share of agriculture’s GDP of India. Fish and fish product exports emerged as the largest group in agricultural exports of India and in value terms accounted for Rs. 47,620 crore in 2018-19. India’s buoyant seafood industry have visionary target of achieving USD 10 billion in export by 2022. Various challenges, problems, opportunities and solutions for the Indian seafood industry will be analyzed and discussed regarding this changing scenario of the world’s commoditizing seafood industry.
Why neglect, if you truly know the beauty? Innovative marketing strategies for conservation of threatened freshwater fishes of Western Ghats

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Western Ghats, one of the eight hottest hotspots of global biological diversity, harbors exceptionally high freshwater fish diversity and endemism. Approximately, 320 species of freshwater fishes are known from the Western Ghats of which 60% are endemic to the region and one-third are threatened under various IUCN Red List categories. Getting attention and priority is the primary step for effective species conservation. Species that are perceived as ‘beautiful’ receive more attention than ‘less attractive’ species. Most endemic and threatened fishes of the Western Ghats are not attractive, thereby receiving less or no attention. Here, we expose the beauty of some of the attractive and ‘eye catching’ fishes of Western Ghats to highlight the importance and value of threatened species, that co-occur with them. The present study is an alternative approach of conservation, primarily directed to the designing method inspired from pattern and colouration of fish scales. We use some of the brightly coloured attractive fishes of Western Ghats as a model organism to conserve co-occurring endemic and threatened fishes. Live colouration and scale patterns were used to create digital designs for use in products such as dresses, photo frames, postcards, book covers, mugs, earrings, bracelets, key chains etc. This study is an innovative approach to conserve freshwater fishes of Western Ghats by focusing on species aesthetics. There is an urgent need to raise the attention of people towards less attractive and charismatic species to better appreciate and protect the species that critically support the functional diversity of an ecosystem.
Legal Regimes, Policies and Governance (LRP)
Monitoring sustainability of women entrepreneurs in ornamental fish culture

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Ornamental fish keeping is the second-largest hobby in the world next only to photography, and ornamental fish are the most popular pets. In Kerala, aquarium-keeping has been growing at a steady pace in recent years, and hence there is a growing demand for ornamental fishes in the domestic market. KUFOS had taken an initiative to encourage the residents of this panchayat, to develop an entrepreneurial venture in order to rear ornamental fish as well as to equip the rural people with training in the relevant areas pertaining to ornamental fish culture. Currently, one of the major factors that inhibit the participants from rearing is various diseases that affect them as well as not having the technical know-how to control the same. Unsteady demand and lack of marketing facilities are the critical factors that prevent the development of the entrepreneurial units. Further, it was observed that Guppy and Goldfish are the predominant species that are being reared by the participants. In conclusion, participants requested that training in the following areas would be beneficial: Breeding of Oscar and Discus, Diseases-Identification and Treatment, Live Feed Culture, Preparation of Ornamental fish food, Aquatic plants, and Waste Management. A few of the entrepreneurs have commenced a project in which they plan to engage in fish farming and would like to obtain support from KUFOS. Lastly, some of the participants have opined that they may be given access to the Amenity center for marketing their ornamental fish.
LRP-PO-02

Blue economic resources: prospects and challenges for India and ASEAN States

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India and ASEAN are poised to strengthen trade ties in multiple areas including marine products and services. India and ASEAN together account for 6 percent of global GDP and more than 25 percent of the global population. 95 percent trade by volume is by sea. Also, the ocean contributes USD 1.5 Trillion a year in value-added to the global economy. Ocean assets have been estimated to be USD 24 trillion. The blue economy is given importance due to the abundance of resources surrounding the mainland of India and ASEAN. It is believed that, if rich maritime resources are tapped effectively, several issues including poverty, unemployment, food security, and ecological imbalance could be tackled easily. To completely harness the blue resources, India and ASEAN must accelerate focused efforts on transforming the available resources into value-added products; exploring more resources; and also enhancing maritime connectivity and enacting policies. Now, the majority of the India-ASEAN trade is with three countries; Singapore, Malaysia, and Thailand. Other countries too have tremendous potential as evidenced by sound GDP growth figures and Ease of Doing Business Rankings. However, there exist issues and challenges especially in fisheries management sector and blue economy. Identifying those issues and developing effective solutions are important. This necessitates attention from researchers, policymakers and other stakeholders. The explorative study identifies prospects and problems associated with blue economic resources surrounding India and ASEAN countries. The member wise and product wise mapping are carried out. Suggestions for improvements are also provided.
LRP-PO-03

Marine fisheries extension in India: some reflections

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An effective extension system is vital for the dissemination of information and technologies to the relevant stakeholders and feeding back the technology generation system with the needs of the end users. Also, the system has onus of propagating the policy goals among stakeholders. Fisheries being the sunrise sector require an efficient extension system to harness the possibilities as well as to address the potential challenges. With the changing focus on the sustainability of the marine fisheries sector, a different orientation is needed for extension. Further with the new goals of increasing the income of the producer fishermen, it is important to develop sustainable value chain to realise major share of consumers’ rupee. This in turn requires broadening the scope of extension across the value chain. Policy support is imperative to maintain the vibrancy of the fisheries extension, which in turn require the increased expenditure on fisheries extension. Assessment of trends in expenditure on fisheries extension points out that the expenditure is very meagre, considering the potential and challenges of the sector. Growth rate in extension expenditure in fisheries sector was found to be 4% during 2005-06 to 2013-14. When coastal states taken separately, it was 6.61%. The study calls for strengthening the fisheries extension system with focus on technology management and dissemination.
Resource dependency and governance ability of Chilika fishers - an analysis

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Resource dependency and governance ability are two important aspects of the sustainable management of natural resources. The former connotes the relationship among resource users and resources whereas the later portrays the ability of the community to manage their own resources. This study attempted to explore the resource dependency and governance ability of the fishers of Chilika Lake, the largest brackish water lake in Asia. Four villages from different sectors (north, central, south and outer channel) of the lake were chosen based on the maximum number of fisher households. Data on a set of 32 different indicators were collected from fifty households from each village and Critically Vulnerable Coastal Area (CVCA) threshold assessment methodology was used. The resultant CVCA decision matrix indicated that among the four sectors, village from the outer channel sector was medium resource-dependent (0.57) whereas the rest of the three-sector villages were highly resource-dependent. However, governance ability all the four villages fall into in medium category (0.58), the score being the lowest for outer channel sector (0.43). Our observation infers that high resource dependency with medium governance can lead to over-exploitation of the resource with continued loss and rapid degradation of the ecosystems. Hence more inclusive community-based management strategies to be evolved to diversifying the fisher livelihood to reduce the fishing pressure on the ecosystem.
Stakeholders’ feasibility analysis on fishery-based enterprise development process in island backwater ecosystem

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Stakeholders’ feasibility analysis (SFA) is pivotal for an entrepreneurship development process in which stakeholders are the focal point and their interest and attitude ultimately determines the success and failure of an enterprise. This requires a planned and detailed framework towards determination of stakeholders for establishing a successful enterprise in a locality. The SFA primarily focuses on technical and economic point of view which lacks systematic approach and often resulted in closure or discontinuation of an enterprise at the very early stage itself. Hence, a study was initiated to determine and classify the stakeholders’ using systematic approach in Kadamakkudy Island, Ernakulam district, Kerala, India as part of a fish-based enterprise development process. The stakeholders’ viz., end users (EUs) and service providers (SPs) were contacted for the study. A systematic framework was drawn for classifying the stakeholders using salience model. Totally, nine stakeholders selected under service providers’ category for determination of stakeholders. Based on the willingness, interest possession and ability to support, the stakeholders were classified. A customized overall stakeholders’ feasibility index (OSFI) was also developed by analyzing the resource, technological, financial, information and extension networking feasibility of different stakeholders separately for assessing the level of stakeholders’ feasibility i.e., end users.
Sanctuary based indigenous fish conservation: a case study from Kannur, Kerala

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Fish sanctuary is a demarcated area for protection of fishes through natural proliferation in the water body. A sanctuary was established at Pamburuthy region located in Valapattanam River originates from the Brahmagiri reserve forest of Western Ghats. Seeds of fishes such as Pearl spot (*Etroplus suratensis*), Milk fish (*Chanos chanos*) and Freshwater prawn (*Macrobrachium rosenbergii*) were released in the sanctuary. The fish catch data were collected up to 10 km extent surrounding the sanctuary from March 2014 to February 2015 (pre construction) and March 2015 to February 2016 (after starting the construction and completion) in Pamburuthy. Total fish production from the areas was increased from 102.20 t to 114.5 t with an increment of 12%. *Chanos chanos* has become an important component in the fish catch after the stocking with the increased production of *Macrobrachium rosenbergii*. Interestingly, *Elops machnata* (a predatory fish) also started contributing to the catches after establishing the sanctuary. There was an increase in the landing of grazers such as *Scatophagus argus* (45%), *Gerres filamentosus* (20%) and *Etroplus suratensis* (9.2%) in the surrounding area of the sanctuary. Materials used for setting up the sanctuary were found to enhance the food availability at the site and must have promoted the natural recruitment. Construction of sanctuary in water bodies is one of the best ways to conserve the indigenous fishery resources and also for increasing the fish production in the surrounding areas towards improving the livelihood of the local fisherfolk.
Fishing regulation effects on fishers with minimum legal-size perspective along the Kerala coast

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Minimum legal size is one of the management tools in fisheries to tackle the problems of juvenile fishing. This particular study was conducted to analyse and assess the change in income of fishers after the implementation of minimum legal size. Primary data from 200 respondents across mechanized, motorized and non-motorized fishing sectors were collected from six coastal districts of Kerala by proportional sampling method and the methodological tools like descriptive statistics, cost-return analysis, Garretts ranking technique and paired t-test were employed to analyse the data. The change in income of fishers due to the adoption of minimum legal size was found to be decreased in mechanized and motorized sector with 3.0 and 2.1 per cent respectively while, the income was found increased by 0.4 per cent in non-motorized sector. The benefit-cost analysis between adopters and non-adopters of minimum legal size revealed that the adoption of minimum legal size has not affected the fishers much, as they are able to fetch more prices for their catch. This kind of management measures is necessary for the sustainable management of fisheries resources so that, gradually the marine capture fisheries of India will be managed well.
LRP-PO-08

Understanding the effectiveness of the Indian Wildlife Protection Act using syngnathid fishes as a case study

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Syngnathids are on the decline and listed in international conservation regulations including the IUCN Red List and CITES. In India, seahorse harvests and exports are banned since 2001 vide their inclusion in the Wildlife Protection Act (WLPA). However, their clandestine trade which continues despite strict regulations is a major bottleneck for reviving the population in critical habitats such as the Gulf of Mannar (GoM), a marine protected area. The WLPA has done little to regulate exports, and illegal trade continues to flourish in and around the GoM. In the GoM, which accounted for an annual export of around eight tons of seahorses prior to 2001, implementation of WLPA has transformed the trade into illegal activity. Although strict enforcement during the past decade resulted in reduced harvest, review of seizure data reveals that seahorses continue to be traded illegally. Surveys revealed that no fishers on the west coast of India were aware of the legal protection of marine taxa included under the WLPA, 84% on the east coast were aware. Although syngnathids are a conservation flagship, fishers consider them as an income source, with trade ban impacting their livelihoods. Improving syngnathid conservation requires refining existing legal and enforcement strategies and moving towards community-based governance comprising measures such as regulated fisheries, by-catch reduction, protecting critical habitats, alternate livelihoods, and improved awareness.
Empowering rural women through ornamental fish culture: case study of an institutional intervention from Kozhikode district, Kerala

Lijo Thomas and B Pradeep
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The emerging status of ornamental fish keeping as one of the most popular hobbies in the country and the favorable agro-climatic conditions prevailing in the state of Kerala offers significant scope for promoting this activity as a source of supplementary farm income. Ornamental fish farming has failed to gain critical momentum due to institutional weakness in providing an enabling environment to the practitioners. This paper describes a societal intervention in promoting ornamental fish farming among the rural women of Kozhikode district in Kerala leveraging institutional hand holding, close monitoring and support for marketing initiatives. The impact of the programme in terms of additional income generation, employment generation is analysed. The sustainability of the programme is assessed in terms of its ability to remain viable without external input subsidies. The non-monetary benefits arising from the programme is also quantified as part of the comprehensive economic analysis of the intervention. The results indicate that institutional support and sustained hand holding facilities are critical for the success of programmes aimed at promoting such non-traditional income generating enterprises suited for rural areas. The returns on investment in such programmes be significant as scaling up can be achieved with significant economies of scale.
The Blue Economy – the new horizon for equity, social security and sustainability

K Mohandas
Department of Agriculture Development and Farmer’s Welfare,
Government of Kerala

The state has a long coastline of 590 km with nine coastal districts out of total fourteen. It also has 400,000 hectares of rich inland water bodies. Around 3.1 per cent of the total population in the state is fishermen as per 2011 Census inhabiting in 222 marine and 113 inland fishing villages. The fisher folks in the state increased from 1.24 lakhs in 2015-16 to 10.39 in 2018-19. However, the recurring natural calamities and socio-economic conditions have made fishing as a nonviable occupation for the fishermen population in the state. This has been aggravated by the tsunami, recent cyclones other climate change related events. The fishermen are the most vulnerable and socio-economically affected population in the state. As the fisheries and aquaculture sector contributes around 8.5 per cent of the Gross State Value Added (GSVA), from the primary sector, its declining share in is a matter of concern. Strategic development of the sea food economy, in the midst of these environmental and structural challenges often limits the opportunity for sustainable livelihoods. Policies, strategies and standards have to be evolved for sustaining the ocean health (one of the key features of the Blue Economy), good governance, economic growth and poverty reduction in the fisheries sector. The Blue Economy has the potential to initiate and alleviate these problems, once the cumulative impact of various economic sectors within the fisheries sector to the living and natural resources are mitigated and more responsible, environmentally, socially and economically effective approaches are evolved and realized.
Environmental sciences in its wide perspective have plenty applied areas making contributions to most of the main stream activities of the country, including: Ocean technology, Coastal and harbor engg., Fisheries technology, Agricultural sciences, Green houses studies, Dam safety & environment, Climate controlled chambers, Global warming based investigations, Hydro-dynamic model engg. of coastal processes, Architectural & structural engg. etc. The technological developments and their established applications in these areas have opened scope for new academic educational activities to make competence among the concerned to take up environmental issues scientifically and confidently. The author has already showed it practically by designing and implementing the respective topics in five nos. PG level courses of university education. This paper deals with two major aspects, namely: 1. Indigenous technological developments which consisted of more than 150 sensors & their associated electronics, novel signal processing techniques and Energy Integration Processes for monitoring and systematic analysis of different areas under environmental sciences. These developments have been implemented in more than 300 institutions all over the country. 2. New concept formulated for five nos. different PG level academic topics, blended with observational techniques and instrumentation, in order to make detailed and holistic monitoring, systematic studies and analysis exposing the complex interdisciplinary nature of most of the related applied areas. The author is ready with required materials to extend the same design of PG level subjects to most of the above mentioned areas also, as he has already developed sensors and observation techniques needed for their analysis through many novel investigations and experiments. The technology involved here are fully indigenous, matching to our national mission MAKE IN INDIA into reality. These academic developments could be made possible, as the basic technology have been developed indigenously and implemented in many departments, though out the country. Unbiased and true basic information is the fundamental and essential pre-requisite of every serious effort for sustainable management of the environment and its resources, which is achieved through related electronic instrumentation using location specific sensors, to expose the complex interdisciplinary nature of different areas of applied sciences. More than one dozen national training courses were conducted during the service of the author in ICAR-CIFT with participation of senior and experienced scientists, engineers and subject matter specialists, which were sponsored by Dept. of Electronics- Govt. of India, Dept. of Agri. Engg. of ICAR and DST of Govt. of India. Most of the related technologies have been commercialized through NRDC of India and released to five firms including Keltron and implemented in more than 300 institutions belonged to CSIR, ICAR, DRDO, IITs, NITs, SNOM-Navy, ONGC, MOES, GSI, Indian Navy, agricultural and other universities, Colleges of engg., technology & applied sciences, survey agencies etc. who require interactions in open environment as part of their routine activities. Further, the technology has been used for establishing electronic infrastructural facilities in more than five dozens of institutions under different categories, as the essential requirements for systematic interactions including: new investigations and experiments for exposing their complex interdisciplinary nature.
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