

Book of **Abstracts**



9th Indian Fisheries Forum

Renaissance in Fisheries: Outlook and Strategies

19-23 December 2011, Chennai

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Renaissance in Fisheries: Outlook and Strategies - Book of Abstracts

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Foreword

Asian countries derive substantial economic, social and nutritional benefits from fisheries sector with significance for rural development and poverty alleviation. In India, the sector has been recognized as a powerful income and employment generator to over 14 million fishers and farmers, majority of whom live in over 4,114 coastal villages, besides hamlets along major river basins and reservoirs. The sector offers cheap and quality animal protein to the people ensuring nutritional security and through the export earnings worth ₹ 12,902 crores which is equal to US\$ 2,860 million and a number of subsidiary industries, which plays a major role in stimulating and strengthening the economic growth of the nation. However, several issues such as coastal overfishing, depletion of fish stocks, impact of climate change on biodiversity and abundance, disease in aquaculture and trade related issues have emerged in recent years. Demand projections for fish by 2012 is 9.99 million tonnes at an estimated annual consumption growth rate of 3.5% and the required annual growth rate for meeting the demand would be in the order of 5.4%. All these call for an integrated strategic planning at the national level and it is time to take stock of our achievements, capabilities, challenges as well as opportunities.

The Asian Fisheries Society – Indian Branch (AFSIB) since its inception in 1986, has been providing a platform for discussion at the national level on issues related to research, development, education and policies by organizing Indian Fisheries Forum (IFF) every three years in different parts of the country. **The 9th Indian Fisheries Forum (9th iff) will be hosted by the Central Marine Fisheries Research Institute (CMFRI), at Chennai during 19-23 December 2011.** The main theme of the 9th iff is ***“Renaissance in Fisheries: Outlook & Strategies”***. It would have a comprehensive look for the fisheries and aquaculture sectors, for achieving greater synergy among the stakeholders and planning strategies for capture fisheries and aquafarming to build higher levels of sustainability and profitability. The forum would also address the issues of impact of climate change and its mitigation, resource constraint and species diversification for the expansion of fish production activity; and encourage young scientists to undertake need-based and resource specific research. An international symposium sponsored by the Bay of Bengal Large Marine Ecosystem (BoBLME) is scheduled to be held during the forum on 21 December, 2011 with theme: *Bay of Bengal–Ecosystem Approach to Fisheries Management*.

The 10 scientific sessions cover thematic areas of contemporary interests such as (i) Fishery resources, recreational fisheries and sustainable management, (ii) Aquaculture production and management, (iii) Fish health and nutrition, (iv) Genetics, breeding and biotechnology, (v) Environment impacts and aquatic health, (vi) Harvest and post-harvest technology, (vii) Socio-economics, marketing and livelihood, (viii) Fisheries trade, policies and governance, (ix) Climate change and natural disaster management, and (x) Fish and fish related biodiversity. Each session will also have a lead lecture by an invited expert, followed by oral presentations of selected research papers. The papers presented in the forum will be subjected to scientific review for publishing in the ***Indian Journal of Fisheries*** (NAAS Rating 4.9), a journal published by CMFRI on behalf of the Indian Council of Agricultural Research (ICAR), New Delhi.

Ever since the announcement of the 9th iff, there has been an overwhelming response and a record number of 645 abstracts were accepted, which include 422 oral presentations and 223 poster presentations. This indicates the immense trust of the Indian Fisheries fraternity in Central Marine Fisheries Research Institute - the premier fisheries research institution in the entire South Asia. The abstract committee has included as many abstracts as possible in the oral/platform presentation category, with parallel sessions for different themes on each day. The diversity and depth of the topics covered in the book of abstracts highlight the intensity of fisheries research going on in the



country and imparts us the confidence that we all are concerned about sustainability, equitability and inclusive development. I would like to congratulate the Editorial Board for their untiring efforts in editing, making the lay-out, designing the cover page, proof reading and bringing out the Book of Abstracts. All those who have toiled behind the screen to bring out this milestone document in the history of Indian fisheries are gratefully acknowledged. I profusely thank the Bay of Bengal Programme Inter-Governmental Organization (BOBP-IGO), Chennai for the timely printing of the Book of Abstracts.

We extend a warm and hearty welcome to all the participants at the 9th iff. The venue will be "IMAGE" (Indian bank Management Centre for Growth and Excellence) at R.A. Puram, Chennai, Tamil Nadu. We expect your full involvement in scientific sessions and hope you will enjoy the stay in Chennai.

The patron of the 9th iff, Dr. S. Ayyappan, Secretary, DARE, Govt. of India and Director General, ICAR; Chairperson, Dr. B. Meenakumari, Deputy Director General (Fisheries), ICAR; Chairman, Prof. (Dr.) Mohan Joseph Modayil and office bearers of the AFSIB are whole-heartedly thanked for their valuable inputs, guidance, suggestions and support in organizing the forum. The co-sponsors of the event – Government of India, Indian Council of Agricultural Research (ICAR), New Delhi; Department of Animal Husbandry, Dairying and Fisheries (DADF), Ministry of Agriculture, New Delhi; Ministry of Earth Sciences (MoES), New Delhi; Union Territory Lakshadweep Administration; Central Marine Fisheries Research Institute (CMFRI), Kochi; Central Institute of Brackishwater Aquaculture (CIBA), Chennai; Central Institute of Fisheries Technology (CIFT), Kochi; Central Institute of Fisheries Education (CIFE), Mumbai; Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar; Central Inland Fisheries Research Institute (CIFRI), Barrackpore; National Bureau of Fish Genetic Resources (NBFGR), Lucknow; Directorate of Coldwater Fisheries Research (DCFR), Bhimtal; Food and Agriculture Organization (FAO), Rome; National Fisheries Development Board (NFDB), Hyderabad; Department of Biotechnology (DBT), New Delhi; Marine Products Export Developmental Agency (MPEDA), Kochi; Coastal Aquaculture Authority (CAA), Chennai; The Indian National Centre for Ocean Information Services (INCOIS), Hyderabad; National Biodiversity Authority (NBA), Chennai; Bay of Bengal Programme (BOBP), Chennai; National Bank for Agriculture and Rural Development (NABARD), Mumbai; Council for Scientific and Industrial Research, New Delhi; National Institute of Ocean Technology (NIOT), Chennai; Fishery Survey of India (FSI), Mumbai; Indian National Science Academy (INSA), New Delhi; Bay of Bengal Large Marine Ecosystem Project (BoBLME), Phuket, Thailand; Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) (Indian Institute of Remote Sensing), Dehradun; Department of Atomic Energy, Mumbai and Marine Biological Association of India (MBAI), Kochi are gratefully acknowledged for their generous financial support.

While thanking all those who have contributed to the 9th iff, I would request each and every one to take active participation in the scientific deliberations so as to effectively address all major issues in the sector for strategic research and interventions.

Kochi - 682 018
December, 2011

Dr. G. Syda Rao,
Convener, 9th iff
and Director, CMFRI, Kochi



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Fishery Resources, Recreational Fisheries and Sustainable Management

FR- O : Oral presentation
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FR-O 01**Reducing bycatch and discards: a priority for marine fisheries of India**

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Since modernization of fishing industry, large amount of non-target marine life is being landed by fishing trawlers along with the catch. While the entire bycatch brought by multiday trawlers is landed at some fish landing centres like Veraval and Tuticorin, multiday trawlers generally discard the low value bycatch, except the catch from the last haul. The discard volume is normally higher during monsoon months as there is no demand for the bycatch. The single day trawlers, on the other hand, bring the entire bycatch to the shore. In India an estimated average of 0.35 million tonnes of low value bycatch (2008-10) valued at Rs. 170 crores is landed annually. The highest landing was at Veraval in Gujarat where an estimated 38507 t (25.5% of trawl catch) of low value bycatch was landed by multiday trawlers in 2010. The bycatch being in a putrefied/semiputrefied stage, fetches very low value and is dried and used as manure. At Mangalore, an estimated 25067 t was landed during 2010. In single day trawlers, 40% of the catch landed was trash, dominated mainly by stomatopods. Discards by multiday trawlers was to the tune of 11777 t (12% of the trawl catch) during 2010. Juveniles of finfishes and shellfishes constitute a major portion of the bycatch. The composition of discarded catch from multiday trawlers at Mangalore shows that 78% is constituted by low value fauna and the rest by juveniles of commercially valuable species. During 2006, juveniles of *Nemipterus mesoprion* formed 42% by number and 22% by weight (2914 t) of the bycatch landing at Mangalore.

If the juveniles were not caught and the fishes exploited as adults, an additional 23% in value (Rs. 2.9 crores) would have been realized. Low value bycatch is constituted by 100-250 species of marine organisms and multiday trawlers mostly discard the low value bycatch. However, the percentage of monthly discards by trawlers has been exhibiting a decreasing trend over the years and landing of bycatch was on the increase mainly due to higher demand and market value for the bycatch. A disturbing trend is the inclusion of sardines and smaller sizes of quality fishes in bycatch to fetch higher price compared to the lower market price. The price of bycatch varies from place to place and it depends on the quality and constituent. For example, in Chennai fishing harbour, the price of bycatch varies from Rs. 5-100/kg depending upon the quality and demand whereas in Veraval bycatch is sold at Rs. 2/kg

Investigation on geo-temporal distribution of juveniles and adults of fishes in the fishing grounds along the Mangalore coast on a GIS platform has been attempted on a participatory mode. The abundance of juveniles of each species in space and time is available and based on the distribution maps, the fishermen could be advised to skip fishing grounds where high concentration of juveniles of commercially important fishes are recorded. Regulatory based solutions for reducing the bycatch by trawlers and the environmental and social implications of bycatch in trawl fisheries are discussed. Value addition to the low value bycatch and prescription of quality standards are required for efficient utilization of bycatch.

FR-O 02**Status of Indian Ocean tuna fishery with special reference on the strategies for the sustainable development and management of tuna fishery in the Indian EEZ**

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Tuna belonging to the family Scombridae, are important worldwide for their economic and



ecological value. They are large, oceanic fish and are highly migratory pelagic species inhabiting tropical and subtropical waters of the world oceans. The Pacific Oceans produced 70.2% followed by the Indian Ocean (20.4%) and the Atlantic Ocean (8%) and the rest by others. The percentage composition of different species indicates that the catch was dominated by skipjack tuna constituting 58% followed by yellowfin 25%, bigeye 10%, albacore 5% and the remaining by other species. It is evident from the analysis of the catch data that the standing stock of several species of tunas in the world declined to such levels that the sustainability of the resource is under severe stress requiring urgent conservation and management measures. In Indian Ocean, tuna catches increased rapidly from about 1,79,959 t in 1980 to about 8,32,246 t in 1995. The catch continued to increase up to 2005 reaching 12,01,465 t, forming about 26% of the world catch. Since 2005 onwards there was a decline in catch and in 2008 the catch was only 9,13,625 t. The principle species caught in the Indian Ocean are skipjack and yellowfin. Western Indian Ocean contributed 78.2% and Eastern Indian Ocean shared 21.8% of the total tuna production from the Indian Ocean. The Indian Ocean stock is currently overfished and has very little or no proper management regulations aimed at sustaining the stock.

Tunas are one of the major exploited marine fishery resources of Indian seas having good domestic demand as food fishes. All India tuna production continued to increase with fluctuations from 848 t in 1951 to 60,307 t in 2009, with a peak production of 64,006 t in 2006. In the coastal fishery, landings from the FAO areas 51 and 57 were 64% and 36% respectively. Among the oceanic species, skipjack and yellowfin were dominant contributing 22,060 t and 13,507 t respectively whereas among the coastal tunas, kawakawa was predominant (58.4%) followed by longtail tuna (13.5%) and frigate tuna (11.1%). Gear-wise, 35% of the catch was obtained in gillnet followed by pole and line (18%), purse

seine (14%), longline (13.5%), baitboat (11%) and the remaining in other gears. Tuna export from India commenced only from 2005 with 16,627 t worth Rs. 63.31 crores, which increased to about 37,392 t during 2007-08 and since then there was a decline. The importing countries were South East Asia, Japan, UK and Middle East. Some quantity was also exported to USA, mainly the chilled tuna and value added tuna products. Though India is blessed with rich coastal and oceanic tuna resources, except the coastal tuna fishery, there is no organized fishery for oceanic tunas. Deployment of drift gillnet, longline and high sea purse seine fishing fleet for the exploitation of oceanic tunas from Indian seas is discussed and various suggestions for the sustainable development and management of the oceanic tuna fishery are given.

FR-O 03

Applications of remote sensing in the validations of Potential Fishing Zones (PFZ) along the coast of north Tamil Nadu, India

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The present paper deals with the applications of remote sensing and advantages obtained in validations of Potential Fishing Zones (PFZ) that are disseminated for the benefit of fishing community along the coast of north Tamil Nadu, India. Mapping Chlorophyll Content (CC) and Surface Seawater Temperature (SST) using satellite remote sensing as a tool to study the distribution and abundance of fishery resources is gaining momentum. The periodic PFZ advisories released by the Indian National Centre for Ocean Information Services (INCOIS) would be of great benefit for the fishing community of the entire coastline of India in the timely location of fish shoals resulting in the saving of valuable human efforts, fuel cost, searching time for fish shoals and over all reduction in fishing cost. The fish catch in PFZ is 3-4 times higher when compared to non-PFZ



area. The PFZ validations and feedbacks were undertaken through selected group of active fishermen identified at the major selected fish landing centres along the coast of north Tamil Nadu from April 2007 to March 2011. With a view to validate the advisories and to qualify the potential benefits of the technology, concurrent validations have been carried out. The results of the PFZ validations and feedbacks data obtained during the present study are discussed.

FR-O 04

Application of food web model to identify key stone species in a reservoir ecosystem in Kerala, India

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Keystones are defined as relatively low biomass species with a structuring role in their food webs. Quantitative approaches are needed to identify unusually important or influential, 'keystone' species particularly for conservation purpose. Since the importance of some species may largely be the consequence of their rich interaction structure, one possible quantitative approach to identify the most influential species is to study their position in the network of interspecific interactions. A network structure of the reservoir ecosystem is built using Ecopath with Ecosim software for characterizing the interaction structures of each species. This study was conducted at Karapuzha reservoir, located at Wayanad district of Kerala. In this paper the keystone species of the functional groups (species or group of species) of food web model of a reservoir ecosystem is examined. The species in this reservoir are assembled into 15 functional groups from detritus to aquatic birds. The total system throughput in the reservoir is 30039 t/km² with a connectance index of 0.277. The system omnivory index is estimated at 0.109. The sum

of all detritus flows into detritus is 11,268.45 t/km². The analysis of the mixed trophic impacts presented here allows ranking of functional groups by their keystone index. The keystone index varied from 0.610 for phytoplankton to 2.839 for aquatic birds. The important result is that keystone species exert their high impact by means of top-down effects, a feature initially suggested being a defining characteristic of keystone species. *Clarias gariepinus* has a very high keystone index at 2.168 which shows how much influence an invasive species has on the food web of this reservoir ecosystem. The study shows that lower biomass species in this reservoir ecosystem are showing very high keystone indices.

FR-O 05

Bayesian estimation of maximum sustainable yield based on Schaefer's model for Kerala, Karnataka, Tamil Nadu and West Bengal

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The Bayesian framework allows us to have the estimates of posterior densities of the parameter of interest in addition to that of the parameters the model used. Also, it allows incorporation of prior information into the scientific decision process. Time series data on total marine fish landings and fishing effort expended in terms of hours of operation for the period 1990 to 2008 corresponding to the maritime states of Tamil Nadu, Kerala, Karnataka and West Bengal were used here for estimation of posterior probability distributions of maximum sustainable yield (MSY) through Bayesian approach.

The prior probability distributions for the Schaefer model parameters such as carrying capacity (K), intrinsic rate of growth (r), Virgin Biomass (B₀) and catchability coefficient (q) were also used as inputs for estimation in addition to the time series data on catch and effort.



Informative Gaussian priors were used for K and r , non-informative Gamma priors were used for q , informative; lognormal priors were used for B_0 , informative inverse Gamma priors were used for process error variance and non-informative inverse Gamma priors were used for observation error variance. The OpenBugs, computer software for Bayesian estimation using Markov Chain Monte Carlo algorithm (MCMC), was used to get the estimates of posterior densities of all the parameters and MSY with 10000 updations for the MCMC algorithm. The mean, median, standard deviation and 97.5% confidence intervals were also worked out for all the parameters.

FR-O 06

Marine fisheries of Andhra Pradesh: a decadal analysis

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The catch and effort data on marine fisheries of Andhra Pradesh was analyzed for 11 years from 2000 to 2010. The annual marine fish landings of Andhra Pradesh ranged from 1.9 lakh t in 2000 to 2.5 lakh t in 2010 with an average of 2.01 lakh t. Fishing effort in terms of fishing hours increased by 10% in the mechanized sector during this period, whereas fishing effort in terms of fishing units decreased by 27.5% in the motorized and traditional sectors. Pelagic finfishes were the dominant group contributing 55.6% to the total marine catch, followed by demersal finfishes (27.1%), crustacean (14.3%) and molluscan resources (1.1%). Trawl net was the major gear contributing 43.5% to the total catch, followed by gillnets (23.6%) and seine nets (8.8%). There has been a distinct change in the species composition of pelagic resources over the decades. First half of the decade was dominated by lesser sardines (19%) and the second half by ribbonfish (14%). Regarding crustacean resources, the landings of

penaeid prawns has increased over the years by 8.7% from 22,657 t in 2000 to 24,629 t in 2010, as against that of non-penaeid prawn landings which have decreased by 24.5% from 2685 t in 2000 to 2027 t in 2010. Crabs have shown significant increase in landings by 161% from 2,791 t in 2000 to 7,277 t in 2010. The other major resources such as demersal and molluscan fluctuated without exhibiting any distinctive trend. The catch trend of major fish species was analyzed. The catch of oil sardine and mackerel showed wide inter-annual fluctuations. Oil sardines fluctuated from a maximum of 19,125 t in 2000 to a minimum of 5679 t in 2003. Mackerel landings fluctuated from a maximum of 22,763 t in 2009 to a minimum of 6418 t in 2007. Other pelagic resources namely carangids and tunas have registered continuous increase in catch over the years; the former from 9,964 t in 2000 to 14,179 t in 2010 and the latter from 2,899 t in 2000 to 8,458 t in 2010. Around half of the tunas landed were contributed by the yellowfin tuna, *Thunnus albacares* caught mainly in hooks and lines. Their annual landing has increased on an average at Visakhapatnam from 395 t during 2001-2005 to 2,918 t during 2006-2010. The perception of tuna fishing changed with the advent of oil drilling at Kakinada and Visakhapatnam when congregation of yellowfin tunas on the surface waters were observed which were found associated with their favoured prey squid, attracted to the surface by huge lights used by the drilling vessels. Landings of some of the demersal resources namely, threadfin breams, croakers, lizardfishes and goatfishes have also increased substantially during the period. Threadfin bream landings have increased by 302% from 1,209 t in 2000 to 4,858 t in 2010, croaker landings by 57% from 8,054 t in 2000 to 12,649 t in 2010, lizard fish by 241% from 1,062 t in 2000 to 3,620 t in 2010 and goatfish by 241% from 3,501 t in 2000 to 6,856 t in 2010. Cephalopod resources have also shown a substantial increase of 278% during the period ranging from 1,011 t in 2000 to 3,824 t in 2010. Overall an increasing trend in marine fish landings of Andhra Pradesh was observed during the period under report. Mechanized fishing effort showed an increasing trend whereas motorized and traditional effort showed a declining trend.



FR-O 07**Status and potential of tuna fisheries in Indian waters**

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Tuna fishery along the Indian coast including island territories was monitored during 2006-2010. Commercial fisheries for tuna and tuna like fishes of the country involve coastal based fleets of varying specifications with different craft-gear combinations and large Letter of Permit (LOP) vessels. The former undertake short duration fishing trips and exploit mainly surface tunas in the outer shelf and adjacent oceanic areas. With the development of targeted fishing for oceanic tunas during 2005-'06, the production improved since 2006 and reached the maximum of 129,801 t in 2008. The fishery was supported by nine species, five coastal/neritic species and four oceanic species. Coastal tunas form 57% of the tuna catch and was represented by little tuna (*Euthynnus affinis*), frigate tuna (*Auxis thazard*), bullet tuna (*Auxis rochei*), longtail tuna (*Thunnus tonggol*) and bonito (*Sarda orientalis*). The principal oceanic species, which formed 43 % of tuna catch, were yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*) dogtooth tuna (*Gymnosarda unicolor*) and big-eye tuna (*Thunnus obesus*). The average annual tuna harvested by LOP vessels was 87,239 t during 2006-10. Production during the period ranged between 1,00,268 t in 2008 and 78,904 t in 2010. Fishery was supported by three species dominated by yellowfin tuna and small proportion of big-eye and dogtooth tuna. Stock assessment indicated that considerable scope exists for increasing tuna production from Indian waters.

Tuna harvest (in tonnes) by coast based fleets and LOP vessels during 2006-2010

Fishery /year	2006	2007	2008	2009	2010
Coastal fishery	112049	116867	129801	107735	95372
LOP fishery	88016	85770	100268	83238	78904
Total tuna	200065	202637	230069	190973	174276

FR-O 08**Biology, fishery and population dynamics of *Dasyatis alcockii* (Annandale, 1909) from Mumbai waters**

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Dasyatis alcockii is the most dominant species among 14 species of rays landed in Mumbai. Fishery, biology and stock assessment of the species were investigated from trawler landings at New ferry wharf in Mumbai during 1989-2009. The food mainly consisted of crustaceans comprising of squilla, shrimp *Solenocera* and non-penaeid prawn *N. tenuipes* followed by fish *Coilia dussumieri*, bivalves, cephalopods and polychaetes. The average volume of food in the stomach was significantly different among immature and mature individuals of both the sexes and intensity of feeding increased with the size and maturity of fish. The relationship between disc width (cm) and weight (kg) of 935 males and 945 females did not show significant difference between the sexes and the common expression for the species is $W=0.0000166L^{2.7042}$. The smallest mature male measured 44 cm and the female 52 cm while pregnant and postnatal females were 63 cm 74 cm in disc width respectively. The size at first maturity of females was 63.5 cm and at that time they were of 3.3 years old. A pregnant female carried a single embryo. Mature and pregnant females were encountered during October - June and post-partum during March-May while free swimming young ones (24-32 cm) were present in almost all the months. Based on the size of fully developed



intra-uterine embryo (21.8-28 cm) and the post-parturition free swimming new born fish (24-28 cm), the gestation period of the pregnant female is one year. The life-span of the species is about 10-12 years.

The size-frequency in disc width of 972 males and 1091 females by Bhattacharya method and Gulland-Holt plot in FiSAT software gave von Bertalanffy growth parameters L_{∞} 109.2 cm and 120.4 cm and annual K 0.25 and 0.23 for the two sexes respectively. During 1990-95, the annual total and natural mortality coefficients for males and females were 1.65, 1.28 and 0.5, 0.46 respectively while exploitation ratio for the two sexes were 0.70 and 0.64 which suggested over-exploitation of the stock. With average annual catch of 241 t during the period, the species constituted 48.2% of the catch of rays that contributed 0.8% of the total marine fish landings by the trawlers. Annual catch of the species fluctuated widely but exhibited declining trend from 406 t in 1989 to 171 t in 2009. Slow growth, late maturation, single offspring and exploitation of mature stock resulted in steady decline in the catch. Like most of the elasmobranch resources, *D. alcockii* calls for conservation and stringent management to sustain the stock in future.

FR-O 09

Alarming invasion of exotic fishes in the Yamuna river system

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The river Yamuna is a main tributary of the Ganga river system. Total length of the river from its origin at Gangotri in Greater Himalayas to confluence with the river Ganga at Allahabad is 1376 km. The river traversing through vast and varied catchments forms myriads of

micro-habitats which harbour rich piscine diversity. A total of 108 fish species belonging to 74 genera, 29 families and 9 orders have been reported from the river, in which about 90 species are found at Allahabad. The upper reaches of the river consists upland species like *Schizothorax richardsonii*, *Tor putitora*, *Tor tor*, *Labeo dero*, *Garra gotyla*, *Barilius bendelisis*, *Glyptothorax pectinopterus* etc, while the middle stretch harbours Indian major carps, other carps, catfishes, exotics (*Cyprinus carpio communis*, *Oreochromis nilotica*), clupeids, featherbacks and others.

The river Yamuna is an extreme example of over-exploitation of the riverine resource for human use. The water discharge of the river is abstracted at Dak Patthar in Uttarakhand and Hathnikund in Haryana. As a result, the running voluminous river has been changed into a narrow, shallow, semi-running or stagnant channel and the crystal clear, pollution free water turned into dark brown, stinking, sink of domestic city sewage and agricultural run-off. The shallow sluggish flow concentrated with effluent load has drastically altered the pristine feeding and breeding grounds, hence affected the valuable native fish species like *Labeo rohita*, *Labeo calbasu*, *Catla catla*, *Sperata aor*, *Sperata seenghala* and *Wallago attu*. Under the changed ecological conditions, the vacant habitat/niche has been occupied by the hardy exotic fishes - tilapia and common carp. During 1967-68 the Indian major carps (IMC) and catfishes alone constituted more than 50% of the catches at Agra, Mathua and Etawah centres. Now the river in general and its middle stretch in particular, is fully dominated by tilapia and common carp. In 2010, an estimated landing of 178.0 t was recorded from the Allahabad stretch of the river Yamuna in which exotic fishes alone contributed 47.74% (common carp 30.28% and tilapia 17.46%), major carps 16.34%, catfishes 12.27% and other fishes 23.65%. Appearance and establishment of different exotic species in the river and the above details are discussed in the paper.



FR-O 10

Exploitation of marine algae in countries of Indo-Pacific regionV. S. KRISHNAMURTY CHENNUBHOTLA^{1*}, M. UMAMAHESWARA RAO² AND K. S. RAO¹¹Former Principal Scientist, Central Marine Fisheries Research Institute, P.B. No.1603, Ernakulam North P.O., Kochi-682 018, Kerala, India²Former Professor, Department of Botany, Andhra University, Visakhapatnam, Andhra Pradesh, India

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Marine algae are harvested from the coastal waters of numerous countries of Indo-Pacific region due to their value as food, feed for animals, fertilizers and a source of various minerals, trace elements and phycocolloids. The global production of marine algae has been assessed at four million tonnes (wet weight). The Indo-Pacific region produced 2.6 million t wet weight. As per the data available, the highest production (1 million t) is from China followed by Japan (7 lakh t) and Korea (4 lakh) t. The lowest being from New Zealand (50 t). The NW Pacific Ocean, covering Japan, China, Korea and Philippines, ranks the largest in production, processing and utilization of marine algae. In India, the annual production of marine algae has been estimated at 2,60,876 t. The bulk of production comes from Tamil Nadu coast and Andaman-Nicobar Islands amounting to 60 %. The rest comes from Gujarat, Maharashtra, Goa and Kerala. In addition to the above, 2% of production comes through cultivation of *Kappaphycus alvarezii*.

In the Indo-Pacific areas, some genera of marine algae are used as food for human beings. *Nori* (*Porphyra* sp.), a red alga, is very popular in the Japanese diet and it has high protein content (25-35% of dry weight), vitamins and mineral salts, especially iodine. The bulk of algal production of Japan consists of *Porphyra*, *Undaria*, *Laminaria*, *Monostroma*, *Enteromorpha* etc; that of China consists of *Porphyra* and *Laminaria*; that of Republic of Korea consists of *Porphyra*, *Laminaria* and *Undaria*; that of Taiwan consists of *Gracilaria* and *Porphyra* and that of Philippines consists of *Kappaphycus* and *Caulerpa lentillifera*. The algae produced from Philippines are exported and a significant amount of *Laminaria* produced in China

is processed for alginates locally. The culture of *Euclima gelatinae* was introduced to Hainan Island of China in 1660, while *Gracilaria verrucosa* was cultivated commercially in the late 1950's. The only marine alga used as food in India is *Gracilaria edulis*, a red alga, especially by coastal population in Tamil Nadu. In recent years, *K. alvarezii* cultivation was started along coast of Tamil Nadu for carrageenan and liquid fertilizer production. Along Tamil Nadu and Kerala coasts, the marine algae are directly applied as manure for coconut plantations. In Sri Lanka, Myanmar, Indonesia and Thailand, *Gracilaria*, *Caulerpa* etc. are collected for export purpose. In Indonesia and Vietnam, the coastal populations consume marine algae as food and culture operations in these countries are still in initial stages.

Among the other uses, marine algae are also finding a place in integrated aquaculture systems. The brown and red algae collected from natural habitats or cultivated on artificial substrata are mainly used for the extraction of polysaccharides (agar, carrageenan and alginate) which are employed in various industries (pharmaceutical, textile and food), for culturing microbial organisms in genetic engineering and in a host of other items. With the algal resources available, polysaccharide industry is also well established in India. In view of the shortage of food production in Indo-Pacific region, augmentation of marine algae through culture practices is of utmost importance at the present juncture.

FR-O 11

Fishery and population dynamics of the sand lobster *Thenus unimaculatus* (Burton & Davie, 2007) landed by trawlers at Sakthikulangara fishing harbour along the south west coast of India

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The average annual catch of *Thenus unimaculatus* from trawlers during 2005-



2010 was 19 tonnes forming 0.73% of the total marine fish landings at Sakthikulangara. The average CPUE during the period was found to be 0.09 kg/hr while the highest was recorded in the year 2010 (0.2 kg/hr) and the least during 2006 (0.03 kg/hr). On an average, males outnumbered females forming 51% of the catch. Berried females contributed around 17% of the catch. Peak fishery was observed during November to February which coincided with the peak breeding season. Total length of males varied between 61-230 mm while females were recorded in the size range of 46-250 mm. ANCOVA results for length-weight relationship using carapace length (mm) and weight (g) between the sexes was not found to be significantly different ($p > 0.05$) which indicates that the data can be pooled for establishing the length weight relationship of *T. unimaculatus*. Growth rates of males ($a = 0.00237$, $b = 2.64$, $r^2 = 0.95$) and females ($a = 0.00156$, $b = 2.76$, $R^2 = 0.96$) were identical till the first 2 years after that the latter recorded higher growth. Growth parameters estimated by von Bertalanffy's growth equation were: $L_H = 240$ mm, $K = 0.15$ for males and $L_H = 260$ mm, $K = 0.23$ for females. Mortality rates M , F and Z computed for *T. unimaculatus* were 0.29, 1.02, 1.31 for males and 0.37, 2.17, 2.54 for females. Fecundity varied between 14750 to 33250 eggs in individuals with carapace length of 61-84 mm. Exploitation ratio was found to be higher in females (0.85) in comparison with males (0.78).

FR-O 12

Fishery, biology and population characteristics of yellowfin tuna (*Thunnus albacares*) exploited from the Indian EEZ

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The fishery and population characteristics of yellowfin tuna, *Thunnus albacares* were

monitored during 2006-10. A variety of crafts and gears were used for exploiting yellowfin tuna all along the coast and island systems. Production from coast based fishery was nominal (4,490t/yr) during 1985-2005 with wide annual fluctuations. Targeted fishery for oceanic tunas led to increase in catch since 2006 to an all-time high production of 37,963 t in 2007. Catch by Letter of Permit (LOP) vessels during 2006-10 varied between 77,718 t in 2010 and 98,761 t in 2008 with an average annual yield of 85,928 t. The coast based fishery exploited mainly surface tunas from the outer shelf and adjacent oceanic areas and the catch was supported by 22-201 cm length with mean at 73.9 cm. Length at capture in gillnets were estimated as 50.2 cm and in hooks and line as 78.7 cm. The length at first maturity was 54.5 and 57.6 cm respectively for male and female and optimum length for exploitation was 61.1 cm. They spawn round the year with peak during July-October. Relative fecundity varied between 197,263 and 8,14,557/kg body weight with a mean of 4,36,330. Recruitment was round the year with peak in May-August accounting 60.5% of the annual recruitment. They are nonselective carnivores in feeding habit and mainly feed on carangids, clupeids, belonids, hemiramphids, ribbonfishes, mesopelagic fishes, pelagic crabs and cephalopods. Growth parameters of the species were; $L_\infty = 211.1$ cm (FL), $K = 0.27$ /year and $t_0 = -0.056$ years. The spawning stock biomass formed 85.8% of the standing stock. Study indicated scope for improving the catch by expanding fishery to deeper areas.

FR-O 13

Fishery and feeding habits of yellowfin tuna (*Thunnus albacares*) from Lakshadweep waters

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The yellowfin tuna *Thunnus albacares* is a high value oceanic resource in the Lakshadweep



Sea. Targeted fishing for the yellowfin tuna in Lakshadweep islands commenced since 2008. Pole and line, troll line and drift gill net are the major gears operated using traditionally designed mechanized Pablo boats of 25 to 34 feet overall length. Fishing operations are mainly undertaken during the non-monsoon season (September to May) and no major fishing activities during monsoon (June-August). The estimated landing of tuna from four islands of Lakshadweep (Minicoy, Kavaratti, Androth and Agatti) during September 2010 – March 2011 was 2386.6 t. Maximum yellowfin tuna landing was recorded from Minicoy (81%) followed by Androth (16%), Agatti (2%) and Kavaratti (1%). Smaller sized yellowfin tuna with fork length (FL) measuring 42-46 cm were observed throughout the year. Swarming crab, *Charybdis smithii* was the most preyed food component with an Index of Relative Importance (IRI) value of 87.5% followed by *Auxis thazard* (5.3%) and *Cheilopogon* sp. (0.8%). Since the inception of the National Agricultural Innovation Project on “Value chain on oceanic tuna fisheries in Lakshadweep seas”, targeted fishing for yellowfin tuna resulted in 37% increase in landings of the species.

FR-O 14

Fishery and bionomics of little tuna, *Euthynnus affinis* (Cantor, 1849) exploited from Indian waters

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Euthynnus affinis, with an average annual landing of 40,757 t during 2006-2010 formed 36.3% of the total coastal based tuna catch and the bulk (65.1%) of the coastal tuna catch of the country. The fishery, biology, growth and stock structure of the *E. affinis* was studied in detail. Gillnets (49%), hooks and lines (29.7%), ringseines (9.1%) and purseseines

(8.1%) were the major gear exploiting the fish. Fishery was sustained mainly by the 1-2 year old fishes (34 to 50 cm). Size at first maturity was estimated at 37.7 cm and fecundity was 3,08,150 eggs. Spawning was observed round the year with peaks during July-August and November-January. *E. affinis* was found to be a nonselective feeder foraging on finfishes, crustaceans and cephalopods. The length weight relationship is given by $W=0.0254 L^{2.889}$ and growth was isometric with no significant difference between sexes. Age and growth were estimated using length based methods. The von Bertalanffy growth parameters estimated were $L_{\infty} = 81.4$ cm, $K = 0.33/\text{year}$ and $t_0 = -0.0550$. Mortality estimates were $M = 0.65901$ and $Z = 1.15$ and $F = 0.49$ with the exploitation ratio $E = 0.43$. The maximum sustainable yield estimate was higher than the average annual catch indicating scope for further exploitation.

FR-O 15

Assessment of the fishery and stock of striped bonito, *Sarda orientalis* (Temminck and Schlegel, 1844) along Indian coast

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The fishery and population characteristics of *Sarda orientalis* were monitored during 2006-2010. The species is emerging as fishery in many coastal states in the recent years. They were exploited by trawl (50.8%), gillnet (32.3%), handline/longline (12.3%) and purse seine (4.6%). Annual catch varied between 257 t and 1551 t with an average of 849 t during the period. Fishery occurred almost round the year with peak landing during July-September. Major share of the catch was contributed by Kerala (65.6%), Andaman and Nicobar (23.4%) and Gujarat (6.6%).



Catch comprised 16 to 62 cm population with major share of 34-50 cm fishes. The length-weight is given by the relationship $W = 0.0217 L^{2.87}$ and the growth was isometric in the species. The growth parameters L_{∞} and K were 73.5 cm and 1.3/yr respectively. Natural Mortality (M) was 1.65 and total mortality (Z) was 5.11. The fishing mortality coefficient (F) was 3.46 and the exploitation ratio (E) was 0.68. Their size at maturity was 34 cm and they spawn almost round the year with peak during May-September. The average relative fecundity was 4,04,048 eggs/kg body weight. Estimate of size at capture is 37.4 cm and L_{opt} 36 cm. As per VPA, a total of 2 million fishes were recruited to the fishery in Kerala when they were at 16 cm in length. The number of survivors decreased with increasing fish length and only 5466 of them reached 62 cm in length. The prediction analysis (Thompson and Bell method) showed that the fishing level in Kerala has not reached the MSY of 1035 t and also MSE which will be reached at an F-factor of 2.4. The spawning stock biomass at this level was 14% of the virgin spawning stock biomass. Study shows that the resource is at its initial phase of exploitation and has considerable scope for improving production.

FR-O 16

Fishery biology and stock structure of skipjack tuna, *Katsuwonus pelamis* (Linnaeus, 1758) exploited from Indian waters

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Fishery and population dynamics of *Katsuwonus pelamis* (Linnaeus), the second dominant species of oceanic tuna fished along the Indian coast was studied during the period 2006-2010. The length frequency data of *K. pelamis* in gillnet as well as pole & lines were

used for estimation of the growth parameter using FISAT software. The total landing showed an increase from 5,882 t in 1985-89 to 20,919 t in 2006-2010. The length of skipjack ranged from 12 to 82 cm FL. On an average 23.2% of landing of skipjack was contributed by northwest coast, 31.4% by southeast coast, 31.7% by Island systems, 12.3% by southwest coast and 1.3% by northeast coast. Among the maritime states, the major contributors were Lakshadweep (29.9%), Andhra Pradesh (18.3%), Gujarat (13.2%), Tamil Nadu (12.8%), Kerala (10.2%), Karnataka (2.08%) and the rest by Orissa, West Bengal, Puducherry and Andaman and Nicobar Islands. They spawn round the year with peak during September-December. Fecundity estimated for this species was 3,00,718/kg body weight. Recruitment pattern showed that young recruits enter the fishing grounds during most part of the year with peak during February-May. The length-weight relationship was $W=0.0109 L^{3.147}$. The estimated von Bertalanffy growth factors (VBGF) were $L_{\infty} = 92.0$ cm, $K=0.32$ yr⁻¹, $t_0 = -0.0012$. Estimated total mortality (Z) = 1.41, natural mortality (M) = 0.55676 and fishing mortality (F) = 0.85324. Studies indicate good scope for further increase in the yield. There is an urgent need for the international co-operation among adjacent tuna fishing nations to avoid issues related to sharing of resources.

FR-O 17

Fishery and dynamics of dogtooth tuna, *Gymnosarda unicolor* (Rüppell, 1838) exploited from Indian seas

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The fishery and dynamics of dogtooth tuna *Gymnosarda unicolor* (Rüppell, 1838) exploited along the Indian coast was studied. *G. unicolor* was landed mainly in Kerala and Lakshadweep and the catch has shown an



increasing trend. They were exploited mainly by hooks and line. The average annual landing by coastal fishery was 130 t (2006-2010) and by LOP vessels was 1,311 t. The size of dogtooth tuna in the catch ranged from 32.5 to 162 cm in fork length. The length weight relationship was $W=0.0105 L^{3.065}$. The length frequency data of *G. unicolor* in hooks and lines were used for the estimation of growth parameter using FiSAT software. Von Bertalanffy growth parameters (VBGF) were $L_{\infty} = 163.6$ cm, $K=0.43 \text{ yr}^{-1}$, $t_0=-0.12$. Estimated total mortality, natural mortality and fishing mortality were 1.06, 0.57 and 0.49 respectively. The estimated t_{\max} was 12 years and it reaches 51.3 cm, 90.5 cm, 116.1 cm, 132.7 cm and 158.0 cm in 1, 2, 3, 4 and 8 years of life. Fecundity estimated for this species was 3, 15, 244/ kg body weight. The estimated $L_m = 62.0$ cm, $L_m/L_{\infty}=0.39$, $L_{\text{opt}} = 67.7$ cm, $L_{\text{opt}}/L_{\infty}=0.61$ and $W_{\infty}=64.0$ Kg. The species mature and spawn round the year with peak during August-January. Young recruits enter the fishing grounds during most part of the year with peak during February-May. Along the Lakshadweep coast, *G. unicolor* was mainly exploited during September- March. Distribution pattern shows that this species occurs in tropical and sub-tropical seas from the longitude 40° E to 160° E and from the latitude 30° N to 40° N of the Indian and Pacific oceans.

FR-O 18

Fishery, biology and population characteristics of longtail tuna, *Thunnus tonggol* (Bleeker, 1851) caught along the Indian coast

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Fishery, biology and population characteristics of longtail tuna, *Thunnus tonggol* were studied during 2006-10. They were exploited by gillnets (63.2%), hooks and line (20.3%) and

ringseines/purseseines (16.5 %). The annual landing during the period varied between 6,073 t and 9,140 t with an average of 7,332 t. About 81.5 % of the total catch was realized from northwest coast alone. Fishery was supported by 32-93 cm fishes with 51.4 cm as mean length. Size at capture was estimated as 43.7 cm and the optimum length for exploitation (L_{opt}) was 53.8 cm FL. The length-weight relationship ($W = 0.0147 L^{3.01}$) showed that growth is isometric for the species. The species is non-selective in feeding and fed on pelagic finfishes, crabs and cephalopods. Species matured at (L_m) 49.8 cm and spawned round the year with peak during September-March. Relative fecundity was 1,32,840/kg body weight. Recruitment was almost round the year with peak in January-April and August-September accounting 64.6%. Size at capture and mean size of the species is lower than the size at maturity and L_{opt} , which necessitates measures to increase size at first capture. Growth parameters of the species were; $L_{\infty} = 107.5$ cm (FL), $K = 0.40/\text{year}$ and $t_0 = -0.0431$ years. Natural mortality (M) was 0.66, total mortality (Z) and fishing mortality (F) were 1.59 and 0.92 respectively. Spawning stock biomass formed 58.6% of the standing stock. Stock assessment indicated scope for improving the production by 20 to 35% of the present yield.

FR-O 19

Biology and fishery status of the bullet tuna, *Auxis rochei* (Risso, 1810) in Indian waters

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A*uxis rochei* is the smallest of all tuna species available in Indian waters. Its distribution is reported from all maritime states but forms a fishery of commercial importance only in the south west region (Karnataka and Kerala) with



targeted fishery being carried out in southern Kerala. The average annual catch during 2006-2010 is 3,131 t contributing 2.8% of the total tuna landings. Commercial exploitation is mainly by small hooks and lines (70.3%) and gillnets (24%) and the rest by trawls and purse seines. Commercial catch is comprised of mainly 0-1 yr old fishes. The length weight relationship is given by the formula, $W=0.0076 L^{3.249}$ with no significant difference between the sexes. Size at first maturity was estimated at 23.6 cm and fecundity was 12,03,258 eggs. *A. rochei* spawn throughout the year with peak during July-September. Diet studies indicated that species is nonselective in feeding habit with finfishes, crustaceans, cephalopods and zooplankton comprising the main prey items. Age and growth were estimated using length based methods. The von Bertalanffy growth parameters estimated were $L_{\infty} = 42.3$ cm, $K = 0.61/\text{yr}$ and $t_0 = -0.0337$. Mortality estimates were $M = 1.16306$; $Z = 5.90$ and $F = 4.74$ with a high exploitation ratio of $E = 0.80$ calling for appropriate management measures to be adopted for continued exploitation at sustainable levels.

FR-O 20

Fishery, population characteristics and stock structure of frigate tuna, *Auxis thazard* (Lacepede, 1800) exploited from Indian waters

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The fishery, population characteristics and stock estimates of frigate tuna *Auxis thazard* from Indian waters was studied during 2006–2010. The average annual catch was 11,157 t, which contributed to 13.2% of the total tuna catch. The length weight relationship, $W = 0.045 L^{2.7}$ showed that growth was isometric for the species. Length at first maturity was 29.7 cm and relative

fecundity was 807,986/kg body weight. The von Bertalanffy growth equation was: $L_t = 57.95 [1 - e^{-1.2(t + 0.0075)}]$. Length at first capture was 32.83 cm. The natural mortality, fishing mortality and total mortality were 1.65, 3.24 and 4.89 respectively and exploitation ratio was 0.66. E_{\max} was 0.778, which is higher than the present exploitation and the maximum sustainable yield was 13,100 t, which is higher than the average annual catch indicating scope for further exploitation. The yield per recruit was 332.3 g. Maximum yield and yield/recruit can be obtained by doubling the present fishing effort, but at the increased fishing effort, the increase in yield is only 2.93% and hence it is suggested that the present level of fishing can be continued.

FR-O 21

Assessment of changes in the cephalopod species composition using Markov chain

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The cephalopod landings in the Visakhapatnam Fisheries Harbour, Andhra Pradesh has shown an interesting pattern during the period 1998-2010. The total cephalopod production in Visakhapatnam during 1998-2010 was 12113.6 t with an average annual production of 931.8 t. The total effort during the period was 1,68,10,029 and average annual effort was 12,93,079. The effort also increased over the period from 1,39,462 in 1998 to 24,61,167 in 2010. The average catch per unit effort was 1.03 kg. The catch rate was very low during 2002 to 2006 in spite of the effort being high. The introduction of large mechanized boats since 2000 has increased cephalopod production and also caused changes in the species dominance pattern. Markovian model is employed to assess the change in the species dominance over the 13 year period. The shifts in the dominance



patterns of the *Loligo duvaucelli*, *Sepia pharaonis* and *Sepia aculeata* are discussed. The possibility of short term prediction on the species dominance pattern by employing the Markovian model is demonstrated.

FR-O 22

Fishery and diet composition of the cobia *Rachycentron canadum* (Linnaeus, 1766) exploited along Karnataka coast

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The fishery and food of cobia, *Rachycentron canadum* caught off Karnataka, southwest coast of India during 2007-10 was studied. An estimated 302 t was landed annually along this coast and formed 0.09 % of the total fish catch of the region. Peak landings were during October followed by April. Gillnets landed large sized cobia and contributed to the bulk of the catch (53%). Maximum catch by this gear was during September-October. The trawl was the next dominant gear and landed fishes of all sizes groups with maximum catch during April-May. The trawl catch contributed to 45% of the total cobia landings. The fishery was constituted of fishes with total length ranging from 26 to 125 cm with mean at 58 cm. Juveniles dominated the catch. Contents of 177 non-empty stomachs were analyzed for the Index of Relative Importance (IRI) and Prey Specific Abundance. *R. canadum* was found to be nonselective generalist carnivore feeder, foraging on micronektonic pelagic or benthic organisms (crustaceans, fish and molluscs) available in the epipelagic waters. Teleost fish (48%), crustaceans (44%) and molluscs (8%) contributed to the diet. *Decapterus russelli* (18.0%) and *E. devisi* (10.0%) were the dominant finfish groups; crabs (*Charybdis* spp. and *Portunus* sp.) with an IRI of 23.5% followed by *Acetes* sp. (16.6%) were dominant among crustaceans and squids (*Loligo* spp.) (5.8%) and octopus (4.1%) comprised the dominant mollusc

prey items. Diversity in the foraging behavior of cobia of different size groups was also studied.

A fast growing fish with very high demand both in the domestic and export market, it is a preferred candidate species for aquaculture the world over. Being a large pelagic predator, it forms an important link in the food chain of the ocean system. Studies on diet are essential in understanding the role of food items in the food chain during different phases of growth, a prerequisite for management and optimizing catch from the wild as well as for formulating ideal feed for the mariculture of cobia.

FR-O 23

Studies on the advantages of application of Potential Fishing Zone forecasts on purse seine fishing off the coast of Goa

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Remote sensing technique of predicting Potential Fishing Zone (PFZ) using satellite derived data based on parameters such as sea surface temperature and chlorophyll including recently added parameter namely surface wind, is becoming an extraordinarily effective and powerful tool in marine fisheries. This paper enumerates the advantages derived due to the application of PFZ forecasts disseminated through various modes viz., FAX, e-mail and Electronic Display Boards (EDBs) to the fishing community at the different jetties in Goa. Feedbacks on the total catch from the notified and non-notified PFZ areas were obtained. A quantitative analysis was made to assess the benefits in terms of net profit fetched due to the reduction in search time and higher catch, fuel cost, distance travelled and other expenditure incurred during the fishing operation. Some tips as to where and when the fishing is to be taken up using the PFZ advisories were also indicated. The extent of success in the fishing operation carried out within and outside PFZ areas was



also analyzed. It was observed that PFZ advisories were useful to purse seine operators fishing in the pelagic areas from 20 to 100 m depth. The PFZ advisories were more effective for pelagic species such as Indian mackerel (*Rastrelliger kanagurta*), oilsardine (*Sardinella longiceps*), seerfish (*Scomberomorus guttatus*), skipjack tuna (*Katsuwonus pelamis*), coastal tuna (*Euthynnus affinis*), lesser sardine (*Sardinella fimbriata*), horse mackerel (*Megalapsis cordyla*) and ribbon fish (*Lepturacanthus savala*) which are either plankton feeders or carnivores. The use of PFZ forecasts indicated 30 to 70% reduction in fish search time, fuel consumption and human drudgery.

FR-O 24

Oilsardine fishery of Malabar region, Kerala - an assessment based on biological reference points

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Malabar region of Kerala comprising the districts of Kasaragod, Kannur, Kozhikode and Malappuram has been known for oilsardine fishery. During the present study covering the period 2001-2009, the annual oilsardine landing was found to vary from 70,397 t to 1,35,289 t with its percentage contribution to the total catch ranging from 36 to 51 with an average of 46. Ring net was the major gear contributing 87 to 98.4 % of the total oilsardine landings. In this gear, the catch per unit effort (CPUE) varied from 1,932 to 3,276 kg with an average of 2685 kg. Quarter-wise analysis of oilsardine landing by ring net showed maximum contribution in the fourth quarter (October-December) during 2001 to 2006. In 2007 and 2008, maximum catch was recorded in the first quarter but the maximum effort was in third quarter. In 2009, both the maximum catch as well as effort were recorded in the third quarter. The size composition in the fishery showed the range of minimum size groups from 4 cm in 2001 to 9.5 cm in 2009 whereas

the largest size groups varied from 20 cm in 2006, 2008 and 2009 to 22 cm in 2002. The mean size groups varied from 10.9 cm in 2002 to 13.5 cm in 2009 but the variation was found not significant. The parameters L_{∞} , K length weight relationship etc. were found out to apply the Thompson and Bell method. From these, the total biomass, spawning stock biomass (SSB), its percentage with respect to virgin SSB at various levels of F-factor, MSY, MSE etc. were estimated.

Table 1. Results of prediction analysis

Year	MSY		MSE		Present
	F-factor	SSB(%)	F-factor	SSB(%)	
2001	1.0	6	0.8	10	6
2002	2.4	9	2.2	11	34
2003	2.4	5	2.0	6	23
2004	1.4	5	1.4	5	11
2005	2.2	11	2.0	13	29
2006	1.6	6	1.4	8	14
2007	4.2	13	3.4	17	44
2008	3.6	5	1.8	14	34
2009	2.4	2	2.4	2	16

The study showed that the fishing level had not reached the MSY or MSE level except in 2001. At the same time, it was not advisable to increase the fishing level as the spawning. Stock biomass (SSB) percentage with respect to the SSB of virgin stock was very low. Hence, based on the results of the present study it may be concluded that fishing can be continued at the present level of exploitation.

FR-O 25

A study on the reef fishery of south India

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Indian subcontinent with its coastline extending over 8,000 km and subtropical climatic condition has very few coral and rocky reef areas when compared to other regions of the world. In India, these reef patches are distributed along the east and west coasts at restricted places. Bellwood (1996) established a consensus list of fish families as a working definition of a reef



fish assemblage - "fish families that would be found on any living coral reef, irrespective of its biogeographic location". An attempt was made to study the diversity of reef fishes of South India and the islands of Andaman and Lakshadweep. Based on Belwood's (1996) classification, grouping of the reef fishes landed was done at selected centres along the coast.

Serranidae, Lutjanidae and Lethrinidae, popularly known as rock cods, snappers and pigface breams respectively were the major reef fishes all along the coast. Landings showed considerable changes during the last three years in Karnataka with an increase in major perch landings and a slight decline in the minor perch fishery. However, not much variation was noted in other centres. Seasonal fishery exists for the reef fishes at Kochi, Varkala, Quilon during October – March, at Karnataka during August – December and at Agati during monsoon. Over a two year period, 500 species of reef fishes belonging to 69 families was recorded from the different localities. Diversity indices were compared between the east coast, west coast and the Andaman Islands. Diversity of fishes in the three ecosystems was studied using Shannon-Weiner diversity; east coast had higher reef fish diversity compared to west coast and Andaman islands. Margalef (d) species richness index also showed higher values for east coast compared to west coast. The east coast also had highest value (0.92) for Pielou's evenness (J') index. The study highlights the importance of documenting the species richness and diversity of reef fishes on the Indian coast which will help in evolving suitable strategies for the protection and management of these resources.

FR-O 26

Crustacean by-catch from trawl fishery along north Tamil Nadu coast

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Trawl fishing along the north Tamil Nadu coast is done by trawlers operating from Chennai.

The fishing grounds lie in the depth range of 10 to 70 m at a distance of 15 to 80 km from the shoreline, extending between Ongole in south Andhra Pradesh and Nagapattinam to the south of Chennai. Although commercial trawling targets penaeid shrimps, about 70-80% of the catch is made up of finfish, both commercial and non-commercial, and other resources like molluscs, echinoderms etc. While early accounts of shrimp trawl in Indian waters do not give an estimate of the actual finfish catches or discards, in the last two decades, shrimp trawling has been redefined as trawl fishing, with a major turnabout towards utilization of finfishes and other marine resources caught in the shrimp trawl. Over-exploitation of shrimp resources or of particular grounds has probably paved the way for a reduction in the catches of commercially valuable shrimp species. This highly valued resource has been relegated to a mere 7-10% of the total trawl landing at Chennai during 2005-2010. More alarming is the fact that shrimps and other crustaceans find a prominent place in the low-value trawl by-catch that is usually landed in a state of decomposition and fetches only a very low price. Another matter of concern is the presence of a high percentage of juveniles of almost all major commercially important crustaceans in the by-catch.

About 53% of the crustaceans in the by-catch are crabs, represented by a wide range of families and genera. The major species of crabs in the landings are the juveniles of commercially important *Portunus sanguinolentus*, *Portunus argentatus*, *Portunus gladiator*, *Charybdis lucifera* and *Charybdis hoplites*. Others include *Calappa* sp., *Dorippe frascione*, *Arcania heptacantha*, *Liagore rubromaculata* etc. Stomatopods are another important group in the low value by-catch consisting of several species like *Oratosquilla nepa*, *Oratosquilla woodmasoni*, *Oratosquilla gonyptes*, *Harpiosquilla harpax*, *Harpiosquilla annandeli*, *Harpiosquilla raphidae* etc., forming about 23% of the crustaceans in the by-catch. Shrimps, forming about 18%, are represented chiefly by juveniles and spoilt specimens of *Metapenaeus* spp., *Metapenaeopsis*



stridulans, *Parapenaeopsis* spp., *Trachypenaeus* spp., *Solenocera crassicornis* and *Parapenaeus longipes*. Lobsters in the crustacean by-catch, represented by the scyllarid lobsters *Petrarctus rugosus* and *Thenus* sp., formed about 6%. Species richness was highest in the year 2008. Annual biodiversity index was highest in the year 2007. Seasonal abundance showed a peaking of biodiversity index in June-July, the species richness was also highest during those months.

FR-O 27

Length weight relationships of *Meretrix casta* (Chemnitz) from four estuaries along north Kerala, India

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Meretrix casta (Chemnitz) is cited as vulnerable under the IUCN list. Knowledge on growth in terms of length and weight is important for implementing management and conservation measures. The length weight (L-W) relationships of the edible clam *M. casta*, collected from four estuaries along the south west coast of India are presented in this study. The linearised equation of the length weight relationship $W = a L^b$ was computed for clam samples collected from Moorad and Chaliyar estuary in Kozhikode, Kavvai estuary in Kasargod and Mahe estuary in Puducherry. In *M. casta*, the L-W relationship between males and females was not found to be significantly different and therefore a combined equation was derived. The L-W relationship for *M. casta* from Moorad estuary was found to be $\text{Log } Y = -0.9814 + 2.9192 \log X$, $r = 0.897$. The L-W relationship for *M. casta* from Chaliyar estuary was found to be $\text{Log } Y = -1.2596 + 3.0909 \log X$, $r = 0.903$. The L-W relationship

for *M. casta* from Kavvai estuary was found to be $\text{Log } Y = -0.9870 + 3.0548 \log X$, $r = 0.614$. The L-W relationship for *M. casta* from Mahe estuary was found to be $\text{Log } Y = -3.5272 + 2.906 \log X$, $r = 0.937$. In all four cases, the growth in length was accompanied by weight increase and the growth was isometric ($b = 1$).

FR-O 28

Food and feeding habits of ribbonfish *Trichiurus lepturus* (Linnaeus) in coastal waters off Gujarat along the north west coast of India

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Ribbon fish forms one of the major landings along the coast of Gujarat. There is a targeted fishing for the ribbonfish using large meshed and wide winged mechanized multiday trawlers. To study the feeding habits such as intensity of feeding and major food components of *Trichiurus lepturus* in different seasons of a year, gut content of 1114 numbers of fresh specimens were analysed for three years since January 2008 to December 2010. Size of the fishes ranged from 260 mm to 1239 mm Preanal Length (PL) with a mean size of 742.5 mm PL. Though they fed on a variety of fishes and shellfishes all through the year, *Acetes* sp., clupeoids (*Sardinella* spp., *Ilisha* spp. and *Stolephorus* spp.), cephalopods (*Loligo* spp., *Sepia/Sepiella* spp. and *Octopus* spp.) and mackerel dominated. Feeding intensity during the pre-spawning seasons was significantly greater than the remaining periods and the fish showed distinct preference for *Acetes* sp. and cephalopods during these months. Changes in food and feeding habits of this species during the three years are dealt in detail in this study.



FR-O 29**Seasonal variations in the diet of Indian oilsardine, *Sardinella longiceps* off Cochin, Kerala**

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An attempt was made to find out seasonal fluctuations in the stomach contents of the oilsardine, *Sardinella longiceps* caught by ring seine units from the inshore waters off Cochin during the period January-December 2010. *S. longiceps* mainly feed on diatoms, dinoflagellates and zooplankton. During pre-monsoon season (February-May), *Pleurosigma* was present in 70% of the stomachs analysed followed by *Thalassiosira*, *Biddulphia* and *Coscinodiscus*. During monsoon (June-September) season, 87.5% of the stomachs analysed contained *Coscinodiscus* followed by *Thalassiosira* and *Pyrophacus*. During the post-monsoon (October-January), again, the frequency of occurrence of *Pleurosigma* (74.19%) was higher followed by *Biddulphia* and *Thalassiosira*. Copepods were present in the diet throughout the year. It appears that different items of phytoplankton and zooplankton were dominant in the diet depending on their seasonal abundance in the coastal waters. High intensity of feeding was observed during the monsoon period, which coincided with maximum spawning activity of oilsardine in this region.

FR-O 30**Satellite based Potential Fishing Zone (PFZ) advisories - acceptance levels and benefits derived by the user community along Kerala coast**

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Intensive validation of Potential Fishing Zone (PFZ) advisories generated using integration

of Ocean Colour Monitor (OCM) derived chlorophyll concentration and Advanced Very High Resolution Radiometer (AVHRR) derived sea surface temperature (SST) by the Indian National Centre for Ocean Information Services (INCOIS) along Kerala coast during the period 2003-2011 revealed positive relationship between PFZ advisories and occurrence/ abundance of commercially important pelagic fishes such as oilsardine, Indian mackerel, anchovies, carangids and coastal tunas. Fishing operations undertaken on or closer to dates on which related SST/chlorophyll images have been received yielded positive results. When the gap increases, the yield within PFZ is likely to come down unless the features remain more or less in the same location as revealed by the succeeding satellite imagery. The fish catch within PFZ gave higher CPUE and net profit compared to the results of operations outside PFZ. Average income derived by vessels which operated within PFZ were considerably higher than vessels which operated outside PFZ. The usefulness of PFZ advisories, the only short term marine fishery forecast available in the country, for artisanal, motorized and mechanised sector fisherfolk towards obtaining comparatively higher catch per unit effort for the above mentioned major pelagics is proved beyond doubt through the results of more than 100 controlled experiments conducted onboard, more or less identical commercial fishing vessels operating almost identical fishing gear along Kerala coast.

FR-O 31**Fishery based biodiversity assessment in Karnataka**

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Karnataka state has three maritime districts with a 300 km long coastline and is one



among the frontline capture fishery state along the west coast of India. The catches of pelagic and demersal fishery resources of the Karnataka coast indicate rich marine faunal diversity. This rich diverse fauna comes from 25,000 km² continental shelf area and a vast number of brackish water environments. The total marine fish diversity now stands at 412 species from 115 finfish families, 161 species of crustaceans, which include 33 species of shrimps from 8 families, 105 species of true crabs from 18 families, 14 species of hermit crabs from 2 families and 9 species of lobsters from 3 families. There are about 234 molluscan species recorded from 65 families, in which 145 gastropods and 70 bivalves and 16 cephalopods are included. The overall biodiversity potential of this coast is phenomenal owing to the highly diverse estuarine and marine conditions. The special effort made on the eve of International year of biodiversity yielded 22 species of finfishes which were not recorded from this coast earlier. A comprehensive list of available species in the region will go a long way in confirming the distribution pattern of marine fauna and also aid in assessing the marine biodiversity.

FR-O 32

Marine biodiversity : crisis and concerns with special reference to overfishing

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India is one among the world's 12 mega-biodiverse countries. In the biogeographic perspective, it is an important eco-region of the world constituting the prime and integral part of the Indian subcontinent characterized by its tri-junctional juxtaposition with the Ethiopian, Palaearctic and Oriental realms. As a reflection of the biodiversity potential, India is endowed with a coastline of about 8000 km, an Exclusive Economic Zone (EEZ) of 2.02 million km² integral to its continental shelf and the offshore islands, and a variety of coastal

ecosystems encompassing estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, sandy stretches and coral reefs. However, as is the case with the world scenario, it is in ever-increasing danger, despite the acknowledged notion that it is crucially important for the survival of humanity. We are not even aware of the full dimension of the potential of biodiversity. At the global level, altogether fewer than 2 million species of animals, plants and microorganisms have been identified. The number of species from all groups and all habitats of seas could be of the order of several million but only a small share of this wealth is at present known to us. Even the most recent global inventory, the Ocean Bio-geographical Information System (OBIS), has no more than 1,16,603 valid marine species listed.

With regard to the marine biodiversity of India, the number of species known could be of the order of 13,000 or higher. The species-inventorying has been done in detail only in the case of commercially important groups such as fishes or molluscs, and is very weak with respect to other groups and minor phyla or microbial organisms. In terms of spatial coverage, probably only two-thirds of the total marine habitat has been covered till today and the remote islands and other minor estuaries still virtually remain unexplored. The unknown diversity of life in coastal/marine ecosystems far exceeds what is already known. The benthic, or bottom-dwelling, plants and animals in oceans represent the lesser and least-known ecosystems/habitats on earth. The prospect of protecting the coastal/marine ecosystems appears so vast to be out of reach of individuals. Concern for self does not expand sufficiently to embrace concern for species, and definitely not for all species, to which one is connected by evolution. All the marine groups which are under severe threat due to over-fishing along with their diversity status, exploitation level and strategies for their effective conservation are dealt separately in this paper.



FR-O 33**Diversity of invertebrates in the trawl bycatch along the Coramandal coast**

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Invertebrate diversity in the bycatch from trawls operated off Cuddalore, Parangipettai and Pazhayar was studied during February 2010 – January 2011. Eight benthic groups namely brachyuran crabs, shrimps, stomatopods, cephalopods, gastropods, bivalves, echinoderms and jellyfish were found in the bycatch. Altogether 67 species of invertebrates in Cuddalore, 75 species of invertebrates in Parangipettai and 76 in Pazhayar were recorded during the study. In Cuddalore waters, shrimps were found to be the dominant group with 23% of the total invertebrate bycatch, followed by gastropods with 21%, cephalopods and brachyuran crabs with 20% each, bivalves and echinoderms with 12%, 2%, respectively and stomatopods, jellyfish with 1% each. On the other hand, in Parangipettai, gastropods topped the list with 23% of the total invertebrate by-catch, followed by cephalopods (22%), shrimps (19%), brachyuran crabs (18%), bivalves (13%), stomatopods and echinoderms (2% each) and jelly fish (1%). With respect to Pazhayar, as in Parangipettai, gastropods formed dominant group with 30% followed by shrimps with 24%. Brachyuran crabs, bivalves, cephalopods, stomatopods, echinoderms and jelly fish contributed 16%, 11%, 9%, 5%, 4% and 1%, respectively to the total invertebrate bycatch. Shannon diversity varied from 1.84 (March) to 4.13 (July) in Cuddalore, from 2.03 (February) to 4.21 (October) in Parangipettai, 3.50 (June) to 4.77 (February) in Pazhayar; species richness ranged from 2.30 (December) to 5.80 (June) in Cuddalore, 3.17 (November) to 5.12 (January) in Parangipettai, 4.03 (June) to 6.60 (February) in Pazhayar; evenness index ranged from 0.40 (March) to 0.94 (October) in

Cuddalore, 0.48 (February) to 0.95 (July) in Parangipettai, 0.82 (December) to 0.95 (February) in Pazhayar; taxonomic diversity values varied from 50.48 (March) to 81.78 (June) in Cuddalore, 45.08 (February) to 81.67 (October) in Parangipettai, 69.34 (December) to 83.53 (July) in Pazhayar; total phylogenetic diversity values varied from 733.33 (December) to 1783.3 (June) in Cuddalore, 883.33 (July) to 1516.7 (January) in Parangipettai and from 1033.3 (June) to 1716.7 (February) in Pazhayar.

FR-O 34**Catch composition of the deepsea shrimp fisheries of southern coast of India**

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The deep-sea shrimp trawl fisheries of Kerala and Tamil Nadu were monitored during 2008-2011. Regular observations were made at major fish landing centers in Kollam, Cochin and Tuticorin and the catch compositions were studied. Unsorted samples were collected to identify the species at regular intervals. Trawling operations for deep sea shrimps are mainly carried out at depth range between 170 to 480 m. Catch was constituted mainly by crustaceans to the order of 60 to 80% of total catch. At times, the bycatch exceeds more than 80% and the entire haul discarded without being taken on board. The catch comprised a variety of elasmobranchs, fishes, crustaceans and molluscs. A total of 202 fish species of 38 families, 18 crustacean species of 12 families and 5 species of molluscs from 4 families were identified. The targeted group in the catch was dominated by five species such as *Aristeus alcockii*, *Heterocarpus woodmasoni*, *Heterocarpus gibbosus*, *Plesionika spinipes* and *Metapenaeopsis andamanensis*. Myctophids represented by 8 species dominated the finfish group in the bycatch. Out of 18 species of



deep-sea elasmobranchs identified, 6 species are commercially important for oil industry. Deep-sea nonconventional fish species like *Neopinnula orientalis*, *Rexea prometheoides*, *Polymyxa baxteri*, *Ostichthys kaianus*, *Cyttopsis rosea*, *Zenopsis conchifer*, *Diaphus watasei*, *Pristigenys nipponia* and *Sphenanthias whiteheadi*, which are suitable for human consumption are landed along with shrimps in considerable quantity.



FR-O 35

Myctophid resource in the deep-sea shrimp trawl along the Kerala coast

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Myctophids were caught as bycatch in deep-sea shrimp trawlers operating along the Kerala coast of India. Catch composition and biology of major species were monitored during 2009-2011. Around 200-300 trawlers were operating for deep-sea shrimps from August to May, with an intense operation during November - February. They are mainly operated off Vizhinjam, Kollam, Alapuzha, Kozhikode and Eezhimala at depths ranging between 270 and 500 m. Total bycatch was estimated as 19,750 t/year and myctophids as 7900 t/year. Bycatch mainly comprised finfishes, crabs, lobsters and molluscs; among them finfishes formed 60-70%. Myctophids constituted 40% of the total bycatch. Catch of myctophids was contributed by four species, dominated by *Diaphus watasei* contributing 70-85% of the catch. *D. watasei*

was observed round the season and others only seasonal. Detail study on the length frequency, biological aspects and proximate profile of *D. watasei* has been done. *D. watasei* were represented by 5-13 cm (SL) size range. Mature species were observed round the season with a peak during summer months. They are carnivorous in feeding habit, mainly feeding on crustaceans and molluscs. Proximate composition and fatty acid profile are almost comparable with that of other commercial fishes, so that they can be utilized as an alternative low cost protein for future.

FR-O 36

Fishery and length frequency studies of three species of butterfly rays (Pisces: Gymnuridae) represented in the catches of north Andhra Pradesh

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Butterfly rays contribute a sizeable portion to commercial fishery resources off Visakhapatnam (lat 17°44'N, long 82°23'E) almost round the year. Of the species of butterfly rays of commercial importance in north Andhra Pradesh, *Gymnura poecilura*, *Gymnura japonica* and *Gymnura zonurus* were found to form a greater part of the catches. Butterfly rays are restricted to the inner continental and coastal shelves with a depth range up to 40 m, sometimes extending even up to 80 m. Major portion of the catch is landed by trawlers followed by gillnets. The fecundity is too low where a female produces few young ones usually less than six as a result of which, this is considered to be highly vulnerable group and included in the category of A2d+3d+4d. Out of the five species of genus *Gymnura* listed in the IUCN Red data book of threatened animals (IUCN, 2005) two species *G. poecilura* and *G. zonurus* are represented in the catches of north Andhra Pradesh. Conservation status of these fishes requires information through the actual field surveys. There is no information



available on the biology and fishery of this species from the region. The present paper deals with the fishery and length frequency studies of *G. poecilura*, *G. japonicus* and *G. zonurus* as this information is essential to ensure long term conservation and sustainable production.

FR-O 37

Fish assemblages of the Sunderbans estuarine system: an analysis based on the estuarine set bag net fishery

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Sunderbans represent the largest single chunk of deltaic mangrove forest on this planet formed at the mouth of the Ganga-Brahmaputra river system. The Indian part of Sunderbans covers an area 9630 sq. km and is under the jurisdiction of South as well as North 24 Parganas districts of West Bengal. The fisheries activities in this region are mainly artisanal with varying types of fishing gears, of which the 'estuarine set bag net' (ESBN) is the most widely employed gear for capturing the fisheries resources of this unique ecosystem. This paper makes an attempt to provide information on the fish assemblages of this ecosystem based on ESBN catches. A series of surveys were conducted and 210 samples from 7 sampling stations were collected; three in the Hooghly zone (Nischintapur, Kakdwip and Fraserganj) and four in the Thakuran-Matla zone (Canning, Sajnekhali, Gosaba and Patherprathima) from June 2010 to September 2011. Data were analyzed using PRIMER software for estimating the different diversity indices such as species richness, Shannon-Weiner diversity index, dominance and evenness index and for cluster analysis. A total of 26,445 fishes were collected which belonged to 179 species under 137 genera, 63 families and 16 orders. About 84.5% of the fishes belonged to five families, viz., Clupeidae (44.86%), Engraulidae (14.45%), Harpadontidae (13.94%), Sciaenidae

(6.33 %) and Gobiidae (4.91 %). Sciaenidae was the dominant family in terms species richness (20 species) followed by Gobiidae (19 species), Engraulidae (10 species), Clupeidae (9 species) and Ariidae (7 species). Overall catch composition shows that *Escualosa thoracata* is the most abundant species contributing to 42.45% of the total catch, followed by *Harpadon nehereus* (13.94%), *Otolithoides pama* (5.13%), *Stolephorus indicus* (5.10%) and *Odontamblyopus rubicundus* (4.05%). Cluster analysis revealed that there is significant difference in the fish assemblages between the Hooghly and Thakuran-Matla zone which can be attributed to the increased freshwater flow to the Hooghly estuary due to water release from Farakka Barrage, thereby reducing the salinity to almost freshwater conditions in Nischintapur and Kakdwip during monsoon season. Since the ESBN fishery covers a vast area and uses very fine meshed netting (locally called 'mosquito net'), it indiscriminately captures the juveniles of finfishes and shell fishes and is now a growing matter of concern in the conservation of aquatic biodiversity of the Sunderbans estuarine system.

FR-O 38

Population parameters, mortality and recruitment of the featherback *Notopterus notopterus* (Pallas) from Bhadra reservoir, Western Ghats, India

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The population ecology of the freshwater fish *Notopterus notopterus* (Pallas) from Bhadra Reservoir, in the Western Ghats was studied from November 2001 to November 2002. A total of 1400 individuals ranging from 10.8 to 33.3 cm size were subjected to analysis. The values of growth parameters obtained were L_{∞} = 38.8cm and K = 0.81. The maximum length recorded (L_{max}) was 33.3 cm. The von Bertalanffy growth curve was fitted for length data of *N. notopterus*.



The total mortality was 5.34 year^{-1} . The natural mortality and fishing mortality rates were 1.4 and 3.94 year^{-1} respectively. The results of length structured VPA are also discussed.

FR-O 39

Status and potential of watershed based fisheries development in Uttarakhand Himalayas

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Virtually, rivers form the major source (95%) of fish for consumption to local inhabitants in Uttarakhand Himalayas, against 50% in plain states of India that results in wide demand-supply gap in the region. In Uttarakhand, the present highest annual fish production level of 6422 t is 6 times lower than the quantity required (39,684 t) to meet recommended demand of 200 g per individual per week. About 70-75 % of fishing is carried out in 5th-6th-order streams and rivers, followed by 7th-order rivers (24-29 %), negligible in 4th-order streams and almost no fishing in first- to third-order streams of the region due to lack of fishable population and yield limitation. Fishing in rivers of the region is often very unhealthy and destructive in nature that needs strict surveillance through all means. The potential for revenue generation through angling and sport fishing of trout, *Oncorhynchus mykiss* (rainbow trout) and *Salmo trutta fario* (brown trout) and mahseer (*Tor* spp.) is immense in the region. Composite carp culture of both Indian major carps (IMC) and exotic carps in plains and foothills, exotic carps in mid-hills, trout in higher hills and conservation of local fish species in different elevations of Himalayan region may bridge the wide supply-demand gap and promote fisheries. Integrated fish farming along with accommodative agriculture has immense potential in the Himalayan region. Fish farming in the region is constrained by multiple common

problems of overstocking, lack of fish seedlings of appropriate size (40-50 g), non-adoption of recommended practices etc., which should be mitigated suitably. Propagation of rescheduled carp farming calendar (April-December), stocking of grown-up carp seedlings at 1-2 per m^2 density on the onset of summer, adequate feeding and water quality management enhanced the carp yields $1,000\text{-}2,000 \text{ kg ha}^{-1} \text{ year}^{-1}$ to $3,000\text{-}4,500 \text{ kg ha}^{-1} \text{ year}^{-1}$. Fish production potential and future managerial thrusts identified for the promotion of watershed based fisheries development in the region are discussed in the paper.

FR-O 40

Study on temporo-spatial changes in inland water bodies of Ratnagiri district using remote sensing and GIS

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Reliable and up-to-date information on the extent and distribution of fisheries resources over time and space is required for conservation, management and development of fisheries sector. For proper planning it is necessary to know the resource profile and associated infrastructure to suggest management measures for their sustainable use. Remote Sensing (RS) and Geographical Information System (GIS) have emerged as powerful tools that generate data required for micro and macro-level planning of inland fisheries management on sustainable basis. The aim of the present study is to assess temporo-spatial changes in inland water bodies in Ratnagiri district of Maharashtra state during pre-monsoon and post-monsoon seasons using remote sensing and GIS in order to prepare an inventory so that suitable management measures can be planned for optimum utilization of these water bodies. Satellite images of LISS III sensor of February 2006 and November/December 2006 were used to know the information of water bodies for pre- and post-monsoon periods of the study.



area, respectively. All the inland water bodies in the district were extracted from the satellite images by onscreen digitization. In the Ratnagiri geodatabase; water spread area, geographic location, and number of water bodies in post- and pre-monsoon periods were included. Maps showing the water bodies in pre- and post-monsoon periods for different Taluks were prepared. Users can make queries using Structured Query Language (SQL) to select water bodies with desired attributes. In pre-monsoon period, water spread area was 1417.8712 ha (59 nos.) which increased to 1674.0853 ha (63 nos.) in post-monsoon period showing 15.30% change in area of the district. Khed taluk had the largest water spread area of 425.7309 ha in post-monsoon and 376.6114 ha in pre-monsoon period with six water bodies, whereas Ratnagiri taluk had the lowest water spread area of 39.2546 ha and 49.7765 ha with in pre and post-monsoon periods respectively with three water bodies. The results of the study will be useful in rationally chalking out fish seed stocking and harvesting strategies in Ratnagiri district.

FR-O 41

Geospatial mapping of fisheries profiles of Indo-Gangetic plains through GIS

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The Indo-Gangetic plains (IGP) comprise of five contiguous states – Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. All these states have huge inland water resources in the form of lakes, reservoirs, ponds, tanks and rivers with great potential for inland fish production through scientific management. In the present study, an attempt was made to identify inland water bodies suitable for fish production in the Indo-gangetic plains by geospatial mapping. Geospatial mapping is a location based study and it is a part of intelligence GIS which is expected to be a useful tool for fisheries scientists, aquatic resource managers and policy

planners in developing and planning strategies for better utilization of aquatic resources. In this context, a study was conducted where mapping of fisheries profile of Indo-genetic plains was performed using GIS tool having a critical geographic dimension. For this purpose, the core system of fisheries data of Indo-genetic plains was accessed and integrated from different sources at state level. Data were brought in tabular form through Microsoft Excel and then joined to digitized map of Indo-gangetic plains. Mapping was carried out using Arc Info (9.3.1 version) GIS software. This was further synchronized and integrated to generate three thematic maps based on different criteria. Map 1 conforms different layers like (i) average fish production and (ii) inland water resources in different forms. Map 2 presents census data of fisherman and their occupation. Map 3 is fisheries business map, which contains different layers such as (i) fish consumption (rural and urban) (ii) demand and supply of fish and (iii) fish business flow directions.

FR-O 42

Effect of hydro-electric power projects on population dynamics of native and exotic fishes of river Ganges in Garhwal Himalaya

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Over 44 hydro-electric power projects have been proposed in Uttarakhand. Among them, many projects are under construction and some of them have been completed. In Garhwal Himalaya, approximately 18 hydro-electric power projects are planned on river Ganges upstream from Rishikesh till Gomukh. Among these, a major hydro-electric power project – Tehri –Hydroelectric-Dam-Cooperation (THDC) is fully functional. Hydroelectric power projects



do submit an environmental assessment report initially before the project starts but in case of Uttarakhand, much data is not available on how these projects have impacted the native fish species. To make the situation worse, besides these hydro-electric power projects, the state government has an extensive exotic species introduction program that has been carried out in many rivers of Garhwal region.

As there is no base line data available on the population of different fish species in Garhwal Himalaya, the present study was focused on establishing base line data on populations of various species in Ganges and its major tributaries in Garhwal Himalaya. A case study was carried out in the sites of Maneri Bhali Phase I and Phase II hydro-electric power project. The data collected during the study suggests that the main fish of these snow fed rivers of Garhwal, snow trout (*Schizothorax* species) is still abundant but its population is dwindling. In some pockets, the exotic species brown trout (*Salmo trutta*) is having a considerable impact on native fish population. As there is no long term data base on population dynamics, the problem of dwindling native species might look trivial at this time but if immediate attention is not paid to this problem, an ecological catastrophe is likely to happen.

FR-O 43

Commercial exploitation and marketing of the edible bivalve *Paphia* spp. in major estuaries of Ratnagiri in Maharashtra

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Bivalves are benthic molluscs occurring in intertidal to subtidal areas. Many species of bivalves occur abundantly along the Konkan coast, of which *Paphia* spp. has commercial importance. *Paphia* spp. locally called "tasara

mula" has delicious flavor and taste which is fetching good price due to great demand in local market of Konkan region as well as also in international market. Bivalves are generally either hand picked or collected with scoop nets. The traditional gear used to catch the clam is locally called as "khonda" in Ratnagiri district. The clams provide a source of financial sustenance to the rural fishers of coastal areas. Delicious food items like clam curry, clam masala, clam fry etc. are the common products prepared in Ratnagiri district. A study was conducted on the commercial exploitation of *Paphia* spp. from Mirya, Sakhartar and Bhatye estuaries of Ratnagiri, with the traditional gear "khonda" of different mesh sizes viz., 10 mm, 20 mm, 30 mm and 40 mm and its marketing. The data was collected from June 2007 to May 2008. The exploitation of clams begins with the onset of low tide. Khondas with 10 mm and 20 mm mesh sizes, catch smaller sized clams, where as bigger clams are caught in gears of mesh sizes 30 and 40 mm. After one haul, fishermen usually decides which mesh size net is to be used in the respective area. Ideal depth of water for operation is 3-5 feet. Yield from one gear depends upon availability of clams in that particular area and it varies with skill and experience of fisherman. It is sold in the market as 'sher' (small quantity comprising one unit) and four shers makes one 'payali'. Price of one payali varies between Rs. 20-120/- Dried clams have more value than fresh clams and fetches price in the range of Rs. 150-300/- per payali.

FR-O 44

Population biology of the Asian green mussel, *Perna viridis* (L.) from St. Mary's Islands off Malpe, near Udupi, India

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The population biology of the green mussel *Perna viridis* (L.) inhabiting the intertidal rocky shore at St. Mary's Islands off Malpe, Udupi district, Karnataka, India was studied from



December 2004 to December 2005. The settlement and recruitment of young mussels occurred during August to December 2005. The shell length ranged from 0.61 to 13.32 cm. The von Bertalanffy growth equation for length was $L_t = 13.69 [1 - e^{-0.42(t + 0.38)}]$. The maximum length recorded (L_{max}) was 13.32 cm. The growth performance index (Φ) was 3.896. The total mortality (Z) was 1.43 year⁻¹. The natural (M) and fishing mortality (F) rates were 1.27 year⁻¹ and 0.16 year⁻¹ respectively. Total mortality for entire population ranged from 0.538 (October 2005) to 2.2492 (December 2004). The cohort size was reduced to 50% within 6 months after settlement. The maximum and minimum densities of mussels were 5404 nos. m⁻² (December 2004) and 1744 nos. m⁻² (October 2005) respectively and the average was 3105 nos. m⁻². The biomass (total weight) of mussels varied from 37745 g m⁻² (November 2004) to 8910 g m⁻² (December 2005) with the average value of 22754 g m⁻². The biomass values (total weight, wet weight, dry weight, shell weight) increased with the increasing growth of mussels. The specific production fluctuated between 0.0488 (June 2005) and 0.1318 (January 2005). The exploitation rate was very low (0.11). The principal component analysis (PCA) performed between the biological data of *P. viridis* and the environmental variables produced a total of 3 components and accounted together for 90.8% of total variance. The component 1 accounted for 66.85% of variance followed by component 2 for 16.73% of variance and component 3 for 7.23% of variance.

FR-O 45

Food and feeding habits of Indian mackerel, *Rastrelliger kanagurta* from Mangalore coast

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Investigations on food and feeding habits will throw more light on migratory and shoaling

habits of pelagic species of fish, and it is particularly very important for a species of high commercial value like the Indian mackerel, *Rastrelliger kanagurta*. A total of 1124 specimens were examined during the period August 2003 to July 2004 from Mangalore region. Both qualitative and quantitative analyses were carried out to study the feeding habits of *R. kanagurta*. Qualitative analysis comprised identification of all organisms encountered in the stomach and quantitative analysis was carried out by the numerical method. The gut content had highest percentage of zooplankton, followed by phytoplankton and algae, miscellaneous items and semi-digested matter. Greater percentage of fishes had stomachs with considerable quantity of food during October and November indicating active feeding. Moderate feeding was noticed during December, March, August and September. Poor feeding was observed during April to July. Empty stomachs were observed during March to June. The details of percentage occurrence of various food items in the stomach content of *R. kanagurta* in various size groups were considered.

FR-O 46

Length weight relationship and relative condition factor of *Otolithes cuvieri* Trewavas, 1974 from Ratnagiri waters

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The study deals with the length-weight relationship and relative condition factor of *Otolithes cuvieri* collected from Ratnagiri, west coast of India during December 2009 to September 2011. A total of 655 specimens (333 male and 322 female) ranging from 83-310 mm in total length and 7.6-328 g were used for the study. The relation between total length and weight of fish is described as $\log W = -4.931 + 2.97 \log L$ for males, $\log W = -5.106 + 3.054 \log L$ for females and $\log W = -5.024 + 3.016$



Log L for sexes combined. The regression coefficient 'b' was found to be not significantly different from 3 indicating isometric growth. The mean relative condition factor (K_n) values ranged from 0.88 to 1.23 for males, 0.85 to 1.21 for females and 0.88 to 1.22 for sexes combined. The length-weight relationship and relative condition factor indicated the well-being of the species.

FR-O 47

Age and growth estimates of the freshwater snakehead, *Channa punctatus* (Bloch) from three Indian rivers

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Age and growth of spotted murrel, *Channa punctatus* (514 specimens) collected from the three Indian rivers viz., Ganga, Gomti, and Yamuna during January 2010 to June 2011, were estimated using otoliths. The translucent and opaque zones on the otolith surface were identified and the number of translucent zones was counted. The estimated ages of the fish ranged from 1 to 5 years. The values for allometric coefficient 'b' of length-weight relationships (LWR) indicated positive allometric growth from the rivers, Ganga (3.2613) and Gomti (3.1291) while isometric pattern of growth was obtained from the river Yamuna (3.0778). Results for LLR between total length (TL) and standard length (SL) of the fish from all the selected rivers, indicated high correlation with most of the coefficient of determination values greater than 0.93. von Bertalanffy growth function (VBGF) was fitted to length-at-age data obtained from otoliths. The VBGF equations were expressed as: $L_t = 24.8 (1 - e^{-0.3159(t+1.3612)})$ for river Ganga, $L_t = 27.5 (1 - e^{-0.3137(t+1.3070)})$ for river Gomti, and $L_t = 28 (1 - e^{-0.3102(t+0.8704)})$ for river Yamuna. The growth function indicated that the fish grew rapidly during first three years of life and then the growth rate gradually

decreased from Ganga and Gomti rivers. In river Yamuna, the fish grew rapidly during first four years after which growth increment was very little. The results of the present research work may be utilized by researchers, fishery managers and policy makers for sustainable fishery management and conservation of *C. punctatus* in Indian waters in general and Ganges river basin in particular.

FR-O 48

Age and growth of top snail, *Telescopium telescopium* in the mangroves along Nethravathi estuary Mangalore, Karnataka, India

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Mangrove is a unique ecological environment and forms habitat for wide variety of marine invertebrates. *Telescopium telescopium* lives in intertidal zone of the estuary. It prefers soft, liquid muddy substrates and frequently found in shady areas of the mangrove. It has a wide distribution throughout coastal mangroves of India. They are deposit feeders, feeding mainly on mud and detritus in the mudflats during low tide. *T. telescopium* spawns in low water mark during April - July. They are seldom used for human consumption, but exploited for the lime industry in India.

The top snail *T. telescopium* were collected from mangroves along Nethravathi estuary between May 2009 and April 2010 to examine length-weight relationship and age and growth. The length-weight relationship derived for the species was $W = -0.5072L^{2.5007}$. The maximum b value was 3.8992 (August 2009) and minimum was 1.8323 (March 2010). The age, growth, mortality and population structure of *T. telescopium* were estimated. The estimated asymptotic length (L_∞) and growth constant (K)



was 12.28 cm and 0.63 year⁻¹ respectively. The theoretical age at the time of birth (t_0) estimated was 0.045 years. The growth rate obtained was 5.6, 2.9, 1.5 and 0.84 cm at the end of first, second, third, and fourth year respectively. The growth curve showed maximum growth during early stages which gradually decreased during later stages. The life span of *T. telescopium* was found to be up to 5.0 years. The total mortality (Z) was 3.74 year⁻¹. Based on ambient temperature (29.0 °C) the estimated natural mortality (M) and fishing mortality (F) were 1.72 year⁻¹ and 2.02 year⁻¹ respectively. The recruitment pattern ranged from 2.06 (December, 2009) to 19.42% (April, 2010) during present study. The *T. telescopium* showed a continuous recruitment throughout the study period.

FR-O 49

Trend analysis of Indian major carps landings in different states of India

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Due to the fast growing nature and good demand, Indian major carps (IMCs - *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* and *Labeo calbasu*) enjoy a prime position in the Indian aquaculture scenario. Taking advantage of the mutually compatible and complimentary food habits of these carps, composite carp culture has been developed from 1970s and demonstrated a gradual increase in the fish production from 3-4 t/ha/year to 10-15 t/ha/year. In this communication, an attempt has been made to assess the sustainability and consistency in IMC landings in different states of India during 2000-2007. For this study, time series data on IMCs landings was compiled and tabulated from the Hand Books on Fisheries Statistics, Department of Animal Husbandry, Dairying and Fisheries. Year-wise top ten states in terms of IMC landings were identified from 2000 to 2007. It was observed that in all the

years, ranking of top 10 states were not the same. Taking into account the rankings of the states in different years, 13 major states (West Bengal, Andhra Pradesh, Uttar Pradesh, Orissa, Bihar, Karnataka, Maharashtra, Assam, Chhattisgarh, Jharkhand, Madhya Pradesh, Punjab and Uttaranchal) were considered. In our study, West Bengal ranked first in all the years from 2000 to 2007. Andhra Pradesh and Uttar Pradesh secured second and third ranks respectively from 2001 to 2007. Uttaranchal and Chhattisgarh recorded the lowest IMC landings from 2000 to 2007 respectively. The annual growth rate of IMC landings in West Bengal was 8.01% (2000-2001), 12.28% (2001-2002), 5.25% (2002-2003) and 22.38% (2003-2004) whereas a negative growth rate was recorded during 2004-2005 (-10.59%), became stagnant during 2005-2006 and thereafter increased by little margin (9.36%) during 2006-2007. A pragmatic change was observed in the annual growth rate of IMC landings in Uttaranchal during 2006-2007 (1880.02%) and a significant growth rate of 116.84% was recorded in Chhattisgarh during 2000-2001. Although West Bengal maintained the first rank in terms of IMC landings during the entire period (2000-2007), the average annual growth rate was low (6.59%) compared to Uttaranchal (69.41%) which recorded the highest among 13 major states of India.

FR-O 50

Fishery resources of Gautami-Godavari estuary and Kakinada bay

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There is a need for scientific study in the field of taxonomy and fish faunal diversity of rivers, estuaries and coastal areas, since these are the most threatened areas of pollution and many fishes are under the process of extinction. The presented work was an attempt to acquire and study species level data, such as abundance and diversity from three major fish landing



stations in the vicinity of Gautami-Godavari estuarine system and Kakinada bay. More precisely, the study area was located in the eastern delta between 16° 59' 2" N; 82° 16' 50" E to 16° 44' 9"N; 82° 18' 39" E on the northern side of the Gautami-Godavari estuarine area along the coast of Andhra Pradesh, between April 2005 to March 2007.

The results of the study revealed that, there were 430 fish species identified belonging to 266 genera from 119 families. Among the 430 fish species, 303 were estuarine inhabitants, 122 were marine and the remaining 5 freshwater inhabitants. Most alarming point in this study was that, more than 10% (46 species) of the identified fish species from this study area were on the IUCN Red List. Out of 430 finfish species, 128 species are newly reported from Godavari estuary and 14 species are new reports from India as per the records of Fish base and Zoological Survey of India. The total fish landings from these three landing stations during 2005-06 accounted to 2768 t, estuarine landings were 87% and the marine landings 13%. The major groups which contributed to total fishery during 2005-06 were elasmobranchs 0.8%, catfishes 1.92%, clupeids and anchovies together 7.8%, perches 0.3%, mugilids 6.24%, trichuirids 6.07%, mackerels 6.82% and pomfrets 2.9%, while shrimps contributed 34.6% and crabs 15.3%. During 2006-07 the total landings were 2629 t in which estuarine species formed 85% and remaining 15% recorded were marine. The major groups contributed to total fishery during 2006-07 were elasmobranchs 1.46%, catfishes 2.11%, clupeids and anchovies together 2%, perches 0.24%, mugillidae 2.5%, trichuirids 28.2%, mackerels 2.2% and pomfrets 1.65% altogether finfishes comprising 40.4%, while shrimps contributed 32.5% and crabs 15.5%. The Central Inland Fisheries Research Institute, (Krishna and Godavari Unit), was the first to furnish a detailed record on landings of Gautami-Godavari estuarine mangrove system for the period 1963-65 after the construction of a dam on river Godavari in 1850. In the present study an attempt has been made to define fish species diversity based on multivariate

procedures as detailed by Clarke and Warwick, 1994 and Clarke and Gorley, 2001. Essentially, the protocols included a two way approach of initial clustering (Bray-Curtis) similarity through a dendrogram followed by an ordination through Multi Dimensional Scaling on the basis of seasonal abundance data by applying PRIMER-V tool. Further, k-dominance plots were plotted to know the number of species contributed to the maximum at each landing station.

FR-O 51

Impact of plastic pollution on fisheries in Hooghly estuary

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Hooghly estuary, the lower stretch of river Ganga is stressed with various types of pollution. Problems created by plastic litter are mostly unnoticed. During recent survey in lower Hooghly estuary, it has been observed that existing fisheries are severely affected by the problems created by non-biodegradable plastic materials in waters. The most affected fishing gear was *Beenti jal* (bag net). Plastic litters often clog the pocket of bag net, trap silt and hinder strong water current, resulting in tearing of net from handle due to water pressure. Fishermen have been facing much problem day-to-day, towards separation of fish from the heaps of garbage. Small economic fishes often mingle with plastic garbage laden with silt in bag net catch and thus it becomes difficult to separate. Other fishing gears like *Charpata jal* (set barrier), *Chhandi jal* (gillnet) etc., are also found to be affected by plastic debris. Mechanized fishing crafts are also observed to be affected with such plastic materials which get entangled in propeller. Major reasons of plastic pollution in this stretch of the river have been discussed in this paper. Management measures are warranted to tackle the menace of plastic pollution in lower stretch of Hooghly estuary.



FR-O 52**Maturation and spawning in lizardfish, *Saurida gracilis* (Quoy and Gaimard) off Mangalore coast**

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The results of the present study on the maturation and spawning of *Saurida gracilis* caught along Mangalore coast revealed size at sexual maturity as 27 cm (total length) in male and 27.5 cm in female. Sex-ratio of male-female was found to be 1:1.004. Study on spawning periodicity of *S. gracilis* indicated that this species spawns once in a year over a prolonged period, which extends from September to February with peak in October to November. The fecundity of fish ranged from 51,121 to 1,36,625 eggs, with an average of 93,873 eggs. Log-linear relationship was established between fecundity and total length, fecundity and body weight as well as fecundity and gonadal weight of the fish.

FR-O 53**Length weight relationship of reba carp *Cirrhinus reba* (Hamilton 1822) collected from Vadavar river at Lower Anicut, Tamil Nadu**

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The length weight relationship of the reba carp *Cirrhinus reba* (Hamilton-1822) collected from Vadavar at Lower Anicut, Tamil Nadu was derived based on 390 specimens ranging from 74 to 235 mm in total length and 86 to 157 g total weight. The samples were collected during April 2010 to March 2011.

Based on the calculations, the relationship for male and female could best be expressed as $\log W = -2.295 + 3.215 \log L$ ($R^2 = 0.911$) and $\log W = -2.362 + 3.2838 \log L$ ($R^2 = 0.9308$). The Condition factor (K) was also determined for both the sexes. The mean condition factor values for males and females obtained are: 0.91 ± 0.10 and 0.94 ± 0.11 respectively. The length weight relationship showed that growth was isometric with significant difference between sexes.

FR-O 54**Allometry and condition index in the freshwater bivalve *Parreysia favidens* from river Bhadra, India**

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The morphometry, length-weight relationship and condition index of freshwater bivalve *Parreysia favidens* inhabiting the river Bhadra in the Western Ghats were examined from October 2001 to December 2002. The linear regression equations of length-breadth and length-width for the entire study period were $L = 0.2653 + 0.5992 B$ and $L = 0.2176 + 0.4403 W$ respectively. The monthly *b* values of length-breadth and length-width relationships varied from 0.5371 (November 2002) to 0.6915 (July 2002) and from 0.4132 (October 2002) to 0.5242 (July 2002) respectively. The data on length-total weight ($W = 0.2418 L^{2.785}$), length-wet tissue weight ($W = 0.04859 L^{2.599}$) and length-dry weight ($W = 0.01177 L^{2.499}$) showed nonlinear patterns. The coefficient of allometry, *b* values ranged from 2.2485 (November 2002) to 3.4107 (July 2002) for length-total weight relationship and from 2.2779 (December 2002) to 2.8346 (January 2002) for length-wet tissue weight relationship. The values for length-dry tissue weight fluctuated between 2.1528 (December 2002) and 2.9736 (January 2002). The monthly mean values of the condition index varied from 4.57 (October 2001) to 8.95 (April



2002). The variation in condition index followed the breeding period and seasons. The data indicated that the condition of mussels was fairly good from April to October. The best time for commercial exploitation appears to be during April to October when the mussels are in good condition.

FR-O 55

Effect of different baits on catching *Scylla serrata* (mud crab) in Mirya estuary of Ratnagiri in Maharashtra state of India

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Mud crab (*Scylla serrata*) occurs throughout the coastal region of Konkan where it forms important estuarine fisheries. It has delicious flavor and taste which is fetching good price due to great demand in local market as well as in international market. In the present study, effect of different baits on catching *S. serrata* using the traditional trap called "Zhilla" has been studied for the period September 2010 to August 2011. Small sharks, goat ear and skin; poultry head and legs as well as dry fish were used as baits. Catching of *S. serrata* was done four times a month using each type of bait. Totally 20 Zhilla's comprising 5 Zhilla's for each bait were used for single catching operation. Each Zhilla is checked 5 times at an interval of 45 min since the starting of operation. The frequency of catching crabs was higher using the baits with small sharks while it decreased with goat ear, poultry waste and dry fish waste respectively.

The process of catching operation starts with onset of high tide and stops when low tide starts. It was found that, the frequency of crab catching increased with smell of bait and with increase in water level, but it depends on overall availability of crabs present in the area. Also

Zhilla's which are placed in Mangrove areas got maximum catch as compared to non-mangrove area. The size of the crabs caught in operation varied between 50 to 250 g. The details of crab catching operation are discussed in the paper.

FR-O 56

Ontogenetic dietary shift in ten co-occurring fish species in an ancient south east Sri Lankan reservoir, Tissawewa

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Ontogenetic shifts in diet are the norm for demersal fishes. A variety of potentially interacting factors may account for the prevalence of these shifts. The Ontogenetic dietary shift were determined for ten co-occurring fish species of a tropical fish community in the Tissawewa reservoir, a shallow south east Sri Lankan reservoir. The fish community consisted of two introduced exotic tilapias and eight indigenous riverine species including five cyprinids, one clarid, one hemiramphid and one gobiid. Fishes were collected monthly, using three types of gear i.e., gillnets, bottom trawl and cast net. Gillnets made of multimesh monofilaments consisting of six different mesh sizes (12.5 mm to 50 mm stretched mesh) were used. In order to determine ontogenetic diet shift, the total size range of fish was divided into six size-classes. To study the feeding ecology, the contents of the anterior 1/3 part of the gut of fish were analyzed per species, and per size class from samples collected on different occasions. The relative biovolume of food items in the gut was estimated according to the point method. Analysis of variance was performed to test whether significant difference exist in ontogenetic dietary shift among species.

Based on the gut content analysis, five feeding guilds were distinguished: the detritivorous *Amblypharyngodon melettinus*, the herbivorous



Oreochromis mossambicus and *Oreochromis niloticus*, the benthivorous *Puntius chola*, *Puntius sarana* and *Puntius dorsalis*, zooplanktivorous *Rasbora daniconus* and *Hyporhamphus marginatus*, and the piscivorous, *Mystus* spp. and *Glossogobius giuris*. Significant ontogenetic diet shift was observed in members of all the feeding guilds. Juveniles of the fishes in herbivorous feeding guilds fed on insects and zooplankton and as they grow, the diet shifted to detritus matter. *P. chola* and *P. dorsalis* shifted their diet from zooplankton and microbenthos to insect matter and mollusk as they grew. Juveniles of the *P. sarana* fed on insect matter, zooplankton and microbenthos, while adults shifted their diet to fish and molluscs. Members of the juveniles of zooplanktivorous feeding guild, ontogenetically shifted their food items from zooplankton to insect, macrophytes, and algae as they became adult. Juveniles of *G. giuris* and *Mystus* spp. those represent piscivorous feeding guild, feed on insect matter, zooplankton and macrophytes, while adults feed on small fishes revealing clear ontogenetic dietary shift. The results indicated that fish community in the Tisawewa reservoir exhibit clear ontogenetic dietary shift, which facilitates effective resource partitioning through lesser intraspecific competition.

FR-O 57

Biometrics of the wedge clam, *Donax faba* (Gmelin) from the Panambur beach, Karnataka

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Clams under the genus *Donax* are commonly found in the wash zone and has a worldwide distribution in tropical and temperate zones. The length-weight relationships of *Donax faba* inhabiting the sandy beach at Panumbur, near Mangalore coast of

India have been studied from April 2009 to March 2010. The *b* values of length-total weight, length-wet weight and length-dry weight relationships were 3.2151, 3.5555 and 3.2611 whereas the corresponding *a* values were 0.000096, 0.000006 and 0.000004 respectively. The relationships between length-total weight, length-wet weight and length-dry weight were $W = 0.000096L^{3.2151}$, $W = 0.000006L^{3.5555}$ and $W = 0.000004L^{3.2621}$ respectively. The data on monthly mean values of biological parameters such as length (L), total weight (TW), wet weight (WW), dry weight (DW) and number of individuals (n) and *b* values of length-total weight (LTWb), length-wet weight (LWWb) and length-dry weight (LDWb) relationships were subjected to cluster analysis (CA) in order to understand the groupings of biological parameters. Principal component analysis (PCA) was performed for biological as well as environmental parameters such as air temperature (AT), water temperature (WT), sediment temperature (SD) and rainfall (RF) to understand the relationship between biotic and abiotic variables.

FR-O 58

Reproductive cycle and maturity stages of *Johnius carutta* (Bloch, 1793) off Visakhapatnam, south east coast of India

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*S*ciaenids (*Johnius* spp.) form a commercially important group of fishes in the catches of both the mechanized and traditional craft along the Andhra and Orissa coasts. Spawning season of *Johnius carutta* was assessed based on gonado-somatic index and monthly occurrence of matured females. The adopted scale of seven maturity stages of ovaries was observed for a period of two years from January 2008 to December 2009. In assigning the correct stage of ovary development, the general appearance,



its relative length to the abdominal cavity, development of ova and the percentage of different groups of ova were taken into consideration. Monthly distribution of ripe (stage-6) and spent (stage-7) females were considered for ascertaining the probable spawning season of *J. carutta*. The restricted brief spawning period of the species lasts for three months from February to April and spawn only once in a year. The peak breeding activity was observed in the month of February (26.64%) followed by March (18.62%) and April (15.38%) in which high gonado-somatic index (GSI) values were recorded. Spent females were observed from June to December with a peak in the months of August (13.78%) and October (10.80%). The size at first maturity was estimated as 17.5 cm in females. The total number of mature eggs varied from 38,810 to 154,928 in individuals of length range 15.63 to 21.63 cm.

FR-O 59

Length weight relationship of *Labeo calbasu* (Hamilton, 1822) from Vadavar River at Lower Anicut, Tamil Nadu

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A total of 110 specimens of *Labeo calbasu* (Hamilton - 1822) consisting of 88 males (136-421 mm TL weighing 42.1-1300 g), 9 females (237 - 442 mm TL weighing 18.5 - 1200.5 g) and 13 juveniles (102-238 mm TL weighing 32.3-108.9 g) were collected from Vadavar river at Lower Anicut during a period of one year (April 2010 to March 2011). Their length weight relationship was estimated and the results are discussed in the paper. The regression equation calculated for males is $\log W = 2.7122 \log L + -1.5264$, $\log W = 2.3208 \log L + 0.8112$ for females and $\log W = 1.9224 \log L + -0.5979$ for juveniles. While testing the regression coefficients against the negative allometric growth, no significant variation among male, female and juveniles was

evident suggesting a good correlation between the length-weight ($b < 3$). Further, the regression equation was fitted separately for each group and the slopes were further tested to find out the variation, if any among them. The population significantly varied at 5% level and the results are discussed.

FR-O 60

Studies on the torpedo electric rays of the genus *Torpedo* (Pisces: Torpedinidae) off Visakhapatnam, Andhra Pradesh

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The impacts of removal of non-target organisms from the ecosystem through incidental catch or bycatch remain largely unstudied around the world. Many species in the marine ecosystem have thus become endangered or threatened. One among such groups include torpedo electric rays belonging to genus *Torpedo* (Houttuyn, 1764). Torpedo electric rays are taken as bycatch in demersal fisheries including coastal artisanal fisheries, trawls and trammel nets. When these are discarded at sea, the probability of their survival is less. At present these are assessed as data deficient globally, due to very little information available on catches and population trends (Notarbartolo di Sciana, 2005). Most of the species of the genus *Torpedo* have relatively restricted distribution. In order to assess the impact of fishing on this group, there is an urgent need to have information on species composition, distribution in space and time, abundance, behaviour and biology. This information is very much required to conserve and protect these groups from extinction. Seventeen species of the genus *Torpedo* are listed in the IUCN Red List data deficient species in the year 2010, among which, *Torpedo fuscomaculata*, *T. marmorata*, *T. panthera* and *T. sinuspersici* are represented in the catches off Visakhapatnam. The present paper deals with



distribution, abundance and some aspects, on the biology of the above four species off Visakhapatnam, along the coast of Andhra Pradesh.

FR-O 61

Inventorying inland water bodies of Ratnagiri district in Maharashtra state of India using Remote Sensing and GIS technologies

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At present, India is producing about 7.6 million tonnes of fish annually out of which 4.63 million tonnes come from inland fisheries. Inland fish production contributed only about 36% to total fish production of 2.34 million tonnes in 1970-80 which has increased to about 61% in the last three decades. This shows significant improvement in inland production and increasing pressure on the water bodies. In the coming years, the population in urban areas is expected to increase tremendously and there will be competing demands for domestic, commercial, industrial, agriculture and aquaculture activities on available water resources. In order to meet the soaring demands, there will be enormous pressure on freshwater resources. For effective management of water resources, there is a need to have a clear understanding on the availability and whereabouts of these resources. Phenomenal increase in inland fish production has been possible mainly due to the significant contribution from aquaculture over the years. For sustainable development and management of the aquaculture sector, there is an urgent need to develop an up-to-date inventory of water bodies along with their seasonality. Remote Sensing (RS) and Geographic Information System (GIS) with their advantage of spatial, spectral, and temporal availability of data covering large and inaccessible areas within a

short time have emerged as powerful tools for assessment, monitoring and management of water bodies. In the present study, an effort has been made to prepare an inventory of water bodies and study their seasonality in Ratnagiri district of Maharashtra using RS and GIS technologies. The input data comprised of spatial and non-spatial (attribute data) data. In spatial data; satellite images and base maps were used. ERDAS IMAGINE and ArcGIS softwares along with GPS were used for the study.

FR-O 62

Gonadosomatic index of reba carp, *Cirrhinus reba* (Hamilton, 1822) from Vadavar River, Lower Anicut, Tamil Nadu

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The present study was undertaken to determine the gonadosomatic index (GoSI) of reba carp, *Cirrhinus reba* from Vadavar river, Lower Anicut, Tamil Nadu during April 2010 - March 2011. It was observed that both sexes attained mature stage in July simultaneously. The gonads attain the minimum and maximum GoSI values of 2.4 and 18.2 in males and 2.8 and 16.1 in females. This species has only one spawning period in a year with short duration falling from June to August as evidenced by the peaks of GoSI. The maximum GoSI values were noticed in both sexes in the month of July, which may be attributed to the peak period of spawning. However, GoSI values indicate that the mature specimens of *C. reba* are encountered in Vadavar river, only between June and August suggesting the reproductive period. The GSI values provide an idea regarding the pre-spawning, spawning and post-spawning period of the *C. reba*. The results of the present study also indicated that the GoSI values were observed to be high during the spawning period and it does not show any correlation with total length of the specimens.



FR-O 63**Food and feeding habits of the mud crab, *Scylla serrata* (Forsk., 1775) from some major estuaries of Ratnagiri**

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Present study deals with the nature and composition of food items and feeding habits of *Scylla serrata* from Mirya, Sakhartar, Bhatye and Shirgaon estuaries of Ratnagiri. A total of 4538 specimens were examined during September 2010 to August 2011 from this region. This species was found to be omnivorous which feed mainly on mollusks (49-51%), crustaceans (19-21%), plants and debris (29-32%). In *S. serrata*, the foreguts were found to be less than 50% full, and semidigested matter was found in considerable quantity. Detritus was the major food group in small crabs (<65 mm) and in adults (<120 mm) specimens, remains of crustaceans and fishes formed the major food item.

FR-O 64**Food and feeding habits of *Johnius carutta* (Bloch, 1793) off Visakhapatnam, south east coast of India**

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The food and feeding habits of *Johnius carutta* (Bloch, 1793), was studied for a period of two years from January 2008 to December 2009 and a total number 3,406 gut samples were analyzed. The food items observed in the diet of *J. carutta* were broadly classified into five categories namely teleost fish, crustaceans,

polychaetes, molluscs and other miscellaneous food items. The fish is a benthic feeder and also a carnivore, feeding chiefly on teleosts and free living crustaceans at bottom. *Squilla* and teleost fish constituted continuously in the food spectrum for 12 months. The "composite index" values clearly indicated that *Squilla* (35.62) is the most preferred food item of *J. carutta*. Other food items largely preferred were *Acetes* (18.03) followed by teleost fish (16.62), shrimp (10.38) and polychaetes (6.26). The average gastro-somatic index values observed are relatively low during pre-monsoon (1.27), moderate during monsoon (1.74) and relatively high during post-monsoon (2.18).

FR-O 65**Gastro-somatic index in the freshwater reba carp, *Cirrhinus reba* (Hamilton, 1822) from Vadavar River, Lower Anicut, Tamil Nadu**

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In the present investigation, the gastro-somatic Index (GaSI) was studied in the freshwater reba carp *Cirrhinus reba* from Vadavar river, Lower Anicut, Tamil Nadu during the period April 2010-March 2011. Observations on the variations of GaSI were in agreement with the monthly variations on the fullness of stomach. The GaSI values varied between 4.6 – 11.9 in males and 5.1 – 11.7 in females. The GaSI values in both the sexes were high during October to January which gradually decreased in June to September, as the peak period of spawning is in July for both sexes. However, feeding improves after the major spawning period in July, attaining peak period during June – August. Low feeding is considered to be closely related with maturation of gonads, breeding and spawning. The low feeding activity during the peak breeding may be attributed to the fully developed gonads, permitting limited space for the stomach below the vertebral



column for food intake. The monthwise variations in values of GaSI was found to be much more in the case of females as compared to males because of the fact that ovaries occupy more space as compared to testes. In the present study, the GaSI was found to be directly linked to low feeding during spawning season.

FR-O 66

Food and feeding habits of the lizard fish, *Saurida gracilis* (Quoy and Gaimard) off Mangalore coast

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Present study dealt with the nature and composition of food items, feeding habits and intensity of feeding of *Saurida gracilis* from Mangalore waters. This species was found to feed mainly on *Platycephalus* spp., *Stolephorus* spp., *Nemipterus* spp., *Saurida* spp., squids, shrimps and other teleosts. Semi-digested matter was also found in considerable quantities. The proportion of fishes, which had actually fed, was highest in April followed by November and March and poor feeding was noticed in December followed by October, January and September.

FR-O 67

Stages of sexual maturity in young sturgeons caught in the south Caspian Sea in 2009

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Sturgeons are high valued commercial fishes belonging to the family Acipenseridae, one of the oldest families of bony fish in existence.

Sturgeon are native to subtropical, temperate and sub-Arctic rivers, lakes and coastlines of Eurasia and North America. Twenty seven species of sturgeons live in the northern hemisphere. The Caspian Sea is the most important habitat of 6 species of sturgeons viz., *Acipenser persicus*, *Acipenser stellatus*, *Acipenser gueldenstaedtii*, *Acipenser nudiiventris*, *Acipenser rhuthenus* and *Huso huso*. They are slow-growing and mature very late in life, requiring over 10 years in some species. The present study was aimed at determination of age composition and sexual maturity stages of sturgeons captured from the southern area of the Caspian Sea in 2009.

A total of 58 numbers of sturgeons (46 *Acipenser persicus*, 6 *Acipenser stellatus* and 6 *Acipenser gueldenstaedtii*) were captured, gonads were collected and fixed in Bruin's solution. The fixed gonads were processed for histology, sectioned and stained by Hematoxylin and Eosin (H & E) and were studied under light microscopy. Results showed that 89 % of captured sturgeons were females and 11 % were males, out of which 87 %, 4.3 %, 8.7 % were at stages I, I-II and II respectively. Among *A. stellatus* 50% were at stage I and 50% at stage II. All of *A. gueldenstaedtii* (n = 6) were females out of which 66.7 % were at stage I and 33.3 % were at stage II. Histological studies of gonads also showed that the sturgeons examined were all juveniles and was at stages I or II of sexual maturity.

FR-O 68

Restoring fisheries of northern Sri Lanka

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In Sri Lanka, fish consumption is high and an important part of the daily diet. Most of the 50,000 t of fish and prawns landed in the Jaffna district annually during the early 1980s were sold to the domestic market. In some years, the



fishing activity around the Jaffna Peninsula, lagoons and islands produced more than 25% of the fish supply for Sri Lanka. There is a high local demand for crustaceans, molluscs and fish and elasmobranchs including prawns, crabs, lobsters, beche-de-mer, conch, cuttlefish, squid, sardines, herring, barracuda, seer, carangids, rockfish, sharks, skates and rays. These species are caught by the local fleet of trawlers, mechanized fibre glass boats and indigenous craft operating in the Jaffna Lagoon, Palk Bay, Palk Strait, Pedro Bank, and the Indian Ocean off the east coast.

Before the civil conflict in Sri Lanka, fishing was the major industry in the Jaffna district supporting boat building, fish net production, ice factories, fish processing and marketing. Most of the infrastructure and at least half of the fishing capacity was destroyed during the conflict. There was no fishing permitted within the military controlled High Security Zone. More than 30% of the population was displaced, so the number of fishing families dropped from 22,000 to 5,500 between 1983 and 1996. The fish landings and domestic supply of fish started to decline in 1983 and have remained at low levels for the last 20 years. However, the recent changes in the political climate have led to new prospects for restoring the fisheries in northern Sri Lanka. The peace process has encouraged re-settlement of 14,000 fishing families in Jaffna and re-establishment of the fishing industry. Fishing and transport restrictions have been relaxed. Fishermen are joining co-operative Societies to get access to loans for boats and fishing gear. The number of Fishermen's co-operative Societies has increased by 30% and more than 100 are now participating in the rehabilitation and development of the fishing sector in Northern Province of Sri Lanka. Currently, the focus is on the need to strengthen the government sector and develop cooperative fisheries management strategies with the Fishermen's co-operative Societies to enhance sustainable development and utilisation of the marine resources. For successful restoration and development of the fisheries sector, every aspect of fisheries management will need to be re-established. Of particular importance are the

international fishing agreements for shared stocks and enforced protection of fishing grounds. Foreign vessels often operate within the coastal waters of Sri Lanka and heavy fishing pressure of inshore stocks will hinder the development of the local fishing sector around the Jaffna Peninsula and Mannar District. Negotiations and mediation between Jaffna fishermen and the south Indian fishermen need to be facilitated in order to resolve the dispute about access and resource sharing around the north-western coast of Sri Lanka. Under these circumstances, there is great uncertainty about the status of the fisheries resources. Some migrating or offshore species may have become depleted in the absence of fisheries enforcement. While other inshore species may be under exploited as there has been much lower fishing pressure by the local fishing communities. Consequently, research, fishery monitoring and stock assessment will have a vital role in identifying appropriate development strategies for a sustainable fishing industry in the future.

FR-O 69

Frequency of fish sound and recording using computers

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Fish can make sounds that may be used for communication purposes among themselves. It is assumed that fish language is species specific. We may hear the sounds of fishes even in air when the fishes are being caught and specially when they are caught by anglers. Sound produced within water media by fishes may often remain in the same medium. Penetration of such sounds in air may also be possible as found in catfishes. It is a fact that the catfishes have prominent languages among all other fin fishes. Authors have found that sound produced by fishes is recordable. This fish sounds seems to be fish languages originated from the membrane attached to the air bladder of individual fishes. This membrane is lipoprotein in nature and



its thickness is variable owing to fish age. Frequency of sound is variable owing to such sound producing membrane thickness. It is obvious that young fish has thinner membrane but small air bladder. Fish sounds also depends on the dimension of airbladder, air pressure within it and air volume. An experiment was conducted on *Channa* sp. and sounds were recorded, the details of which are discussed in the paper.

FR-O 70

Gastro-Somatic Index in black rohu, *Labeo calbasu* (Hamilton, 1822) from Vadavar river of Lower Anicut, Tamil Nadu

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Investigations on the Gastro - Somatic Index (GaSI) of *Labeo calbasu* from Lower Anicut of Tamil Nadu were carried out during April 2010 to March 2011. The total weight and gut weight of individual fish were measured GaSI was calculated. GaSI was determined at different length and weight ranges of individual fish. GaSI values recorded in fishes were : 2.54 in males, 2.82 in females and 1.36 in juvenile specimens. GaSI values recorded in fishes from the highest peak ranges of the river were: 15.08 (July) in males, 6.59 (September) in females and 12.80 (October) in juvenile specimens. The results indicate that the GaSI in *L. calbasu* increased with size and weight of the fish.

FR-O 71

Gonado-somatic index in black rohu, *Labeo calbasu* (Hamilton, 1822) from Vadavar River of Lower Anicut, Tamil Nadu

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A study on seasonal variations in the gonado-somatic index (GoSI) of the black rohu,

Labeo calbasu was carried out during April 2010 to March 2011 from the Vadavar River of Lower Anicut. GoSI was calculated based on the total weight of the fish and gonad weight of the fishes sampled at monthly intervals. GoSI values of *L. calbasu* ranged from 0.3 to 2.76 in males and 1.91 to 16.9 in females and showed peak value in the month of November in male and during July in female. Higher values of GoSI were observed from July to November which ranged between 0.5-2.76 in male and 1.9-16.9 female. The fish spawned once in a year with one spawning peak as indicated by the gonado-somatic Index. The results indicated that the GoSI of fish increased with increase in size and weight of the fish.

FR-O 72

Seasonal variations in biochemical parameters of the endangered catfish *Ompok pabda* (Hamilton, 1822) of Tripura

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The population density of *Ompok pabda* (Hamilton, 1822), which is regarded as an economically important and endangered catfish is largely declining due to ecological and anthropogenic effects. During summer climate (32.41 ± 1.73 °C), *O. pabda* showed 19.05 to 23.52 % higher growth rate f ($r = 0.0987$, $p < 0.001$). Virtually, low temperature during the winter climate (10.07 ± 2.32 °C) largely affects the growth of this species and as a result the fish does not show any growth at all. The total serum cholesterol level ranged from 232.12 mg/dl during summer to 297.64 mg/dl in winter. HDL level recorded in summer was 161.07 ± 7.964 mg/dl and in winter it was relatively higher (219.12 mg/dl). During winter climate (10.07 ± 2.32 °C), fish performs poor swimming, resulting in reduced utilisation of



total cholesterol as well as HDL. During winter climate (12.22 ± 2.14 °C) the glucose level recorded was relatively lower as compared to that of summer. ($r=0.9482$, $p<0.001$). The enzyme levels for alpha amylase in the blood plasma ranged from 12.11 to 20.07 U/100 ml, while SGPT levels ranged from 25.786 to 32.979 U/ ml. While attempts are being taken for conservation studies of the species, the role of temperature under various climatic conditions may be given due consideration.

FR-O 73

Comparative histology of the alimentary canal of the chocolate mahseer, *Neolissochilus hexagonolepis* (McClelland) during the different life-history stages in relation to food and feeding habits

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The present study was undertaken to observe the morphological and functional development of the alimentary canal of chocolate mahseer from fry to yearling stage. The alimentary canal of the fry reveals carnivorous nature of the species with a low relative gut length (RLG.). The value of the RLG. increases from fry to yearling stage. With increase in age and body-length, feeding habits of the fish changes from carni-omnivorous to herbi-omnivorous. The structure of the alimentary canal gets modified accordingly as it grows from fry to yearling. Villi are simple and unbranched in the alimentary canal of the fry, whereas in the fingerlings and yearlings, the villi become long, branched and complex. The histological features of the alimentary canal of the species during different life history stages are dealt in detail, with respect to its food and feeding habits.

FR-O 74

Ex-situ conservation of the golden mahseer, *Tor putitora*

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Mahseers, the largest freshwater scaly fishes which feared extinction, have fortunately caught the attention of fishery scientists. One such species is golden mahseer (*Tor putitora*). The importance of mahseer as a game fish is well known. It also fetches high market price. Therefore it is important that the fish needs to be propagated and conserved. Directorate of Coldwater Fisheries Research, Bhimtal has standardised the protocol for artificial breeding of golden mahseer. Hatchery produced seed has been transported to different states of India and foreign countries for enhancing the population in the reservoirs/ rivers/ streams. The mahseer seed has been ranched in the natural water bodies of India as ex-situ conservation measure, in order to enhance the population of this important fish as well as to conserve its germplasm from extinction.

FR-O 75

Fish and fisheries of Suvarnavathy Reservoir, Cauvery river basin, Karnataka

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Suvarnavathy Reservoir was constructed in the year 1985 across the River Suvarnavathy (a tributary of river Cauvery) which is located in Chamarajanagar district of Karnataka State. The river originates in Nasrur Ghat range and flows a distance of 88 km before joining Kabini river near Nanjangud. The principal



morphometric features of the reservoir are : Latitude: 10°, 49' N, Longitude: 70°, 1'E, Area at FRL: 490.57 ha, maximum depth: 22.86 m, mean depth: 7.25 m, C/A ratio: 79.0 and flushing ratio: 3.01. The reservoir receives significant inflow from north-east monsoon and becomes full in December-January. The reservoir is moderately deep, has 'V' basin, steep banks and has low dendricity. Although polymictic, due to sheltered location, the reservoir frequently exhibited thermal stratification with clinograde distribution of oxygen. The water was low in transparency without inorganic turbidity (mean: 1.9 ± 0.4 m), mildly alkaline (mean pH: 7.6 ± 0.2) and moderately rich in electrolytes (mean: 140.9 ± 45.4 μ S/cm). Clinograde distribution of oxygen, high chlorophyll 'a' (mean: 64.5 μ g/l) and gross primary production rates (mean: 2.5 g C/m²/d) were recorded. The Carlson Trophic Index for secchi depth is 61.5 and for chlorophyll 'a' is 72.2. Based on limnological parameters, the reservoir is assessed as productive.

Fish fauna consists of 26 species belonging to 11 families of which, six are stocked (catla, rohu, mrigal, common carp, grass carp and tilapia, *Oreochromis mossambicus*) and the rest are autochthonous. There are no major piscivores. Gillnet is the only fishing gear employed for harvesting fish. The reservoir is under lease to a society. The average fish seed (often advanced fry of around 4.0 cm) stocking rate for the years 2007 to 2010 was 838 no./ha/year with catla constituting 41.6%, rohu 19.1%, mrigal 11.3%, common carp 23.7% and grass carp 4.3%. Indian major carps overwhelmingly dominated the catch (>90.0 %) with the rest constituted mainly by tilapia and others. The stock of endemic medium carps (*Puntius sarana*, *Cirrhinus reba*) is very low. All the three stocked species *Catla catla*, *Labeo rohita* and *Cirrhinus mrigal* exhibit good growth in the reservoir. The yield increased by 48.3% to 172 kg/ha in 2008-09 from 116 kg/ha in 2007-08 (base year) because of i) stocking of advanced fingerlings of major carps of 8 to 10 cm size in second half of 2007, ii) regulated fishing (using gillnets of mesh bar 5 cm and above) and iii) increase in

effort. Sustained stocking in 2008-09 resulted in further increase in yield by 69.8% to a high of 197 kg/ha in 2009-10. The CPUE increased from 14.5 kg in base year to 15.8 kg in 2009-10, in spite of increase in effort by whopping 54.6%. The estimated increase in gross income to the society in 2009-10 over 2007-08 was to the tune of Rs. 11,72,000/- and to the individual fisher Rs. 22,000/-. Recommendations suggested to the lessee society for further enhancement of fish Ld are : stocking of major carp fingerlings of 10 cm and above; reducing the stocking density to 300-500 fingerlings; harvesting carps of only 1.0 kg and above; reducing the number of fishing holidays; least preference for stocking of common carp, grass carp and giant freshwater prawn.

FR-O 76

Exploitation of penaeid prawn resources by small mechanized trawlers in the Bay of Bengal off Visakhapatnam: scenario for a decade

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Small trawlers (9-11 m OAL), suited for short-term cruises (2-5 days) exploit penaeid prawn resources in the nearby waters up to a depth of 70 m in the Bay of Bengal off Visakhapatnam both in the northern and southern directions. Annual fishing effort ranged from 4,05,141 to 10,78,796 h with an average of 5,97,412 h. Penaeid prawn catch varied from 703 to 4,323 t with an average of 2,119 t. Catch per hour (CPH) of penaeid prawns ranged from 2.19 to 4.92 kg with an average of 3.54 kg. Penaeid prawn contribution to total fish landings ranged from 6.7 to 18.32% with an average at 13.7%. Increasing trends were observed in both fishing effort as well as penaeid prawn catch over the period. Penaeid prawn catch was supported by 24 species, of which



Metapenaeus monoceros dominated followed by *Metapenaeus dobsoni*. Mean annual species composition and CPH for each species were estimated for two spells, one for 2001-2005 and the other for 2006-2010. The CPH for all penaeid prawns increased by 103% from spell -1 to spell-2. CPH for five species has declined where as for other 19 species it has increased. Expected catch for each year was estimated using Schaefer production model (CEDA; $r^2=0.72$) and observed that exploitation was under expected rate during 2001-2005 and it was above expected rate during 2006-2010, which is indicating the necessity of restricting fishing effort at present level.

FR-O 77

Management implications of marine fisheries development in Tamil Nadu after the 2004 tsunami

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The 26th December 2004 tsunami caused severe damage to aquatic habitats and devastated coastal communities along the Tamil Nadu coast. The short term impact on the fisheries was severe and the following year, the annual fishery production dropped by 20%. More than 43,000 t in catch reduction (60%) occurred in Ramnad, Cuddalore and Pudukkottai districts. Since 2005, catches have

steadily increased reaching 4,00,000 t in 2009-2010. In the past, at least 70% of the fishery production in Tamil Nadu was landed by traditional boats, known as kattumarams. In 1980, there were more than 44,240 of these non-mechanised boats, which represented 94% of the fishing fleet. Following the tsunami, almost half of the fishing boats were destroyed and in 2006, only 24,230 traditional boats remained in the fishery. Since then, many of the traditional boats have been replaced by larger boats with engines that have greater fishing power as well as more efficient fishing gear which can access distant fishing grounds. The number of mechanized boats has risen in recent years to more than 30,000 and now represents 65% of the fishing fleet in Tamil Nadu. In addition, there are a large number of mechanised fishing boats based in other states and countries that exploit the same fisheries resource. Hence, there is more fishing pressure on the stocks as the fishing power of the fleets has increased with mechanisation. Critical fish habitats, such as sea grass and mangroves, were affected by wave action and sedimentation during and after the tsunami. Environmental factors that drive population dynamics cause episodic fluctuations in recruitment or natural mortality and these are known to impact fishery production, particularly if combined with a reduction in environmental carrying capacity. Fishery management strategies should take this into account and caution is required to avoid overfishing of the stocks that have been ecologically impacted by the tsunami. Further research is required to assess the recovery of fish habitats and to monitor the effects of fishing on the fish populations, so that ecologically sustainable catch levels can be estimated.



FR-P 01**Resource dynamics of the Indo-Pacific sailfish, *Istiophorus platypterus* (Shaw & Nodder) from the south eastern Arabian sea**

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The average billfish catches from the Indian EEZ during 2002-2007 period was 4561 t which increased to an estimated 7856 t during 2008-2010 period and nearly 80% of this was caught from the Arabian sea by the drift gillnet cum longline units. In the Indian Ocean region, billfishes (marlins, swordfish and sailfish) are considered as data deficient resource in the IOTC database. Sailfish *Istiophorus platypterus* which was the major component of the billfish catch at the Cochin Fisheries Harbour (CFH) where a fleet of gillnet-cum-longline units are regularly operated for oceanic fishes such as yellowfin tuna, seer fishes and pelagic sharks, including billfishes. Length range of sailfish landed at CFH during 2005-2010 was 80-230 cm with inter-year variations in size groups contributing to the fishery. Length-weight relationship was estimated as $0.024 L^{2.65}$ while growth parameters L_{∞} and K (annual) were estimated as 262 cm and 1.0 respectively. Diet preferences of fishes in the size range 180-227 cm indicated highest percentage occurrence for fish (81%), followed by crabs (31%) and molluscs (25%). Trigger fishes (*Balistes* spp.) dominated in the diet followed by carangids like *Selar* spp. and *Decapterus* spp. Ova diameter of vitellogenic oocytes in a ripe gonad with hydrated eggs indicated oocyte diameter in the range of 200-1300 μ with a major mode at 700 μ and a minor mode at 1200 μ indicating hydrated eggs are released in batches at probably close intervals. Absolute fecundity from a ripe stage ovary was estimated as 20,97,481 eggs (1750 eggs per gram ovary weight) with hydrated eggs forming about 31% of the total eggs, giving a

batch fecundity of about 541 eggs per gram ovary weight. Exploitation rate (E) indicated that in spite of billfishes occurring mostly as by-catch in the targeted fisheries for yellowfin tuna and pelagic sharks, the considerable number of fishing units operated exert heavy (>0.6) fishing pressure on the resource.

FR-P 02**Morphometric relationships of the spiny lobster, *Panulirus homarus* (Linnaeus, 1758) from southern Indian coast**

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The spiny lobster *Panulirus homarus* supports gillnet, trammel net and trawl fisheries along the southern region of the Indian coast. The commercial catches of lobsters landed along the Tamil Nadu coast were sampled sex-wise for various body dimensions such as carapace length (CL), total length (TL), total weight (W), carapace width (CW), second abdominal segment width (AW) and length of third walking leg (3rd WL) and morphometric relationships calculated for a carapace length range of 20 to 110 mm. Linear regression equation $y = a + bx$ and the power function $y = ax^b$ were used to study the relationships between CL & TL and CL & 3rd WL. The first derivative $dY/dCL = abCL^{b-1}$, where Y is TL, was used to study the growth tendency of TL in relation to CL. A negative allometry, $b < 1$ was found for males, which also reflected in their decreasing growth rate, TL in relation to CL. In females, the growth rate, TL in relation to CL was greater than males and almost constant (isometric growth). The relationship between TL & W showed some degree of variability for both males and females and this can be ascribed to the error during measurement of TL due to the flexibility in the region of cephalothorax and abdomen. For a given carapace length, females are slightly longer (total length) than males and have a wider second



abdominal segment with the difference increasing as animals increase in size. The relationship between CL & W showed significant difference between sexes and a general negative allometry $b < 3$. This negative allometry was more pronounced in males which also reflected in their lower growth rate, W in relation to CL. The female lobsters were heavier than males of an equivalent carapace length, especially sizes beyond the size at maturity (60 mm CL).

Table. Morphometric relationships of *Panulirus homarus*

Relationship	r^2	Sex	Regression	N
CL x TL	0.9716	M	TL = 3.566CL ^{0.9278}	462
	0.9559	F	TL = 2.8918CL ^{0.9898}	350
CL x W	0.9800	M	W = 0.0012CL ^{2.9058}	462
	0.9597	F	W = 0.0013CL ^{2.9205}	350
CL x TL of 3 rd walking leg	0.9634	M	3 rd WL = 1.0029CL ^{1.17}	462
	0.8771	F	3 rd WL = 2.2198CL ^{0.9634}	350

The size at maturity for males was inferred as 63 mm CL using the onset of allometric growth of the third walking leg as an indicator of maturity. The relationship was also explained using the power function equation $Y = ax^b$, where positive allometry, $b > 1$ was found for males indicating faster growth rate of 3rd WL beyond the size at maturity. The utility of the morphometric relationships in fixing the minimum legal size for fishing and export of lobsters is discussed. Existing minimum legal size for export is fixed on the basis of weight, which is not convenient for the fishermen to comply with and carapace length being the standard length, minimum legal size should be fixed on the basis of carapace length. The need for strict enforcement of management regulations for continued sustainability of the high value resource is emphasised.

FR-P 03

Food-web and trophic structure of Karapuzha reservoir in Kerala

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The trophic structure of an ecological community is represented by the food web,

showing the flow of material and energy among different kinds of organisms. A mass-balanced model of Karapuzha Reservoir was constructed using 15 ecological groups to describe the food web and trophic flows. Karapuzha reservoir with an area of 855 ha was constructed in 1979 by damming the Karapuzha River in Wayanad district of Kerala, India. The tilapiine fish, *Oreochromis mossambicus*, the most dominant fish in the reservoir ecosystem, was observed to play important ecological roles and have evolved important fisheries. The fishery is generally targeted towards the tilapiine population. Lindeman spine analysis revealed trophic pathways with up to five levels in the Karapuzha reservoir model. The trophic aggregation routine showed that most of the biomass and flows are concentrated on trophic levels II and III. Biomasses associated with the highest trophic levels (TL IV and V) were very small, 0.733 and 0.351 respectively. The energy flows are concentrated in the lower part of the food web. The mixed trophic impact matrix indicates that very small fraction of changes in biomass of *Clarias gariepinus* would have negative effects upon eels and snake heads. Similarly small changes in *O. mossambicus* biomass would have negative impact upon the planktivorous fishes. Eels have negative impact on most of the fish groups and even the aquatic birds. The network summary statistics computed for the model suggest an overall picture of the Karapuzha Reservoir as a system of a low degree of maturity.

FR-P 04

Marine fisheries data handling - initiatives and possibilities onto the dynamic data restructuring

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Marine fisheries as a resource based domain has very high degree of data dependency when it comes to critical analysis.



In the Indian context, the marine fisheries scenario being a complex paradigm of interwoven sublimities which need highly focused handling for better inference. CMFRI has been pioneering the case of neutral observation of marine resource landings across the country and has developed a sound statistical design to estimate the resources landed and effort expended for any geo-temporal continuum since 1961. Needless to say, marine fish landings, under Indian conditions being an incessant activity, the volume of data leapfrogs in a matter of weeks. The heterogeneity of the data resources make the storage and retrieval of the individual data bits very important. As modern databases are constrained and defined by the software applications which propel them, a lot of compromises are being made in between. CMFRI has dovetailed the evolution of IT infrastructure development throughout its global trends and has chosen the easiest and most universal flat file format for storing basic data. But with the availability of powerful hardware and equally powerful 32 and 64 bit application wares like MySQL, Oracle etc., the data storage paradigm needs a thorough relook. This work deals with the probable models for data storage, segregation resulting in maximum granularity and tries to dig out some possibilities of pattern building which could be treated as the pre-cursor to full-fledged mining exercise. The data storage is done using MySQL server and the mining efforts were made using SAS OLAP Cube Studio 4.2.

FR-P 05

Passive geo-referencing of commercial marine fish landings and spatio-temporal investigations

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Indian marine capture fisheries has undergone a sea change in the last two decades. While

there has been near consistent increase in the overall landings reported from various parts of the coast line, the role of exponential spatial expansion is unmistakably evident. An attempt was made to study the geo-spatial patterns of landings reported at five major fishing harbours of Kerala with specific reference to their plausible fishing grounds. The fishing grounds were zeroed in by the Haversine function of estimation of curved distances using R software functions with the vital inputs like the distance, depth and direction of the trips made by the crafts sampled by the CMFRI personnel during the period 2008- 2009. The resultant data have been analysed under (i) proportion of the catches landed from in-shore (8 nautical miles) area and the off-shore area, (ii) the resources typical of trip-distance combinations, (iii) the probable communion of fishing grounds tapped by crafts, (iv) temporal/ seasonal variation in trips and its impact on the catch composition and (v) thematic overlay of the spatio-temporal facets of fishery.

The results provide very valuable insight onto the aspects like consistent shift in the patterns of preferences over time and the palpable difference in the catch composition from similar gears focusing on similar grounds. This setup when expanded to a wider time scale in retrospection would give a better understanding of the dynamics of resources vis-à-vis a perceptible pattern over different phases of annual fishing calendar. Towards eliminating errors due to the enquiry based prediction of fishing locations, the depth as well as the species matrix netted were used as concomitant indices.

Table. Spatial distribution and landing extremes of oilsardine landed by ring seines from major harbours of Kerala during 2008- 2010

Distance (in km)		Fishing Ground (in degrees)				Catch range (kg per craft)	
Min	Max	North	South	East	West	Min	Max
4	100	10.322	8.734	76.51	75.42	8	35700



FR-P 06**Time series forecasting of marine fish landings in Kerala**

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Kerala with a coastline of 590 km and a network of inland water bodies occupies the foremost position in marine fish production in India, accounting for almost 20% of the total landings. Marine fisheries play an important role in the coastal economy of the state and is home to over 15% of the country's total marine fishermen population.

Estimated total marine fish landings in Kerala for the period 1961 to 2009 were analyzed using Spectral analysis and ARIMA modelling. The Spectral analysis is mainly focused on identification of fishery landing cycles and ARIMA modelling is used for forecasting the fishery landings in next three years. The Fisher test on the periodogram analysis suggests a five year significant cyclical element in the series and the suitable model was identified as ARIMA (0, 1, 5). The techniques were evaluated based on their efficiency to forecast fishery landings. The study provides forecast of marine fish landings in Kerala for next three years along with the confidence limits (Table).

Table . Forecast of marine fish landings in Kerala for next three years

Model		Forecast		
		2010	2011	2012
ARIMA (0, 1, 5)	Forecast	615402	640497	630420
	UCL	774246	803303	794298
	LCL	456559	477690	466543

FR-P 07**Status of demersal finfish fishery resources of Malabar region**

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The gearwise catch, effort and species composition data collected from four coastal districts of Malabar i.e., Malappuram, Kozhikode, Kannur and Kasaragod during 2001-10 were

analysed. During this period, the annual average landings were 2,14,619 t. The annual catch showed fluctuations between 2,05,598 t in 2009 and 2,69,997 t in 2003. The demersal finfish catch showed a declining trend from 1,25,257 t in 2001 to 59,030 t in 2008, mainly due to the decline in trawl catch from 63,560 t (2001) to 18,295 t (2008). The gearwise contribution of demersal resources landed showed that trawls contributed 88.4% of the catch followed by ring seine (3.6%), gillnet (2.5%), hooks & lines (0.5%) and the rest were by other gears. The annual average catch rate was highest in hooks & lines (81.2 kg/U), followed by trawl (19.5 kg/h), ring seine (12.1 kg/U) and gill net (4.8 kg/U). The annual catch rate has shown a declining trend in all the gears. Seasonal abundance of catch indicated that peak catch was recorded during second and third quarter of the year, which contributed more than 60% of the catch. Minimum catch was recorded during the first quarter. The average catch data for the period 2001-2010 showed that the demersal finfish resources contributed 13.8% of the total marine catch in this region.

The major resources that contributed to the demersal fin fish catch were threadfin breams (35.6%), soles (24.2%), lizardfishes (9.1%), other perches (8.6%), rock cods (6.3%), silverbellies (4.5%), elasmobranchs (1.9%), snappers (0.6%), big jawed jumpers (0.8%), and others (8.4%). The contribution of demersal resources showed fluctuations during 2001-2010. In general, it was seen that the catch of most of the demersal finfish resources showed a declining trend. Further, the analysis revealed changes in the species composition of major group such as threadfin breams, sharks, sciaenids, flatfishes, lizardfishes, silverbellies and flatheads.

FR-P 08**Marine recreational fishing in Andamans, India**

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India has vast source of streams, rivers, lakes, lagoons, reservoirs and seas with rich sources



of some of the finest game fishes in the world. These rich sources, majority of which are relatively untapped, provide ample scope for freshwater and marine recreational fishing in the country. With the improved economy and changing life styles of Indian youth, there is large potential for targeting the Indian market for recreational fishing. Andamans, Lakshadweep, Orissa, Goa and Kerala coasts offer conducive conditions in establishing marine recreational fishing. However, only in Andamans an established marine recreational fishing is in vogue. Sea angling was started as an established enterprise in Andamans by 2005. Twelve sports fishing companies are registered with Department of Fisheries, Andamans. Altogether 26 vessels are registered under these 12 companies out of which 11 vessels are based at Port Blair and 15 are at Havlock Island. The vessels range in size from 5.18 to 19.45 m LOA fitted with OBM of 10 to 250 hp. The vessel has to be registered to get a license for conducting sports fishing. Popping, jigging and trolling are the main types of recreational fishing techniques carried out at Andaman waters. Circle hooks or barbless hooks are used in the lines to have minimum injury to the fishes caught. Different types of steel, plastic, rubber and feather jigs and lures are used for angling. Rod and reel using dyneema and PA monofilament lines are used as fishing gear/implements. The angling activity exclusively is of the 'catch and release' type viz., the catch is released back in to the sea and is not retained unless injured severely. Proper care is taken during handling of the catch so that fishes have minimum injury. Season starts by mid October and lasts till May end. Mid January to end of May is the best season. Area of operation is as per the license, but normally ranges between 10 and 200 m depth. The main game fishes targeted are giant trevally, dog tooth tuna, yellow fin tuna, Spanish mackerel, grouper and barracuda.

Majority of the clients participating in sport fishing activities from Port Blair are Europeans. However, Indian anglers also have started showing interest in sea angling. Some of the

vessels based at Havlock cater to Indian clients for small duration fishing trips. Even though there is good demand for marlin and sail fish angling, the Indian sector is not equipped to cater to the client's demand. Lack of infrastructure like OBM servicing, vessel dry-docking and bunkering facility for the vessels at the jetty and lack of clear policy for sports fishing are some of the problems faced by the sector.

FR-P 09

A study on the diversity of reef fishes of Andaman Islands

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One of the most colourful and diverse groups of animals in the sea is the coral reef fishes. Reef fishes are characteristic of, but not restricted to coral reefs. They constitute an important fishery in Andaman Islands, accounting for nearly one third of the total fish landed. The shelf region around the islands support extensive fringing reefs in addition to vast sandy beaches, rocky shores and extensive mangrove belts around the coasts. This marine environment with a variety of habitats harbour a rich variety of fish fauna. Results of a survey carried out at 14 locations which included North, Middle and South Andaman and also Little and Great Andaman Islands i.e., Ranghat, Baratang, Hut Bay, Havelock, Haddo, Bamboo Flat, Phoenix Bay, Wandoor, Dignabad, Burmanalla, Chatham Island and Junglighat in Andaman Islands to assess the abundance of reef fish species are presented. Fishes were identified to species level and their abundance recorded. A preliminary checklist counting 101 different species, distributed among 65 genera, 39 families including 4 new records, is provided. Diversity indices are plotted and presented. Alpha diversity was highest at Wandoor, the most speciose family was Serranidae. The giant grouper, *Epinephelus lanceolatus* was also



sighted among the landings of reef fishes. The fish comes in the Vulnerable (VU) (A2d) in the IUCN Red List Status and is being exploited in large numbers in the island. Another striking feature noticed in the study are the variation in colour patterns of many fishes from the islands compared to their relatives from the mainland, pointing to the camouflage associated with reefs. The data presented could be used as a starting point for conducting further studies on the reef fishes of the area.

FR-P 10

An account of the trawl fishery off Puducherry coast

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With a coastline of 45 km, the union territory of Puducherry is comprised of four regions viz., Puducherry, Karaikal, Mahe and Yanam, spanning a total area of about 675 sq. km. The fisheries harbour at Thengaiyithu near Puducherry was commissioned in 2003. The harbour provides berthing facility for 330 medium sized mechanized wooden trawlers and 60 FRP boats for gillnetters. The trawl boats operate between Marakanam in the north to Pazhayar in the south at a depth range of 20 to 60 m. The annual trawl landing at Puducherry harbor during the period 2003-2009 ranged between 414 and 3821 t. The average annual landing for the seven year period was 2236 t and the average annual fishing effort was 48522 h. The average annual CPH was 46.1 kg. Minimum catch rate of 15.6 kg/h. was recorded in 2003 and maximum catch rate of 207.5 kg/h. recorded in 2008. Demersal finfish constituted 37% of the average annual landing, while pelagic finfish formed 25%, crustaceans formed 16% and molluscs 21%.

The landings include commercial varieties of prawns, lobsters, cuttlefish and fishes like threadfin breams, sardines, mackerel, goatfish, lizardfish, perches and croakers. Large perches, threadfin breams and elasmobranchs are the dominant groups among the demersal resources that contribute to the total landings at Puducherry, forming about 39, 29 and 24% of the demersal catch, respectively. Among the pelagic resources, carangids (54%), clupeids (17%), seerfish (7%), tunas (5%) and ribbonfish (4%) are major contributors to the landings. The crustacean landings are dominated by prawns, followed by crabs. Lobsters and stomatopods form less than 5% of the crustacean landings. Among the molluscs, cuttlefish form about 62% of the landings, followed by squids (33%) while gastropods form only about 4%.

FR-P 11

Species diversity and seasonal variations in dolnet fishery along the coast of Maharashtra

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Dolnets operated in three major centres along the coast of Maharashtra viz, Arnala, Sassoon Docks and Versova were studied for species diversity for a period of one year (Jan-Dec 2010). Fishery resources were evaluated on monthly basis by random sampling of the catches in three centres. In this study, species diversity index was used to examine the variations in species richness and species relative abundance and multivariate technique was used to explore the changes in species composition. This study compares the three centres and the seasonal variations in species composition and diversity. Total catch in dolnet in Arnala was estimated at 2051 t for the effort of 42,438 (hauls) and catch rate was 16 kg/h. Major groups contributing to dolnet



fishery at Arnala were Bombayduck (44%), anchovies (27%) and non-penaeid prawn (13.8%). More than 60% of the catch comprised of juveniles. In Sassoon docks total catch of 479 t was estimated at an effort of 10,996 and the catch rate was 44 kg/h. Major groups contributing to the fishery were penaeid prawns (16%), anchovies (16%), non-penaeid prawns (12%), Bombay duck (11%), croakers (8%), crabs (8%), shads and cephalopods (4%). In Versova, total catch was estimated at 245 t with an effort of 1,231 units and catch rate was 0.2 kg. Major groups contributing to dolnet fishery at Versova were non-penaeid prawns (75%), penaeid prawns (6%), flatfishes and ribbonfishes (4%). Shannon diversity index in the three centres were in the range of 1.9 to 3.0 with highest value in Sassoon Docks and lowest in Arnala and the evenness index exhibited a similar picture to that of species diversity with a range of 0.5 to 0.7. Cluster analysis was carried out on the fish composition observed in three centres to understand the affinity between the centres. The similarity matrix ranged from 48.8 to 58.7. Two well defined clusters were observed. Arnala and Versova formed one cluster with maximum similarity to which Sassoon Dock got linked. Seasonal variations were studied in three centres. In Arnala, the Shannon diversity index ranged from 1.4 to 1.8 and evenness ranged from 0.4 to 0.5. The high value of diversity index was during post-monsoon. The similarity matrix ranged from 65.11 to 72.99 and the post-monsoon and monsoon formed one cluster to which pre-monsoon got linked. In Sassoon Docks, the Shannon diversity index ranged from 2.05 to 2.70 and evenness ranged from 0.71 to 0.72. The high value of diversity index was during pre-monsoon. The similarity matrix ranged from 24.04 to 43.14 and the monsoon and pre-monsoon formed one cluster to which post-monsoon got linked showing similar species landings during monsoon and pre-monsoon. In Versova, the diversity index ranged from 0.79 to 2.24 and evenness ranged from 0.61 to 0.72. During monsoon, there was no diversity as *Acetes* was the major resource landed and the similarity was between

pre-monsoon and post-monsoon. Comparison of diversity of dolnet fishery between centres and seasons is discussed in detail in the paper.

FR-P 12

Assessment of Antarctic flying squid *Todarodes filippovae* Adam, 1975 resource in Southern Indian Ocean

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The Antarctic flying squid *Todarodes filippovae* is a large muscular epipelagic ommastrephid squid distributed in the Southern Ocean. Adam (1975) described this species based on the specimens collected from Southern Ocean (35° S-38° S, 66° E-77° E) in the year 1967. So far, *T. filippovae* is poorly known in Southern Indian Ocean and no other taxonomic description is available. In the present study, this species is systematically described with colour photographs. During the 5th Indian Expedition to Southern Ocean, 37 specimens (27 kg) of *T. filippovae* were opportunistically caught on 1st February 2011, at 38° 59'S, 57° 29'E of Southern Subtropical Front (STF) using only one hand jig from 1.00 am to 2.05 am. The STF is the highly productive, hydrographic boundary between warm, saline subtropical gyre waters and sub Antarctic cooler waters. Among the 37 specimens caught, 36 were females with dorsal mantle length (ML) of 331 ± 21 mm and single male of ML 210 mm. The bioaccumulation of heavy metals in *T. filippovae* tissues were analysed for recommending for human consumption. The levels of Cd, Fe, Mn, Ni, Cu, Zn and Hg in mantle muscle tissues with mean values of 0.80, 22.62, 2.01, 6.00, 20.18, 111.61 and 1.64 µg/g dry weight respectively were detected. These trace element concentrations were within the permissible limits recommended for human consumption. The squids *T. filippovae* are largely exploited in Tasmania, Australia and New Zealand by commercial squid jigging boats due to the



potential commercial value. The present study gives the preliminary information about the abundance of *T. filippovae* in Southern Indian Ocean. To launch large scale exploitation of the squids, further stock assessment studies in the region are needed. The morphometric analysis, oceanographic parameters and seabirds associated with *T. filippovae* are discussed in detail in the paper.



The Antarctic flying squid *Todarodes filippovae*

FR-P 13

Deep-sea decapod crustacean fauna of the West coast of India

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Information on the crustacean resources of the deeper waters, below 200 m off the Indian coast is scanty. Exploratory surveys by FORV Sagar Sampada (Cruise no. 241, 250 and 281) at 165 -1070 m depths, between Trivandrum in the south to Veraval in the north (Lat. 08° 21'N - 20° 38'N and Long. 76° 11'E - 69° 14' E) have enhanced the knowledge on the distribution and diversity of decapod fauna along the west coast of India. A total of 52 fishing operations were conducted, of which EXPO was operated at 30 stations and High Speed Demersal Trawl (HSDT) was used at 22 stations. 27 decapod species were identified, of which 19 were shrimps from the families Aristeidae, Oplophoridae, Pandalidae, Penaeidae, Solenoceridae, Pasiphaeidae and Glyphocrangonidae, four were crabs from the families Majidae,

Portunidae and Homolidae, two were lobsters from the families Nephropidae and Palinuridae, and two squat lobsters from the families Galatheididae and Chirostylidae. Despite the high species richness in decapods, the count of most of the species were low and five of them constituted more than 70% of total capture. The most abundant decapods species recorded was *Charybdis smithii* followed by *Plesionika spinipes*, *Aristeus alcocki*, *Solenocera hextii*, *Metapenaeopsis andamanensis* and *Aristaeopsis edwardsiana*. Decapod species were distributed from 160 to 1000 m depth zone and HSDT showed a higher catch rate than EXPO. The paper also attempts to provide depth-wise distribution of deep-sea crustaceans along the west coast of India.

FR-P 14

Seamount associated fishery along the West coast of India

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Seamounts off the west coast of India are intensely fished by longlines and gillnets operated from Kochi. Fishery and catch composition of this fishery were monitored during 2009-2011. Seamounts are undersea mountains raising from the seafloor and peaking below sea level mainly with rocky and coral bottom and support diverse fauna of permanent and migratory resources. Several of these species form aggregations for spawning or feeding and are the target of large scale fisheries. Nearly 30-100 boats are regularly fishing over these areas with fishing duration varying between 2-3 weeks. Catch varied between 4-11 t/trip. More than 90% of the catch from seamounts are constituted by marlins, sailfishes, sword fishes, sharks, rays and tuna and the rest by groupers, carangids and snappers. A total of 57 species belonging to different families and genera were recorded. Catch composition and information provided



by fishing crews indicate large aggregation of sharks, sailfishes and young ones of both yellowfin and skipjack tuna.

FR-P 15

Biological aspects of spinyjaw greeneye, *Chlorophthalmus bicornis* (Norman, 1939) from the Southeastern Arabian Sea

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The biology of spiny-jaw green-eye fish *Chlorophthalmus bicornis* (Norman, 1939) from southeastern Arabian Sea was studied based on the specimens landed by deep-sea shrimp trawls operated off Cochin during 2009-2011. Bathymetric data collected on trawling grounds shows that the species is abundant at 300-500 m depth zones. *C. bicornis* forms a major portion of the by-catch of deep-sea shrimp trawls throughout the year, with peak during November-January. Size range of 98-175 mm total length (TL) were observed in the by-catch landings. Mature specimens were observed to dominate during November-January, indicating spawning activity. Absolute fecundity was estimated and ranged from 3616- 4317 eggs. Length at maturity was estimated at 122-125 mm TL. Stomach content analysis indicated that *C. bicornis* feeds mainly on deep-sea shrimps, acetes, squids, lobsters and other fin fishes.

FR-P 16

Biometric relationships of the Indian abalone, *Haliotis varia* Linnaeus, 1758 from Mandapam waters of Gulf of Mannar, South-east coast of India

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Abalones, which have high commercial value among the molluscan resources exploited worldwide, are distributed in India along the

Mandapam and Tuticorin coastal waters of the Gulf of Mannar, south-east coast of India. Owing to the high demand of small live abalones in the world market, the Indian abalone, *Haliotis varia* is considered as a candidate species for mariculture. The biometric relationships, including length-weight relationship, in different size groups of *Haliotis varia* collected from the 'paars' of Mandapam coastal waters of the Gulf of Mannar, were studied and presented. In *H. varia*, the length-weight (L-W) relationship between males and females in the same size group was not significantly different and therefore a combined equation was derived. The L-W relationship had reasonably good fit in medium sized abalones (shell length (SL) 25-35 mm, $R^2=0.8368$), while it was poor in small sized abalones (SL 15-25 mm, $R^2=0.2609$) and lowest in large sized abalones (SL 35-45 mm, $r^2=0.1641$). The L-W relationship in different size groups indicated that the growth in length and weight was initially allometric and subsequently became isometric in medium sized abalones and finally reverted back to allometry. In all other biometric relationships such as shell length- shell width (SL-SW), shell length-shell height (SL-SH) and shell width-shell height (SW-SH), allometric growth was observed in all the size groups. The results of the study may form the baseline information on the abalone population in Indian waters to facilitate their commercial exploitation.

FR-P 17

Observations on the monsoon prawn fishery and hydrobiology of prawn fishing grounds of Gulf of Kutch region during 2010

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In the present investigation, prawn samples were collected from the landing centres and



from the prawn fishing grounds of Madherkhi, Surajbari (Chera) and Tikkar of Kutch region from July to August 2010. During the study period, hydrobiological parameters such as salinity, temperature and pH were recorded, water samples from the prawn fishing ground were fixed for dissolved oxygen (DO), gross primary productivity (GPP) and net primary productivity (NPP). Samples from the prawn fishing ground were also subjected to nutrient (nitrate, phosphate, silicate and ammonia) analysis. The fishery details such as catch, effort, total catch, total value, active fishermen and number of families were also recorded during the study period in selected three areas. The prawn fishery starts by the first week of July and ends by the end of August or middle of October, based on the strength of monsoon. The fishery continued for about 55 days at Surajbari; 45 days at Mandherkhi and Tikkar. *Metapenaeus kutchensis* formed about 99% of the prawn catches of the area. *M. kutchensis* of 38-103 mm in total length were represented in the catch, but juveniles of 67-86 mm formed the basis throughout the study period with minor fluctuations in the catches. The sex-ratio distribution of the samples showed higher proportion of females in the catches in all the three areas. With the data collected during the period regression equation was fitted between total length and carapace length; and total length and total weight for the two sexes separately. In these three study areas, totally 1150 active fishermen were engaged in fishing with the average catch/day/man being 36.66 kg and the estimated total catch for the study period was 2550 t worth Rs. 20.42 crores. Among hydrobiological parameters recorded, salinity showed much variation when compared to all other parameters. The consequent lowering of the salinity of the creek waters during the monsoon period play an important role and serve as a convivial environment for the aggregation of juvenile prawns into the Gulf which support the seasonal fishery in these areas.

FR-P 18

Reproductive dynamics and stock assessment of *Metapenaeus dobsoni* (Miers, 1878) exploited by trawlers off Kozhikode, Kerala, Southwest coast of India

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The data for this study was collected from Puthiappa, one of the major trawl landing centres of Kozhikode during 1997 to 2007. The annual catch of *Metapenaeus dobsoni* varied from 248 t in 1999 to 735 t in 1997. The annual percentage contribution of this species to the total prawn catch fluctuated between 29% in 2003 and 51 % in 2000 with an average of 41%. The main fishing season is from November to June with peaks in May and December. The size of males in the total catch ranged from 41 to 105 mm with a mode at 71-75 mm and that in females ranged from 46 to 125 mm with a mode at 76-80 mm. Females dominated in the total catch by 54.9%. In females immature formed 2%, early maturing 33%, late maturing 15 %, matured 23 % and spent 27%. The main spawning was in February followed by a secondary spawning in November and a minor peak in August. The size at first maturity was 77.5 ± 1.0 mm and the minimum size of matured female was 61 mm. The size fecundity relationship of female was $Y = 0.0000000558 L^{6.074}$ ($r = 0.973$). The population fecundity index was maximum in January (69.97×10^{10}) followed by March (62.74×10^{10}). The average monthly egg production was 9.6×10^{10} numbers and the average monthly recruits was 39.4×10^6 numbers. The egg recruit ratio was 5843:1. The growth parameters L_{∞} and K, are 106 mm and 1.8 for males and 125 mm and 2.0 for females. The natural mortality based on longevity was calculated as 2.33 for males and 2.23 for females. Length-weight relationship of the species is, male: $W (g) = 0.00993046 L (cm)^{2.7568}$ ($R^2 = 0.839$, $n = 715$) ; Female: $W (g) = 0.00628567 L (cm)^{3.0067}$ ($R^2 = 0.912$, $n = 772$). The stock



assessment studies shows that though the fishing pressure can be increased in this species by 20% to attain MSE and by 60% to attain MSY, the spawning stock biomass at these levels are only 17.6 % and 13 % respectively. But at the present level of fishing the spawning stock of female is 21% with respect to the virgin biomass. So, further increase in fishing pressure from the present level may affect the spawning stock. Hence it is better to continue the exploitation of this species at the present level.

FR-P 19

Stock assessment and reproductive dynamics of Indian white prawn, *Penaeus (Fenneropenaeus) indicus* H. Milne Edwards, 1837 exploited by trawlers off Kozhikode, Kerala, Southwest coast of India

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The data collected from one of the major trawl landing centres of Kozhikode during the period 1997 to 2007 is used for this study. The annual catch of Indian white prawn varied from 42 t in 1999 to 486 t in 1997. The species formed 8% (1999) to 32% (2003) with an average of 16% in the total annual prawn catch. The main fishing season was from November to June with a peak in April. The average monthly catch was 196 t. The size in the catch ranged from 56 to 180 mm in males and that from 66 to 190 mm in females with a main mode at 121-125 mm in both the sexes. Females dominated in the total catch by 53.2%. Length-weight relationship of the species is:

$$\text{Male : } W \text{ (g)} = 0.0022014 L \text{ (cm)}^{3.4359} \\ (R^2 = 0.956, n = 728)$$

$$\text{Female : } W \text{ (g)} = 0.0016404 L \text{ (cm)}^{3.5502} \\ (R^2 = 0.960, n = 728)$$

The growth parameters L_{∞} and K are 178 mm and 1.6 for males and 191 mm and 2.0

for females respectively. The natural mortality based on longevity was calculated as 2.06 for males and 2.21 for females. The main spawning was observed in April and a secondary spawning in December. The size at first maturity was 141.9 ± 1.6 mm and the minimum size of matured female was observed at 113 mm. The size fecundity relationship of female was $Y = 0.00000000176 L^{6.566}$ ($r = 0.9587$). The population fecundity index (PFI (10^{10})) in April was 975 and that in December was 78.87. The average monthly egg production was 8.38×10^{10} numbers and the average monthly recruits were 4.9×10^6 numbers. The stock assessment using Thompson and Bell model showed that the spawning stock was overexploited at the present level. As the fishery already crossed the MSE level at the F-factor 0.8 (present F-factor=1), the increase in fishing mortality by 20% to attain the MSY is not advisable. But the spawning stock biomass even at the MSE level is only 13.2 % of the virgin biomass. So by reducing the fishing pressure by 50% from the present level, the spawning stock in the biomass can be increased to 20%.

FR-P 20

Stock assessment and recruitment dynamics of kiddy prawn, *Parapenaeopsis styliifera* (H. Milne Edwards, 1837) from Puthiappa, Kozhikode, Southwest coast of India

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The data for the period 1997 to 2007 was used for this study. The annual catch of *Parapenaeopsis styliifera* varied from 107 t in 2004 to 572 t in 1997. The fluctuations in the catch showed significant positive correlation with fluctuations of the total prawn catch. The species formed 25% of the total prawn catch of this area. The annual contribution of this species to the annual total catch ranged from 14% to 31%.



The main fishing season is from November to June with a primary peak in May and a secondary peak in December. The size in the catch ranged from 41 to 110 mm in males and that from 41 to 125 mm in females. Females dominated in the total catch of *P. stylifera* by 50.7%. Length- weight relationship obtained for the species is:

$$\text{Male : } W \text{ (g)} = 0.0068812 L \text{ (cm)}^{2.9607} \\ (r^2 = 0.769, n = 632)$$

$$\text{Female : } W \text{ (g)} = 0.004437 L \text{ (cm)}^{3.1476} \\ (r^2 = 0.857, n = 638).$$

The growth parameters L_{∞} and K , obtained are, 113 mm and 2.4 for males and 135 mm and 2.55 for females respectively. The natural mortality based on longevity was calculated as 3.54 for males and 2.79 for females. The main spawning was observed in March (60%) and December (55%). The size at first maturity was 80.2 ± 1.4 mm and the minimum size of matured female was at 61 mm. The size fecundity relationship of female was $Y = 0.0000196 L^{4.715}$ ($r = 0.986$). The population fecundity index (PFI (10^{10})) in December was 31.43 and that in March was 25.45. The average monthly egg production was 2.69×10^{10} numbers and the average monthly recruits was 17.6×10^6 numbers.

The predictive analysis of the fishery using Thompson and Bell model shows that though the fishing mortality can be increased by 40% to reach the MSY, the yield will not be profitable at this level. To attain the maximum sustainable economic yield, the fishing pressure has to be reduced by 20% from the present level of fishing. Moreover the spawning stock biomass (SSB) at the present level is only 18% of the virgin biomass (B_0) and at the MSY level it is 12% of B_0 . But at the MSE level, the SSB was 22% of the B_0 . So to maintain at least 20% of the SSB in the biomass and also to obtain a profitable yield, the fishing pressure has to be reduced by 20%.

FR-P 21

Present status of spiral Babylon fishery along Tamil Nadu and Puducherry coast of India

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In India, the marine gastropods contribute to important fisheries, provide nutritious food and are also valuable foreign exchange earners to the country. The shell has many industrial uses and is an object in making eye catching shell articles by deft craftsmen. Men, women and children participate in fishing gastropods, which provide employment and income in coastal rural areas. *Babylonia* sp., commonly known as 'Whelk,' or 'Spiral Babylon' and 'Puramuttai chank' (dove egg shell) in local parlance and 'Baigai' in the trade sector, is a marine edible gastropod. It is widely distributed in the Indo-Pacific region. It is extensively fished from Tamil Nadu at places such as Gulf of Mannar, Poompuhar, Nagapattinam, and Chennai using whelk trap, which consists of a net bag supported with an iron frame of circular and square shape on the top. The peak fishing season is from June to October with high catch rates (150 kg/Unit). The fishery is composed mainly of one species, *Babylonia spirata*, the size range of which ranges from 15 to 50 mm and weight varies from 6 to 21 g. A study of seasonal maturity stages indicated that the animals have a primary peak breeding period during October to December and secondary peak during April-May. Growth was found to be isometric and the maximum size encountered in the fishery was 55 mm. Biochemically, the meat has more than 60% protein, 9% carbohydrates and 9.1% lipids. Live *Babylonia* is exported to Japanese, Korean, Singapore, Hong Kong, Thailand, UAE, Maldives and Chinese markets. The price at landing centers range from Rs.180-200/kg.



FR-P 22

Biology and length-weight relationship of *Ilisha filigera* (Valenciennes, 1847) in MumbaiR. K. PRADHAN*, V. D. DESMUKH, S. K. CHAKRABORTY
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The present study on biology and length-weight relationship of big eye shad, *Ilisha filigera* (Valenciennes, 1847) is based on the data collected from October 2010 to April 2011 from Naigaon, Versova and New Ferry Warf landing centres of Mumbai. It is a high priced fish liked by the coastal people and having some export demand also. The species contributes substantially to the Indian fishery. A total of 353 fish specimens of different size were collected and studied for the present investigation. The morphometric characters were compared which showed a very high degree of correlation. The length-weight relationship showed a good degree of correlation for both males, females and both the sexes pooled. The 'b' value obtained for the pooled data of both sexes is 3.3452 with a correlation coefficient (r) of 0.9540, and the relationship is $W = 0.002336 L^{3.3452}$. Food and feeding study indicated that the species *I. filigera* is a carnivore mostly feeding upon *Acetes* sp. and smaller fishes. The occurrence of digested matter was very frequent in the present study. Occurrence of spent and mature ovary in most of the months indicates that the species is a multiple breeder having prolonged breeding season. The study of gonado-somatic index indicates that the peak breeding season is during February and March and lean breeding season in other months. The size at first maturity of species obtained from the occurrence of mature specimen according to size is about 310 mm. Fecundity of the species ranged from 18128 to 41824 with a mean of 30,679 and average relative fecundity with respect to body weight is 101.3 ± 6.27 numbers per gram body weight.

FR-P 23

Length-weight relationship of an endemic freshwater prawn, *Macrobrachium lar* (Decapoda, Palaemonidae) in streams and ponds from the Andaman and Nicobar Islands

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Macrobrachium lar, local and endemic species of Andaman & Nicobar Islands is known to inhabit streams, rivers, lakes and ponds. Length weight relationships of this fresh water prawn, collected from the selected streams and ponds during the year 2008 were calculated. A total of 238 specimens in the size range of 60-167 mm in total length (128 and 110 females and males respectively) collected from the various streams, while 281 specimens in size ranges of 63-118 mm in total length (157 and 124 females and males respectively) caught from the ponds using cast net were examined. As there was no significant difference in the slopes and elevations of both sexes from each source, data were pooled to arrive at a common equation for each source. The combined equations of LWR of *M. lar* were $W = 0.0007 L^{2.6695}$ for streams and $W = 0.00006 L^{3.205}$ for ponds. The correlation coefficient 'r' was found to be 0.86 for streams and 0.89 for ponds. The regression coefficient *b* for this species was either marginally higher (ponds) or significantly lower (streams) than 3.0 ($p < 0.01$), suggesting allometric growth. The present results indicated that prawns sampled from ponds are heavier than those of streams at any given length.

FR-P 24

Length-weight relationship of two species of sharks and rays from Andhra PradeshMUKTHA MENON*, G. MAHESWARUDU,
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Eelasmobranchs are of special concern to fishery managers due to their slow growth



rates, low fecundity and long population replacement time which is further compounded by limited information on growth and population status of most species. This is particularly important in tropical countries like India where elasmobranchs form a regular component of the multi-species fishery both as targeted catch and by-catch in the mechanized and non-mechanized sectors and where information on growth and stock status is limited. Andhra Pradesh, along the east coast of India contributed an annual average landing of 7035 t of elasmobranchs during 1985 - 2010 which was composed of 3746 t of sharks, 2998 t of rays and 291 t of skates. The most common shark species landed along the Andhra coast were *Iago omanensis* (Norman, 1939), *Shyrna lewinii* (Griffith & Smith, 1834), *Carcharhinus limbatus* (Muller & Henle, 1839) and *Carcharhinus sorrah* (Valenciennes, 1839). The most common ray species landed along the Andhra coast were *Gymnura poecilura* (Shaw, 1804), *Himantura jenkinsii* (Annandale, 1909), *Dasyatis kuhlii* (Muller & Henle, 1841) and *Gymnura japonica* (Temminck & Schegil, 1850). Data on length and weight were collected from June 2010 to September 2011 for the two most commonly landed shark species namely *I. omanensis* and *S. lewinii* and two ray species namely *G. poecilura* and *H. jenkinsii* from Visakhapatnam Fishing Harbour. The collected data were used for estimating length-weight relationships for each species. Relationships fitted to only females of each species are presented here since enough data on males was not available during the time period. The length and weight data was fitted to the equation $W=aL^b$ after logarithmic transformation. The length-weight relationship for *I. omanensis* was estimated as $W = 0.000064(L)^{2.51}$ ($R^2 = 0.66$) and for *S. lewinii* it was estimated as $W = 0.000007(L)^{2.93}$ ($R^2 = 0.91$). For *G. poecilura*, the length-weight relationship was estimated as $W = 0.000002(L)^{3.21}$ ($R^2 = 0.97$) and for *H. jenkinsii* it was estimated as $W = 0.0001(L)^{2.795}$ ($R^2 = 0.89$). Estimating length-weight relationships is a first step towards gaining more information about growth rates

which in turn is needed for population assessment studies. Field data on elasmobranchs is generally limited to length measurements alone, which can be used as inputs for stock assessment models only if the length-weight relationship is known for a particular species for a particular area.

FR-P 25

Aspects of fishery and biology of bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Elasmobranchii: Echinorhinidae) from the southwest coast of India

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The bramble shark *Echinorhinus brucus* (Bonnaterre, 1788), is one of the abundant deep-water shark in the fishery landings along the southwest coast of India but is poorly known among the sharks of the world. Although there is no direct/targeted fishery for *E. brucus* in Indian waters, it commonly occurs as by-catch along with several other deep-sea sharks and chimaeroids in the targeted deep-sea shark fishery for gulper sharks, deep-sea shrimp trawl and the hooks & line/gillnet fishery. Published reports on the biological aspects of deep-sea sharks from Indian waters especially of *E. brucus* are meager. The present study on fishery and biological aspects of bramble shark is therefore pertinent to address the issues for sustainable deep-sea shark fisheries along the southwest coast of India (Arabian Sea). Very high landings of *E. brucus* are common in Cochin (Kerala), a major deep-sea shark fishery centre in the southwest coast with peak landings recorded during March- May and September- November during 2008-2010. The processing depends on extraction of liver oil and also subsidiary trade of salted-dried meat, jaws and fins. Length frequencies of the sharks studied were 62 to 318 cm total length. *E. brucus* exhibited ovoviviparous mode of reproduction and



ovarian fecundity ranged from 10 to 33. The sustainability issues are addressed in the context of the observation on the size ranges caught, sex related variation in catch composition and occurrence of gestating females in the catch. High prevalence of gravid females and juveniles are key issues in the local fishery.

FR-P 26

Observations on some biological aspects and food and feeding habits of spade nose shark (*Scoliodon laticaudus*) landed along Saurashtra coast

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Spade nose shark (*Scoliodon laticaudus*) locally known as "Sandhi" belongs to family Carcharhinidae and mainly occupies near shallow coastal water areas of Saurashtra coast. It is exploited by trawls and gillnets throughout the year in fair abundance. Periodical fish samples were obtained from the commercial gill netters and trawlers of Saurashtra coast from April 2009 to March 2010. The length range of *S. laticaudus* was found to be 22.30 cm to 68.50 cm. The dietary components of the species was studied and expressed as a percentage of numerical composition (C_N), percentage of gravimetric composition (C_W) and percentage of frequency of occurrence (F). The major food item in the stomachs of the species was determined using an Index of Relative Importance (IRI). The gut contents of the fish varied in number, weight, and their frequency of occurrence with species to species. The study showed that prey items that were smaller in size constituted the major bulk, while the large size prey items were eaten in fewer numbers. The food was mostly comprised of fishes, shrimps and squids. Food and feeding analysis confirmed the carnivorous feeding behavior of

this species. Highest quantity of shrimp food (83.56%) in gut content was observed during January. There was no evidence of cannibalism. Overall sex ratio was 1.18 that showed the predominance of females over males. As there is less information about the biological aspects of this species from this area, the results of the present investigation may play a vital role in the management of fishery resources as well as for the efficient exploitation of this species.

FR-P 27

Reproductive biology of *Valamugil burchanani* from estuaries of Dakshina Kannada

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In view of dwindling fish resources due to over-exploitation, there is an urgent need of taking up conservation measures for sustainable capture fisheries. In this connection, it becomes essential to ascertain the breeding seasonality, behaviour and the reproductive biology of commercially important fishes, so that appropriate management strategies can be adopted to avoid recruitment over-fishing and growth over-fishing. This present investigation was carried out on reproductive biology of commercially important mullet (*Valamugil burchanani*) from estuaries of Dakshina Kannada coast during the period November, 2008 to October, 2009. The species spawned only once in a year over a prolonged period extending from August to January with a peak in November to December. Data on size at first maturity of *V. burchanani* using cumulative frequency method indicated that the female attained first maturity at 177 cm while the male at 181 cm. Males always recorded lower values of Gonado-Somatic Index (GSI) when compared to females owing to greater ovary weight. The



GSI values were high during August to January with peak in November to December implying prolonged spawning for this fish along Dakshina Kannada coast. The absolute fecundity of fish ranged from 31,168 to 1,24,154 eggs with an average of 59,591 eggs. The sex-ratio was 1:0.65. There was an overall predominance of females in the population. Histological results support the findings from the biological results which elucidated the spawning season of *V. buechani* extending from August to January with a peak in November to December.

FR-P 28

Elasmobranch fishery of Kerala with emphasis on the diversity, abundance and conservation status of sharks and rays landed at Cochin Fisheries Harbour

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Elasmobranchs, comprising of sharks, skates and rays form an important fishery along the Indian coast. Though, elasmobranchs were mainly landed as by-catch in different gears until mid 80's, off late the increased demand for shark fins, liver oil, meat and cartilage both for export as well as domestic market, led to targeted fishing on the stocks leading to increased harvest of several large oceanic as well as deep sea shark species. The present paper discusses the elasmobranch fishery of Kerala with special reference to the diversity and abundance of sharks and rays landed at Cochin Fisheries harbour (CFH) during 2010. In Kerala, 4435 t of elasmobranchs were landed in 2010 forming 8.4% of the all India elasmobranch landings. At CFH, major share of elasmobranchs are landed in mechanized drift gillnet-Hook and line (MDNHL) units, which are generally operated from vessels fishing at >100 m depths along the west coast stretching from Cochin to Ratnagiri. In the elasmobranch

landings, sharks contributed 73% (567 t), rays 26% (559 t) and skates formed only 1% (32 t). A variety of species were observed in the shark fishery at CFH with major contributions by *Carcharhinus limbatus* (33.5%), *Carcharhinus falciformis* (16.3%), *Sphyrna lewini* (15.5%) and *Alopius superciliosus* (13.8%). Length range of *C. limbatus* landed at Cochin was 80 to 309 cm, annual mean size being 190.5 cm. *S. lewini* landed at Cochin ranged in length from 70-289 cm with annual mean size of 175.3 cm. Towards the second half of the year, a spurt in the landings of the silky shark *C. falciformis* ranging in TL from 90-298 cm was observed in MDNHL catches at CFH. The ray fishery at CFH was supported mainly by *Mobula japanica* (78.9%) and *Taeniura meyeni* (44.3%). The size of *M. japanica* landed ranged from 100-289 cm in disc width with annual average mean of 213.2 mm. Towards the last quarter of the year, considerable rise in the landings of *T. meyeni*, *Himantura fai* as well as *Rhinoptera javanica* was noticed. The catch is usually auctioned at the harbour and in most cases the auctioned catch is taken to slaughter place nearby for removing fin and liver and the meat is sent to the local market. In the case of sharks, sometimes fin is removed at the landing centre itself and taken for drying. In case of rays, sometimes gills are removed at the landing centre for drying for export purpose.

Exploitation of elasmobranchs at present along the Indian coast is unbalanced. Eventhough there is scope for expanding the commercial exploitation of elasmobranchs at several places, this needs to be done with caution. Elasmobranchs are considered as the most valuable group harvested from the seas and the slow recovery rate from the effect of fishing pressure makes them highly vulnerable. Overfishing due to increased demand has endangered many shark species of the world. Many shark and ray species landed in Kerala are listed in the IUCN Red List in Near threatened/Vulnerable category with *Sphyrna lewini* being listed as endangered.



FR-P 29**Length-weight relationship and relative condition factor of Indian mackerel, *Rastrelliger kanagurta* from Mangalore coast**

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Specimens (1124) of the Indian mackerel, *Rastrelliger kanagurta* were collected from territorial waters of Mangalore coast during August 2003 to July 2004. The length-weight relationship for the sexes combined was $W = 0.0045 L^{3.2234}$. The relative condition factor for male showed that the condition remained low in the size range 11 to 13 cm followed by a sudden recovery in the next successive size groups till 19 - 21 cm. In case of female, the relative condition factor remained lowest (1.0324) in the size range 11 - 13 cm. A gradual rise was observed up to size range 19 - 21 cm. But again, a sudden decrease was noticed in the size range 21 - 23 cm. The seasonal fluctuation in the relative condition factor of both the sexes was attributed to the sexual cycle and food intake.

FR-P 30**Length weight relationship and relative condition factor of *Gerres filamentosus* (Cuvier) off Mangalore coast, Karnataka**

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Gerres filamentosus is known to inhabit shallow coastal waters, estuaries and

backwaters. The study deals with length weight relationship and relative condition factor (Kn) of *G. filamentosus* (Cuvier) off Mangalore coast during the period, July 2009 to June 2010. Length weight relationship derived are : $\log w = -1.8067 + 2.9672 \log L$ (for females), $\log w = -1.7266 + 2.9069 \log L$ (for males) and $\log w = -1.5885 + 2.7213 \log L$ (for indeterminates). The relative condition factor (Kn) was determined for each sex. Mean Kn for females, males and indeterminates was found to be 1.0108, 1.0111 and 1.0179 respectively. The length weight relationship and relative condition factor shows that the growth of *G. filamentosus* is satisfactory in the population off Mangalore coast.

FR-P 31**Age and growth of top snail, *Telescopium telescopium* in mangrove along Nethravathi estuary, Mangalore, Karnataka, India**

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Mangrove is a unique ecological environment and forms habitat for wide variety of marine invertebrates. *Telescopium telescopium* lives in intertidal zone of the estuary. It prefers soft, liquid muddy substrates and frequently found in shady areas of the mangrove. It has a wide distribution, found throughout the coastal mangroves of India. They are deposit feeders, feeding mainly on mud and detritus in mudflats during low tide. The species spawn in low water mark during April – July. They are seldom used for human consumption, but exploited for the lime industry in India. The top snail *T. telescopium* were collected from mangroves along Nethravathi estuary between May 2009 and April 2010. The calculated *b* value of length-weight relationship of *T. telescopium* was $W = -0.5072 L^{2.5007}$. The maximum *b* value was 3.8992 (August 2009) and minimum was 1.8323 (March 2010). The age, growth, mortality and population structure



of *T. telescopium* were estimated. The estimated asymptotic length (L_{∞}) and growth coefficient (K) were 12.28 cm and 0.63 year⁻¹ respectively. The theoretical age at the time of birth (t_0) was 0.045 years.

The growth rate of *T. telescopium* was 5.6, 2.9, 1.5, and 0.84 cm at the end of first, second, third, and fourth year respectively. The growth curve showed maximum growth during early stage and gradually decreased during later stages. The life span of *T. telescopium* was found to be upto 5 years. The total mortality (Z) was 3.74 year⁻¹. Based on ambient temperature (29.0 °C) the estimated natural mortality (M) and fishing mortality (F) were 1.72 year⁻¹ and 2.02 year⁻¹ respectively. The recruitment pattern ranged from 2.06 (December, 2009) to 19.42 % (April, 2010) during the present study. *T. telescopium* showed continuous recruitment throughout the study period.

FR-P 32

Breeding seasonality of *Otolithes ruber* (Schneider, 1801) along Dakshina Kannada coast

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Sciaenids are among the important groups of demersal fishes landed by commercial trawlers in Indian waters. They are commonly called as croakers and in Dakshina Kannada coast they are locally called "Kallur" (in tulu). Out of forty five species of sciaeinds, fourteen species are known to contribute to the fishery along the Dakshina Kannada coast, among which *Otolithes ruber*, *Otolithes cuvieri* and *Johnnieops osseus* are prominent ones. The common name of *O. ruber* is tiger toothed croaker. It is one of the important demersal fish landed by commercial trawlers and found up to the depth of 50 m. Present study was

conducted to ascertain the breeding season and some biological aspects for better management of fishery. During the period from March 2009 to February 2010 a total of 290 specimens were collected, of which 160 were male and 130 were female. Relative condition factor (K_n) showed higher values in the months of December and April in male and female respectively and gonado somatic Index (GSI) values were higher in both the sexes during the period September to November. Male attained maturity earlier than female. Fecundity of *O. ruber* ranged from 48,625 to 2,31,396 eggs with an average of 1,16,118 eggs and ova diameter ranged from 0.04 to 0.99 mm. The present study concludes that *O. ruber* spawns only once a year from September to November with peak breeding in October.

FR-P 33

Population dynamics and stock assessment of *Labeo calbasu* (Hamilton) in Kodar Reservoir, Chhattisgarh

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The dynamics and stock assessment of *Labeo calbasu* in Kodar reservoir, was studied using length-frequency based analysis to evaluate growth parameters and maximum sustainable yield (MSY). The study revealed that the stock of *L. calbasu* was more or less under optimum exploitation. Any major change in the exploitation results in a reduction in the yield per recruit. Results obtained from the length-weight relationship showed that the "cube Law" could not be followed for *L. calbasu* in the reservoir system and the species showed an allometric growth pattern. As the age increased, the number of individuals was found to decline. The age groups 2+ and 3+ dominant in the commercial catches of *L. calbasu*. The age groups 1+ and 3+ with length from 22–26 cm



and 42–46 cm respectively could not be recorded in more numbers due to the use of variable mesh sizes during harvest in different years. The population is highly variable in different age groups, but the proportion of age group 1+ was highest with lengths of 22–26 cm and 27–31 cm. The results indicated that the growth in *L. calbasu* is faster initially which gradually reduces with age.

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Status of fish landing centres in Andaman Islands

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The Andaman group of islands is the place where major fishing activity of the island system is going on. The traditional set of crafts has been somewhat replaced by big trawlers and mechanized crafts, while the use of bows, arrows and spears for catching fish has given away to the use of gill-nets, purse-seines and trawls. The nature and scope of marine fishery exploitation in the north and middle Andamans is completely different from the south Andamans. Major landings include sardines, mackerel, snapper, sharks, seer fish, barracudas, groupers, cephalopods, flat fishes, shrimps, mullets, carangids, crabs, half-beaks, milkfish, siganids etc. There are 9 major landing centres each in north and middle Andaman and around 12 in south Andaman. Among these landing centres, none stands to the level that could qualify itself for major fishing harbour. During the present study it was observed that most of the landing centres do not have the minimum facilities needed for handling fish. The landing centres with at least the minimum facilities are Junglighat, Durgapur and Mayabunder. The conditions in other fishing centres are far below the standards and most of them being unhygienic and even without proper sanitation.

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Reproductive biology of *Nemipterus mesoprion* (Bleeker) off Mangalore coast

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Fishes belonging to the family Nemipteridae popularly called as “threadfin breams” constitute an important marine demersal fishery of India, exploited mainly from 40 to 100 m depth and are of great commercial value. Hence, the present investigation was undertaken to study the reproductive biology of *Nemipterus mesoprion* during 2005–06 and 2006–07 along Mangalore coast in south-west coast of India. Spawning periodicity indicated that this species spawns intermittently with peak season extending from September–December to March–May. Based on the percentage occurrence of mature fishes in various size groups, it was inferred that female attained maturity at smaller size than male. The size at first maturity of male and female was at 153 mm and 144 mm respectively. Female showed higher gonado-somatic index (GSI) values than male in all the months throughout the study period. Fecundity of *N. mesoprion* was found to vary from 8,135 to 50,236 ova with an average of 23,944 ova depending on the size of fish. Sex-ratio indicated an overall dominance of female over male where the male-female ratio was found to be 1:1.15 and 1:1.04 for first and second year of the study respectively. Size based sex-ratio showed high significant difference in different size groups in the year 2005–06, but such variations were not observed in the year 2006–07.



Nemipterus mesoprion

FR-P 36**Fishery and population parameters of *Nemipterus japonicus* (Bloch, 1791) exploited off Kerala, south India**

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Threadfin breams are one of the most dominant group among the demersal fisheries resources along the Kerala coast, landed mainly by multiday trawlers operating beyond 100 m. Among threadfin breams, *Nemipterus japonicus* contributes to over 25% of threadfin bream landings of the state. Large quantities of this species are landed by trawlers at Cochin and Neendakara Fisheries Harbours of the state during August-May with the peak landings during August-September. The present paper is based on the observations made on threadfin bream landings at the above landing centres during the period from January 2007 – December 2010. A total of 2092 specimens collected from the trawl landings during the period formed the material for the study. The species composition and length composition data of the observation centres were weighted to get estimates for Kerala. For estimating growth parameters, the pooled length-frequency data for the period 2007 to 2010 were analysed using the FiSAT package. Total fishing mortality (Z) was estimated using the length-converted catch curve method and natural mortality rate (M) by Pauly's empirical equation. The length-based Virtual Population Analysis (VPA) was carried out for different years using the annual length-frequency data. Yield/recruit was estimated using Beverton and Holt yield per recruit model.

Length of *N. japonicus* in the fishery ranged from 10 to 34 cm, mean size being 19 cm. The growth parameters were estimated as $L_{\infty} = 35.5$ cm and $K = 0.7$ per year. The average total (Z), natural (M) and fishing (F) mortalities estimated were 3.01, 1.33 and 1.69 respectively. The average

exploitation rate (E) was calculated as 0.56. VPA indicated that maximum fishing mortality occurs at 19.5 cm with maximum numbers caught in the size range 19 – 20 cm. Spawning stock biomass formed 88% of the standing stock biomass. The yield per recruit curve indicated that Maximum Sustainable Yield (MSY) can be obtained at exploitation rate of 0.576, which is close to the current exploitation rate of 0.56.

FR-P 37**Population variation of *Megalaspis cordyla* (Linnaeus, 1758) along the Indian coast based on morphometric and meristic analyses**

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The horse mackerel, *Megalaspis cordyla* (Linnaeus, 1758) is a moderately large marine fish species of commercial interest in the Indian pelagic fisheries. Considering the current assumption of a single large horse mackerel (*M. cordyla*) population along Indian coast, the present study aimed to compare geographically distant populations from the Bay of Bengal coast and Arabian Sea coast of India based on morphometry and meristics. The samples of *M. cordyla* were collected from locations viz., Digha and Mandapam in Bay of Bengal along east coast, and Cochin and Mumbai in Arabian Sea region along west coast of Indian peninsula. Digital photographs of individual fishes were taken to extract 20 morphometric variables. Nine meristic characters were also counted. The analysis of variance of five morphometric traits showed significant difference between the fish samples of east and west coasts and those traits were eye diameter, pre-pelvic length, pre-anal length, anal fin length and caudal peduncle depth. The four traits that revealed location-wise variations were head length, preorbital length, second dorsal fin length and anal fin length. The



chi-square test of meristic traits showed significant variation between the Bay of Bengal and Arabian Sea populations and also between the Mandapam and Digha populations. The morphometric and meristic study clearly revealed variations in traits of fishes from Arabian Sea and Bay of Bengal, which are definitely sufficient to separate these populations. The Mandapam population exhibited a marked separation from all others for both morphometric and meristic characters indicating that there is a resident population of *M. cordyla* in the Gulf of Mannar fishing area. The relatively structured coral reef surroundings and environmental discreteness of the Gulf of Mannar, could lead to isolation of the population.

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Preliminary studies on biology of *Lutjanus johnii* (Bloch, 1792) from Maharashtra waters

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Growing concern of marine aquaculture practices emphasized need to study the candidate species such as *Lutjanus johnii* for culture in marine conditions in India. Present study was carried out on this species to provide information regarding length weight relationship, fecundity, food and feeding habits. Sampling was carried out during December 2009 to February 2010. The total length ranged from 120 to 765 mm with the corresponding weight ranging from 26 to 5313 g. The sex ratio was estimated as 1:0.17. Indeterminant specimens were 8.5% followed by immature (78%), mature (9.8%) and gravid (3.7%). Gut content revealed that the species mainly feeds on crabs (43.2%) followed by fish (22.6%), prawns (19.2%), squilla (8%) and 7% was digested matter beyond recognition. The number of maturing ova ranged from 47,700 to 2,10,300.

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Eco-fishery status of Kakorikota beel of Majuli Island, Assam

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The present study was undertaken to assess eco-fishery status and management practices of Kakorikota beel of Majuli Island, Assam, during May 2010 to May 2011. Water and soil quality recorded during the present study suggested that the beel ecosystem is moderately productive. Among the fish families encountered, Cyprinidae dominated with 37% of the total species recorded. The species contribution was seen lowest by families Balitoridae, Cobitidae, Sisoridae, Badidae, Gobiidae, Erethistidae, Belonidae, Nandidae, Synbranchidae, Anguillidae, Anabantidae, Heteropneustidae, Clariidae, Tetraodontidae, Notopteridae and Mastacembelidae together contributing 29%. Among the catfishes the family Bagridae contributed 10%, followed by Schilbeidae and Siluridae contributing 5% and 4%, respectively. The other families encountered were Channidae (7%), Osphronemidae (4%) and Ambassidae (4%). About 66% of fish species have food as well as ornamental value, 25% were found to have only food value, 4% were non-food ornamental fishes and 5% fishes were found to have food, ornamental as well as sports values. The yearly fish catch in the Kakorikota beel, as reported by lease-holder, from 2002-2003 to 2010-2011 indicated that the fish catch shows a declining trend.

The Kakorikota beel exhibits diverse fish population supporting a multi-species fishery, which is more complex to understand but is more resilient. Though the beel has multi-species fisheries, only a few species dominated the landings. Carnivorous fishes are more in numbers, which will definitely affect the



autostocking or recruitment process. Siltation in the connecting channel and poaching are also other problems observed. Immediate needs of fishers of the beel include proper transportation, communication and marketing facilities, construction of fish hatcheries to encourage aquaculture practices. The data generated in the present study would help to evolve appropriate strategies for sustained development of fisheries of the Kakorikota beel.

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Misidentification in fishery: case of deep-sea pandalid shrimp *Plesionika quasigrandis* Chace, 1985 as *Plesionika spinipes* Bate, 1888 from Indian waters

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The genus *Plesionika* has wide distribution all over the world and it is one of the most species rich genera in the family Pandalidae. Nine species of *Plesionika* are reported to occur in Indian waters and most of them are rare in the fishery except, *P. martia* and *P. ensis* and the so called *P. spinipes*. In the present study, based on morphological characters we confirm that *P. spinipes* in the deep-sea shrimp fishery along the southern coasts of India is *P. quasigrandis*. The *Plesionika narval* group consist of fourteen species including *P. quasigrandis*, *P. spinipes* and *P. grandis*. The "narval" group is characterized by the rostrum being very long and armed with numerous closely set teeth along almost the entire length on both sides. *P. quasigrandis*, *P. spinipes* and *P. grandis* have morphological resemblances among each other and this has led to misidentification of *P. quasigrandis* in India as *P. spinipes* for long time. *P. quasigrandis* differs from *P. spinipes* in several important characters including colour pattern, morphometry and geographic distribution. *P. quasigrandis* is distinguished from *P. spinipes* by the more widely spaced dorsal rostral teeth (posterior 10 ventral

teeth corresponds to eight or fewer dorsal teeth in *P. quasigrandis* versus more than eight teeth in *P. spinipes*) and the proportionally shorter penultimate segment of the third maxilliped. Body of *P. quasigrandis* is pinkish red in color and no stripes on the abdomen. *P. spinipes* has four very narrow longitudinal red strips on each side of the abdomen. The reference molecular signatures (partial sequence information of cytochrome c oxidase I gene) of *P. quasigrandis* was also generated. The morphometric characters of *P. quasigrandis* collected from west and east coast of India are also discussed.

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Status of commercial exploitation of marine fishes along the Gujarat coast during 2009 to 2010

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The study was conducted for a period of two years from 2009-2010 to estimate the commercial exploitation of marine fishes along the Gujarat coast. The fishery data was collected from the local landing centres and analyzed as per standard methods. Gujarat contributed 16% to the all India marine fish landings. Marine fish production was estimated at 5.07 and 5.06 lakh tonnes in 2009 and 2010 respectively. There was an increase of 10% in the total landings during 2009 over the preceding year and a marginal decrease of 0.3% in the year 2010. The landings of demersal fishes in 2010 was 1.7 lakh tonnes (32.8%), pelagics 1.15 lakh tonnes (29.4%), crustaceans 1.15 lakh tonnes (22.7%), molluscs 0.54 lakh tonnes (10.7%) and others 0.2 lakh tonnes (4.4%). The single largest group non-penaeid prawns formed the major landings followed by ribbon fishes, sciaenids, Bombay duck, and catfishes. The gear-wise landings indicated that multi-day trawlers contributed 61% of the total landings followed



by mechanized dol-netters (23%), outboard gill-netters (7%), single-day trawlers and mechanized gill-netters 4% each and the rest by other gears. Among pelagics, the most dominant group was ribbon fishes (37%) followed by Bombay duck (25%) and carangids, seerfish and tunnies with 9% each. Among demersals, croakers (27%), perches (25%), catfish (20%), lizard fish (7%), elasmobranchs (5%) and pomfret (4%) dominated in the landings. Among the molluscan resources, squid was dominant (54%), followed by cuttle fish (45%). The highest landings was recorded during October to December and the lowest during April to June. An observation from the study is that the smaller sciaenids like *Otolithes cuvieri* and *Johnius glaucus* replaced the commercially important larger sciaenids like koth (*Otolithoides biauritus*) and ghol (*Protonibea diacanthus*). Similarly there was an increase in the landings of commercially important fishes like king seer, yellow fin, skipjack and other tunnies. The annual growth coefficient for the commercially important five species of demersal fishes ranged from 0.11-0.99 and the exploitation ratio ranged from 0.41-0.56. The exploitation ratio was higher for demersal stocks than the pelagic stocks exploited off Gujarat. As the exploitation ratios for several demersal species are close to 0.5, further increase in exploitation may not be feasible.

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Food and feeding habits of commercially important demersal fishes off Veraval coast

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Stomach contents of nine species (*Pampus argenteus*, *Saurida tumbil*, *Saurida undosquamis*, *Nemipterus japonicus*, *Nemipterus mesoprion*, *Priacanthus hamrur*, *Otolithes cuvieri*, *Johnius glaucus* and *Arius thalassinus*) of

commercially important demersal fishes of Veraval coast were examined. Periodical fish samples were obtained from the commercial trawlers of Veraval from January 2009 to October 2010. The dietary components of each species was studied and expressed as percentage of numerical composition (CN), percentage of gravimetric composition (CW) and percentage of frequency of occurrence (F). The major food items in the stomach of each species were determined using an Index of Relative Importance (IRI). The gut contents of the fish varied in number, weight and frequency of occurrence from species to species. The study showed that prey items that were smaller in size constituted the major bulk, while the large size prey items were eaten in fewer numbers. *S.tumbil*, *S.undosquamis*, *N. japonicus* and *N. mesoprion* chiefly fed on *Acetes* spp. and juvenile fin fishes, whereas *O. cuvieri*, *J. glaucus* and *P. argenteus* fed mostly on prawns, *Acetes* spp. and fish larvae. The food of the *A. thalassinus* consisted of crustaceans and fishes. Prawns and juvenile fin fishes were the most important food items consumed by majority of the species. The feeding index did not show any significant variation in different months during the two years of observation. However, the feeding intensity was slightly higher during September to December. The results of the present investigation may play a vital role in the management of fishery resources as well as for the efficient exploitation of the species.

FR-P 43

Marine fish landings- on the estimation of precision and related coverage issues

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The estimation of landings and effort expended in relation to the marine fishery resources tapped in India has been traditionally performed using stratified sampling procedure. The inherent presumption of this sampling



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**Indian marine fisheries scenario-
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paradigm is to zero-in on the primary and secondary sampling units which are defined by the spatio-temporal units like state- month etc. Once the sampling plan is adopted more than one parameter is estimated using the same with varying degrees of coverage. The present work attempts a detailed analysis of the stratification patterns followed, sampling steps adopted and the data management in face of unique eventualities taking up the Gujarat survey figures collated by CMFRI during the calendar year 2009-2010. Efforts are made to estimate the standard errors of the estimated parameters using the conventional as well as the non-parametric bootstrap methods. The bootstrap errors seem to be more robust in face of extreme disruptions in the coverage encountered. This work also unravels the impact of insufficient representation of a population dimension and also tries to attempt redemption possibilities using post-stratification type of planning. With the possibility of data hybridization looming large in the near future, this work attempts the possible ways of including the survey information provided by similarly placed agencies with due care taken for the quality of the data received, thereby boosting the coverage and hence the confidence levels of the estimated parameters. It is found that plugging in method of additional information is most efficient at the psu level, landing centre day level. The post-raising merging of the estimated figures are prone to a lot of sampling violations and thereby hiking the noise well over accepted norms.

Table. Estimated landings and precision figures for one zone under Gujarat State for the year 2009

Zone	Month	Landings (t)	SE
G1	01	13976.78	4634.767
G1	02	28471.3	1908.764
G1	03	1612.111	467.5012
G1	04	5665	
G1	05	11363	
G1	06	4158	
G1	08	36195.07	40107.61
G1	09	10285	6599.931
G1	10	4318.38	3170.731
G1	11	25155.9	26908.54
G1	12	9400.75	12353.99

Indian Marine Fisheries is a bundle of contradiction when viewed from the businessmen point view. It is here we come across subsistence fishing rubbing shoulders with entrepreneurial fishing. The irony is complete with more number of active fishermen religiously pursuing their vocation without owning a single craft, the mainstay for fishing. As per 2005 census, India has 61.7% of fishing families who regularly venture into the seas as pure labourers. These figures had geographic and social skews also. The other side of this, the fishermen with craft who did not venture out was hardly 1%. This paradox throws up the most important question, whether the concept of "absentee craftlordism" is prevalent in India? Now this work attempts at tracing relevant facts and figures by way of combining the infrastructure status recorded in 2005 census and the estimated effort and landings for the various districts in the subsequent three years. The picture thus derived smacks under utilisation of crafts and hence clearly indicate over capitalization. An attempt is also made to link the related infrastructure facilities like boat building yards and curing/ peeling yards as potential surrogates for fishery production. Finally effort is made to look at possible undercurrents within the socio-economic machinations and the marketing as well as other infrastructure trappings and their relations thereof.

Table. Summary status of information utilised as per 2005 census

Item	Number
States/ UTs	11
Lower categorisations	4534
Personal details categories	7
Occupational Indicators	16
Educational indicators	3
Craft/ Gear indicators	63+ 17
Other related infrastructure	76



FR-P 45**Lizardfish landings by mechanized trawlers at Visakhapatnam fishing harbour during 2001-2010**MADHUMITA DAS¹*, G. MAHESWARUDU¹, G. SYDA RAO², MUKTA MENON¹ AND PRATIBHA ROHIT³¹Visakhapatnam Regional Centre of Central Marine Fisheries Research Institute, Visakhapatnam, Andhra Pradesh, India²Central Marine Fisheries Research Institute, P.B. No. 1603, Ernakulam North P. O., Kochi – 682018, Kerala, India³Mangalore Research Centre of Central Marine Fisheries Research Institute, Mangalore, Karnataka, India

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Lizardfish is one of the commercially important demersal finfish resources exploited by sona boats and small mechanized trawlers off Visakhapatnam coast in the Bay of Bengal. Catch and effort data on lizard fish landings, by small mechanised trawlers and sona boats, collected at Visakhapatnam Fishing Harbour during 2001-2010, was analysed. Increasing trend was observed in annual catch from 792 t to 3,117 t with an average of 1,581 t. Contribution of sona boats (66%) was higher than that of small mechanized trawlers (34%). Annual fishing effort ranged from 7,70,279 h to 25,78,976 h with an average of 15,83,442 h. Similarly CPH ranged from 0.6 kg to 1.4 kg with an average value of 1.0 kg. The contribution by sona boats was higher mainly due to higher fishing effort (64.5%) than that of small trawlers (35.5%). Contribution of lizardfish to the total fish landings ranged from 2.2% to 6.0% with an average of 3.8%. Contribution of lizardfish to the total fish catch by the sona boats was higher during the months of May to August with higher CPH. While the contribution of lizardfish by the small mechanized boats was higher during the months of May to September with higher CPH. Lizardfish catch is supported by five species viz., *Saurida undosquamis* (46.4%), *Saurida tumbil* (33.8%), *Saurida micropectoralis* (16.9%), *Saurida longimanus* (0.5%) and *Trachinocephalus myops* (2.5%). Seasonal landings of *S. undosquamis* and *S. tumbil* have revealed that productive period was July to November for sona boats, and February and June to September for small mechanized boats. The size structure of the catch

and the effort of the exploited resource for a decade gives an insight about the state of the resource in the ecosystem.

FR-P 46**Fish faunal diversity of Tripura, India**

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Fish faunal availability of Tripura was recorded in the year 2009-10. In total, 103 species belonging to 12 orders, 27 families and 63 genera were recorded. Out of them 98 from natural water resources and 5 species recorded from the culture ponds of Tripura. The family Cyprinidae contributed the maximum (32%), followed by Bagridae (8%) and Sisoridae (6%). Maximum number of species belonged to the genus *Puntius* (7.14 %) followed by *Barilius* and *Mystus* (5.1 % each) and *Channa* (4.08%). Cast nets (dia 3.7 m and 1.0 m), drag nets and locally made bamboo traps were employed to catch these fishes. Fish species like *Chitala chitala*, *Hilsa ilisha*, *Aspidoparia morar*, *Acanthocobitis botia*, *Schistura scaturigina*, *Schistura nagaensis*, *Chaca chaca*, *Rita rita*, *Pseudeutropius atherinoides*, *Amblyceps mangois*, *Bagarius bagarius*, *Channa orientalis* and *Tetraodon cutcutia* have become rare in the water bodies. Over exploitation, habitat destruction and construction of flood control embankments etc. are some of the causes for the depletion of these species from the water bodies.

FR-P 47**Density and biomass of clams in Kali estuary of Karwar, Uttar Kannada, west coast of India**SONALI S.¹ MHADDOLKAR¹* AND U.G. BHAT²¹Karwar Research Centre of Central Marine Fisheries Research Institute, P.B.No.5, Karwar - 581 301, Uttara Kannada, Karnataka, India.²Department of Marine Biology, Karnatak University, P.G. Centre, Kodibag, Karwar - 581 303, Karnataka, India.

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A detailed study was undertaken on the occurrence, density and abundance of



clams near Kali estuary for the period October 2007 to May 2008. Three stations viz., Station 1 (near estuarine mouth), Station 2 (Nadangadda mudflat) and Station 3 (Kinner) were selected for the present investigation and fortnightly samplings were done for a period of eight months. In Station 1, maximum density of clams was observed during December 2007, whereas, in Station 2, maximum total density was recorded during November-07 and the maximum density recorded during December 2007 in station 3. Total Biomass of clams was maximum (11810.12 g/m²) during December 2007 and minimum (484 gms/m²) during April 2008 in Station 1. In station 2, a maximum total Biomass of 8617.7gms/m² was recorded during May-08, and minimum of 36.8 gms/m² during December 2007. In Station 3, maximum total biomass of 15736.49 gms/m² was observed during December 2007. The present study revealed the abundance of clams was more in Station 3 when compared to Station 1 and 2.

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Length weight relationship and condition factor of *Botia dario* (Hamilton) from Gumti River of Tripura, India.

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B*otia dario* (Hamilton) is a small size species and available in rivers of Tripura, India. This species has great economic value as an ornamental fish. The length-weight relationship and condition factor of *B. dario* from Gumti River of Tripura, India was studied for the first time. Wide range of fishing gear such as cast nets and traps were used to catch the fish from various region of Gumti River and identified using keys and descriptions. Specimens were stored in coolers containing ice and transported to the laboratory for further analysis. Total length and weight were measured using standard

methods. The degree of association between the length and weight was computed from linear regression analysis. The length weight relation of *B. dario* from Gumti river of Tripura was calculated as: $\log W = -2.07 + 3.2 \log TL$ ($r = 0.98$). A positive correlation between length and weight has been indicated by the correlation coefficient (0.98). The parabolic equation derived was: $W = 0.0085(L)^3$. The 'b' value of 3.2 indicates that length weight relationship follows the cube law for isometric growth. The condition factors recorded was 1.25 ± 0.192 .

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Length-weight relationship and morphometry of *Johnnieops sina* (Cuvier, 1830) from Ratnagiri

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Length-weight relationship, morphometric and meristic characters of *Johnnieops sina* (Cuvier 1830) from Ratnagiri waters were studied by the examination of 464 male and 417 female specimens collected during December 2009 to November 2011. These fishes ranged from 100 to 195 mm in total length and 10.51 to 111.7 g in weight for male and 105 to 232 mm in total length and 12.9 to 170 g in weight for female. The length-weight relationship was calculated as $W = 0.0000103L^{3.013283}$ (male), $W = 0.00000954 L^{3.055963}$ (female) and $W = 0.0000086 L^{3.071843}$ (pooled) indicated isometric relationship. Coefficient of variation was highest for inter-orbital length (39.06) and lowest for total length (12.42). From the present meristic investigation, the fin formula can be written as B. VII, D.9-11/26-32, P. 15-19, V. 5-7, A. 2/7-8, C. 17-19, GRL. 12-16. The slight variations observed in the fin rays may indicate different stocks.



FR-P 50

Description of morphometric characteristics of the goatfish, *Upeneus sundaicus* (Bleeker, 1855), a new record from Visakhapatnam waters

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Mullidae, commonly comprises of red mullets, is a family of small size fishes with two dominating species *Upeneus vittatus* and *Upeneus sulphureus* in Indian seas. *Upeneus moluccensis* and *Upeneus tragula* also contribute to goatfish landings at Visakhapatnam coast. The present paper describes a new record of goatfish *Upeneus sundaicus* that was collected on 15th October, 2010 at Visakhapatnam fishing harbour as a stray specimen in the trawl by-catch. *Upeneus sundaicus* is commonly called 'ochre band goatfish' was reported by Thomas (1969) in the Gulf of Mannar in India. The external distinguishing characters of *U. sundaicus* are : bronze coloured dorsally, dark brown on head and body shading ventrally to pale yellow at belly. Head is with red pigmentation at snout. A dark orange red longitudinal stripe extending mid-laterally from behind eye to caudal fin base is observed in fresh specimen. Barbels yellow and dorsal fins yellowish with faint orange red stripes. Caudal fin brownish yellow with five orange red oblique bars on the upper lobe and lower lobe is devoid of bars and is with a triangular orange red tinge along the inner margin. The total length and wet weight of the newly recorded specimen caught in Bay of Bengal at 70 m depth was 141 mm and 30 g. Other morphometric measurements of the specimen were taken, photographed and specimen was preserved in the fish museum. Based on current available data, an expansion of the geographical distribution of the species from the southern waters to north eastern waters along the east coast of India is suspected.

FR-P 51

Fishery and some aspects of reproductive biology of two coastal species of tunas, *Auxis thazard* and *Euthynnus affinis* represented in the catches of north Andhra Pradesh

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Extensive efforts are under way in many research laboratories around the world to study the commercially important, epipelagic, highly migratory species of tunas. Though the status of exploitation and stock assessment of tunas in the coastal fishery sector of EEZ of India has been investigated, it has been emphasized that development of a strong database for resource information, particularly acquisition of fishery data and information on reproduction of tunas is of utmost importance for proper management of tuna fishery. Reproduction in tunas is one of the least studied problems and there is no information on this aspect along north Andhra coast. The present paper incorporates the information on fishery and results of the study that was undertaken to understand some aspects pertaining to reproduction, particularly spawning potential (fecundity), spawning period, maturity of gonads in relation to size of the fish, ova diameter and gonado-somatic indices of two coastal tuna species, *Auxis thazard* (frigate tuna) and *Euthynnus affinis* (kawakawa) that are represented in the commercial catches of this region. The present data has been critically compared and discussed with the data from other regions.

FR-P 52

Low value bycatch and discard associated with bottom trawling at Tuticorin Fishing Harbor, Gulf of Mannar coast

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Tuticorin fishing harbour (8.48° N Lat., 78.11° E Long.) is one of the major landing centres



along Gulf of Mannar coast of Tamil Nadu, where 65 % of fish of Tuticorin district is landed. Average annual landing by trawlers during 2009-2010 was estimated as 40,000 t. At Tuticorin Fishing Harbour, the mechanized trawlers start for fishing early in the morning at 0500 hrs, reach the fishing ground after 2-4 h of travel and fishing operations will be carried out for 4 to 6 h. Three to four hauls will be taken per day, each haul lasting for 1.5-2 h and the boats return to the harbour on the same day before 2300 hrs. The low value bycatch (LVB) landed at Tuticorin was collected over a two year period from June 2008 to April 2010. The trawlers after the monsoon ban of 45 days starting from 15th April to 30th May, begin their operation in shallow areas between 50-120 m depth, later extends to deeper areas and by the end of the season extends over 400 m depth. During the beginning of the season, trawlers get good catches at the rate of 2 to 4 t per unit per day and this will continue for 3 months. Maximum catch and catch rate was seen in July followed by August. The average annual quantity of LVB landed was 4,561 t forming 11.4% of the total trawl landings. The quantity of LVB was maximum in November followed by July whereas February-April season recorded moderate catch rate. Percentage of bycatch in trawl landing was maximum in October- December and April. A total of 82 species consisting of fishes, crustaceans, cephalopods and gastropods were identified in the LVB, represented by thirty-seven families of finfish, four families of crustaceans, three families of cephalopods, and three families of gastropods besides egg cases of chimeras.

FR-P 53

Mantle length and maturation in exploited stock of Pharaoh cuttlefish, *Sepia pharaonis* along Karnataka coast

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Sepia pharaonis are amongst the most important cuttlefish resources in the trawl

fishery of Karnataka. Analysis of length composition patterns of *S. pharaonis* in commercial catches along the coast indicated two pulses in recruitment to the fishery. Seasonal trends in relative proportion of *S. pharaonis* under different maturity stages and dorsal mantle length (DMLs) in the population were analysed in this study based on the commercial trawl catches. Reproductive activity in different months was determined based on the gross morphology of the gonads. Maturity stages were classified macroscopically in a scale of I-IV as immature, maturing, spawning and post-spawning stages. Mature cuttlefishes were available in the fishing ground from September to March. Spawning was observed in the inshore waters with seasonally intense peak during the post-monsoon period in October/November followed by a minor pre-monsoon peak in February/March. From May/June to August the cuttlefishes were in immature stage. Immature cuttlefish of smaller sizes in the length class 30-50 mm DML appeared in the fishery from January through March and later in June suggesting two recruitments to the fishery. $L_{m50\%}$ curves using logistic function for males and females indicated that fifty percentage of *S. pharaonis* attained maturity at a length of 171 mm, when the entire spawning season was considered. In post-monsoon spawning, $L_{m50\%}$ was attained at 214 mm while in the pre-monsoon spawning, the cuttlefish attained maturity at a smaller size of 121 mm. In February/March, smaller cuttlefish are observed to attain maturity even at a minimum size of 61 mm in males and 125 mm in females.

Females with fully ripe ovary carrying smooth ripe eggs for ovulation were observed from September, in larger specimens of DML 160 mm onwards. It was observed that the $L_{m50\%}$ for females for the cohort in September to December was 218 mm, whereas during January-March, $L_{m50\%}$ decreased to 130 mm. In male cuttlefishes, $L_{m50\%}$ during the period September-December was 211 mm. In January-March period $L_{m50\%}$ was attained at a smaller size of 116 mm in males. The first cohort (post-monsoon cohort) which supports the major



fishery, was composed of medium-sized, fast growing, early maturing individuals, whereas the second cohort (pre-monsoon cohort), comprised of slow growing, late maturing and large-sized individuals.

FR-P 54

Fishery of malaco-fauna in the Subarnarekha Estuary (Balasore, Orissa) and their conservation

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Mollusca, one of the most interesting group among invertebrate community, occur in abundance in seas, shallow coastal waters, estuaries and brackishwaters. A survey was undertaken at Subarnarekha Estuary, one of the major estuary of north eastern part of Orissa (Latitude 21°34' - 21° 37' and Longitude 87° 20' - 87° 27') during 2006-2010. A total of 82 molluscan species were recorded, of which Gastropods formed the dominant group represented by 46 species, followed by pelecypoda (bivalves) comprising 36 species. Among the bivalves *Meretrix meretrix*, *Anadara granosa*, *Mocoma birmanica*, *Sanguinolaria (Soletellina) acuminate* and *Glaconome sculpta*, *Barnea candida* *Meretrix meretrix*, *Meretrix casta*, *Paphia textiles* and *Macra luzonica*. were exploited as sources of quick lime and also used for making decorative articles. Gastropod species like *Pugilina cochilidium*, *Cerithidea (Cerithideopsis) cingulata*, *Bursa spinosa*, *Tonna sulcosa*, *Murex tribulus*, *Umbonium vestiarum* and *Telescopium (Telescopium) telescopium* formed potential sources of shell fisheries. Molluscs are being exploited as a source of human food from ancient times. Apart from this, shells of molluscs are utilized for preparation of decorative materials, preparation of lime for fish and poultry feed etc.. Most of the fishermen families are engaged in collection of molluscs and their processing in many villages surrounding Subarnarekha Estuary. Mainly women and children are engaged in

collection of molluscs by hand picking and the adults of the family are deployed in the processing of the shells. The present study aimed at documenting the molluscan fauna, their habitat and distribution in the Subarnarekha Estuary, as well as to highlight the socio-economic aspect of the trade on molluscs from this estuary. The need for conservation of these molluscs is also discussed.

FR-P 55

Emerging pole & line fishery for yellowfin tuna, *Thunnus albacares* in Lakshadweep Islands

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Lakshadweep Islands scattered in the Arabian Sea between 80°N - 12°30' N latitudes and 71° E - 74° E longitudes are known for their rich tuna fishery. The existing pole & line fishing has mainly focussed on exploiting skipjack tuna. Other tunas such as yellowfin, kawakawa and frigate tunas formed part of the by-catch. Targeted fishing for yellowfin tuna, *Thunnus albacares* using pole & line is an emerging fishery in Lakshadweep and has gained popularity since 2010. The design and operation of the pole & line generally used for fishing tunas have been suitably modified so as to catch large sized yellowfin tunas. The modified version has two bamboo poles which are joined with a nylon rope so as to maintain a distance of around half a meter between the two poles. A monofilament nylon line with a barbless hook on the distal end is tied to the centre of the nylon rope. Two to four persons are involved in handling one such modified set of the poles & line. The fishermen from Kavaratti Island pioneered this type of fishing by introducing a Maldivian boat model along with the local Pablo boats. The Maldivian boat



models are bigger (45-48" OAL) as compared to the Pablo boat (35-38") and have better endurance out at sea with a fish hold capacity up to 5 t. Fishing is mostly carried out around Agatti Island. Presently it is estimated that there are 16 units (2 Maldivian models and 14 Pablo boats) with the crew mainly from Agatti and Kavaratti involved in exploiting yellowfin tuna using the modified poles and line fishing technique.

The fishing operation consists of two stages - the first to collect suitable bait fishes and the second to exploit yellowfin tunas. Bait fishes are collected from the lagoons either early in the morning of the fishing day or the previous

evening. Apogonids are the main baits used and when there is a shortage of Apogonids, Caesionids and Clupeids (sprats) are used. Though distribution of yellowfin tuna has been reported throughout the island systems, fishing on a commercial scale using the modified pole & line is presently carried out mostly near Bangaram and Agatti islands. Exploitation on a commercial scale is now slowly spreading towards Kavaratti, Amini and Kadmat islands. The existing pole and line has been suitably modified to exploit only larger sized yellowfin tunas (> 10-30 kg). A brief account of the emerging fishery for large sized yellowfin tunas along with the advantages over the existing type of fishing in Lakshadweep is described.





Aquaculture Production

AP- O : Oral presentation
AP- P : Poster presentation

AP-O 01**Development of cobia, *Rachycentron canadum* and pompano, *Trachinotus blochii* aquaculture in India – the way forward**

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Cobia *Rachycentron canadum* and silver pompano *Trachinotus blochii* are two marine finfish species with very high potential for aquaculture in India. Fast growth rate, adaptability for captive breeding, lowest cost of production, good meat quality and high market demand especially for sashimi industry are some of the attributes that makes cobia an excellent species for aquaculture. In recent years, seed production and farming of cobia is rapidly gaining momentum in many Asian countries. Envisaging the prospects of cobia farming in India, broodstock development was initiated at the Mandapam Regional Centre of Central Marine Fisheries Research Institute in sea cages during 2008 and the first successful induced breeding and seed production was achieved in March – April 2010. Trials on sea cage farming carried out at Mandapam showed that the fishes attained an average weight of 2.5 kg in six months and 7.3 kg in twelve months. The species can be grown in low salinity and experiments revealed that upto 15 ppt the growth and survival is comparable to that in seawater. These results point out the possibility of developing a lucrative cobia aquaculture enterprise in the country. However, standardization of technologies for seed production and farming of cobia to suit our environmental conditions have to be further pursued on a priority basis so that India can also emerge as a contributor for cobia production in the near future. Similarly, among the many high value marine tropical finfish that could be farmed in India, the silver pompano is also one of the topmost, mainly due to its fast growth rate, good

meat quality and high market demand. The species is able to acclimatize and grow well even at a lower salinity of about 10 ppt and hence is suitable for farming in the vast low saline waters of our country besides its potential for sea cage farming. At Mandapam Regional Centre of CMFRI, successful broodstock development, induction of spawning and fingerling production of silver pompano was achieved during July 2011 for the first time in India. Subsequently two more seed production experiments were also done successfully and now farming trials are progressing. This can be considered as a milestone towards the development of pompano aquaculture in the country. The current achievements in cobia and pompano can be considered as the first step towards the aquaculture development of the two species. The establishment of biosecure broodstock centres, standardisation of breeding, larviculture and nursery rearing protocols and farming demonstrations in pond and sea cages are the steps to the way forward. Hence it is required to invest and establish infrastructure for the different phases from seed to product development viz. required broodstock facility for the production of viable fertilised eggs throughout the year (ii) hatchery facility for meeting the seed requirements (iii) grow out facilities and (iv) product processing and distribution system. It is felt that both cobia and pompano are potential aquaculture giants having vast domestic and global business prospects.

AP-O 02**An experimental study on culture of black tiger prawn *Penaeus monodon* (Fabricius) in open sea floating cage**

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The black tiger prawn *Penaeus monodon* is the most suitable species for shrimp culture due to its fast growth and adaptability to wide



range of salinity. In India, tiger prawn was adopted by all the prawn farmers all along the coast as it fetches high returns. Culture of tiger prawn reached the peak in nineties after establishment of 232 hatcheries. But prawn culture industry has been facing setback due to eruption of dreaded White Spot Syndrome Virus (WSSV) disease since 1995. WSSV is more virulent and erupt when prawn is subjected to stress conditions under high density culture. Other alternates to avoid disease in prawn culture are to opt for flow through system and open sea cage/pen culture systems to reduce stress by providing fresh seawater. In view of the above factors, the present experiment was designed and carried out to assess the feasibility of culture of *P. monodon* in the open sea cage during April-August 2009. One 6 m diameter HDPE circular floating cage was installed off Visakhapatnam in the Bay of Bengal (GPS location 17° 42' 641 '' N; 83° 29' 639 '' E) at 10-12 m depth. Outer net made of 40 mm mesh size webbing, cylindrical in shape with 8 m diameter and 4.5 m height was fixed to outer ring of cage frame to avoid predators. Middle net made up of 10 mm mesh size webbing, cylindrical in shape with 6 m diameter and 5 m height, was tied to hand rail that was fixed at one meter height from the cage base frame. Purpose of this net is to rear the shrimp from 70-80 days onwards. Inner net is similar to middle net in dimensions, but was made up of 2 mm mesh velon screen to rear the post-larvae for a period of 70 days. Sinkers were fixed to inner net to facilitate resting on the middle net.

About 1.5 lakh PL₂₃ of *P. monodon* (mean total length 16.1 mm), subjected to WSSV test and formalin test, were stocked in the cage. The ranges for salinity, temperature and pH were 25-33 ppt, 26-28 °C and 8.0-8.4, respectively. Shrimp feed of C.P. Aquaculture Private Ltd., varying in different sizes, suitable to different growth stages of the prawn, was fed in this trial. During first 17 days, feed was given twice a day at 08.00 hrs and 16.00 hrs. From 18th day onwards, the feed was given thrice a day at 08.00 hrs, 13.00 hrs 17.00 hrs. The feeding

rate per day was 2.82 -9.6 kg/one lakh larvae. *P. monodon* registered a growth rate of 0.86 mm (TL)/day during first 30 days; 0.89 mm/day during 31-60 days; and 0.86 mm/day during 61-90 days. Due to accumulation of algae, periodical cleaning of inner and middle nets was done once in every week to facilitate adequate water exchange. After 100 days, about 192 kg of prawn was harvested and size of prawn was 80.02 ± 16.12 mm TL/ 4.26±2.84 g wt. The computed FCR was 4.26 and the survival was 31 %. Though the present study demonstrates the possibility of culture of *P. monodon* in open sea floating cage, growth, survival and FCR are not comparable to those recorded in the pond culture; this may be due to high density per unit of volume in the present study (332 prawns/ one tonne).

AP-O 03

Development of nursery rearing system for Asian sea bass, *Lates calcarifer* (Bloch, 1790) in the floating cage in sea

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Of late, fin fish culture in floating cages in the sea has been attracting researchers as well as private entrepreneurs. Culture of Asian sea bass, *Lates calcarifer* in floating cage has been demonstrated successfully by CMFRI. In cage culture, fingerlings of about 30 g size, able to resist wave conditions, are used for stocking in cages. To attain stockable size, hatchery produced fry has to undergo nursery rearing for two months in the pond/ in captive tanks, which is expensive and inconvenient to the entrepreneurs. In view of avoiding land based nursery rearing system, an experiment on nursery rearing of sea bass fry directly in the sea was designed and carried out in a 15 m



diameter HDPE floating cage for a period of 145 days during March-July, 2010. The cage was moored at 10-12 m depth in the Bay of Bengal off Visakhapatnam. The cage was fixed with three nets (15 diameter x 4.5 m depth) of different mesh sizes. Outer net made up of 40 mm mesh size webbing was fixed to the outer frame to avoid predators; the inner net made up of 25 mm mesh size webbing was fixed to the inner frame to retain the fish; one nursery rearing net made up of 10 mm mesh size webbing was placed in the inner net for rearing the fingerlings during initial period. Two hapas, each measuring 6 m diameter and 4.0 m depth, were fixed in the nursery rearing net by giving 3 m space in between. A bird net made of 100 mm mesh size nylon webbing was fixed to the top of the cage to prevent predation by sea birds. A sum of 10,000 of Asian sea bass fingerlings (mean total length 55 ± 0.46 mm and weight 1.19 ± 0.07 g), produced from the hatchery were stocked in the two hapas, 5,000 in each happa, after proper acclimatization to seawater salinity. Mixed feeding strategy was followed in this trial by feeding with *Artemia* flakes, three days old live *Artemia* and shrimp feed at different times and different quantities. *Artemia* flakes were given at 09.00 hrs; *Artemia* flakes and three days old live *Artemia* at 14.00 hrs; and shrimp feed at 19.00 hrs. Live *Artemia* and *Artemia* flakes were replaced by fresh *Acetes* after 45 days. It was further supplemented with trash fish after 60 days. After 45 days, all the surviving fingerlings from two hapas were counted (92.0%) and released into the nursery rearing net (10 mm mesh size). Stocked population attained size 78 ± 3.28 mm TL/ 3.53 ± 0.11 g weight after 40 days; 100 ± 9.51 mm TL/ 19.16 ± 6.24 g weight after 70 days; 127 ± 16.88 mm TL/ 43.34 ± 13.38 g weight after 100 days; and 165 ± 35.66 mm TL/ 72.50 ± 46.27 g wt. after 130 days. As the fish grew, nursery rearing net was removed after 100 days, releasing the fish in to inner net. The experiment was terminated after 145 days with a production of 924 kg. At the termination of the experiment, the fish attained the size 198 ± 32.02 mm TL/ 113.75 ± 57.05 g weight with 81% survival.

Thus the present experimental study demonstrated the feasibility of nursery rearing of Asian sea bass in the floating cage in the sea avoiding land based nursery system.

AP-O 04

Development of nursery rearing procedure for mud crab, *Scylla serrata*: survival and growth of hatchery reared megalopa in field based nursery rearing systems

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Mud crab, *Scylla serrata* is one of the most commercially valuable crustaceans in several Indo Pacific countries. Development of aquaculture of mud crab has been in slow pace owing to the difficulties in developing suitable technique for the mass rearing of fragile larvae. Many of the challenges in mud crab seed production is rooted not only in raising the larval survival but also in producing the juveniles of stockable size in grow out production systems. The nursery rearing is the essential intermediate step between controlled production of larvae in commercial hatcheries and grow out production systems. In order to develop a low intensive nursery rearing procedure, hatchery reared megalopa was cultured in earthen ponds in two phases: primary nursery phase (megalopa to 2 g) and secondary nursery phase (2 g to 30 g). The experiments lasted for 30 days and 42 days respectively. In the primary nursery phase, a series of experiments were carried out to evaluate the effect of stocking density (30 no./m² and 45 no./m²), influence of rearing units (hapa nets versus earthen ponds, direct stocking) influences of different substratum (artificial seaweeds versus natural seaweeds) and influence of rearing environment (open lagoon versus earthen ponds). In the secondary nursery phase, two experiments were carried out and the influence of two stocking densities was



evaluated. Survival and growth performances (weight gain, daily weight gain and SGR) were evaluated after each of the two nursery phases. In primary nursery phase, the highest survival of $66.68 \pm 10.15\%$ was observed in the hapa nets fixed in the earthen ponds stocked at 30 individuals/m² (with natural sea weeds). Growth was significantly higher ($P < 0.05$) in the hapa net fixed in the earthen pond when compared to the crabs reared in the open water hapa (4.76 ± 0.28 and 0.93 ± 0.05), although no significant difference was observed in survival between the two rearing environment. The crabs stocked with artificial seaweed yielded a significantly higher wet weight than the ponds with natural sea weed (9.46 ± 0.87 and 4.76 ± 0.29). No significant difference in growth and survival was observed between megalopa reared in the hapa nets fixed in the earthen ponds and megalopa reared directly in the earthen ponds ($p > 0.05$). In the secondary nursery phase crabs of C 7-8 stages were reared in earthen ponds at two stocking density (5/m² and 10/ m²) for 42 days. Although there was no significant difference in survival between the two treatments ($p > 0.05$; 51.9% and 47.8 %), crabs at lower density attained significantly higher final weight (28.15 ± 2.92 and 22.5 ± 1.04 g). These results suggest that culture of *S. serrata* juveniles in earthen ponds provides seed crabs of stockable size for the grow-out culture without great loss in survival within 72 days of nursery rearing.

AP-O 05

Effect of temperature on incubation period, hatching efficiency and survival in lobster larval rearing systems

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Among all environmental factors which can play a limiting role in larval survival and growth, temperature is the most important. In

tropical lobster species, warmer temperatures can promote faster growth rates and shorten the development cycle. However, increase in temperatures beyond a certain optimum may cause detrimental effects to the larvae. The effect of temperature as a promoting/limiting factor in lobster larval development was studied through a series of experiments on the sand lobster, *Thenus* sp. at the Kovalam Field Laboratory of CMFRI in Chennai.

In egg-bearing broodstock reared at 36-37 ppt salinity and 8-8.2 pH with minimum light exposure, the incubation period was found to decrease from 39-41 days at 25-27 °C to 32-35 days at 28-30°C. Hatching usually occurs in the morning hours (7-8 a.m.) following the lowest dip in water temperature in tandem with diurnal cycle (4-6 a.m.) and natural light stimulus at sunrise. At lower temperatures (25 and 26 °C) hatching efficiency decreases and takes place in two spells (two days, i.e. 24 hr gap between hatching spells). At higher temperatures (29 and 30 °C), hatching occurs faster, and in a single spell. At temperatures >30 °C, hatching takes place in a single spell; however, naupliosoma are disfigured, with crumpled legs and yolk laden head region. These naupliosoma are not in a capacity to swim and hence settle and finally die. Larvae reared at higher temperature (29 & 30 °C) showed 80% survival in the first 7 days of rearing while survival was only 65% at 27°C. Conversion from phyllosoma 1 to phyllosoma 2 was also found to be higher (25%) at higher temperature (29 and 30 °C).

AP-O 06

Cage culture of Asian seabass, *Lates calcarifer* in river system at East Godavari, Andhra Pradesh

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CMFRI has developed and experimented with five versions of open sea cages at different



locations in India with funding from the Ministry of Agriculture, Government of India and National Fisheries Development Board (NFDB), Hyderabad, CMFRI. The Institute entered into mariculture with the introduction of open sea cage culture at almost all the maritime states in India. From the first open sea cage launched off at the Visakhapatnam coast during 2007, CMFRI has carried out modifications and innovations in cage culture.

At Antarvedi, in East Godavari district of Andhra Pradesh, a suitable site with 10 m depth and sandy bottom was selected for cage culture. The site was advantageous with access to the sea in 500 m, good water flow and tidal exchange, high biological productivity along with transportation and communication facilities. Sea bass fry measuring an average 2-4 cm collected from the natural waters during September - November 2010 were reared for a period of 90 days in a private fish pond in 2m x 2m x 1.5 m HDPE hapa. Periodic grading of the fry was carried out to avoid cannibalism. During December 2010, about 8500 nos. of juvenile seabass weighing 50-70 g were transported and stocked in two 6 m diameter high density polyethylene (HDPE) cages installed in the river system. Each cage was anchored using four coconut poles drilled about 10 ft into the river bed. Outer and inner nets were HDPE and a bird net was also provided on top. Due to the heavy flow in the site, the bottom ballast was tied to the poles along with the nets to retain the entire volume of the net. The fish were fed *ad libitum* twice a day with chopped low cost fish procured from local fishing village for a period of six months. Samplings of the fish were done in every 30 days to determine growth. The salinity of the site ranged from 0-25 ppt during the culture period. After six months, the fish were harvested at a size ranging from 600 g to 1500 g. Total production of three tonnes was obtained from single cage. The entire culture operation was carried out in a public-private-participation mode with total involvement of a local progressive aquaculturist, along with his workers. Along with the cage frame and net,

CMFRI has provided the complete technical support to the farmer. This has helped in publicizing the technology among the public in East Godavari area.

AP-O 07

Investigations on prawn farming activities in and around Chilka and its impact on the water quality parameters

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Chilka is the largest brackish water lake in Asia and also the second largest one in the world. Chilka is situated between 19°28' and 19°54' North latitude and 85°05' and 85° 38' East longitude. The lagoon is connected with the Bay of Bengal through an outer channel at Satapada. It is fed with different rivers and their tributaries like Daya, Nuna and Bhargavi and Mahanadi draining out silt and land runoff. It is highly productive but simultaneously a fragile ecosystem. There are more than 141 villages harbouring nearly 2 lakhs fisher folk population who depend on this lake for their livelihood. Moreover, powerful lobby works here for making easy money by misutilizing this ecosystem. The flora, fauna, river inflow, silt deposit and the water quality makes the lake a harbouring ground of many valuable fish and crustacean seeds. Chilka was designated as a Ramsar site in 1981 considering the ecological importance of the lake with high productive ecosystem, rich biodiversity and socio-economic condition of the coastal fishers. This designation marks the commitment of the Government of India to undertake measures for ensuring its wise use, striking a balance between maintaining biodiversity and sustaining livelihoods. Government of Odisha created the Chilika Development Authority (CDA) in 1992 for restoration of the ecosystem. But lack of stringent law and their enforcement make the lagoon vulnerable to many miscreant activities leading to pollution and loss of biodiversity. This



study reveals the most important prawn farming practices carried out in and around Chilka and its impact on the lake. Preliminary work on the analysis of water quality can throw light for utilizing the water bodies of Chilka in very scientific and productive way.

AP-O 08

Farming potential of milkfish, *Chanos chanos* under different stocking densities in low saline brackishwater of the Sunderbans, India

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Milkfish *Chanos chanos* (Forsskål, 1775) is an economically important and widely cultured food fish of the south-east Asia. In India, milkfish farming is dependent on natural seed availability during April to June in the south-west and October to December in the south-east coasts. However, unavailability of wild seeds in West Bengal coast has been the main hindrance for undertaking its culture. To explore the culture potential of milkfish as an alternate species in low saline brackishwater (2-10 ppt) of the Sunderbans region, on-farm trials were conducted at different locations of Kakdwip and Namkhana, South 24 Parganas. Stocking densities of 4000 (T1), 7000 (T2), 10000 (T3) and 25000 (T4) number/ha were evaluated as four treatments in duplicate ponds (0.09-0.4 ha) in culture trials of 250-300 days. Milkfish seeds (0.12-0.21 g) brought from the Tamil Nadu coast were stocked and fed with powder feed mixture or floating pellet diet or both based on availability at 2-5% of biomass daily. Ponds were fertilized monthly with cattle dung, urea and single super phosphate at 500, 30 and 30 kg/ha, respectively. At harvest, growth in term of mean body weight was

significantly higher ($P<0.05$) in T3 (354.1 ± 11.7 g) followed by T2 (283.8 ± 10.7 g), T1 (92.8 ± 1.5 g) and T4 (72.9 ± 2.5 g). Significantly higher survival ($P<0.05$) was noted in T1 ($83 \pm 5\%$) and T2 ($83 \pm 2\%$) compared with T3 ($60 \pm 2\%$) and T4 ($42 \pm 2\%$). However, T3 recorded the highest production (2033 ± 68 kg/ha), which differed significantly ($P<0.05$) from that of T2 (1655 ± 32 kg/ha), T4 (666 ± 6 kg/ha) and T1 (316 ± 40 kg/ha). The present study concluded that stocking density of 10000 numbers/ha would be appropriate for production of milkfish in low saline brackishwater. The present findings support the possibility of milkfish culture in the Sunderbans.

AP-O 09

Culture of Asian seabass *Lates, calcarifer*, (Bloch) in open sea floating net cages off Karwar, south India

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Cage farming of marine finfish is an alternative to meet increasing food fish demand. Culture of Asian seabass in open sea floating net cages made of either HDPE or GI pipes has been demonstrated off Karwar, S. India. Fish were fed with chopped oilsardines feed four times daily. Various growth parameters like Average Daily Growth Rate (ADGR), Survival Rate (SR), Specific Growth Rate (SGR) and Biomass Index (BI) were enumerated. Mean weight and length at the end of the 150 days experimental period was 1.02 kg and 412.05 mm, respectively with SR of 68.8 % (Table). Fish were fed with approximately 2.2 t of feed during the culture period. Economics of the culture revealed a net income of Rs. 3,18,020/- from 1764 kg of fish. Cost of production per kg was Rs.69.71. The need to standardize stocking densities and feeding rate has been emphasized.



Table Mean growth, ADGR and SGR of Asian seabass at monthly interval

Days	Mean weight (g) (\pm SE)	Mean length (\pm SE)	ADGR (g)	SGR
30 day	13.49 \pm 2.80	106.00 \pm 8.52	0.042	5.38
60 day	82.125 \pm 32.90	180.86 \pm 23.31	2.22	80.05
90 days	11.50 \pm 0.88	91.03 \pm 7.18	0.37	5.05
120 days	528.00 \pm 117.77	336.00 \pm 30.02	14.38	80.81
150 days	1025.42 \pm 329.67	412.05 \pm 46.66	16.58	28.82

SE: Standard Error

AP-O 10**Development of sea cage systems for finfish farming activities in Indian seas**

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National Institute of Ocean Technology (NIOT) is the pioneering organization that developed sea cages for lobster and mud crab fattening. For marine fish culture, 2x2m square HDPE cages were developed with single point mooring and the parrot fish, *Scarus ghobban* was reared in these cages at Olaikuda village in Gulf of Mannar. As a continuation of these efforts, 9 m diameter HDPE cages were designed, fabricated and deployed with multipoint mooring system. Presently, the cages are being tested in 3 different environments such as protected bay (North Bay, Port Blair), semi enclosed bay (Olaikuda, GOM), and open sea (Kothachathram, Nellore). The cages were stocked with finfish species such as *Lates calcarifer*, *Chanos chanos*, *Caranx sexfaciatus* and *Scarus ghobban*. Overall, the cages are performing well and the growth rate of fishes is satisfactory in all the 3 sites. The present system with the polyethylene knotless nets with mortality bags for the easy removal of dead fishes, marker buoys with solar lights, bird cover net and multipoint mooring is a complete farming system capable of adding any number of cages

with it. Each cage with a cultivable volume of 320 cu.m can support up to 25 to 30 t of fish harvest. Since the system is made out of HDPE without GI pipe or any corrosive materials, the durability of the cage is estimated as minimum of 20-25 years. The ongoing test results are encouraging and the cages are stable even in the rough climatic conditions and the fishes are growing without much stress in these cages. The 'net solidity factor' and the 'drag force' on the rigid components for different field conditions are explained.

AP-O 11**Trial on sea cage farming of cobia, *Rachycentron canadum* in India**

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Cobia, *Rachycentron canadum* has emerged globally as a potential species for sea farming in recent years. Aquaculture research on cobia was initiated from 2007 in India and the first success in the fingerlings production was obtained in March 2010. The present study describes the trial on nursery rearing and grow-out cage farming of cobia for the first time in the country. The nursery rearing was carried out in two phases; the first phase in FRP tanks (7 tonne capacity filled with 5 tonne filtered seawater) for a period of six weeks and the second phase in square sea cages (4 x 4 m) for four weeks. In the first phase, fingerlings of 31 days post hatch (mean length 7.1 \pm 0.1 cm and weight 2.2 \pm 0.1 g) were stocked in the FRP tanks at a density of 500 nos. per tank and were fed with formulated larval diets at a frequency of three times a day. The mean length and weight at the end of first phase were 18.9 \pm 0.4 cm and 43.9 \pm 2.0 g, respectively. In the second phase, the fingerlings were



stocked in nursery sea cages at a density of 2000 numbers per cage and were fed with chopped trash fishes twice a day. Heavy mortality of more than 80% occurred during this period due to severe outbreak of Vibriosis. On completion of the second phase of nursery rearing, the juveniles were transferred to circular sea cages of 6 m diameter and 3.5 m depth for grow-out farming. The stocking density was 400 juveniles per cage. The fishes were fed *ad libitum* with fresh sardines once a day. The fishes attained an average weight of 2.5 kg in six months and 7.3 kg in twelve months. The feed conversion ratio (FCR) recorded at the nursery phase I, nursery phase II and grow-out phase were 1.2, 3.1 and 7.8, respectively and the corresponding specific growth rates (SGR) were 7.1, 1.7 and 1.3. The present trial indicates that cobia is a lucrative species for sea cage farming in India. However, further trials are required to estimate the optimum stocking density to obtain the best feed conversion ratio and growth rate and also to assess the economic viability of cobia farming.

AP-O 12

Sustainable development of marine ornamental fish trade in the Indian context

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The international trade of marine ornamentals has been expanding and has grown into a multimillion dollar enterprise. In the context of the expanding global scenario, it appears very much lucrative for India to venture into this industry. The bulk of the international marine ornamental fish trade is dependent on wild collection. India is endowed with vast resource potential of marine ornamentals distributed in the coral seas and rocky coasts with patchy coral formations. However, destructive collection practices, overexploitation and post-harvest mortality are the major problems of the wild collected marine

ornamental fish trade. Hence, while developing an ornamental fish trade from wild collection, the major aspect that should receive top most priority is to ensure that the trade should not threaten the sustainability of the coral reef ecosystem. In this regard, the major measures suggested are (i) Regulation for collection from the wild, (ii) Introduction of certification for wild collected species and (iii) Development of hatchery technologies for selected species. The Central Marine Fisheries Research Institute (CMFRI) has been focusing on this vital aspect for the past few years. The Institute was able to develop hatchery production methods of twelve species of ornamental fishes (clownfishes and damselfishes) which are in high demand in the international trade. These methodologies developed can be scaled up for commercial level production and a hatchery produced marine ornamental fish trade could be developed in the country. However, it can be reasonably predicted that the percentage of wild caught marine ornamental species will continue to dominate the sector on a global basis in the near future. Based on the current technologies, it is neither possible nor economically viable to hatchery produce all the species required for the trade. Hence the hatchery production of marine ornamental species can be complementary but may not be full replacement for the collection from the wild. The idea behind the establishment of GMAD (Global Marine Aquarium Database) and MAC is indicative of the international trend on wild collection of marine ornamental species. It shows that the wild collection sector is important and at the same time the protection of reefs due to wild collection also is vital. The attitude towards the wild caught sector and tank reared sector of aquarium industry should be mutually supportive. In the immediate future, India can emerge as one of the major source countries for a sustainable marine ornamental trade by formulating appropriate policies for wild collection of species and also by commercial production of suitable species through the development of hatchery technologies.



AP-O 13**Utilization of non-conventional seasonal water bodies for improving livelihood of rural farmers through fish rearing: a case study**

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Karnataka with its rich inland aquatic resources amounting nearly to 9.3 % of the country, has great potential for aquaculture. In addition to these waterbodies, a variety of non-conventional waterbodies have been created under various developmental programmes. Farm ponds, check dams, canal bunds and *govu katte* (village tanks) are rain fed and retain water ranging from 5 to 8 months. Fish culture demonstrations were taken up in selected waterbodies of Kunigal taluk, Tumkur district, Karnataka. Size of the waterbodies ranged from 100 m² to 2000 m². These demonstrations aim to exploit their potential for fish rearing as it would help not only in supplementing protein rich food but also improve the livelihood of rural community. Indian major carps (*Catla catla* and *Labeo rohita*) and common carp (*Cyprinus carpio*) fish seeds were reared at a stocking density of 5000/ha over a period of 6 months or until the water bodies retained water. Fish production in farm pond, canal bund, check dam and *Govu katte* were 1500 kg/ha, 1250 kg/ha, 1300 kg/ha and 1250 kg/ha respectively. The villagers are benefited by getting pertinacious food as well as good revenue from fish sales. This successful demonstration proved the potential of small water bodies for aquaculture in improving the economic status of the fish farmers.

AP-O 14**Open sea floating cage - a device for domestication and brood stock development of greasy grouper, *Epinephelus tauvina*****(Forsskal, 1775) off Visakhapatnam in the Bay of Bengal**

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Live greasy groupers (*Epinephelus tauvina*) were collected from the wild near Bhimilipatnam off Visakhapatnam coast by hooks and lines at a depth of 20-25 m were selected for the development of brood stock and induced breeding. Fish in the range of 2-4 kg were selected and transported to Mariculture hatchery of the Regional Centre for acclimatization. The fishes were degassed, prophylactic treatment given with 200 ppm formaldehyde for 30 minutes and freshwater dip for 5 minutes and then transferred to 10 t cement tanks filled with filtered fresh seawater. A 6 meter diameter HDPE circular floating cage was designed for stocking these fishes moored with 32 m length of 16 mm alloy steel chain attached to a 4 t capacity gabion box. The cage was tied with an outer net (8 m diameter and 6 m depth) made up of 50 mm mesh size webbing to the outer frame to prevent predators. The inner net (6 m diameter and 7 m depth) made up of 20 mm mesh size webbing was tied to the hand rail above the inner frame of the cage for stocking groupers. After two days of acclimatization about 34 brooders (136 kg biomass) of *Epinephelus tauvina* were shifted from the mariculture hatchery and stocked in the cage. Brooders in the cage were being maintained as the female brood stock. Fishes were fed twice in a day @ 5% body weight with *Decapterus russelli* fortified with vitamin E and cod liver oil initially for a period of six months and subsequently they were fed with squid at the same rate and fortified in similar way. Each brooder was tagged by PIT TAG FS 2001 for tracking the gonad development. The ranges of water quality



parameters recorded around the cage were salinity (28-32 ppt), pH (7.7-8.3), temperature (24-30 °C), ammonia (0.01-0.02 ppm) and dissolved oxygen (5.23-6.23 mg/l). Canulation of the each brooder was done during full moon day periodically and ova diameter was recorded. After a period of 10 months, the female brooders attained 5.6-8.9 kg (238 kg biomass) in the cage and the egg size attained a range of 320-550 micron. These brooders were further used for induced spawning with the sex reversed males those were maintained in the hatchery. It was observed that the maturation and gonad development of female brooders is much faster in the open sea floating cage than in the mariculture hatchery.

AP-O 15

Biosecurity practices and their adoption in black tiger shrimp *Penaeus monodon* seed production systems - an exploratory study

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Sustainability of shrimp farming sector in the country is dependent on the nature and quality of shrimp seed produced and shrimp seed quality has a direct relationship with the survival, growth and production of shrimps. Bio-security practices are a set of standard scientific measures that need to be adopted at shrimp hatchery level to exclude the potential pathogens from the delicate animal rearing environment to limit the establishment and spread of pathogens. A study was undertaken in 96 shrimp hatcheries located in Andhra Pradesh and Tamil Nadu to assess the extent of adoption of bio-security practices and its influence on disease occurrence. The hatcheries were assessed with 33 bio-security practices recommended for preventing the horizontal entry and spread of potential pathogens and personnel hygiene management. The findings revealed that bio-security measures like water pressure cleaning of rearing units, disinfection

of *Artemia* tanks and other tanks, disinfection of daily used nets, beaker, cartridge filter, back filter bowl and removal of moulted shell from the brooder tank were found adopted by more than 75% of the respondents. Practices like keeping the main gate always closed, separate vehicle parking and registering of vehicle, separate storage place for dead brooder and live feeds, separate container to collect dead or morbid shrimps, separate equipments and utensils for each sections were adopted by more than 40% of the hatcheries. However, wheel bath for vehicle at the entrance of the hatchery, office and dressing room near the main entrance, prevention of entry of pet and other animals, prevention of entry of pathogen through aeration, prevention of consumption of fish products inside the shrimp hatchery, disposal of dead brooder in incinerator, isolated quarantine facility, hygienic handling of weighing balance, discontinuous water line for each section in the hatchery, specific place for dining, pest control measures, effluent treatment system (ETS) before discharge and existence of recirculatory system (RS) in the hatchery were mostly ignored by the hatchery operators. In case of personnel hygiene, about 65% of the sample hatcheries banned smoking inside the hatchery premises. However, other practices like use of sterilized boots and clothes (0%), exclusive personnel for each section (19%), bathing and change of clothes before entering the facility (1%), disinfection of personnel between work sections (0%), restriction of entry of sick labours (0%), restriction of movement of personnel across sections (21%), foot baths (0%), disinfection of hands before handling brooder, larvae, live feed etc. (16%), disinfection of hands after handling brooder, larvae, live feed etc. (0%) and use of gloves while quarantine and eye-stalk ablation (1%) were found either not adopted or adopted by very few hatcheries. The findings indicated that *Penaeus monodon* hatcheries in the country did not follow the bio-security requirements which are essential for prevention of horizontal entry and transmission of pathogens. Hence, the study suggested for the review of shrimp seed production guidelines and capacity building of



hatchery operators on the principles of bio-security measures and their compliance for the exclusion of potential pathogens in the shrimp seed production environment.

AP-O 16

Biosecure Shrimp Farming Technology (BSFT) for the grow-out culture of tiger shrimp, *Penaeus monodon*

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Against the backdrop of prevailing viral and bacterial disease encountered in shrimp farming, Biosecure Shrimp Farming Technology (BSFT) is an evolving culture practice which provides a means to achieve higher degree of biosecurity with no water exchange. It embraces a probiotic based grow-out culture with the adoption of BMPs, total biosecurity and zero tolerance to antibiotics and chemotherapeutics. This farming system can be a sustainable production alternative that minimizes the environmental, health and economical risk involved. This study was conducted with the objective to evaluate this farming practice, production performances, utilization of biotherapeutic agents in the system. The water, sediment quality, productivity were also assessed in this system with the progression of the culture.

Field trials were carried out in brackish water ponds of size ranging from 0.18-0.375 ha with treatment ponds being managed with probiotic without any water exchange and control ponds without any probiotics but with water exchange. Yeast (*Sacharomyses cerevisiae*) based preparations as water treatment along with feed probiotics *Lactobacillus rhamnosus* was applied at intervals. The culture experiment was conducted following location specific SOPs at a stocking density of 12 pc/sq m. A higher (6.1 % gain) average production was achieved in the BSFT system compared to that of the control

with better FCR (11.3 % reduction). Similarly improved body weight (ABW-33.29 g) at harvest was obtained in treatment ponds compared to that of the control ponds (ABW: 31.17). These ponds registered higher gross primary productivity, plankton density, phosphate and nitrate level but lower ammonia level throughout the culture compared to that of the control. Other parameters influencing productivity like alkalinity, pH, and dissolved oxygen did not show any difference between the control and BSFT ponds. The growth of shrimps in relation to the natural productivity, plankton density and feeding strategy of this farming practice is discussed. The biosecurity measures, avoidance of antibiotics and objectionable chemicals, utilization of environmental friendly probiotics with the advantage of rainwater harvest are the most promising aspects of this technology giving rise to better and assured yield.

AP-O 17

Analysis of salinity on hatching and larval survival of Asian seabass, *Lates calcarifer* (Bloch, 1790)

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Asian seabass *Lates calcarifer* is one of the important candidate food fishes suitable for farming in ponds, cages and pens in marine, brackishwater and freshwater ecosystems. The hardy euryhaline seabass fish species breeds in the sea and larvae enter brackishwater coastal ecosystems. In the natural environment, the eggs and larvae frequent varying salinity conditions. In the present study, an effort was made to evaluate the response of the eggs in different salinity levels. Fertilized eggs obtained from the breeding trials conducted at the Muttukkadu Experimental Station of Central



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Institute of Brackishwater Aquaculture were carefully transferred to the 5 l plastic containers and maintained @ 20 nos/l of water for incubation and hatching with mild aeration. Water quality parameters at different salinity conditions were monitored. The temperature varied between 26.2 °C and 27.5 °C, pH from 7.2 to 8.1, dissolved Oxygen level from 5.4 to 7.8 ppm, ammonia between 0.02 and 0.07 ppm and the Nitrite ranged from 0.001 to 0.003 ppm. The hatching rate was 0% in freshwater (0 ppt). The mean hatching rates were 58.34 ± 0.096 in 5 ppt, 83.14 ± 0.96 in 10 ppt, 90.59 ± 1.07 in 15 ppt, 93.48 ± 0.85 in 20 ppt, 95.09 ± 0.39 in 25 ppt, 92.48 ± 0.58 in 30 ppt, 86.25 ± 0.69 in 35 ppt and 78.27 ± 0.54 in 40 ppt. With reference to the hatching duration, it was observed that at low salinity (5 ppt), the duration was more (18.40 ± 0.078 h) but at higher salinity (35 – 40 ppt), the hatching duration was short (16.82 ± 0.109 h) compared to the salinities ranging between 15 and 30 ppt. (17.06 ± 0.095 h) Though, there was no significant difference in the egg diameter under exposure to different salinities, the eggs size was less at higher salinity range compared to lower salinities. Morphometrically, the size of the larvae was observed to be larger (1.78 ± 0.008 mm in 10 ppt) at lower salinities compared to higher salinities (1.58 ± 0.010 mm in 40 ppt) immediately after hatching. Observations over a period of 96 h indicated that the larvae hatched out in lower salinity (5 ppt) survived only for 24 h. After 48 h, larvae in higher salinity (40 ppt) also died. Even after 72 h larvae hatched out in 10-30 ppt survived indicating desired salinity levels for egg hatching. The survival rate of larvae after 48 hrs was $58 \pm 1.55\%$ in 10 ppt; $65 \pm 0.093\%$ in 15 ppt; $66 \pm 0.7\%$ in 20 ppt; $64 \pm 1.6\%$ in 25 ppt; $62 \pm 1.09\%$ in 30 ppt and $37 \pm 1.33\%$ in 35 ppt. The results of the study revealed that seabass spawn can be incubated in salinity condition from 10 to 30 ppt. Spawns from breeding centers can be obtained and hatcheries can rear the larvae using lower salinity water also, which will be useful for large scale prorogation of seabass.

Culture of pearl spot, *Etroplus suratensis* in floating net cages

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The pearl spot, *Etroplus suratensis* commonly known as “karimeen” in Kerala is an indigenous fish extensively found along the east and south-west coasts of peninsular India. It is an important candidate species for aquaculture in ponds in both brackishwater and freshwater environments. Because of its high market demand and price in the state of Kerala, culture of this species is found economically attractive. Culture of *E. suratensis* was conducted in a floating circular cage system (6 m diameter) moored at brackishwater areas of Vypeen Island, Kochi. The cage frame was constructed using HDPE pipes of 140 mm diameter. The net bags consisted of an inner net bag made with twisted HDPE (1.25 mm) and outer protection net was made with braided HDPE net. The depth of net cage bag was 4 m, which gives an effective volume of 113 m³. The net bags were tied to the HDPE frame and moored in the backwater using anchors and MS chains.

Juveniles of size 8-50 g were collected from wild and stocked in the cages. Feeding was done with commercially available fish pellet feed and wet feed mixture of ricebran and groundnut oil cake (1:1). In addition, cooked rice was given daily one time as a supplementary feed. Feed was given *ad libitum*, three times a day using feeding trays suspended in the cage. Cages were checked periodically for damages and clogging of nets and repairs were done as and when required. Net exchange was practiced periodically and the size of the meshes was increased as the fish grew. Initially the inner net was of mesh size <10 mm which was increased to 14 mm, 18 mm, 22 mm etc. as fish grew. The water quality parameters of the culture site and growth of the fishes were recorded



periodically. Fishes were harvested after a culture period of 6 months. During this period, fishes were grown to a size range of 120-200 g with a survival rate of 62%. The harvested fishes were marketed locally at an average price of Rs.200/kg. Compared to cage culture of carnivorous fishes, the farming of this fish was found to be more profitable. Cost of feed forms the main operational cost for finfish culture. By culturing omnivorous species like pearl spot, the cost of feed can be reduced. These fishes were found to graze on the algae attached to the net bag, which formed natural feed for the fishes. Because of the grazing behavior of these fishes, clogging of net cages with algae was reduced considerably. Considering the high market demand for this particular fish in the state of Kerala, cage culture for pearl spot can be promoted as an economically viable aquaculture practice in the state. The seed for stocking can be sourced either from wild or from hatcheries where juveniles of these fishes are produced.

AP-O 19

Spawning, early development and feeding behaviour of marine ornamental purple firefish, *Nemateleotris decora* (Randall & Allen, 1973) under hatchery conditions

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The purple firefish, *Nemateleotris decora* is a hardy marine ornamental fish with magnificent colours, i.e. light pink to white body, dark purple rear end, purple and red fins, and it has a very high demand in the industry and the species are being exploited from nature for the trade. Hence this study was undertaken on reproductive behavior, captive spawning, embryonic and larval developments, and the developments of suitable live feeds and larval

rearing technologies for this species as a model for the captive production of other high-value ornamental fishes. Ten fishes ranging from 60-100 mm TL were stocked in glass aquaria (500 l) for pair formation in the out door transparent roofed hatchery and the tanks were provided with curved earthen tiles for hiding purposes. Four pairs of *N. decora* began spawning 180 days after acquisition with a photoperiod of 14: 10 h (light and darkness). Spawning was initiated by the female who signalled her readiness to spawn by displaying to the male. Each spawning consisted of around 400 to 500 elliptical shaped eggs with a total length (TL) of 1.1 ± 0.1 mm and average total width (TW) of 0.4 ± 0.51 mm. Fertilized eggs were attached to the ceiling of shelters provided via adhesive filaments at the proximal end. During incubation period (96 h at a water temperature of 28 ± 1 °C), the male guarded the eggs more than the female. The morula stage and cleavage phase were completed at 16 and 20 hpf respectively. Silvery colouration with black spots was noticed at 48 h during incubation, and at 96 h, the embryo was fully developed with wriggling movements to hatch out under complete darkness. The hatching percentage ranged from 85 to 90%. The newly hatched photo positive larvae measured 1.6 ± 1 mm TL, the mouth gape varied between 0.9 ± 0.1 mm with transparent body, eyes and a small yolk sac, and healthy larvae were also actively moving on the surface of the water. The prominent part of the chondrocranium of the first feeding larvae are the hyoid, hyomandibulosymplectic cartilage, ethmoid and Meckel's cartilage. First feeding larvae consumed *Nannochloropsis oculata* and *Chlorella salina* (50000 cells/ml), and was provided with 24 h light. Zooplankton feed (ciliate *Euplotes*) was used for co-feeding from the first to the 7th dph. Subsequent weaning was done with super small rotifer *Brachionus rotundiformis*, *B. plicatilis* and copepod with newly hatched artemia nauplii and metanauplii of artemia from the 8th to 10th, 11th to 19th and 20th to 30th dph respectively. This is the first scientific study on the breeding and juvenile



production (35 to 40 dph) of *N. decora* under hatchery conditions

AP-O 20

Survival and growth of juvenile pompano, *Trachinotus blochii* at different salinities

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The silver pompano, *Trachinotus blochii* is a suitable marine finfish aquaculture species because of its fast growth rate, easy weaning to pellet feeds and tolerance to a wide range of salinities. In an eight weeks experiment, survival and growth of juvenile pompano reared at different salinities was investigated. The experiment was conducted in triplicate in 100 tanks with 15 fish per tank. Water temperature was maintained at $30 \pm 1^\circ\text{C}$ and dechlorinated tap water (0 ppt) was added to seawater (35 ppt) in order to achieve treatment salinities. Wild caught juveniles with average length range 4.38 ± 0.44 cm and initial weight of 1.6 ± 0.21 g were used in the experiment. Control groups were maintained at 35 ± 1 ppt. The salinity in the first set of experiment was reduced to 25 ppt, the second set was reduced to 15 ppt and third set to 5 ppt respectively. During the trials, fish were fed to satiation twice daily with artificial diet (INVE-NRD feed, Thailand) of required pellet size. Fish from each tank were counted and weighed collectively in every seventh day, until the end of 56 days trial to monitor the survival and growth. Survival among treatments was not significantly different ($p < 5\%$) throughout the growth in terms of weight was not significantly different ($p < 5\%$) from the control group.

There is no significant difference in between different treatment at 5% level. This study indicates that the farming of pompano might be feasible in salinities up to 5 ppt in the tropical conditions

AP-O 21

First results of nursery rearing of Asian seabass, *Lates calcarifer* (Bloch, 1790) in open small floating seed cages in the Subarnarekha estuary, Balasore, Orissa

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Successful nursery rearing of Asian sea bass, *Lates calcarifer* was demonstrated in floating seed cages in Subarnarekha estuary (Bay of Bengal), Balasore, Orissa at 5-8 m depth. Four circular floating HDPE seed cages of 2 m diameter each, made up of 90 mm pipe were designed for the present study. Two sapphire nets of 2 m diameter and 2 m depth (Garware make), made up of 2.0 mm mesh size were used as inner seed net as well as outer predator net for each cage. Each seed cage was moored with 12 mm cross linked galvanized chain fitted with a revolving shackle and anchored in the bottom with a 2 t capacity gabion box. Fry of Asian sea bass (2.0 cm TL) was segregated from mixed fry that was collected from the Subarnarekha river mouth area for stocking in the seed cages. Out of four seed cages, two were stocked with 30,000 fry in each (Treatment 1) and the other two were with 50,000 fry in each (Treatment 2). The feeding regime comprised of Acetes and wheat flour mix during initial period for one month and minced trash fish during the subsequent period of rearing. During the first month, fry was fed at the rate of 100 % of the biomass and gradually it was reduced to 20 % by the end of fourth month. Trash fish was minced and passed through 3 mm mesh initially for one month (second month of culture) and it was passed through 5 mm mesh net during subsequent period of rearing, suitable to the mouth size of fry. As fry grew, after two months of rearing period the nets were replaced with



5.0 mm mesh size nets. The ranges of water parameters during rearing period were 7.2-8.1 for pH, 16-23 ppt for salinity, 23-28 °C for temperature and 5.8-7.9 mg/l for dissolved oxygen. After four months, the survival was 32 % in treatment -1 and 14 % in treatment-2. Fry attained a size of 8.7 cm TL/ 12 g in treatment-1 and 7.1 cm TL/ 9 g in treatment 2, respectively. Survival rate was recorded to be higher in treatment 1. However, the results of the present trial indicates the advantage of nursery rearing in floating cage over the traditional pond rearing in relation to provision of aeration and water exchange. The present study also indicates scope for further refinement to achieve higher survival rate in sea bass fry rearing in the open sea floating cages.

AP-O 22

Aquaculture in inland saline waters in Punjab – a field study

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Inland salinity has affected productivity of 250 million hectare (ha) land worldwide. About 1.25 lakh ha of land in south-west districts of Punjab (Mukatsar, Ferozepur, Fazilka, Faridkot, Bathinda and Mansa) is affected by underground salinity and water logging problems. It has made these lands permanently unfit for agricultural activities. Soil quality has deteriorated at some places beyond reclamation, making it a zero earning land. In such salt affected water logged areas, where agriculture has very less or no scope, aquaculture is the most suitable option.

Although many brackish water fin fish species have been found suitable for culture in inland saline waters (ISW), in view of non-availability of seed of these species, the present study was taken up to assess the possibility of rearing freshwater carps in these waters. Wide variations in water chemistry were recorded for the water samples collected from

different locations during the survey. Bioassay studies revealed that salinity tolerance of carps varied with species and increased with size of fish. Common carp appeared most tolerant to inland salinity (up to 12 ppt) followed by rohu (10 ppt), catla (8 ppt), grass carp (8 ppt) and mrigal (2 ppt). Higher salinity tolerance was recorded in fry more than 5 cm in size. On the basis of relative salinity tolerance, rohu and common carp were selected for onfarm monoculture trials in ISW. Trial ponds (0.2 acre each) were constructed in salt affected waterlogged area in village Shajrana (district Fazilka), where the underground water salinity was 15 ppt. Fish fry were reared for a period of one year. Salinity in the trial ponds was maintained below 8 ppt by adding canal water. About 75% and 82% survival with an average productivity of 2.83 and 2.55 t/ha/yr was recorded from rohu and common carp monoculture trial ponds, respectively. Common carp also attained maturity in the ISW having salinity up to 8 ppt. Captive breeding and seed production of common carp was also carried out successfully in ISW. More than 90-94% fertilization rate and 95-98% hatching success was recorded in different sets of breeding trials conducted. The spawn exhibited satisfactory growth to fry of 3-5 cm within 30 day and 8-10 cm in 60 days. The results reveal immense potential of freshwater carp culture in ISW. In view of variable water chemistry, location specific carp culture package is however required to be developed.

AP-O 23

Preliminary study on captive brood-stock development and induced breeding of the Cauvery carp, *Puntius carnaticus* (Jerdon 1849)

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The present study was aimed at developing a technology for captive broodstock development and induced breeding of the



Cauvery carp, *Puntius carnaticus* (Cyprinidae), with the ultimate goal to revive its fishery. The initial fingerlings/sub-adults for raising brood-stock were collected (using a cast net) from the river Cauvery at Ramanathapura in Karnataka. After sedation, they were transported live to Mangalore, acclimatized and reared in mud-bottomed prepared ponds. The fish were fed with a specially formulated diet containing 33% protein. On attaining maturity, the sex of brooders was determined based on morphological features - the swollen and soft abdomen in female and firm and round abdomen in male and the papillomatous growth on the upper snout. The captive brooders thus developed were induced bred with a ready-to-inject spawning agent, ovaprim, at a dosage of 0.8-1.0 ml/kg female and 0.4-0.6 ml/ kg male. Details on breeding response, fertilization rate, hatching period, hatching rate and egg and early development were recorded. The interval between hormone injection and stripping ranged between 15 and 18 h at 26-28.5 °C, with breeding response being partial. The fertilization rate varied between 25 and 88%. The hatching period and hatching rate were 41-47 h (26-28°C) and 0-2.5%, respectively. The egg and early development proceeded normally; the yolk-sac absorption period was 3 days. The newly hatched fry possessed two yolk-sacs. The chromatophore pigmentation and pectoral fins appeared on the second day.

AP-O 24

Nursery rearing of seabass - a new avocation for small farmers

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Cage culture has made possible the largescale production of commercial finfish in many parts of the world and can be

considered as the most efficient and economical way of raising fish. Cage culture demonstrations using sea bass conducted by CMFRI in various parts of India proved the suitability of seabass for cage culture in Indian coastal waters. Seabass is a carnivorous voracious feeder; and it is highly cannibalistic in its early stages. Stocking of uniform sized fishes is very vital for attaining good production from seabass cage culture. Thus nursery rearing of seabass fry till stockable size for cages is essential before release for grow-out culture. Food and feeding and regular grading are the most important factors that affect the survival rate of sea bass in nurseries. The major advantages for nursery rearing is that it enables control over cannibalism, production of uniform sized fishes for stocking and shortening of culture period during grow out.

Nursery rearing trials were conducted in hapas erected in brackishwater ponds at Vypeen Island. Each hapa was 2mx1.5 x1m in dimension and sea bass juveniles of 15-20 mm were stocked at a rate of 1500 to 2500 fry/hapa. The juveniles were acclimatised for group feeding so as to minimise the feed loss. Feeds like macro zooplankton for eg. mysids, chopped trash fish or pellet feeds etc. can be given based on the size of the juveniles. Grading was done every fourth day and uniform sized fishes were segregated and stocked together. The survival was around 90 % and cannibalism was very less. During early morning hours, the oxygen levels were low in the pond water. This was mainly due to the low water exchange in the hapa due to clogging of the nets. This could be controlled by providing additional aeration to the hapa. Periodical cleaning of the hapas also increased the water flow in hapas. The rearing was done for a period of 45 days and the fries which reached 8 to 12 cm in size with a an average body weight of 60 g were transferred to the cage. In the second trial, the initial size of the fries varied from 25 to 30 mm in length. Since the initial size was higher, chopped fish/shrimps were given as feed from initial days of rearing itself. Grading was



done every fourth day and uniform sized fishes were stocked together. This reduced the cannibalism and survival was very good (90 %). The growth was encouraging and fishes reached a size of 10 to 15 cm in three months with a body weight of 90-120 g.

Nursery rearing phase of the seabass culture can be taken up as a new short term avocation for women and small farmers in their backyards with minimum inputs. The farmers can source their seeds from hatcheries and rear them up to stockable size in cages. Since the duration of this culture is 2-3 months, the harvesting can be done in short periods. By doing nursery rearing separately, the farmers can get uniform sized bigger fishes for stocking in their cages. This will reduce the culture period for grow out farmers and reduce the additional expenditure for nursery rearing phase. This will also help the hatchery operators to sell the products at an early stage by reducing the nursery rearing phase in hatchery.

AP-O 25

ADS-BW: User-friendly aquaculture database system for brackishwater culture practices

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○wing to the availability of a vast amount of data in aquaculture and fisheries, the microcomputer user needs to store, retrieve selectively, and display items of possible interest. According to Consultative Group of International Agriculture Research, sustainable farming is the successful management of resources to satisfy the changing human needs, while maintaining or enhancing the quality of environment and conserving natural resources. Farmers satisfaction includes issues such as productivity, profitability, and social acceptability. Both sustainable farming and farmers satisfaction in a particular area indirectly depends upon the data culture practices on from

that area. Due to the importance of the culture practices information, research institutes have carried out farm survey for collecting the required information in the form of questionnaires. Since hundreds of questionnaires have been collected by the research institutes, it has become a herculean task to view the detailed information on queries. With this objective in view, software viz. Aquaculture Database System for BrackishWater (ADS-BW) was developed for the management of information on brackishwater aquaculture practices collected by the research institute. ADS-BW databases and user-friendly modules are managed by Integrated Development Environment of Access. The database structure was created in MS-Access with 27 tables and the relationship set between the two tables was designed by one-to-one mapping cardinality. The 'farmer identification number' was designed as a primary key that stores and retrieves the information for a particular farm. The main screen of this software was designed into four modules namely, Entry, Search, User Manual and Exit. The entry module consists of 27 sub-modules. Each sub-module allows the user to add culture practices information into their corresponding table for storing. The search module consists of 24 sub-modules. Each sub-module allows the user to retrieve the stored information on any field combinations according to the requirements from their corresponding tables. The retrieved information can be displayed on screen in the reported format and also it can be export to MS Word or Ms Excel. In addition, the basic statistical analyses like frequency, percentage, mean and standard deviation was designed in the output screen based on their requirements. The user manual is self-explanatory which gives the step-by-step execution of the software. The exit module is used for closing the system. The system has been tested using the farm data collected from the brackishwater aquaculture area in West Bengal. The system is found to be working perfect. The proposed software can easily be adopted by other research institutions with similar farm data storage and retrieved requirements.



AP-O 26**Application of biofloc technology (BFT) for the sustainable aquaculture of giant freshwater prawn, *Macrobrachium rosenbergii*: effect on water quality and production**K.K. PRAJITH¹* AND B.MADHUSOODANA KURUP²¹Aquaculture Laboratory, School of Industrial Fisheries, Cochin University of Science and Technology, Kochi-682 016, Kerala, India²Kerala University of Fisheries and Ocean Studies, Panangad, Kochi - 682 506, Kerala, India

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Biofloc technology is the latest technology for sustainable aquaculture. In India this technology is not yet popularized. Biofloc is thought to provide a package of microbial proteins and nutrients that is directly accessible to the cultured animals. The present research was to study the efficiency of this technology in the grow-out system of giant freshwater prawn *Macrobrachium rosenbergii*. Indoor experiments was carried with a stocking density of 15 prawn/m². Animals were fed with feed containing three protein percentages viz., 32, 28 and 24 with or without biofloc technology application. Tapioca powder was used as biofloculating agent. Water and sediment parameters were estimated at definite intervals. Whole treatments were maintained for 180 days without water exchange. ANOVA results of the prawn growth parameters shows that the production from higher protein fed system and lower protein fed with Biofloc application was the same, so the protein level can be reduced from 32 to 24, without affecting the yield. So farmers can adopt culture with 24% protein containing feed with Biofloc technology application. Toxic metabolite compounds like ammonia is shown to get reduced by the bacterial metabolism. The reduced protein percentage in the feed is compensated by the consumption of flocculated microbial protein by the prawns. In effect, BFT facilitated conversion of more N inputs of the pond in to harvestable products. Use of lesser protein will reduce the production cost. So the result of this experiment shows that biofloc

technology is the futuristic technology for increasing the ecological and environmental sustainability of prawn farming. The research is important because it provides the solutions for the problems that obstruct the development the aquaculture sector. The study concludes that the major benefit of application of BFT in aquaculture systems as:

- Act as built-in bioreactors and improve water quality
- Provide extra source of feed for the cultured animal
- It opens the idea of harvesting the biofloc as animal protein replacement in aqua feeds.
- Ensures biosecurity, improve ecological and environmental sustainability

AP-O 27**Growth and nutritative value of brine shrimp, *Artemia* sp. biomass produced using different agro byproducts**AMAR B. GAIKWAD¹, A.R.T. ARASU¹*, PREM KUMAR¹, J.K. SUNDARAY¹, N.K. CHADHA², S. DAM ROY², P. B. SAWANT² AND AVINASH RASAL²¹Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R.A. Puram, Chennai-600 028, Tamil Nadu, India²Central Institute of Fisheries Education, Versova, Mumbai-400 061, Maharashtra, India

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Brine shrimp *Artemia* sp. is an indispensable component in the seed production of fish and shellfish in hatcheries. Pre-adults (biomass) of *Artemia* is commonly used in rearing post larval stages as a source of live feed. Biomass are harvested from the salt pans. In the present study, an attempt was made to evaluate the efficiency of using different agro byproducts for producing *Artemia* biomass under controlled conditions. *Artemia nauplii* Instar 2 stage was stocked @ 5,000/l and fed with the extracts of agro byproducts like rice bran, ground nut cake, till seed cake, ground nut cake and rice bran mixture and till seed cake and rice bran mixture. The ingredients



selected were powdered in dry condition using a mix i.e., grinder and the powder was soaked in water over night with vigorous aeration. The content was filtered through a 60 micron filter net and the extract was supplied as feed. The feeding rate was 60 mg/day (on dry weight basis) and the experiment was conducted for 15 days. All the treatments were in triplicate and the mean values are presented. The growth and total *Artemia* biomass and the nutritive value of the *Artemia* biomass cultured using different feed were analyzed. From the initial *Artemia* nauplii size of 0.75 ± 0.16 mm with rice bran, after 15 days of culture, the mean size of *Artemia* was 8.02 ± 0.02 mm, 8.10 ± 0.20 mm under feeding with ground nut cake feed, 7.95 ± 0.20 when fed with till seed cake, 8.55 ± 0.16 mm on feeding with combination of rice bran and ground nut cake and 8.52 ± 0.18 mm when fed with mixture of rice bran and till seed cake. The biomass harvested after 15 days rearing was in the order of 1.44 ± 0.11 kg/m³, 1.56 ± 0.12 kg/m³, 1.73 ± 0.14 kg/m³, 1.71 ± 0.011 kg/m³ and 1.60 ± 0.115 kg/m³ for rice bran, ground nut cake, till seed cake, mixture of rice bran and ground nut cake and rice bran and till seed cake feed respectively. The results indicated that for *Artemia* biomass production, the desired feed is the mixture of rice bran and ground nut cake. When the nutritive value of the biomass was analyzed, the protein value was maximum when it was fed with rice bran (50.9 ± 0.01) followed by a mixture of rice bran and ground nut cake (50.20 ± 0.18), mixture of rice bran and till seed cake (50.07 ± 0.11), in ground nut cake (49.56 ± 0.27) and till seed cake (49.06 ± 0.10). However the lipid content was least (6.77 ± 0.10) when the *Artemia* was fed with rice bran alone and the maximum (18.13 ± 0.03) was observed when fed with combination of rice bran and ground nut cake. The carbohydrate content however, was maximum in the *Artemia* biomass fed with rice bran (16.91 ± 0.01) and minimum when fed with till seed cake. There was no significant difference in the moisture or ash content. From the result it would be inferred better biomass

production, the combination of ground nut oil cake and rice bran is the preferred diet.

AP-O 28

Breeding and larval metamorphosis of marine ornamental redhead dottyback, *Pseudochromis dilectus* under captive condition

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The redhead dottyback *Pseudochromis dilectus* is having high export demand in the marine aquarium trade; they are mainly collected from the reef ecosystems of Western and Central Indian Ocean and exported to Sri Lanka. The ready availability of this sexually dichromatic species is limited in the wild as the dwell in crevices in deeper waters. Therefore this study was undertaken to describe the reproduction, captive breeding, larval development and general rearing conditions of *P. dilectus*. Among the sixteen fishes measuring 80-100 mm (male), and 60-80 mm (female) TL stocked in glass aquaria (500 l) for 5 to 6 months, five pairs were formed. Each pair formed was then re-stocked in a 500 l perspex breeding tank in the indoor breeding unit with a photoperiod of 14:10 h of light and darkness by two 30 W lights suspended 20 cm above the water surface. The pairs began to spawn after 60 days of acquisition at an interval of 6 to 15 days. The female gradually laid 25 to 35 mm diameter ball-shaped egg mass while upside down in the burrow, and the male chased off the female to fertilize the eggs, and the spawning behaviour lasted for one to two hours. The number of spherical shaped eggs in the clutches varied between 400 to 500 eggs/pair/spawning ($n=18$ spawning). The size of egg varied between 1743 to 1919 μ m during incubation, and all the eggs were interconnected by fine threads. The clutches of egg (ball shape), however, was not attached to the substrate but remained free inside the



burrow. The period of incubation of the eggs was 96 h at a water temperature of 27 to 28 °C under hatchery conditions. The colour of egg bunch was white or transparent on the first and second day. Later, it turned to black on 3rd day with black spot showing eyes of the developing embryo. On 4th day, the silvery eyes were glittering. The peak hatching (93 ± 2 %) took place under complete darkness shortly after sunset. The total length and mouth gape of the larvae varied between 5.1-5.3 mm and 150-160 µm respectively. Newly hatched larvae were fed with *Nannochloropsis oculata* and *Chlorella salina* in 1:1 proportion (5×10^4 cells/ml), and were provided 24 h light. Of the different combination of live feeds used, a survival of 50 to 60% was obtained in the larvae fed with naked ciliate *Euplotes* from the 0 to 7th dph whereas 45 to 50% survival was obtained in copepod nauplii fed larvae. Colouration (slight red pigmentation) was observed on the 7th dph. On the 8th to 13th dph, the larvae started feeding enriched rotifer *B. rotundiformis*. Nauplii, and meta-nauplii of artemia were fed from day 14th onwards until larval metamorphosis for the pre-settlement stage (10 mm TL). The transformation to juveniles started at around 30 to 35 dph, and it reached 3 to 4 cm TL within 3 months after hatching. This is the first scientific study on breeding of *P. dilectus* under captivity.

AP-O 29

Enhancement and conservation of marine algal resources and associated coastal vegetation - a necessity

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Enhancement and conservation are two watch words for any renewable resource because of its economic importance. The present paper deals with marine algal resources and related

coastal vegetation which play a significant role in the productivity of coastal waters. Enhancement of the algal resources could be made through culture practices of highly priced and fast growing species like *Kappaphycus alvarezii* and installation of artificial reef structures in the coastal waters for providing additional substratum for the growth of marine algae. About 844 species of marine algae occur along Indian coast, comprising 434 species of Rhodophyta, 216 species of Chlorophyta and 194 species of Phaeophyta, and most common species are *Ulva*, *Gelidiella acerosa*, *Gracilaria edulis*, *Gracilaria crassa*, *G. corticata*, *Gelidiopsis variabilis*, *Gelidium pusillum*, *Hypnea musciformis*, *Acanthophora spicifera*, *Hormophysa triquetra*, *Cystoseira trinodis* and species of *Sargassum* and *Turbinaria* etc. Various filamentous algae also are found growing epiphytically on marine angiosperms (sea grasses) such as *Halophila*, *Cymodocea*, *Halodule*, *Syringodium*, *Thalassia* and *Enhalus*.

About 40,000 t of marine algae are being exploited annually from natural habitat for production of agar and algin. The agarophytes namely *Gracilaria edulis*, *G. salicornia* and *Gelidiella acerosa* and alginophytes such as species of *Sargassum* and *Turbinaria* are harvested mainly from Gulf of Mannar. Out of these, 13 t of agar and 600 t of algin are manufactured. At present, less than 50% of brown algae are harvested from the natural standing crop, while the red algae especially *Gelidiella acerosa* and *Gracilaria edulis* are overexploited indiscriminately compared to limited resources available in the nearshore waters of Tamil Nadu and Gujarat coasts. This increase in demand for raw material for the Indian agar industry, leads to depletion of agarophyte crop in the natural habitat.

Among the associated coastal plants, mangroves are important and mangrove forests extend up to 6740 sq km along the coast of India. There are about 15 commonly occurring species belonging to genera *Rhizophora*, *Avicenia*, and *Bruguiera* etc. Considering the role of mangroves and marine algae as nursery



grounds to a variety of invertebrates, juveniles of fishes and prawns, these fragile ecosystems must be protected and taken care of. Culture of marine algae and afforestation in case of the mangroves are already in vogue.

AP-O 30

Evaluation of growth performance of postlarvae obtained from *Macrobrachium rosenbergii* broodstock of two varying sizes in nursery and grow out systems

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Heterogeneous Individual Growth (HIG) rate is the most prominent characteristic of prawns. It is essential to transfer the technology to tackle the problems of differential growth rate and low survival rates that are considered as bottlenecks in grow out systems. This study was conducted with the objective to study the growth performance of early settled and late settled post-larvae obtained from broodstock of two varying sizes in nursery and grow out systems.

The prawn seeds produced from hatcheries using wild broodstock were used for the study. The average body weight of small sized broodstock was 95 g and the large sized broodstock was 200 g. From each group of brooders, the larvae settled on the first day and seventh day were used for this study. The early settled post-larvae and late settled post-larvae from large sized berried prawns, early settled post larvae and late settled post-larvae from small sized berried prawns and mixed group of post-larvae from both large and small sized berried prawns were collected. All the 5 groups were reared separately in nursery for 60 days at a stocking density of 200 PL/m². The grow out experiment for all the above five groups were carried out separately in earthen ponds for 120 days at a stocking density of 4 nos./m². After

the grow out period, the growth performance and sex ratio were studied for each group. The performance of early settled post-larvae from large sized berried female prawns was significantly ($p < 0.01\%$) high compared to other groups in weight gain, survival and percentage of male population. Based on results of the present study, by stocking the early settled PL obtained from large sized berried female prawns, a remarkable excess production of 71% could be obtained over and above the control group. The prospective prawn farmers aiming at production maximization could utilize this category of premium quality seeds for better returns. The hatchery owners should also produce and sell such "premium quality" seeds for better and mutual remuneration and for spurring up the demand for such 'quality seeds'. "Broiler prawn" concept could be mooted by capitalizing this finding in order to revive the prawn farming industry.

AP-O 31

Polyculture of mud crab and Asian seabass in tide fed farm – an innovative practice for sustainable aquaculture

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Asian seabass, *Lates calcarifer* farming in pond culture system is emerging as one of the sustainable aquaculture activities. To make it more profitable, polyculture of seabass with mud crab, *Scylla tranquebarica* was attempted for the first time to assess the efficacy of such aquaculture practices. Asian seabass fry of 1.2 mm produced in the hatchery was transported and reared in hapa nurseries @ 200/m² for 45 days duration till they attain fingerling size of 5-7 cm and transferred to pre-grow out cages and reared at a stocking density of 50 nos./m² and reared for a period



of 2 months till they attain the size ranging from 12-19 cm (average size of 15 cm) and weight of 40-78 g (average weight 50 g). Along with this, hatchery produced mud crab seed obtained from Rajiv Gandhi Centre for Aquaculture, Thoduvai, was transported, acclimatized and stocked. The stocking density was @ 3000 nos./ha (1200/0.4 ha) and 3700 nos./ha (1485/0.4 ha) of seabass and mud crab respectively. Stocking was done during the month of January 2011 and harvested in August 2011. Over a rearing period of 8 months, seabass grew to size ranging from 200 to 650 g and crab was in the size between 100 and 150 g. Seabass was fed with formulated feed developed by CIBA. Total feed supplied was 644 kg and fish biomass harvested was 397 kg and FCR for the feed was 1.62. Mud crabs were fed with low cost fishes collected from the fish landing centres. The total quantity of trash fish supplied was 1270 kg and the biomass of crab harvested was 535 nos. (250 kg). The recovery rate of crab was 36% and that of fish was 93%. The FCR was 5.08 for the wet trash fish. The poly culture of mud crab and seabass was found to be more profitable than monoculture and innovative practice of feeding the fishes with formulated feed and the crab with forage fish are complementing each other. The economics of the culture practices and the ecological sustainability are discussed.

AP-O 32

Influence of salinity on growth and survival of early juveniles of spotted scat, *Scatophagus argus* (Linnaeus, 1766)

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The spotted scat, *Scatophagus argus* is considered as one of the important brackishwater aquarium fishes and it is also a preferred food fish in Southeast Asian countries.

It is a euryhaline herbivorous teleost fish, widely distributed in the Indo-Pacific region. Scat is collected from wild for the purpose of aquarium trade. However, their abundance is restricted and their availability is seasonal, which may lead to its overexploitation. To overcome these issues, a comprehensive technology package for breeding and juvenile production of scat has to be developed. The Central Institute of Brackishwater Aquaculture, Chennai has made breakthrough in controlled breeding and seed production of *Scatophagus argus* for the first time in India and the technology is being standardized. Since, this fish is often exposed to variable conditions of salinity in the habitat, understanding the influence of the salinity on their growth and survival would be useful for proposing optimal conditions for its production. Salinity is rated as one of the essential key parameters of the water quality, which can directly influence the fish larval growth and survival. In the present study, an attempt was made to evaluate the effect of salinity on growth and survival of spotted scat *Scatophagus argus* fry. Scat fry of 30 days old (TL, 16.1 ± 0.12 mm / BW 0.151 ± 0.02 g) produced in the fish hatchery, Muttukkadu Experimental Station of Central Institute of Brackishwater Aquaculture were stocked @ 5 nos/l in 5 l capacity glass tanks in triplicate and reared in 0, 5, 10, 15, 20, 25 and 30 ppt salinities for 30 days. Fishes were fed with artificial feed @ 5-8% body weight daily. At the end of rearing period, the results indicated better survival and growth in lower salinities from 5 to 15 ppt in comparison with other salinities. Maximum survival rate of $98.33 \pm 2.89\%$ were recorded at 5 ppt salinity followed by 10 ppt ($96.67 \pm 2.89\%$), 0 ppt ($91.67 \pm 2.89\%$), 15 ppt ($90.50 \pm 5.00\%$), 20 ppt ($88.33 \pm 2.89\%$), 25 ppt ($76.67 \pm 2.89\%$) and 30 ppt ($68.3 \pm 2.89\%$). Scat fry attained maximum body weight of 0.550 ± 0.03 g at 5 ppt and minimum of 0.363 ± 0.06 g at 0 ppt. Similarly, total length of fry reached maximum of 2.6 ± 0.03 mm at 5 ppt and it was minimum of 20.2 ± 0.06 mm at 0 ppt. Differences in the specific growth rate of scat fry when reared in different salinities are discussed.



AP-O 33**Evaluation of greenwater technology for aquatic bioaugmentation using molecular techniques**

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The best approach to a successful aquaculture is to adopt technologies and practices that would make aquaculture operations environment-friendly through environmental and disease management. Greenwater technology is an innovative technique, wherein, economically important finfish in reservoirs or in net cages/pens in shrimp culture ponds, act as bioaugmentor. Euryhaline finfish such as mullet and milkfish have broad diet spectrum and tolerance to poor water quality, which makes them ideal candidate for economically and environmentally viable zero exchange shrimp aquaculture. However, the mechanism of greenwater for bioaugmentation is not clearly understood. In the present paper, greenwater technology by integration of milkfish in shrimp aquaculture has successfully been demonstrated for the control of pathogenic *Vibrio harveyi* and for achieving higher shrimp production in coastal Tamil Nadu. Greenwater mechanism has been ascertained using molecular techniques based on 16S rRNA and functional genes approaches. Metagenomic approach applied in greenwater system of coastal aquaculture, shed light on the high level of species richness among uncultured and cultured bacterial population. This technology is ready for adoption by aqua-farmers.

AP-O 34**Assessment of effects of UV-B radiation on carp larvae and photoprotective properties of seeds of *Achyranthes aspera***MOIRANGTHEM KAMESHWOR SINGH¹, JAI GOPAL SHARMA² AND RINA CHAKRABARTI^{1*}¹ Aqua Research Lab, Department of Zoology, University of Delhi, Delhi - 110 007, India² Ministry of Earth Sciences, C. G. O. Complex, Lodhi Road, New Delhi - 110 003, India

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Two experiments were conducted to study the impact of UV-B radiation on carp larvae. The first one with *Labeo rohita* (rohu) and the second one with *Catla catla* (catla). Rohu larvae were fed with four different diets: D1 and D2 contained 0.1 and 0.5% *Achyranthes aspera* seeds, respectively, D3 contained 800 mg vitamin C/kg diet and D4, control diet. Catla larvae were fed with four different diets: E1, E2 and E3 containing 0.1, 0.25, and 0.5% *Achyranthes aspera* seeds and E4, control diet. Both the species were exposed to UV-B radiation (80 $\mu\text{W}/\text{cm}^2$) for 10 min on every other day. In the experiment with rohu, control diet fed fish were divided into two groups - one was exposed to UV-B and other remains unexposed. Water temperature and pH ranged from 30 to 31 °C and 7.5 to 8.1, respectively throughout the study period in both experiments. Dissolved oxygen level was maintained above 5.0 mg/l with the help of aerator. Survival rate of both rohu and catla were significantly ($p < 0.05$) higher in 0.5% *Achyranthes aspera* seeds incorporated diet fed group compared to others. Similarly highest average weight was also recorded in this group. Biochemical estimations showed that total tissue protein level was always highest in 0.5% seeds incorporated diet fed carps. GOT and GPT levels were minimum in unexposed control diet fed rohu. Among the exposed fish, GPT level was maximum and minimum in vitamin C and 0.5% seeds incorporated diet fed rohu, respectively. Whereas in catla, GOT and GPT levels were maximum in control diet fed group and minimum in 0.5% *Achyranthes aspera* seeds incorporated diet fed group. Nitric oxide synthase level was significantly ($p < 0.05$) higher in 0.5% *Achyranthes aspera* seeds incorporated diet fed group compared to others in both species. Thiobarbituric acid reactive substance level was significantly ($p < 0.05$) higher in control diet fed fish. This was significantly ($p < 0.05$) lower in vitamin C and 0.1% seeds incorporated



diet fed fish. Incorporation of seeds of *Achyranthes aspera* at 0.5% level in the diet of fish showed promising results to overcome the problem of UV-B radiation in aquatic system. This plant ingredient helped the larvae to face the challenge of UV-B irradiation.

AP-O 35

Egg, embryonic and larval development of olive barb, *Puntius sarana sarana* (Hamilton, 1822)

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The egg, embryonic and early larval development of the native olive barb (*Puntius sarana sarana*; Cyprinidae) was studied and documented, under laboratory conditions. The farm reared brood fish of *P. sarana sarana* was spawned through hormone application and the resultant eggs were artificially fertilized using wet method of fertilization. The developmental stages were periodically observed under a stereo microscope and important stages photographed. The time required for each stage was also recorded. The notable stages observed were : 2, 4, 8, 16, 32, 64-cell stages, morula, blastula, gastrula, epiboly, yolk-plug, pea-shaped, bean-shaped, embryo indication, twitching stage, advanced embryo, newly hatched embryo, hatchlings, etc. The eggs were transparent, spherical and adhesive. The average diameter of fertilized eggs was 0.62 ± 0.02 mm. The samples were observed every 15 minutes interval till the completion of morula and subsequently at 45 minute interval till hatching was completed. The newly hatched larvae had an average length of 1.90 ± 0.002 mm. The hatching period was 18-22 h at 25-27°C and the yolk-sac was completely absorbed in 2½ days after hatching. The newly hatched larva had narrow portion of the yolk longer than the bulbous part and the optic vesicles were without pigmentation. The two-day-old larva had prominent eyes, but with

reduced bulbous part of the yolk-sac. On the third day, the pigmentation started appearing, with prominent elliptical-shaped black chromatophore below the notochord in the dorsal fin region; pectoral fins were also conspicuous. The feeding commenced on the third day after hatching. On the 4th day, the chromatophore pigmentation was further enhanced and the caudal fin rays were observed.

AP-O 36

Blue barred parrot fish, *Scarus ghobban* (Forsskal, 1775) culture in sea cages at Olaikuda, Southeast coast of India

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The blue barred parrot fish is the dominant reef fish captured live in considerable quantities between March and September in the Gulf of Mannar (GOM), southeast coast of India. Parrot fishes are captured at a depth of 2-12 m by setting traps made of synthetic and natural fibers. The price of these fishes depends on its size and is categorized into 3 grades as small (<500 g), medium (500 to 1000 g) and premium (>1000 g) with price tags of ' 50, ' 150 and ' 200/kg respectively. A majority of the catch belongs to the smaller size group giving low return to the fishers. However, the demand for these fishes is increasing steadily owing to its flourishing market in the Gulf countries. As these fishes are caught alive, growing the small fishes to just above 500 g would considerably increase its market value. No data is available on the culture of this fish in land based or sea based facilities. The paper describes attempts made to rear juvenile *Scarus ghobban* to the next higher grade for value addition. Two square HDPE cages of 2 x 2 x 2.5 m size were fabricated and deployed at 6 m depth in the sea at a distance of 600 m from the shore near Olaikuda. Live parrot fishes of <500 g



were procured from the trap fishers of the Olaikuda village. The procured live fishes were sorted into two size groups viz. 200-250 g (average 214 ± 16.63 g) and 375-450 g (425 ± 20.64 g) and stocked @ 8.5 kg/m³ in the two cages. Low value shrimp head waste was given as feed @ 10% of total biomass stocked. Physicochemical parameters at the site during the culture were also monitored periodically. The fishes were reared in the cages from 15th August to 15th October 2010. The culture was terminated on 15th October due to severe blooming of the blue green alga, *Lyngbya* sp. and the subsequent onset of the cyclonic season at the culture site. The average weight gain during this 2 months culture varied between 44 g (GR 0.73 g/day) in the smaller group (200-250 g) and 98 g (GR 1.61 g/day) in the bigger group (375-450 g). From the results of the above experiment, it is evident that *S. ghobban* can be acclimatized and grown in the cage environment. The ideal season for culturing fishes in sea cages at this site will be between March and September.

AP-O 37

Culture of Asian seabass, *Lates calcarifer* (Bloch, 1790) in open sea floating cage off Kakinada coast in the Bay of Bengal

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The potentiality of an open sea floating cage for growing Asian seabass, *Lates calcarifer* was assessed in the Bay of Bengal off Uppada, Kakinada, Andhra Pradesh during October, 2009 - June, 2010. One 6 m diameter HDPE circular floating cage was installed at 10-12 m depth with single point mooring method by a gabion box that was loaded with 4 t of granite stones, through a 14 mm cross linked alloy steel chain. The cage was fixed with

two nets, outer net made up of 40 mm mesh size webbing to the outer frame to avoid predators, and the inner net made up of 25 mm mesh size webbing fixed to the inner frame to retain the fish. One nursery rearing net made up of 10 mm mesh size webbing was placed in the inner net for rearing the fingerlings during initial period of 30 days. A total of 4000 sea bass fingerlings were collected from wild and grown in the seed cages off Balasore, Orissa were stocked in the cage in last week of October, 2009. The average length and weight of stocked fingerlings were 137 mm and 30.83 g respectively. The ranges of water parameters such as salinity, temperature, pH and dissolved oxygen were 25-30 ppt, 24-29 °C, 7.3-8.2 and 6.9 -8.4 mg/l., respectively. The stocked population was fed twice daily with trash fish, procured from the nearby landing centres, at 4-6 % of biomass, by chopping into small pieces that are suitable to mouth size of fingerlings. Sampling was done once in a month to check the growth performance of the stocked fish. As the intensity of fouling was high on the fish rearing nets and was reducing the free flow of water, both inner and outer nets were replaced after three months of culture period. The fishes were harvested after seven and half months of culture period. About 1,227 kg of fish was harvested. The length range of harvested fish was from 23.4 to 48.1 cm and the weight range was from 0.25 – 1.425 kg respectively. The average size of harvested fish was 35.6 cm TL/0.58 kg wt. The survival at the harvest was 53.0% and FCR was 1:8.2. Fish gained weight about 2.3 g/day. The results of the present culture demonstration indicated the feasibility of open sea cage farming of seabass *Lates calcarifer* in the Bay of Bengal off Kakinada region of Andhra Pradesh.

AP-O 38

An innovative culture practice for enhancing Asian seabass, *Lates calcarifer* farming in pond culture system

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Improved farming of Asian seabass (*Lates calcarifer*) has gained momentum in recent years using hatchery produced seed. The viability of farming by the farmers is handicapped due to the differential growth of the stocked fishes and the non-availability of required quality seed and feed. To motivate and to create awareness and confidence amongst farmers, a demonstration to prove the techno-economic viability of Asian seabass farming in pond system was undertaken in different geographical locations in brackishwater ponds. The hatchery produced seabass fry (1.2–1.5cm size) were transported to culture sites and reared in *in situ* conditions in the farm site itself in hapa net cages with a stocking density of 200 nos./m³, feeding with formulated feed @ 20% of the biomass initially 4 times in a day and gradually reduced to 10% of the biomass by the end of nursery rearing period of 45 days. Regular grading once in four days was carried out to facilitate rearing of uniform size groups in the hapas. Over a rearing period of 6-7 weeks, fingerling of 6-8 cm size with survival rate of 68-74% was obtained. Fingerlings were transferred to pre-grow out pond partitioned in the grow out pond itself and stocked @ 50,000 nos./ha. Fishes were fed with formulated feed developed by Central Institute of Brackishwater Aquaculture @ 10% of the biomass initially and reduced to 5% by the end of 2 months pre-grow out culture period. Fish attained size of 15cm/48gm – 18cm/70 g with survival rate of 84-91%. The juveniles grown in the pre-grow out system were stocked in the grow out system @ 4-5,000 nos. /ha and fed with formulated feed @ 2-3%. Over a period of 6-7 months culture, fish attained size ranging from 28 cm/0.650kg to 34cm/1.40 kg with FCR of 1.6-1.8. The practice of phasing the culture operation was useful in reducing the differential growth and culture duration and increasing the survival rate ; facilitating concurrent and continuous culture of seabass in nursery, pre-grow out and grow out in

the same system. The details of the techno-economic viability of seabass culture in different culture practices are discussed.

AP-O 39

Growth performance of rohu, *Labeo rohita* in tanks provided with varied levels of sugarcane bagasse as periphyton substrate

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Provision of biodegradable substrates results in the production of biofilm/periphyton which serves as an additional natural food source for the cultured fish. The effect of sugarcane bagasse application in the pond bottom as substrate on water quality, growth performance and production of the Indian major carp, rohu (*Labeo rohita*) was investigated through a 180-day experiment conducted in mud-bottomed, outdoor cement tanks (5 x 5 x 1 m). Water from a nearby well was filled in the tanks, maintaining a level of 90±5 cm; the evaporation loss was compensated through weekly pumping of water. The substrate was provided at different levels - 0 (T₀), 1.5 (T₁), 2.0 (T₂), 2.5 (T₃) and 3.0 t/ha (T₄). Dried cattle dung was applied to each tank @ 5.0 t/ha followed by fortnightly doses of 1.0 t/ha.

Bagasse did not adversely affect water quality; dissolved oxygen levels varied between 6 and 9.6 mg/l over the experimental duration. Only minor differences in periphyton and plankton density were observed between treatments. Survival of fish ranged from 77.5% (T₃ treatment) to 85.0% (T₁ treatment), though it did not differ significantly (p>0.05) among the treatments. The substrate affected fish growth and production significantly (p<0.05) at all the densities tested. The gross fish yield ranged from 3456g/25m² (T₀) to 7904 g/25m²



(T₂ treatment). In T₁, T₂, T₃ and T₄ treatments, yield increased by 68.23, 128.70, 123.35 and 118.66% respectively. The results demonstrated that sugarcane bagasse can be applied as a substrate in pond bottom at a density of 2.0 t/ha for increasing the production of rohu.

AP-O 40

Breaking seasonal barriers in freshwater prawn culture in Bihar

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The commercial importance and popularity of the giant freshwater prawn *Macrobrachium rosenbergii* is gaining recognition due to its high growth rate, hardiness and very low protein requirement in feed. In the present aquaculture scenario of India, as the population grows, more and more people are adopting prawn farming to fulfill the increasing demand for food. In scampi farming, temperature is the most important factor which directly controls the growth and survival of prawns. Temperatures above 35 °C or below 14 °C are generally reported to be lethal and 28-31°C is the optimal. Attempts to culture the prawns beyond December in winter season have paved the way for its possibilities of successful culture in water logged areas of Bihar. To minimize the water temperature effects on the prawns, various type of shelters/ hideouts such as PVC pipes, earthen tiles, trenches and aquatic weeds like *Eichhornia* were provided in ponds which also helped in providing shelters and improving survival rates.

At ICAR research complex for eastern region, Patna, standardization of grow-out technology on monoculture and polyculture of freshwater prawns under multiple water use system has been carried out. Prawns were cultured in the semi-intensive systems involving stocking of PL-20 at 4-20/m² in ponds. Fertilization was used and a balanced feed ration was supplied. In monoculture, prawn yield was 610 kg/ha and survival rate was 50%. Polyculture yielded

730 kg/ha of prawn with survival rate of 69%, along with fish yield of 3321 kg/ ha. With proper farm and water quality management and intensive attention to the health of stock, feed management etc., freshwater prawn culture practices can become a major source of income for rural people as it fetches very high price in market. The present manuscript will greatly help in scientific management of the unutilized water logged areas in particular and for other similar small water bodies in boosting the development of aquaculture in Bihar.

AP-O 41

Yolk and oil globule utilization in the larvae of spotted scat, *Scatophagus argus* and Asian seabass *Lates calcarifer*

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For the newly hatched fish larvae, yolk and oil droplets are the inert energy depots, which are appropriately mobilized and utilized for the provision of energy during early development. The volume and constituents of yolk and oil droplets are the determining factors for the larval growth and related physiological mechanisms, before the initiation of first feeding from exogenous source. Therefore, understanding the utilization of yolk and oil droplets of early fish larvae would help to initiate the feeding protocols during hatchery rearing phase. In the present study, yolk and oil globule utilization in the larvae of brackishwater ornamental fish spotted scat *Scatophagus argus* and Asian seabass *Lates calcarifer* were studied. The larvae of *S. argus* had yolk and oil droplets volume of 0.108 and 0.0098 mm³ respectively at hatching and thereafter, the yolk volume reduced on subsequent days and reached to a low of 0.018 mm³ and 0.012 mm³ at 48 and 72 hrs post respectively. Similarly, the oil droplets reduced to a volume of 0.00119 mm³ at 96 h post-hatch. Yolk and oil droplets were completely absorbed at 96 and



120 h post-hatch respectively. In the case of seabass, the yolk and oil droplets volume were observed with 0.112 mm^3 and 0.0121 mm^3 respectively at hatching and complete absorption of yolk was noticed at 96 h posthatch. The oil droplets reduced to a low of 0.007 mm^3 at 96 h post hatch from 0.0121 mm^3 at hatching and completely utilized at 120 h post hatch. The rapid decline of yolk (83.3% in scat and 84.8% in seabass) within 48 h from hatching indicated its utilization for organogenesis in both the species and thereby enabling the initiation of first feeding. The importance of yolk and oil globule reserves and their utilization between the fish species are discussed in this paper.

AP-O 42

Mamdani fuzzy rule based model for classification of aqua sites for aquaculture development

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In this paper, Mamdani fuzzy rule based model was developed and validated to classify the aquasites for aquaculture farming development based on water, soil, support, infrastructure, input, and risk factor related information. The dataset used in this study were obtained from 65 randomly selected aquasites in the study area such as Bhimavaram (A) (30 sites), Narsapuram (B) (10 sites), and Mogalthur (C) (25 sites), West Godavari district, Andhra Pradesh, India. Dataset gathered from A and B were used to develop the model, and C for validating the model. For input and output linguistic variables of the model, suitable Gaussian and triangular membership functions were selected. Totally, 729 rules with logical AND operator, truncation implication, and centriod method for defuzzification were employed to develop an efficient fuzzy model for decision making about classification of aquasites. The developed model was implemented as a fuzzy rule based tool

using MATLAB (Version 7.0). The model classifies each site in the dataset into one of the three classes such as suitable, moderate or unsuitable. The output of the fuzzy model after running the program for a moderate classification of aquasite is shown in shows that if the water is 0.250, soil is 0.215, support is 0.027, infrastructure is 0.020, input is 0.009 and risk factor is 0.037, then the output after defuzzification according to the boundary conditions on the output variable membership function is 1.41, which belongs to the range of moderate classification of aquasite. For validation of the fuzzy model, first classified the validation set by fuzzy system designed for this purpose and then the same set was classified by aquaculture expert, having enough field experience and knowledge. The model outputs and expert responses were expressed in terms of numbers and the accuracy of classification was calculated. The result shows that the classification results obtained from the fuzzy model showed 92% agreement with the results from the aquaculture expert. Thus the fuzzy based model is a feasible method for classifying the aqua site and also it involves less computation, and has clear implementation and working schemes.

AP-O 43

Status of freshwater community based aquaculture and its economy in rural Odisha, India

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The village community ponds are widely available and poorly used aquaculture resources of the country. The small aquatic resources (< 40 ha) with stake of community and multiple users are being categorized as community ponds. The primary control over these resources is vested with panchayat, local self government, religious trusts or various



community institutions. It accounts for 60% of the total freshwater aquaculture resources available in the state of Orissa. However, these water bodies are under utilized and/or unexploited for scientific fish production owing to several limitations even though the potential of aquaculture development and consequent implications on the food and nutritional security is quite high. In view to record fish production and economic profitability in relation to lease period and various aspects of management practices, an investigation was carried out in eighty-one randomly chosen typical community fish ponds from two representative districts (Khurda and Puri) of Orissa. Data were collected by direct interview of practicing fish farmers in community ponds using structured questionnaires during 2009-10. In general, traditional and extensive carp culture was in vogue, which may be termed as rural aquaculture. Community ponds were leased for 1, 3 and 5 years fetching fish production of 769, 930 and 1634 kg/ha/yr respectively under poorly managed condition and with less input use. Fish production level was significantly ($p < 0.05$) different in three categories of ponds. Presence of aquatic macrophytes, weed and predatory fishes, under dose manure and fertilizer application and/or no use of manure and fertilizer, stocking of fry (small size fish seed) in unprepared ponds, under feeding and/or not feeding to fish had adverse effect on fish production and net income generation in village community ponds. There was significant increase in fish production ($p < 0.05$) by stocking fingerlings (large size fish seed) over stocking fry. Feeding fish with under dose rice bran had significantly increased fish production and net income ($p < 0.05$) over fish not fed with rice bran. Similarly in those community ponds in which fish were fed with even under dose ground nut oil cake (GNOC), the fish production and net income increased significantly ($p < 0.05$) compared to the ponds not fed with GNOC. Share of feed to mean expenditure was found to be 7% only, indicating poor feed input use in community fish ponds. Expenditure on labor

charge for community based aquaculture management was 48%, suggesting labor intensive rather than feed intensive fish farming. Average cost of fish production was Rs. 37/kg fish. Net return on expenditure was 134.4% with profitability index of 1.34 in spite of poor pond management and less input uses, indicating it a highly profitable venture for community farmers. For horizontal expansion of aquaculture in rural area, techno-input intensification is recommended. The socio-political problems need to be mitigated. This may lead to enhanced fish production from community ponds in order to provide family income, self employment, improvement of the livelihood and nutritional security of the rural poor.

AP-O 44

Advanced and innovative inland aquaculture systems to boost up fish production in India

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Although India is blessed with extensive inland water bodies comprising reservoirs, lakes, riverine systems, tanks, ponds, etc, inland aquaculture is yet to develop fully to its potential. The prime factors responsible for this state of affairs are inadequate skill of inland aquaculture practices among fish farmers; lack of confidence among fish farmers to implement innovative aquaculture technologies, reluctance in accepting new species and advanced culture systems and failure on the part of concerned agencies for showcasing effective and viable technologies made available to the farming community. The fact remains that the inland aquaculture systems are not able to produce viable technologies for adoption; and cannot deliver adequate economic returns. For the inland aquaculture sector to advance, it is inevitable that new, intensive and innovative culture systems suitable for various species and



geographical locations are to be introduced. A few such farm-tested culture systems which can be adopted successfully in our water bodies are discussed in detail in the paper.

Synthetic fibre fabric (SFF) lined ponds, fibre reinforced plastic (FRP) cages and biosecured raceways are few innovative and intensive culture systems which can be adopted effectively in inland water bodies to raise fish with substantial economic returns. Studies undertaken at our research farm facility confirmed that FRP cages of different dimensions suitable for various species can be used for rearing fishes such as koi carp, gold fish, and hybrid/monosex tilapia. Similarly SFF lined ponds with surface aerators and CDS are ideal for raising catfish, gold fish, koi carp, etc. on intensive scale. Raceways adoptability to raise crops of scampi, koi and gold fish have been established using the microbial – algal – flocculent based culture practicing. The technical intricacies involved in managing such culture systems are demonstrated and domesticated through training programmes by the centre.

AP-O 45

Efficiency assessment of bundh-cum-hatching pool of Chandra hatchery: a new technology for fish spawn production

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An effective and scientific comparison of 'Chandra Hatchery' (Bundh-cum-Hatchery) with other customary hatcheries has been assessed in regard to infrastructural and functional potentiality for fish spawn production. The deeper and shallower zones with convex platform of the hatching pool resembling the riverine bottom are constructed to facilitate the fish breeding. Moribundity and settling down of eggs are exclusively restricted by providing

additional requirement of oxygen through horizontal and vertical perforated pipes inside the pool resulting in increased survival rates or success rate up to 95 to 98%. Egg holding capacity of the hatching pool is increased up to 500 – 600 l/4 m³ and the eggs are safe due to non-shifting mode of operation. Quality of water is maintained by automatic separation and exhalation of the disintegrated egg shells. The single chamber frame of pool is very much cost effective, in the tune of Rs 15,000/- to 16,000/- only which can reach to even marginal farmers.

AP-O 46

Aeration requirement in distinctive regions of shrimp ponds of *Fenneropenaeus merguensis*

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The exact requirement of aeration in shrimp aquaculture is complex to determine since the production units present different ecological characteristics and, thus, different oxygen demands. To understand the existing oxygen level and to assess the requirements to increase the efficiency of dissolved oxygen (DO) management in extensive shrimp ponds of *F. merguensis*, the present study was conducted by assessing the dissolved oxygen levels at distinctive regions of shrimp ponds at different periods. Measurements of water flow, sludge depth, dissolved oxygen and pH were taken throughout a pond and verified by several transect measurements on different dates in the same pond. The DO in pond bottom ranged from 3.58 to 3.02 ppm, 4.38 to 3.54 ppm, 5.94 to 5.19 ppm at 7am, 12 noon and 5 pm respectively. The surface DO ranged from 3.74 to 3.18 ppm, 4.2 to 3.68 ppm, 5.56 to 4.84 ppm at 7 am, 12 noon and 5 pm respectively. During the early morning, the inner region had significantly lower DO than the outer region. In



contrast, during the evening, inner surface water DO was higher than outer surface water. This was facilitated by the larger effect of variable photosynthesis and oxygen demand. The results of this work indicated that there is need for artificial aeration to fulfill the oxygen requirement during the early morning period to improve the shrimp growth.

AP-O 47

Role of different substrates in periphyton development and growth of *Penaeus monodon* juveniles

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A yard trial was conducted for evaluating the suitability of different substrates for the growth of periphytons and their impact on the growth of tiger shrimp, *Penaeus monodon* juveniles, for a period of 45 days with 5 different substrates - untwisted rope, bamboo, glass slide, PVC pipe, nylon webbing and a control without any substrate. All the treatment were executed in triplicate and assigned randomly between 18 FRP (100 l) experimental out door tanks. All tanks were fertilized with semi decomposed cattle manure, urea and triple super phosphate (TSP) at a dose of 3000, 100 and 100 kg ha respectively. After fertilization, the tanks were left for 10 days to allow periphyton growth on substrates, and subsequently stocked with 1.8 ± 0.2 g juvenile *P. monodon*. Low fishmeal based formulated pellet feed were used for the growth trial. A higher final body weight of 4.5 ± 0.4 g and 3.9 ± 0.7 g was achieved in untwisted rope and bamboo based system with minimum 3.1 ± 0.3 g in control. Significant difference ($p > 0.05$) in pH, salinity, alkalinity, Nitrate-N and Phosphate-P were observed among the treatment. However, there was a significant difference in total Ammonia-N ($p < 0.05$) and Nitrite-N ($p < 0.01$) among the group. Significantly higher Total Ammonia-N,

134 ± 13 µg/l was noticed in control group compared to other substrate based system. Highest periphyton biomass in terms of dry matter was observed in untwisted rope, 25.3 ± 8.7 mg/cm² followed by nylon webbing, 22.5 ± 5.6 mg/cm² and higher ash free dry matter observed in bamboo, 8.9 ± 2.7 mg/cm² followed by untwisted rope 8.75 ± 0.73 mg/cm². Untwisted rope and bamboo seems to be suitable substrate in terms of shrimp growth and periphyton development. They provide suitable substrate for animal grazing. Even though nylon webbing showed good periphyton growth, animal was not able to graze over this substrate

AP-O 48

Soil and water quality variation in banana shrimp, *Fenneropenaus merguensis* cultured ponds during summer and winter crops

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Diversification of alternate shrimp species is an immediate requirement for Indian shrimp farming sector as the monoculture of the tiger shrimp *Penaeus monodon* is highly risky for the sustainability of aquaculture. In order to demonstrate the culture of alternate species and its techno-economic feasibility, banana shrimp *Fenneropenaus merguensis* was taken up during summer and winter crops in the brackishwater farm at Danti - Umbharat Centre of the Navsari Agricultural University, Gujarat. The farm follows all the biosecurity protocols and normal protocols of pond preparation, acclimatization and seed stocking, feeding and application of lime, fermented juice and probiotics, regular sampling and water exchange as and when needed in both the summer and winter crops. Water and soil samples were collected at regular intervals and



analyzed for basic physico-chemical parameters in both the crops. There was not much difference between summer and winter crops with respect to pH and Ca:Mg ratio in pond water and soil pH. The pH, salinity and alkalinity values in pond waters ranged from 7.62 to 8.77, 12 to 45 ppt and 112 to 216 ppm during summer crop and 7.65 to 8.55, 21-41 ppt and 120 to 284 ppm during winter crop, respectively. Total ammonia nitrogen (TAN) and nitrite nitrogen values in pond water and organic carbon content in soil were high and $\text{NO}_3:\text{PO}_4$ ratio was less during summer crop compared to winter crop, where the water salinity and better pond environment with less TAN values were positively correlated with more average body weight of shrimp. Better soil and water environmental conditions in the pond and high average body weight of shrimp during winter crop as compared to summer crop indicated the scope of banana shrimp farming as a profitable winter crop for Gujarat region.

AP-O 49

A study on carp production in short seasonal tanks in Karnataka

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Karnataka state is bestowed with rich and diverse aquatic resources in the form of major (6015) and minor (19697) tanks. The Government of Karnataka has undertaken a programme to improve the water holding capacity of 2000 tanks (seasonal) of the estimated 3700 minor irrigation tanks under the World Bank funded JSYS project. It is estimated that about 600 tanks (30%) are considered suitable for fisheries development. A study was undertaken in ten short seasonal tanks in Northern Karnataka to assess fish production under polyculture at different stocking densities i.e. 1250, 1500 and

2000 fingerlings/ hectare over a period of six months. Polyculture comprised of seven fish species viz. catla, rohu, mrigal, *Labeo fimbriatus*, silver carp, grass carp and common carp at a stocking ratio of 4:3:3 (surface: column: bottom feeders). Results indicate that the fish production was 382, 657, 520, 421, kg/ha at the stocking densities 1250, 1500, 1750, 2000, and fingerlings/hectare, respectively. Growth of fish was highest at a stocking density 1500 fingerlings/hectare. Increasing the stocking density beyond 1500 fingerlings/hectare showed decline in growth of fish. Among the fish species, common carp showed better performance followed by silver carp and catla in all the stocking densities 1250, 1500 and 2000 fingerlings/hectare except at a stocking density of 1750 fingerlings/hectare, in which silver carp showed better performance followed by common carp and catla. However, the growth of rohu, grass carp, mrigal and *Labeo fimbriatus* was poor in all stocking densities. The better performance of common carp in most of the tanks could be attributed to the omnivorous food habit and tolerance to fluctuating environmental conditions at a stocking density of 1500 fingerlings/ha.

AP-O 50

Prospects of banana shrimp, *Fenneropenaus merguensis* as winter crop in Gujarat

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Generally, during winter season most of the shrimp farms are left idle till the end of March because of poor growth of *Penaeus monodon* at lower temperatures (<15 °C). Hence, as an alternative species for the winter season, an experimental study was conducted to evaluate the potential of banana shrimp



F. merguensis, in brackishwater culture areas of Gujarat. Banana shrimp culture can be taken up during the off season of tiger shrimp farming as an additional source of income. Culture trials were conducted in four ponds (0.15 ha each) at Danti, Navsari in collaboration with Navsari Agricultural University (NAU). The ponds were stocked (@ 10 pcs/m²) with PL 20 of banana shrimp produced at Shrimp Hatchery of CIBA, Chennai. The animals were cultured for 136 days. During the culture period the shrimp were fed with commercial feed (*L. vannamei* feed – Crude protein 35%) and their growth and survival were observed on fortnightly intervals. Abiotic parameters (pH, salinity, temperature) were recorded daily and ammonia and nitrite were monitored on fortnightly basis. At harvest, shrimp registered the average body weight of 16.8 ± 1.8 g and counts of 60.11 ± 7.11 . The survival rate was 61.3 ± 19.62 % and total production achieved was 880 ± 246.57 kg. The shrimp was sold at farm gate price of Rs. 205/kg. The study showed that a production of about 1.0 t/ha and could be achieved with low density and minimum input during winter season. Since there is a great demand in domestic market for this shrimp, there is immense scope for its culture as a diversified species for winter crop in the state of Gujarat.

AP-O 51

Breeding and seed production of carps using re-circulated pond and harvested rain water

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High alkaline water (330 ppm) from the bore well hampered breeding and seed production of carps. The eggs were found to be floating during breeding in high alkaline water and the hatchlings developed gas bubbles inside their body on the 3rd day after hatching (DAH). This resulted in the spawn acquiring

positive buoyancy, leading to their inability to swim and consequent crowding at the top of the hatching pool, near the centre and periphery. The crowded hatchlings died either in the hatching pool or later in the nursery ponds with a very poor survival. Hence pond water with a lower level of alkalinity (180-220 ppm) was tried in breeding of major carps. Water from earthen ponds with considerably low alkalinity was pumped in cement tanks. After subjecting the water to the processes of sedimentation (two days), filtration (Biofilter) and aeration (1day), the treated water was stored in an overhead tank from where it was used for breeding of Indian major carps such as rohu, mrigal and catla. The water quality parameters such as alkalinity, dissolved oxygen, pH and ammonia were monitored continuously. Further the water from the breeding pools and the hatching pools were collected and passed again through the process of bio-filtration and aeration and reused for breeding and hatching. The fertilization and hatching rates ranged from 85 to 92%. However the survival rate was found to be 30 to 57% on 4 DAH. The hatchlings at the end of 4th DAH appeared healthy and active. The recirculation process enabled enormous water savings in breeding and hatchery operations. The prospects and problems encountered are discussed in the paper.

AP-O 52

Comparison of growth and colouration of *Carassius auratus* (Linnaeus, 1758) under different culture systems

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The present experiment was conducted for 60 days to compare growth and colouration of *Carassius auratus* (Linnaeus, 1758) among three culture systems such as aquaria (AQ), cement tanks (CT) and cages (CG) suspended in pond. Fry of gold fish with mean length 4.1 ± 0.19 cm and mean weight 2.26 ± 0.24 g



were stocked with 0.2 nos./l and fed with marigold (*Tagetes erecta*) enriched diet at 5% of body weight. Highest ($p < 0.05$) growth was showed in cages (8.14 ± 0.29 cm and 7.96 ± 0.70 g.) followed by cement tanks (7.13 ± 0.17 cm and 6.46 ± 0.22 g) and aquaria (6.51 ± 0.13 cm and 5.65 ± 0.14 g). Survival was highest in aquaria (68%) followed by cages (60%) and cement tanks (59%). Fish skin colour parameters reacted differently according to culture systems. After 60 days of rearing, lightness (L^*) and whiteness (W^*) values decreased in all three systems and highest ($P < 0.05$) was found in aquaria ($L^* 49.0 \pm 1.18$; $W^* 23.5 \pm 1.43$) followed by cement tanks ($L^* 45.2 \pm 1.01$; $W^* 17.9 \pm 0.59$) and cages ($L^* 41.54 \pm 1.31$; $W^* 11.50 \pm 1.04$). Redness (a^*), yellowness (b^*) and saturation (C^*) values increased in all three systems and highest ($p < 0.05$) were in cages ($a^* 36.29 \pm 1.07$; $b^* 55.48 \pm 1.33$; $C^* 66.46 \pm 1.01$) followed by cement tanks ($a^* 31.3 \pm 1.11$; $b^* 52.4 \pm 1.22$; $C^* 61.05 \pm 0.87$) and aquaria ($a^* 22.6 \pm 1.08$; $b^* 45.7 \pm 1.8$; $C^* 57.8 \pm 0.48$). Muscle carotenoid content were highest ($p < 0.05$) in caged fish (24.80 ± 1.44 $\mu\text{g/g}$) followed by cement tanks (19.26 ± 0.63 $\mu\text{g/g}$) and aquaria (12.26 ± 1.13 $\mu\text{g/g}$). At the end of experiment, there were significant differences between aquaria, cement tanks and cages in final mean length, mean weight, percent weight gain, SGR, FCR, FER, PER, colouration and muscle carotenoid content of gold fish.

AP-O 53

Evaluation of growth performance of *Litopenaeus vannamei* at low stocking densities

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Recently *Litopenaeus vannamei* has proven to be one of the most promising candidate species for shrimp farming sector in India. Most of the farmers are going for high stocking

density farming of this species for attaining maximum profit. High intensive farming demands more infrastructure and investments keeping the small and marginal farmers away from the initiation of *L. vannamei* farming. In this context, experimental trials have been carried out at the Brackish Water Fish Farm, CIFE Kakinada centre in order to evaluate the performance of *L. vannamei* at lower stocking rates such as 10 / m²; 20/m² and 30/ m².

Growth pattern and production performance has been evaluated for different stocking densities. Total production was found to be 1.4 t/ha, 2.7 t/ha and 5 t/ha respectively for the stocking rates of 10/m², 20/ m² and 30/ m²

AP-O 54

Zero point culture technique at Kolleru, Andhra Pradesh for blue revolution of Indian major carps.

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Now the fish farmers in Kolleru area, Andhra Pradesh are adopting a new culture technique for enhancing fish production in this region and are producing big size fish for fetching better price. Zero point culture technique is the farming of more than one year old stunted yearlings of 300-500 g size. For one acre 2,000 rohu and 200 catla or 1800 rohu and 200 catla of 300 – 500 gm sized yearlings were used for stocking in the culture tanks. Growth performance was found to be increasing according to the age of the fish up to certain age. The farmers are achieving a production of around 4.5 t per acre in six months time. Rohu grows about 2.0 to 2.5 Kg and catla 3.0 to 4.0 Kg per year. From one hectare a production of about 20 t is achieved per year in this area by the progressive farmers.



AP-O 55**Effect of different stocking density on growth and survival of freshwater prawn, *Macrobrachium rosenbergii***

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A study was conducted to evaluate the growth performance of freshwater prawn *Macrobrachium rosenbergii* under monoculture at different stocking densities. The experiment was conducted in 200 m² earthen ponds in duplicate for a period of four months. The freshwater prawn post-larvae (mean weight 0.17 ± 0.06 g) were stocked at 20,000, 30,000 and 40,000 numbers/hectare. The prawn was fed with commercial feed at the rate of 20% of the body weight for the initial 2 months and rest of the experimental period with 5% of the body weight. Sampling was carried out fortnightly to assess the growth of the prawn. The water quality parameters were also analyzed on a regular interval throughout the experimental period. The results indicate that the growth of the prawn was 20.20 ± 1.50 , 14.38 ± 1.41 , 12.35 ± 1.30 g at 20,000, 30,000 and 40,000 no./ha respectively. The growth of the prawn was highest at the lowest stocking density (20,000 no./ha) and was significantly greater than other two stocking densities. In addition, the highest survival (55.30%) was recorded in lowest stocking density followed by 50.80% (30,000 no./ha) and 44.15% (40,000 no./ha). The results indicate that stocking density at 20,000 no./ha appear to be optimal in terms of survival rate and growth.

AP-O 56**Dynamics of fish-duck integrated aquafarming in tarai agroclimatic region of Uttarakhand**

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The study was conducted in two rectangular earthen ponds of the size of 0.5 ha each. Six species of carps namely, *Catla catla*, *Cirrhinus mrigala*, *Hypophthalmichthys molitrix*, *Ctenopharyngodon idella* and *Cyprinus carpio* were stocked @ 10,000/ha. One of the ponds was completely integrated with rearing of 300 nos. ducks of Khaki Campbell variety. The excreta and spilled over duck feed from the duck house fell directly in to the duck-fish pond. No artificial feeding was done to the experimental fishes. No drastic deviation from the acceptable range of water quality parameter was recorded in duck-fish integrated pond. The plankton volume increased gradually towards the end of the study. The spilled over feed of ducks amounted to 14.37% of the feed given to ducks. Total quantity of 5052.48 kg duck dropping (amounting to 23051.94 kg/ha/yr) was added to the duck-fish pond. The calculated amount of 314.66 kg nitrogen, 228.37 kg phosphorous, 82.98 kg potassium and 2881.50 kg organic carbon/ha/yr got entry to duck-fish pond through recycling of duck excreta. Average survival of 92% in duck and 71.57% in fishes was observed. Production to the tune of 1259.82 kg fish (5039.28 kg/ha/yr) and 449.05 ducks (1796.21 kg/ha/yr) could be obtained from duck-fish pond while only 1178.8 kg fish (4715.20 kg/ha/yr) were recovered from control pond. It is inferred that integrated duck-fish farming is technologically sound, economically viable and environmentally congenial farming practice for earning livelihood in rural areas of tarai region of Uttarakhand. It also helps in reducing environment pollution, employment generation and product diversification.

AP-O 57**Growth compensation in *Oreochromis niloticus niloticus* (Linnaeus) following feed deprivation protocol**

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Compensatory growth is a phase of unusual rapid growth following a period of feed deprivation or restriction in fish. An attempt was made to explore such growth in tilapia *Oreochromis niloticus niloticus* (Linnaeus). Four treatments were planned including control and each was carried out in triplicate in aquaria for 60 days. Fish of treatments D1, D2 and D3 were subjected to one, two and three days of deprivation respectively following two days of feeding while those in control were fed daily. Growth of fish along with water quality parameters were monitored at weekly intervals. There was no significant weight gain in fish between treatment D1 and control, even though feed consumption was significantly low in the former case. Proximate composition of muscle characteristics during termination of experiment indicated no significant difference in protein level between these two treatments while lipid content and ash level varied significantly. However there was significant difference in growth and muscle characteristics among treatments D2 and D3 compared to control. Thus the feeding protocol of D1 has can be tested under field conditions because it can reduce the cost of feed substantially with out compromising the growth in fish.

AP-O 58

Scaling up the hatchery production of clownfish, *Amphiprion ephippium* for commercialization

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Clown fishes are very popular among hobbyists due to its aesthetic appeal and easy adaptability to captive conditions. The present contribution, delivers the successful

captive breeding and mass scale production of *Amphiprion ephippium* for commercialization with private participation at the West Coast Hatchery, Cochin, Kerala. Brooders started spawning after three months of acclimation. Higher reproductive efficiency and hatching success including larval survival was observed to be maximum when the parents were fed with boiled shrimps, squids and egg mass. Newly hatched larvae were transferred to the algae enriched cement tanks and initially fed with rotifer *Branchionus plicatilis*, followed by newly hatched *Artemia* nauplii. Natural light was provided for 12L: 12D in the form of a transparent roof. Young ones were shifted to grow out tanks after a month and fed with boiled shrimps until they attained marketable size. Initially, the survival was observed as 40-50% and latter it has enhanced to 80%. The mass scale production of clown fishes will help to conserve the natural stock in the marine ecosystem and this technology will provide an alternate livelihood to the coastal communities. The methodology adopted for commercialization and hurdles faced were discussed in detail. This is the first report on commercialization of clownfish production in India.

AP-O 59

Duck and goat excreta as fertiliser in fish polyculture pond

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One year grow-out experiment was carried out in two ponds of 0.1 ha each with fingerlings of catla (28.7 ± 8.9 g; 12.6 ± 1.3 cm), Rohu (11.8 ± 4.0 g; 9.9 ± 0.9 cm), mrigal (67.4 ± 24.1 g; 20.0 ± 2.5 cm), silver carp (2.6 ± 1.0 g; 7.1 ± 1.1 cm), olive barb (3.9 ± 2.2 g; 7.1 ± 1.1 cm) and fringe-lipped carp (15.5 ± 4.3 g; 10.9 ± 1.1 cm) stocked at a ratio of 8: 20: 20: 20: 16: 16. and at a combined density of 7,500/ha. The fishes were raised



with the provision of duck (Treatment T-1) and goat (Treatment T-2) excreta as fertilizers at fortnightly intervals @ 10,000 kg/ha/year, including basal application level of 2000 kg/ha/year, and without any supplementary feeding. While important water quality parameters including primary production, and fish growth assessment were carried out at bimonthly intervals, the dry goat and duck excreta was analysed for proximate composition on quarterly intervals. Comparison of the results revealed significant difference in the yield attributes such as growth, SGR and net biomass yield between the two treatments. The gross primary production, net primary production and respiration in treatments T-1 and T-2 were in the ranges of 31.7-671.3, 86.45-787.5 & 3945.75-31387.5 gC m⁻³ hr⁻¹ and 21.75-462.75, 64.58-522.75 & 562-8550 gC m⁻³ hr⁻¹ respectively, showing significant difference between the treatments ($p < 0.05$). While the survival levels of different species and also overall survival were comparable between the two treatments, growth of all the species in treatment T-1 was perceptibly higher than those of treatment T-2. The mean survival and growth in T-1 and T-2 were 83.67 % & 620 g and 84.83 % & 274.5 g respectively. Considerably higher overall gross and net production in T-1 (4071 & 3907.8 kg/ha/year) over T-2 (1834 & 1670.8 kg/ha/year) demonstrated superiority of duck excreta over goat excreta as the organic manure source for carp polyculture system.

AP-O 60

A study of patents in the area of cage culture

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Demand for aquatic products is increasing, resulting in new technological developments in fisheries and aquaculture sector. Among these, cage aquaculture is expanding very fast. Commercial cage culture

started in Norway in the 1970's. Over time, different technologies have been developed and put in practice in different countries. One would believe that some of these new technologies and innovations are protected with Intellectual Property Rights (IPR) like patents, but documented information about this is lacking. The objective of this study is to examine patenting activities (1970-2009) in cage culture. For this, we performed a comprehensive patent search using commercial (Micropat) and free online (www.freepatentsonline.com) databases. The International Patent Classification (IPC) code A01K61/00 was the focus of the search strategy. A total of 129 patents related to cage culture were found from 1970 to December, 2009. Out of these, 46 patents were granted in the USA, 41 in Japan, 32 under World Intellectual Property Organization, 9 in Europe and 1 in the UK. Individual applicants outnumbered organizations. Trade Related Intellectual Property Rights (TRIPS), which is a comprehensive multilateral agreement on Intellectual Property, came in force in 1995. The number of patents granted from 1970-1994, i.e., pre TRIPS era, was 47 in 25 years; whereas from 1995 to 2009 i.e., post TRIPS era, the number was 82 in 15 years. However, patenting activity has shown a decrease in 2000-2004 (25 patents) and also in 2005-2009 (24 patents) compared to 1995-1999 when the maximum patents (33) were recorded. No conclusive reason is proposed for this. The two databases we studied do not contain information on patents granted in India. Thus we collected information from the Indian Patent Office, and studied the period from 1910 to 2000. We found that only one patent related to cage culture was registered in India. This patent was granted in 1989, on 'an open sea aquaculture installation of the type which comprises at least two submersible floating modules each having a rigid framework and at least a breeding cage', for which the assignee country was France and was granted to an individual. Interestingly, a very early patent was granted by the Indian Patent Office in 1918, it was titled 'improvements in or relating to cages for transport of live fish' by an individual from



Hooghly in India. This patent is not related to cage culture but deals with improvements in a cage for transport of live fish. We have not reported patents registered in China in this paper due to lack of access to commercial/free database. It is interesting to note from a study by Xu *et.al.* (2006) that in China about one million cages have been distributed. This number must have increased further in the last five years. Since 1990's China has imported offshore cages from other countries like Norway, Japan, USA and Denmark. As mentioned, USA followed by Japan and Europe have maximum number of patents in cage culture. It is highly probable that these patented technologies have been commercialised with a major market in China; we have not conducted a survey of the market in this area. We conclude that such efforts should be documented and brought to broader notice, as cage culture is being given priority by nations.

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Organic aquaculture guideline and its role in shaping the sector in India

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Organic aquaculture is one of the fastest growing aquaculture sectors with the increasing consumer's preference and associated premium price for natural, antibiotic/hormone free and organic food. Organic aquaculture is the process of production of aquatic plants and animals with organic inputs in terms of seed, nutrients and health management ensuring ecofriendly, biodiverse, holistically sustainable and integrated approach for production. The focus of transformation to organic farming has been a rather narrow preoccupation with the conventionalization process whereby the structure and ideology of the expanding organic sector is seen increasingly to resemble that of the conventional

food and farming sector that it has traditionally opposed. This study seeks to contribute by examining the role of guidelines in shaping this sector since India is yet to engage seriously with organic farming. It draws on the analysis of a wide range of government and organic movement publications. The study also describes the organic aquaculture principles, practices and prospects worldwide and India's stand and road map of development with emphasis on tiger shrimp *Penaeus monodon* as the target species. The vast resources of Bheries, Gheries and Pokkali fields where traditional systems are being followed can qualify for organic status with certification and traceability marks. Besides these systems, the pond based systems can be modified with low input based organic way of farming. Here we attempt to describe and analyse the guidelines formulated by APEDA (Agricultural Product Export Development Authority) and its harmonization with EU and other international bodies, certification and traceability, issues and challenges associated. Organic aqua- farming needs to be adopted widely considering the long term benefits with regard to economy, ecology, health and social welfare.

AP-O 62

Effect of season and treatment of seed with antibiotics on grow out culture of *Penaeus monodon* (Fabricius) at Sunderban

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Experiments in hapa and pond were carried out with hatchery produced antibiotic treated tiger shrimp, *Penaeus monodon* seeds to estimate the antibiotic residues in grow out culture. The analysis of morphological and



hematological parameters of shrimp during two different seasons is presented in this paper. In addition, pond water, soil microbial parameters and physico-chemical characteristics were also reported. The survival rate of the chloramphenicol, furazolidone and ciprofloxacin treated seeds during transport were found to be significantly more ($p < 0.05$) when compared to the untreated seeds. The seeds were stocked in the tide fed ponds @ 5 per sq.m. and the culture was done during monsoon and winter season with no water exchange. Average body weight (ABW) after 134 days of culture (DOC) was 17.40 ± 6.10 g in control and 21.92 ± 6.17 g in antibiotic treated seeds with feed conversion ratio (FCR) of 2.11 ± 0.46 and 2.08 ± 0.49 , and survival rate of 40.20 ± 20.36 and 40.04 ± 10.64 per cent respectively with no significant difference. On comparison of seasonal performance, the ABW was 25.79 ± 2.29 g in monsoon and 13.53 ± 2.23 g in winter crop after 134 DOC with FCR of 1.62 ± 0.03 and 2.57 ± 0.01 and survival rate of 55.62 ± 4.94 and 24.62 ± 4.78 per cent respectively with significant difference in FCR ($p < 0.01$) and survival rate ($p < 0.05$). Hematological parameters such as total hemocyte count (THC), granular hemocyte (GH) and nongranular hemocyte (NGH) counts were not statistically significant between antibiotic treated and untreated animals. Significant difference ($p < 0.01$) was observed in water and soil quality parameters between monsoon and winter crop but not with respect to antibiotic and control group.

AP-O 63

Aquaculture in small water bodies of villages

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The sources of irrigation in Karnataka are canals, tanks, wells, bore wells, lift irrigation and other sources. Amongst these, bore wells

and wells contribute a major share for irrigation (32% and 16% respectively). Bore wells and wells form small water bodies viz., groundwater storage/transit ponds and open wells in villages. These water bodies along with rainwater harvesting structures (farm ponds, check dams, etc), Gokatte, Kunte, quarry ponds and irrigation-canal-fed ponds, together form a category of water resource termed as 'Small water bodies of village (SWBOV)'. Aquaculture was done in suitably modified SWBOV owned/supervised by selected volunteer-farmers, in logically selected representative regions of Karnataka, to find out productivity of each type of SWBOV. Culture protocol in each type of SWBOV varied, depending on its individual characteristics. Total estimated annual potential fish yield from the estimated effective water spread area of SWBOV (47,991 ha) in Karnataka was 1,04,429 t. Fish productivity levels (kg/ha/yr) of SWBOV obtained, with identified limitations, were: Borewell water storage ponds 1723, Rain water harvesting structures 1892, Gokatte 1966, Open wells 1038, Quarry ponds 3193 and Canal-fed ponds 7575. With average productivity of 2129, compared to that of large stagnant surface water bodies like reservoirs (50), tanks (600) and brackish water (818), the category of SWBOV qualifies to be classified as an Inland Fisheries Resource.

For utilization of SWBOV for fish culture, it is required to have a strategy of supply of fish seeds in time, in small numbers to farmers, so that a SWBOV is put to use, as soon as it receives about half a meter water column. Establishing a system of year round supply of quality fish fingerling, of common carp, on a particular day of week to begin with, in small numbers at taluk headquarters, added with extension work, would make fish culture in SWBOV popular. Aquaculture in SWBOV showed many advantages viz., existing SWBOV were better utilized after few inexpensive modifications, crop irrigation was unaffected (in fact, it became more effective due to fertigation), frequent removal of algae and higher plants was avoided, Integrated Farming System was



practiced due to integration with dairy, poultry and other agricultural and horticultural operations, available labor was better utilized, fishes produced could be termed as 'organic food', fishes could be harvested in required quantity at any time, nutritional status of the farmer was increased and supplementary income was realized.

AP-O 64

Small scale cage culture for augmenting aquaculture production in Kerala: A case with *Etroplus suratensis* (Bloch)

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Small scale aquaculture in India deems critical importance in ensuring local food security and employment. The Department of Fisheries, Govt. of Kerala has been stressing the need for introducing modern methods of small-scale cage culture as a means of increasing fish production and supplementing income and alternate employment in the rural areas. Pearlsport (*Etroplus suratensis*) species has been recently elevated to the status of the state fish of Kerala and is being popularized as a suitable candidate species for cage culture through the agencies of the Department of Fisheries. The species commands a very high price of Rs 400-450/kg in the peak season. The popularization of this technology was initiated with the identification and training of prospective farmer groups by the agencies of the State Fisheries Department. The present study probes the effects and consequences of cage culture technology adoption among farmers based on primary data collected from sample respondents during the initial year of culture. A total 268

farmers belonging to 88 groups spread in 21 panchayaths in the coastal districts (Trivandrum, Kollam, Alappuzha, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur and Kasaragod) actively involved in the cage culture program were interviewed to understand the culture technology, socioeconomic status, level of motivation of the farmers and their extent of involvement in the adoption of new technology. Sixty two percent of farmers received practical training from the Department of Fisheries 30% from BFFDA. The size of the cages used for culture varied between 2 to 2.25 m in length, 1.25 to 1.5m in width and depth. Farmers were provided with double walled cages for avoiding the damage to nets by crabs, rats, etc. and several groups (75%) used additional outer cover nets for increased protection. Seeds sourced from local water bodies and procured from seed collectors were used for stocking. Shortage of seeds and the absence of an appropriate feeding strategy suitable for the species were the major impediments in the development of cage culture of pearl spot. With appropriate interventions, cage culture holds the potential to revive and augment aquaculture in the state through its most preferred fish

AP-O 65

A simplified technology for controlled breeding and seed production of pearlspot, *Etroplus suratensis* (Bloch) in cages

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Pearl spot, *Etroplus suratensis* commands good market price as a delicacy and table fish in southern India especially in Kerala. It can be economically cultured in ponds and cages. However, for farming of this fish, large scale requirement of seed may be a limiting factor. The present study helps in evolving a simple method of breeding of pearlspot in cages which



can be easily adopted by the farmers. Nine different trials were conducted utilising different cage sizes (1x0.37x1m, 1x0.75x1m, 2x1x1m), soil containers making available different soil area and depth (rectangular containers, 450*300*70 mm, 450*300*150 mm, 600*400*300 mm, circular containers, 500 mm diameter, height 300 mm) and different soil types. Three to seven brood fish (exceeding total length > 140 mm) were selected based on colouration and appearance of genital papillae and stocked in each of the cages. Water quality parameters recorded during the course of these trials were temperature-29.8-31.4 °C, pH-7.7-8.2, salinity-30.2-31.6 ppt, total dissolved solids-31.59-32.9 ppt and dissolved oxygen 5.2-5.6 ppm. Feeding was done using commercial fish feed (crude protein- 32%; crude lipid- 5%, pellet size- 2mm). Breeding behaviour and parental care of the fish in the different cages were noted. Successful breeding was observed in the trials provided with a minimum cage size of 1*0.75*1 m, soil container filled with stable clay soil providing approximate soil surface area of 0.2 m² and a soil depth 0.25 m; suspended at a depth of 0.5-0.8 m from water surface, over which firm substrates for egg attachment like ceramic tiles, broken mud pots were suspended. Successful breeding involved a sequence of steps like pairing, territorial behaviour, clearing the surface for egg attachment, nest formation, egg attachment on substrates, deposition of hatchlings in pits, guarding the eggs and hatchlings, parental care of the larvae and fry. Hatchlings (850-1500 nos) collected from few cages were reared successfully on live feed (rotifers and artemia nauplii) and commercial larval feed, while in other cages; the hatchlings were allowed to grow with parental care. The success of these trials revealed that pearlspot breeding can be done in small cages suspended with substrates for egg attachment and soil for nesting. A battery of such cages for large scale seed production and easy operation, facilitating collection of hatchlings and fry can be installed in the ponds.

AP-O 66

Effect of stocking density on growth and survival of indigenous catfish, *Ompok bimaculatus* (Bloch, 1794) larvae

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Ompok bimaculatus (Bloch, 1794) is a freshwater catfish species native to India, Bangladesh, Pakistan and Myanmar belonging to the family Siluridae, order Siluriformes. In India, it has wide geographical distribution covering West Bengal, Bihar and North Eastern States of India as well. It is a piscivorous and carnivorous fish inhabiting the lakes, ponds and rivers from an elevation of 100 to 2500 m. *O. bimaculatus* is a highly priced, delicious and well preferred fish because of its unique lipoprotein texture with soft bones, good taste and high nutritional value. Over the last ten years, its wild population has undergone a steady decline (>50%) mainly due to over exploitation, loss of habitat, disease, pollution, siltation, poisoning, dynamite and other destructive fishing, due to which it is listed among the 91 endangered fish species of India according to IUCN status. In aquaculture it did not receive much attention due to lack of sufficient information regarding its breeding potential, larval rearing and culture technology. To promote its conservation, this fish has been declared as the state fish of Tripura in 2007. Recently, the breeding technology has developed in Tripura but its larval rearing technique needs standardization. Hence, an attempt was made to determine the effect of stocking densities on the growth and survival of *O. bimaculatus* larvae for a period of 28 days in trays in the laboratory. The trays were assigned to five treatment groups (20, 40, 60, 80 and 100 larvae/tray i.e. 2, 4, 6, 8 and 10 larvae/l) each having three replicates. The hatched larvae (initial size: 2.35 ± 0.01 mm and 1.14 ± 0.01 mg) were stocked and fed by mixed



zooplankton. The treatments had significant ($p < 0.05$) effects on growth and survival of larvae. Wet weight of the larvae was found to have significantly decreased ($p < 0.05$) at the end of 14 and 28 days of rearing as the stocking density increased. The final gain in length was 10.6 ± 0.20 , 8.4 ± 0.12 , 8.04 ± 0.12 , 5.24 ± 0.12 , 5.31 ± 0.21 mm and larvae reached to 22.48 ± 0.70 , 16.64 ± 0.23 , 16.35 ± 0.15 , 11.45 ± 0.26 , 11.09 ± 0.37 mg over the period of 28 days in respective treatments. The specific growth rate of larvae recorded were 8.04, 6.98, 6.92, 5.64 and 5.52% and percent weight gain was 856, 608, 595, 387 and 371 in the respective treatments. The survival rate up to 28 days was found 72.25, 71.25, 71.45, 55.43 and 45.75% at the respective treatments. The observation corroborates that this catfish larvae can be reared at low densities in stagnant water conditions. Considering the value of larval growth, survival and overall weight gain, the stocking density of 6 larvae/l has been identified as the maximum for larval rearing of *O. bimaculatus* under hatchery conditions.

AP-O 67

Changing trends in the traditional culture practices of freshwater fish among the fish farmers in the northeast region of Cauvery in Sirkali block, Nagappattinam District, Tamil Nadu

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Under the Coastal Bio-village programme of M. S. Swaminathan Research Foundation (MSSRF), a research centre viz., 'Fish for All' was initiated based on the activities and needs assessment of the fishing communities in the tsunami affected areas. JRD Ecotechnology Centre at MSSRF has been working for the last five years through "Fish for All" centre, adopting the concept of improved methods of freshwater fish culture.

The major activities to this direction include capacity building, training on sustainable aquaculture, ensuring access to government departments and available schemes, and use them to help the fish farmers. In this region, more than 90% of the freshwater fish farmers belonging to small scale or marginal category with holdings of less than 0.5 acre to 5 acres per individual. They are largely unorganized and scattered. The farmers mostly opt traditional methods for operating their farms and do not have access to technological innovations and improved methods. Issues identified among the farmers were difficulties in collection of seed from riverside for culture, non-availability of quality fish seed, high fingerling mortality during transportation from hatchery, small size of fish at harvest (stunted growth), lack of technical assistance, lack of skilled workers, high capital cost, middle men commission, non-availability of industrial power tariff for fish farming, lack of contact with government fisheries department, their schemes etc. The details of interventions of 'Fish for All' researchers in helping the fresh water fish farmers to overcome the constraints, and the details of experiments involving 152 farmers are discussed in this paper.

AP-O 68

Spawning, intracapsular development and production potential of viable juveniles of the murex *Chicoreus virgineus* var. *ponderosa* (Sowerby) under laboratory conditions

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Muricids are commercially important gastropods and are exploited for food and shell craft industries. They also occupy a niche in ornamental keeping. Studies on the larval development of muricids in Indian waters are few. Hence, a study was undertaken with focus on the captive brood maintenance, egg laying, intracapsular development and production



potential of individual brooder (size/weight: 80-110 mm/49-169 g (95 mm/112 g). Airlift water circulation system fitted in 1 t FRP tanks having an overturn of 300% water was found suitable for maintenance and maturation of brooders with near cent percent survival over a year of maintenance. An average feeding rate of 20 g live clam /brooder/week was found to be sufficient for maintenance of healthy brooders for spawning. Spontaneous breeding commenced from June 2009 and continued till October '09. Number of egg cases in each spawning varied between 110-140 and got reduced to 10-40 towards the end of the season. Number of eggs within the egg case was highly variable ranging from 100-380. Egg cases were vase shaped and measured 1.2-1.5 cm in height. Eggs were spherical, embedded in jelly mass within the egg case and measured 510-608 μ (578 μ). Intra capsular development is detailed and compared with the earlier report on this species from other areas of Indian coast. Development took nearly 20 days and only few free living juveniles measuring between 1.7-1.9 mm emerged and the rest of the eggs functioned as 'Nurse eggs'. The hatching rate of egg case ranged from 60-100% (78%). Average net production potential of a viable egg case recruited into the habitat was estimated to be 6.7 nos for *C. virgineus* var. *ponderosa* of Gulf of Mannar.

AP-O 69

Acclimatization and growth performance of *Oreochromis mossambicus* in seawater and freshwater conditions

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Gradual acclimation of fingerlings of *Oreochromis mossambicus* from freshwater to seawater was carried out in FRP tanks under laboratory condition. Salinity was increased at a rate of 7 ppt/day and water temperature was

maintained at $29.0 \pm 1^\circ\text{C}$. The duration taken to acclimatize the tilapia fingerlings from freshwater to seawater was 5 days. Experiments were also conducted consecutively to compare the growth and survival of *O. mossambicus* acclimated to full-strength seawater (35 ppt). Similarly, growth and survival of *O. mossambicus* in freshwater was also evaluated as control. At the end of the 30 days experiment, results showed that the fingerlings of *O. mossambicus* in seawater had higher mean body weight (0.15 g/day), faster mean weight gain (4.40 g) and specific growth rate (0.15 % g/day) and higher survival rate (96 %) when compared with fingerlings of *O. mossambicus* in freshwater. Paired t-test confirmed that mean growth values showed significant ($p < 0.05$) differences between freshwater and seawater.

Parameter	Freshwater	Seawater
Mean initial length (cm)	7.30	6.50
Mean final length (cm)	8.10	7.80
Mean increase in length (cm)	0.80	1.30
Mean initial weight (g)	8.40	5.20
Mean final weight (g)	11.10	9.60
Mean weight gain (g)	2.70	4.40
Average daily growth - ADG (g/day)	0.09	0.15
Initial number stocked (numbers)	25	25
Final number obtained (numbers)	24	23
Survival rate (SR)	96	92
Specific growth rate – SGR (%/day)	0.92	2.04
Pellet feed fed (kg)	0.315	0.195
Total weight gain (kg)	0.0675	0.0110
Feed conversion ratio (FCR)	1: 4.70	1: 1.80

AP-O 70

Growth assessment of spiny lobster, *Panulirus homarus* under open sea cage culture in Tharuvaikulam, Thoothukudi, Southeast coast of India

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The potential for using suspended floating open sea cage for the aquaculture of juvenile



spiny lobsters, *Panulirus homarus* was assessed by rearing in small floating cage moored at Tharuvaikulam village of Tamil Nadu coast, south east of India. Juvenile lobsters were grown for 101 days in open sea cages at Tharuvaikulam coastal waters and regularly fed with live clam as natural feed in order to evaluate their growth, survival and feasibility for culture. Juvenile lobsters with average weight of 75.75 g in the cage grew to an average weight of 104.50 g in 101 days with average wet weight gain and survival rate of 28.75 g and 88.50 % respectively. Student's t-test confirmed that mean growth values showed significant ($p < 0.01$) difference between the cages. One way ANOVA test also confirmed that mean growth values of spiny lobster showed significant difference ($p < 0.05$) among different cages. This result clearly indicates that floating open sea cage culture has considerable potential for the aquaculture of spiny lobster juveniles, but, requires the careful site selection and effective feeding.

A. Stocking Details

(Days of Culture	101
Total number of cages	08
Stocking rate / cage (numbers / cage)	250
Mean final length CL at the time of harvest (cm)	12.60
Mean body weight at the time of stocking (g)	75.75
Mean body weight at the time of harvest (g)	104.50
Total number of juvenile lobsters stocked	2000
Final numbers harvested	1770

B. Non – recurring costs - cost of the cages (Rs.)

1,04,000.00

C. Recurring costs (seed, feed, transportation, labour, maintenance etc.) (Rs.)

94,300.00

D. Harvest Details

Total harvested weight of lobsters (kg)	185.995
Selling price (Rs./ kg)	1100.00
Cost of production (Rs./kg)	
(Rs. 94,300 / 185.995 kg)	507.00
Net profit / kg –(Rs./kg)	
(Rs. 1100 / kg – Rs. 507 / kg)	593.00

AP-O 71

Captive breeding of *Heteropneustes fossilis* (Bloch) under controlled conditions at Raipur, Chattisgarh

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Heteropneustes fossilis popularly known as 'singhi' breeds in natural waters. The demand of this fish is quite high owing to its good taste and flavour and fetches high market value. A simple, low cost hatchery with water flow through system was established at Raipur, Chattisgarh for breeding this species. The present paper discusses the results of the breeding trials conducted in the hatchery during July 2011. For the breeding trial, 10 numbers of female and 20 numbers of male brooders were selected for induced breeding. The brooders were injected with ovaprim @ 0.5 – 0.8 ml/kg body weight. An average fertilization rate of 90% was obtained. The hatching results were encouraging with 90% survival from egg to spawn stage, while 70% larval survival from fry to fingerling stage was achieved under three tier system. A total of 25,000 fingerlings were produced from the hatchery. The larvae grew up to 10 – 20 mm in 12 – 15 days of rearing in cement cisterns. After the yolk-sac absorption on the 4th day, the larvae were fed with plankton, egg custard and *Artemia* nauplii, thrice a day. During the trial, all the sets were bred successfully with no mortality of the brooders.

AP-O 72

Comparison of growth and colouration in *Carassius auratus* (Linnaeus, 1758) under different culture systems

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The present experiment was conducted for a period of 60 days to compare growth and



colouration of *Carassius auratus* under three different culture systems viz., aquaria (AQ), cement tanks (CT) and cages (CG) suspended in pond. Fry of gold fish with mean length 4.1 ± 0.19 cm and mean weight 2.26 ± 0.24 g were stocked @ 0.2 nos./l and fed with marigold (*Tagetes erecta*) enriched diet at 5% of body weight. Highest ($p < 0.05$) growth was recorded in cages (8.14 ± 0.29 cm and 7.96 ± 0.70 g) followed by cement tanks (7.13 ± 0.17 cm; 6.46 ± 0.22 g) and aquaria (6.51 ± 0.13 cm; 5.65 ± 0.14 g). Survival was highest in aquaria (68%) followed by cages (60%) and cement tanks (59%). Fish skin colour parameters reacted differently according to culture systems. After 60 days of rearing, lightness (L^*) and whiteness (W^*) values decreased in all three systems and highest ($p < 0.05$) was observed in aquaria (L^* , 49.0 ± 1.18 ; W^* , 23.5 ± 1.43) followed by cement tanks (L^* , 45.2 ± 1.01 ; W^* , 17.9 ± 0.59) and cages L^* , 41.54 ± 1.31 ; W^* , 11.50 ± 1.04). Redness (a^*), yellowness (b^*) and saturation (C^*) values increased in all three systems and highest ($p < 0.05$) was noticed in cages (a^* , 36.29 ± 1.07 ; b^* , 55.48 ± 1.33 ; C^* , 66.46 ± 1.01) followed by cement tanks (a^* , 31.3 ± 1.11 ; b^* , 52.4 ± 1.22 ; C^* , 61.05 ± 0.87) and aquaria (a^* , 22.6 ± 1.08 ; b^* , 45.7 ± 1.8 ; C^* , 57.8 ± 0.48). Muscle carotenoid content was highest ($p < 0.05$) in caged fish (24.80 ± 1.44 $\mu\text{g/g}$) followed by cement tanks (19.26 ± 0.63 $\mu\text{g/g}$) and aquaria (12.26 ± 1.13 $\mu\text{g/g}$). On termination of the experiment, significant differences were recorded in the final mean length, mean weight, percent weight gain, SGR, FCR, FER, PER, colouration and muscle carotenoid content of gold fish, between aquaria, cement tanks and cages.

AP-O 73

Possibility of using vermicomposting technology for recycling organic wastes in aquaculture

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With the increasing thrust on use of organic inputs in aquaculture, attention is now being paid on recycling of different kinds of organic wastes for this purpose. However, for effective utilisation, these organic materials, need to be composted properly in order to avoid development of unhygienic conditions in the culture system. The traditional methods of composting of organic wastes being complicated and time consuming, efforts are now being made to decompose these organic materials through more efficient techniques. Under this context, vermicomposting technology has now emerged as a simple as well as effective method for transformation of wide ranges of organic waste materials into good quality compost within a short period of time with the help of earthworm gut microorganisms. In the present study, the possibility of using this technology for increasing primary productivity of water under mesocosm conditions was assessed. Since large amount of chemical fertilizers are generally applied in fish ponds for enhancing the abundance of fish food organisms, the potential of reducing the quantity of such fertilizer application with the use of vermicompost was investigated. Organic waste materials, collected from a vegetable market, was subjected to traditional composting without earthworm and also using epigeic earthworm *Eisenia fetida*. Both these composts were used to prepare different combinations along with mineral fertilizers and were added to a soil-water mesocosm system. Use of vermicompost in the aquatic system yielded better results in terms of primary production. Application of this kind of compost tended to reduce the quantum of chemical fertilizer input in the culture system. This was attributed to larger occurrence of different plant nutrients and also to the presence of various plant growth promoting substances, antibiotics, vitamins etc. in vermicompost which would have promoted the growth of the primary producers in water over the conventional method of composting.



AP-P 01**Larval rearing of scarlet skunk cleaner shrimp, *Lysmata amboinensis* and fire shrimp, *Lysmata debelius***

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In recent years, lots of effort has been made globally to develop aquaculture protocols for the marine ornamental shrimps, especially, the species of the genus *Lysmata* (cleaner shrimp). These species are very popular in the marine aquarium trade and their trade is fully dependent on wild collections. Although it has good culture potential, it is not yet raised on a commercial scale. These coral reef inhabitants are considered to be key species in the natural habitat and their culture is of conservation interest also. The incubation and larval development (up to sixth stage) of these two species was clearly studied under laboratory conditions and is described and illustrated. The morphology of larval stages is compared with previous descriptions of the closely related species of the genus. The biggest bottleneck for commercial production is the long and variable larval durations. Several larval diets have been tested (microalgae, rotifers, decapsulated cysts, newly hatched nauplii of *Artemia*, meat suspensions, microencapsulated and pelleted feed), but survival beyond 55 to 60 days could not be achieved, mainly due to the lack of suitable diet or the requirement of association with some invertebrates from their natural habitat. The species seems to be highly species dependent in association even during the larval stages.

AP-P 02**Adoption of pen culture technology developed by Central Inland Fisheries Research Institute (CIFRI) in Sonitpur district of Assam**

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Central Inland Fisheries Research Institute (CIFRI) developed pen aquaculture technology using locally available and low-cost materials for raising carp fingerlings as stocking materials in the beels of Assam state based on extensive field trials conducted during 1996-1998. The technology so developed was demonstrated in several beels of the state under National Agriculture Technology Project (NATP) (Jai-Vigyan sub-project) during 2000-2004. In Sonitpur district of Assam, pen culture technology was found to be adopted by Self-Help Group (SHG), Non-governmental Organization (NGO) or other local organizations. One SHG (*Rangapani Beel Atmasahayak Got*) in Rangapani beel (N 26°41' & E 92°49') near Tezpur University adopted pen culture for raising table-size carps. Two numbers of pen enclosures covering 0.24 ha area each were erected in the beel at a cost of Rs.1, 30,844/- during 2008-09 under Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS). The District Fisheries Office, Sonitpur provided the technical guidance broadly following the package developed by CIFRI. The groups stocked were *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Hypophthalmichthys molitrix*, *Cyprinus carpio* and *Ctenopharyngodon idella* @ 6000 fingerlings/ha and fish production obtained was impressive (2,400 kg/ha). Another SHG, Nayanjyoti of Parmaighuli, Balipara Block, Sonitpur also took up pen culture in Rangapani Jan beel in April 2010 with partial financial assistance from Sonitpur District Fisheries Office. The total cost including construction, seed and feed was Rs. 1.06 lakhs, of which 85% was borne by the Fisheries Department. Another pen culture activity was successfully taken up by an NGO (Maandal) in Kachu beel (N 26°49' & 92°48'), Chiloni, covering an area of 1.35 ha in the year 2009-2010 involving a total cost of Rs. 3,73,950/-. In addition, pens constructed by Amarijyoti SHG in Rangapani beel were badly damaged by flash floods. On the other hand,



pen culture operations by Kachu beel Agragami Samiti in Kachu beel was adversely affected by predators such as tortoise, crabs, otters, snakes etc., since they did not take appropriate pre and post-stocking management measures in the pens.

AP-P 03

Effects of salinity on survival and development of zoeal and megalopal larvae of the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758)

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The blue swimmer crab, *Portunus pelagicus*, is a commercially important and a potential aquaculture species in the Indo-Pacific. The larval development of *P. pelagicus* includes four zoeal stages and a megalopa stage. The present study has been conducted to find out the salinity/salinity range suitable for the maximum survival of larvae at zoeal and megalopal stages by rearing them in the laboratory. After initial salinity tolerance trials, seven salinities, i.e., 13, 18, 23, 28, 33, 38 and 43 ppt were selected for the experiment. In zoeal experiments, newly hatched healthy zoea-1 (Z_1) larvae were used with five replicates. Each replicate consisted of 30 Zoea-1 (Z_1) larvae stocked in a 600 ml beaker filled with 500 ml filtered seawater. Aeration was provided to each beaker through fine glass tubes. Feeding pattern was similar in all treatments (Z_1 - rotifer 30/ml & Z_2 onwards rotifer 15 no./ml & *Artemia* nauplii 5 no./ml) and temperature was kept constant at 29 °C, throughout the experiment. The survival and development of the larvae through each zoeal stage were recorded. Results showed that the survival and development of zoeae were best at 28‰. For megalopal experiments, based on the conclusions from the preliminary studies, seven salinities were selected as in the

zoeal stage, from 13 to 43 ppt., with an interval of 5 ppt. To avoid cannibalism, megalopae were reared individually in 100 ml polycarbonate containers, with 30 replicates in each treatment. All the treatments were fed with freshly hatched nauplii (5no./ml) and temperature was kept constant at 28 °C. Each container was closely monitored early morning and evening hours and 4th day onwards observations were also made between 14-15 h to check the moulting of megalopa to crab stage. Result of the salinity studies reveals that 23‰ is the best salinity for the megalopal development and metamorphosis of the crab larvae. At this level of salinity the minimum period required to reach crab stage was 5 days and 60% of the baby crabs produced was moulted on 5th day. It is also clear that for large scale production a range between 23-25‰ is ideal for rearing megalopae.

AP-P 04

Growth performance and nitrogen budgets in fingerling rearing of rohu with organic and inorganic fertilization

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An experiment was conducted in 1 m³ circular cement tanks for 90 days to assess the effect of organic and inorganic fertilizers applied alone as well as in combination on fish growth, water and sediment quality and nitrogen recovery in the experimental tanks. Each tank was stocked with early fingerlings of rohu (*Labeo rohita*) with an average weight of 2.1 g. The four manurial treatments, besides a control, evaluated in triplicate were: application of cowdung @ 43 t/ha/yr (T-1), cowdung @ 10 t/ha/yr, 100 kg N, 50 kg P/ha/yr (T-2), poultry manure @ 3 t/ha/yr, 86 kg N, 30 kg P/ha/yr (T-3), Inorganic fertilizers @ 130 kg N and 68kg P/ha/yr (T-4). Supplementary feed



comprising a mixture of rice bran and groundnut oil cake (1:1 by weight) was provided in the form of moist dough twice daily. Most of the water quality parameters in different treatment tanks were within optimum ranges throughout the experimental period. After three months of rearing, T-3 recorded significantly higher fish growth and production ($p < 0.05$) over other treatments. The budget showed that artificial feed was the main source of nitrogen input which accounted for 50.0-57.9% of the total input, while manuring contributed 35.5-42.9%. Results indicated that only 33-42% of the nitrogen were recovered in the harvested fish, with maximum recovery in T-3. The nitrogen retained in water medium was within 13.025.0% of the total inputs. About 40.0-53.2% of nitrogen accumulated in the sediments of the treatment units, while the accumulation level was significantly less in control (24.7%). The information generated under the present study would help to reduce the nutrient loss in the culture system and thus, minimizing the environmental impact of the effluent water.

AP-P 05

Effect of different stocking densities on growth and survival of hatchery reared Asian seabass, *Lates calcarifer* (Bloch) under captive conditions

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A pilot scale open sea floating cage culture experiment has been undertaken since 2007 at Visakhapatnam coast of India in the Bay of Bengal by CMFRI. The success in open sea floating cage farming mainly depends on the availability of appropriate size seeds. The commercially available hatchery produced seeds are to be further reared before stocking

into sea cages. Holding of hatchery reared seeds to produce a fingerlings at suitable stocking size is an obstacle in sea cage culture. To address this issue an experiment was conducted to study the effect of different stocking densities on the growth and survival rate of hatchery reared Asian sea bass, *Lates calcarifer*. Fishes with a mean total length of 23.9 ± 3 mm and mean body weight of 0.45 ± 0.05 g were stocked in a 5 t FRP tank with 3.5 t of filtered seawater at three different stocking densities namely 1000 nos. m^{-3} , 1500 nos. m^{-3} and 2000 nos. m^{-3} in triplicate. The fishes were fed with commercial dry pelleted feed (Godrej) at 6-8% of fish biomass. The feeding was done at every 4 h in a day with six equal intervals. Water quality parameters were well within the favorable ranges for sea bass culture. The growth and survival under different stocking density was monitored for a period of 90 days. Results observed from these experimental trials showed that the Specific Growth Rate (SGR) was inversely proportional to that of the stocking density ($p < 0.05$), but not much variation was noticed in the survival rate. An overall high biomass production of 1.11 kg/ day was obtained in high stocking of 2000 nos. m^{-3} . The results of this preliminary experiment indicate that these high stocking density techniques with proper feeding and water quality management can be used to produce large number of sea bass fingerlings at stackable size to enhance the open sea cage culture activity.

AP-P 06

Studies on benthic detrital aggregate formation in cultured shrimp pond

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In many cases, aquatic ecosystems are largely sustained by recycling dead organic matter rather than by direct consumption of net primary production. Even though the effects of nutrient enrichment on consumer-resource dynamics are relatively well studied in ecosystems based



on living plants, little is known about the manner in which enrichment influences the dynamics and productivity of consumers and resources in detritus-based ecosystems. Aquaculture systems (like shrimp culture) depends on microbial food web-dependent on microalgae i.e., dead organic matter. Shrimps are known to feed on both algae and detritus with its associated microorganisms. Further, inorganic nutrients released from decomposing detritus stimulate primary production. In the present study, we analyzed water quality, sediment texture as well as sediment nutrients in the detritus collected from shrimp culture ponds. Samples were primarily used to measure the settling volume and further used for estimation of total organic carbon, total nitrogen and total phosphorus for a period of sixty days. Initially the detritus aggregation/settling volume was found to be very less, viz., 4ml/l to 8ml/l and reached upto maximum of 10.3ml/l. TOC concentration ranged between 2.462 to 3.101%; TN ranged between 289.96 to 347.60 mg/100 g and TP was ranged between 65.76 to 67.01 mg/100 g. The primary production values explain that the entire pond was almost evenly distributed with phytoplankton population in which bacillariophyceae dominated.

Benthic organisms are more dependents on detritus based food web and good source of carbon, nitrogen and phosphorus and dominated by spats and polychate. These nutrients are so much essential for shrimp growth as well as influence benthic productivity. The results showed that there was not much variation or fluctuation of these materials

AP-P 07

Effects of stocking density of fry of *Ompok pabda* on survival and growth of fingerlings

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Two experiments viz., E-I and E-II were conducted for rearing of fry to fingerlings of

Ompok pabda in FRP tanks (1.3 m² each), at different stocking densities (1, 2, 3, 4 and 5 lakh/ha) each with three replicates to find out the effect of stocking density on survival and growth of fingerlings. In E-I, the stocking densities, initial size and culture period were respectively 1-2 lakh/ha, 26.1 ± 1.19 mm / 0.06 ± 0.005 g and 112 days. In E-II, the stocking densities, initial size and culture period were respectively 3, 4 and 5 lakh/ha, 25.3 ± 0.39 mm / 0.15 ± 0.005 g and 95 days. Unchlorinated borehole water was used for rearing. Water was replenished at every alternate day from the FRP tanks for first 15 days and thereafter at an interval of 3-4 days to remove the left over food. Fish were fed *ad libitum* with tubifex initially for 37 days of rearing and thereafter upto next 13 days with mixture of both tubifex and boiled chopped chicken viscera and finally only with boiled chopped chicken viscera. Plastic pipes and hydrilla plants were provided as artificial shelters/hideouts.

The survival percentage of fish in E-I and E-II ranged from 74.6 to 97.77 and showed no significant difference among the stocking densities. Average size attained within 112 and 95 days of rearing in different stocking densities ranged from 77.4-100.56 mm / 2.42-3.5 g and 57.23-75.9 mm / 1.15-2.95 g, respectively. The final average body weight, average body weight gain and growth rate were significantly ($p < 0.05$) decreased in higher stocking densities than that of lowest stocking density in both the experiment (E-I and E-II); however, these growth parameters were comparable between the stocking density 3 and 4 lakh/ha, and 4 and 5 lakh/ha. Comparison of the pooled data from these two experiments indicated significant ($p < 0.05$) lower growth in higher stocking densities (2-4 lakh/ha) compared to the lowest stocking density (1 lakh/ha). But at the stocking density of 5 lakh/ha, apparently a higher growth has been noticed compared to densities of 2-4 lakh/ha. Such growth may be due to lower survival and higher liberation size. From the present experiment, it is concluded that the fry



of *O. pabda* can be reared at densities up to 5 lakh/ha to for fingerling production. However, there is further scope for studies at still higher stocking densities.

AP-P 08

Present strategy of shrimp aquaculture in India with special reference to *Litopenaeus vannamei*

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Aquaculture, probably the fastest growing food producing sector now accounts for nearly 50% of the world's food fish. Aquaculture in India, in general is practiced with low to moderate levels of inputs. India utilizes only about 13% of the total potential brackish water resource of 1.2 million hectares. Currently about 19% of the shrimp farmers in India own < 2 hectares, 6% between 2 – 5 hectares and the remaining 3% have an area >5 hectares. Out of the total area of 1,008,788 hectares presently being utilized for shrimp farming in the country. Andhra Pradesh utilizes 44% of the area and contributes 39% of the total production followed by West Bengal. Present study involved visiting shrimp farms and hatcheries in various parts of India and collecting data on various technological aspects and production statistics. The study reveals a demarkable deviation from the long esteemed tiger shrimp (*Penaeus monodon*) farming to newly introduced Pacific white shrimp (*Litopenaeus vannamei*). Despite the presence of various regulations, the farmers are ready to accept *L. vannamei* due to problems that they face with the culture of existing species and the perceived production benefits of the alien species. Among the various advantages over the culture of *L. vannamei*; availability of SPF brood stock and culture with higher stocking densities enables the production of high numbers of shrimp in limited areas, resulting in better

productivity per unit area than that currently achievable with *Penaeus monodon* in India.

AP-P 09

Growth performance of olive barb, *Puntius sarana sarana* (Hamilton) in a recirculatory system

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The olive barb, *Puntius sarana sarana* (Hamilton, 1822) is a widely distributed cyprinid in the waters of South Asia. As a medium carp, the species has high market demand. However, the natural stocks of this species have depleted over the years and is now categorized as a vulnerable group.

A three-month long fingerling rearing study was conducted in a water recirculatory system employing four different feeding rates, viz., 4, 8, 12 and 16% and were designated as T₁, T₂, T₃ and T₄, respectively; each treatment had three replicates. Initially, 30-day-old fingerlings with an average weight of 1.5 g were stocked in each of the 100 l capacity fibreglass tanks and fed with a commercial sinking pelleted feed (2 mm diameter). A survival of 100% was recorded in all the treatments. The overall net weight gain was 3.01, 4.10, 4.39 and 5.30 g in T₁, T₂, T₃ and T₄ respectively. Significantly higher net biomass gain was obtained in T₄ over the other three treatments. The corresponding FCR values were 11.5, 38.0, 31.9 and 61.3. The survival was 100% in all the treatments.

Table Average weight (g) of *P. sarana sarana* at fortnightly intervals

Treatment	Initial wt.	15 days	30 days	45 days	60 days	75 days	90 days
T ₁	1.5	1.83	2.46	2.76	2.88	4.42	4.51
T ₂	1.5	2.66	3.43	4.3	4.67	5.3	5.60
T ₃	1.5	2.2	3.32	4.40	4.48	5.7	5.89
T ₄	1.5	2.73	3.85	6.18	6.24	6.64	6.80



AP-P 10**Survival of Asian seabass, *Lates calcarifer* (Bloch, 1790) fingerlings during transportation in open FRP tanks under different densities**

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Asian seabass (*Lates calcarifer*) fingerlings with an average length and weight of 167mm and 38 g that were reared in 2 m diameter HDPE circular floating seed cages in the estuary and in brackish water ponds at Choumukh, Balasore, Orissa and were transported to Visakhapatnam, Andhra Pradesh. Fishes were first acclimatized in the pond in hapas without feeding for eight hours prior to transportation. Considering the size of the stockable fingerlings, they were transported in six open FRP tanks of 2000 litres capacity each, over a period of 22 hours covering a distance of 650 kilometers. The tanks were filled with 1800 litres of the same pond water in which fishes were reared and oxygenated with oxygen supply from oxygen cylinders kept in the truck to maintain the oxygen at saturation of water in each tank. All the tanks were kept open and covered properly with nets to avoid fish jumping out during transport. The average water quality parameters while stocking the fish in the tanks with reference to water temperature, salinity, pH, D.O. and ammonia were 25°C, 21 ppt, 7.8, 7.2 mg/l and 0.001 mg/l respectively. Sea bass fingerlings were placed in the tanks in duplicates at three different densities of 400 nos. (Treatment 1), 600 nos. (Treatment 2) and 800 nos. (Treatment 3) per tank. Transportation started in the afternoon at 16:00 hrs. and reached the site by 14:00 hrs (next day) covering a distance of 650 km in the month of October,

2009. It was observed that highest percentage of survival (98 %) was recorded in treatment 1, followed by 90 % in treatment 2 and 63 % in treatment 3. Water temperature increased by 21.8 % (32°C) in all the tanks with slight difference in the dissolved oxygen concentrations (reduced to 6.9 - 6.5 mg/l) during transport. Total ammonia increased significantly in treatment 3 (0.019 mg/l) over treatment 2 (0.012 mg/l) and 1 (0.009 mg/l). Mortality rate was highest in treatment 3 (37 %) than in treatment 2 (10 %) and treatment 1 (2%). Higher mortality in treatment 3 may be attributed to higher density that caused increase of ammonia levels. Low density associated with low ammonia levels in treatment 1 resulted in higher survival. From economical point of view it is concluded that treatment 2 (600 fingerlings /1800 l) is suitable for open transport of seabass under above mentioned conditions. However it is possible to transport seabass fingerlings of the same size with little more density with partial replacement of water of same salinity midway with provisions for stable water temperature in the tanks.

AP-P 11**Suitability of farm ponds for aquaculture in different regions of Dakshina Kannada district**

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The state of Karnataka in south-west India has an excellent tropical climate for the development of freshwater fish farming in a variety of aquatic bodies. Various aquatic water bodies are available for this purpose with less input and are mainly used for irrigation of agricultural crops and livestock rearing. These water bodies which are otherwise known as farm ponds are effectively utilized for storage of water, wherein freshwater fish seed rearing activities is now been initiated. The coastal district of Dakshina Kannada is known for its farming of



coconut, arecanut, rubber, banana, rice, fishing activities in the sea etc. The effective utilization of farm ponds located in the agricultural fields has been considered in the present study to examine whether they are best suited for fish seed rearing and to know the impact of various physico-chemical characteristics of selected ponds on growth and survival of fish. Altogether, three different regions comprising of four ponds located at different elevation of Dakshina Kannada district have been identified for the present study. Various physico-chemical characteristics of water and sediment have been analyzed over a period of 9 months. A monthly sampling was carried out to record the growth of stocked fish. Qualitative and quantitative analyses of plankton were also done during the course of study period.

The physical and chemical parameters influenced the growth of fish in the farm pond. The physical parameter water temperature (24.1°C to 35°C) and chemical parameters dissolved oxygen (3.91 to 8.71 mg/l), pH (4.2 and 8.6), CO₂ (3.87 to 19.36 mg/l), nitrite (0.05 to 4.73 µg at./l), nitrate (0.64 to 9.52 µg at./l) and phosphorus (0.3 to 6.83 µg at./l) these maintained the optimum condition of the farm pond that influenced the growth of fish. The sediment characteristics of farm pond also play important role in maintaining the pond water quality. Sediment pH (5.06 to 6.94), available nitrogen (58.03 to 304.53 kg/ha), available phosphorus (15.40 to 563.05 kg/ha) and organic carbon (0.51 to 5.76 %) were also recorded. Four phyla of phytoplankton and zooplankton were recorded. The fish species cultivated are catla, rohu the maximum and minimum length and weight recorded ranged between 242.67 - 162.6 and 355.13 - 178.47g respectively.

AP-P 12

Groundwater modeling in shrimp farming areas

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Understanding the functioning of groundwater in response to coastal aquaculture is not only necessary to develop guidelines for sustainable aquaculture but also envisages integrated water resource management in coastal area. Tidal effect and salinity intrusion are two defining characteristics of coastal zones. The first causes complex variations of water level and unsteady flows in the river and stream network which is the source water for aquaculture activities, while the second is a constraint to agriculture and freshwater resources. Groundwater modelling of coastal aquifers has been widely used as an environmental tool, since the development of digital computers and appropriate numerical models. These models solve the basic partial differential equation that govern the flow of groundwater and solute transport through the saturated and unsaturated porous medium and gives the general realistic trend that is happening in the subsurface regions. Models solve the equations of more complex hydrogeological problems involving aquifer heterogeneities, anisotropic aquifer properties and complicated boundary conditions. In the present paper simulation studies conducted in coastal aquifer of shrimp farming area using Visual MODFLOW in Lower Vellar subwatershed, Chidambaram Taluk, Tamil Nadu has been discussed. The boundary extent of 68.7 sq.km has been selected and the secondary data pertaining to it has been input in the model. The litholog obtained showed that the geological strata in the study area were of three sub layers with different porosity and hydraulic conductivity. The model was calibrated with the water level data obtained from PWD. The groundwater flow model and the velocity vector were obtained and the validation of the model was done. To be precise, the observed head at Portonova is 3.55 m and the calculated head is 3.02 m implying that the reliability of the model is high. The transport modeling was done to



evaluate the rate of movement of ions in the groundwater system and the chlorine concentration was taken for transport modeling. The study showed that the transport of chloride ions were up to 1st layer and the model output at all the three layers are discussed in detail.

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Growth performance of Asian seabass (*Lates calcarifer*, Bloch, 1790) in open sea floating cage off Srikakulam coast, Bay of Bengal

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The growth performance of Asian seabass (*Lates calcarifer*) in an open sea floating cage was assessed in the Bay of Bengal off Baruva, Kothuru, Srikakulam district, Andhra Pradesh (N 18° 52' 284" E 84° 36' 156") during September, 2009 - April, 2010. The 6 meter diameter HDPE circular floating cage was fabricated on the beach near the site and installed with a single point mooring method by a gabion box filled with 4 t of granite stones through a 14 mm cross linked alloy steel chain. About 6000 numbers of Asian seabass (*Lates calcarifer*) fry was procured from private fish seed suppliers, Chennai (mean size 15 mm total length and 0.7 g), transported by air to the mariculture laboratory of VRC of CMFRI, Visakhapatnam. These were reared in the circular FRP tank of 5 t capacity to achieve a stockable size for growth trials in the open sea floating cage. These were stocked at a density of 3000 nos. per tank and fed with minced trash fish @ of 10 % biomass daily with split doses. Under continuous aeration through an air blower in all the rearing tanks 40 % water exchange was done everyday. The ranges of water quality parameters in the tanks during

the rearing period were salinity (28-32 ppt), pH (7.7-8.3), temperature (24-30° C), ammonia (0.01-0.02 ppm) and dissolved oxygen (5.23-6.23 mg/l). After a rearing period of 63 days, these survived fingerlings (66 %) were packed in 30 ppt. salinity filtered seawater in polythene bags with oxygen and transported in early hours of the day and stocked in the cage without any mortality. The cage was stocked with 4000 nos. of fingerlings and the average length and weight of fingerlings at the time of stocking in the cage were 134 mm TL/ 30.83 g wt. respectively. These were fed with trash fish available from the nearby landing centres at 6 % biomass twice daily. The fishes in the cage were grown under similar conditions for a period of 7 months. The range of water quality parameters at the cage site during the culture period were salinity (25-31 ppt), pH (7.4-8.8), temperature (22-31°C), ammonia (0.01-0.03 ppm) and dissolved oxygen (6.33-7.55 mg/l). The fishes attained harvestable size after 7 months of culture duration with the length range 141-410 mm TL and the weight range 0.35-1.4 kg respectively with an average wt. of 0.592 kg. The growth results of this experimental trial have indicated the scope for open sea cage farming of seabass in the north east region of Andhra coast.

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Studies on growth and production levels of pangas, *Pangasiodon hypophthalmus* with two feeding practices at different stocking densities

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Andhra Pradesh is one of the states with highest aquaculture production in India with modified extensive and intensive aquaculture practices. *Pangasius* is being cultured in more than 30,000 ha in Andhra Pradesh. The state has potential for species diversification which can further increase the aquaculture production in the country to meet the demand of nutritional food



security. The study was conducted to determine the growth and production levels of *Pangasius* with different stocking densities by two feeding practices. The *Pangasius* fingerlings of average initial weight 75 g were stocked @ 2000, 4000 and 6000 number/acre and fed with commercial floating feed and traditional feeding (DORB and cakes 80:20) for a period of 165 days under pond culture system.

Two feeding methods applied were broadcasting of floating feed and traditional bag feeding. At the end of the experiment, final harvest weight obtained at various stocking densities were by 810 ± 5.10 g, 645 ± 6.50 g, 550 ± 8.10 g for floating feed and 645 ± 6.50 g, 520 ± 4.50 g, 425 ± 4.90 g for traditional feed respectively. In both the feeding practices, as stocking densities increased, individual growth decreased, FCR and total gross production increased significantly. The maximum production was recorded at higher stocking densities at rate of 3.3MT/acre fed with floating feed where as in traditional feeding 2.55 MT/acre. The study revealed that the broadcasted floating feeds performance was better than traditional bag feeding in terms of higher growth and production levels. In floating feed practices, wastage is minimal and pollution free environment was observed compared to traditional bag feeding.

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Induced breeding of threatened butter catfish, *Ompok bimaculatus* (Bloch)

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The present study was carried out to develop induced breeding and larval rearing technology for *Ompok bimaculatus*, with an aim to promote its fishery in selected water bodies of Karnataka. The brooders collected from an irrigation tank (seasonal) adjacent to Markonahalli Reservoir (perennial) in Karnataka were

transported to Mangalore and acclimatized for two days. The sex of brooders was determined based on morphological features - the swollen and soft abdomen and wide and blunt genital papilla in female; firm and round abdomen and narrow and pointed genital papilla in male. The brooders were induced bred with a single dose of ovatide at 1.0 ml/kg female and 0.4 ml/kg male and also with ovaprim at a single dose of 0.80 ml/kg female and 0.3 ml/kg male. Details on breeding response, fertilization rate, hatching period, hatching rate, egg and early development and nursery rearing were recorded. The interval between hormone injection and spawning ranged between 8 and 12 h at 29-30 °C, with breeding response being either partial or complete. The fertilization rate varied between 70 and 82.4% for ovatide and ovaprim, respectively. The hatching period and hatching rate, were 20-24 h (at 26-28°C) and 72-75%, respectively. The egg and early development proceeded normally; the yolk-sac absorption period was 3-4 days. When fed on sieved plankton and chicken egg yolk suspension, the resultant fry reached 15-20 mm in six days. Of the two spawning agents tested, ovaprim was found to be marginally better than ovatide for the induced spawning of the butter catfish.

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Biofloc technology (BFT)-the futuristic technology for sustainable aquaculture

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The evergrowing demand for seafood leads to the intensification of aquaculture through high stocking density and intensification of the artificial feeding, leading to the aquaculture sector as most cost as well as waste promoting industry. Like other forms of intensive food production, industrial-scale fish farming generates significant environmental costs. The development of aquaculture has to overcome 3 major constraints: a) Produce more fish without significantly



increasing the use of basic natural resource of water and land. b) Develop sustainable systems that will not damage the environment c) Develop systems providing a reasonable cost/benefit ratio, to support the economic and social sustainability of aquaculture but aquaculture development should be in a sustainable manner. Biofloc technology based aquaculture is a sustainable solution for the development of aquaculture industry. BFT is fully based on the concept of Carbon Nitrogen (C/N) ratio. The control of inorganic nitrogen accumulation in the pond is based upon carbon metabolism and nitrogen immobilization into microbial cells. This paper discusses the origin, development, benefits, scope and future research in the field of Biofloc technology based aquaculture. Farmers can adopt this technology for increasing production by ensuring ecological and economical sustainability. The major advantages of the application of BFT to aquaculture culture systems are (i) It is the best means for the control of toxic inorganic nitrogen in water and for accumulating production of microbial protein by adjusting C/N ratio (ii) It can convert uneaten nitrogen for being utilized to produce microbial protein rather than generating toxic component (iii) Microbial protein, the end product which is suspended in the system as microbial flocs can be utilized as feed by shrimps (iv) The level of protein utilization is doubled in microbial reuse system (iv) The dense heterotrophic microbial biomass decreases the outbreak of microbial diseases and finally (v) The technology enables high yield in environmentally and economically sustainable system.

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Role of agriculture lime (CaCO_3) in shrimp, *Penaeus monodon* culture: a case study

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Role of calcium carbonate for shrimp, *Penaeus monodon* culture was studied in eight ponds (each having one hectare area) during

post-monsoon season in the area of Pitchavaram and Vellar estuary, in Tamil Nadu, India. The application of calcium carbonate not only helps to settle down the impurities in the ponds but also helps in the growth of plankton blooms, which serve as live feed organisms for shrimps. Besides, it also arrests black soil formation, which is a common problem in semi-intensive shrimp farms due to excess feeding. The PL20 of *Penaeus monodon* were purchased from shrimp hatchery and brought to site by oxygenated polythene bags, packed in insulated boxes. After proper acclimatization, the seeds were released into respective ponds at the stocking density of $15/\text{m}^2$. In all the ponds, lime was applied from small boats. Prior to lime application, the lime was diluted with water and then applied to ponds in estimated quantity, especially after water exchange. The water quality parameters like salinity, dissolved oxygen, temperature and pH were observed continuously. Lux Waterbase feed was used for feeding the shrimps. Generally the feed management was followed based on the chart provided by the 'Lux Waterbase' Company with slight modifications. The present study, showed that the ponds applied with 3-6 t with of $\text{CaCO}_3/\text{ha/crop}$ yielded better production (<2.2 t for the stocking density of $15/\text{m}^2$) compared to other ponds (>1.4 t for the same stocking density). Excess continuous application of CaCO_3 for a week at the rate of 100 kg/day/ha, resulted in clogging of lime in the gills of shrimps, causing respiratory problems. This can be overcome by continuous exchange of 25% water per day for a week.

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Aquaculture prospects of Indian river prawn, *Macrobrachium malcolmsonii* (H. Milne Edwards) in India

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Macrobrachium malcolmsonii has gained popularity and rose to prominence for its



capacity to earn foreign exchange. However, general decline in juvenile prawn fishery, mixed nature of the wild collected prawn seed and transportation cost are the main constraints experienced to establish prawn farming on a commercial scale. *Macrobrachium malcomsonii* is the second largest freshwater prawn found in the Indian riverine system which drains into Bay of Bengal and Arabian Sea. It attains a maximum size of 243 mm (male) and 200 mm (female) under natural conditions. Commercial fishery of this species occurs in the river Ganga and Godavari in India and Indus River in Pakistan. This species is popularly known as 'white scampi' in the export market which constitutes about 10% of the total farmed freshwater prawn production in India. The species grows, attains maturity, breed and spawn eggs under freshwater condition. The breeding period lasts from May to October in the river Ganga and Mahanadi and April to November in the river Godavari, Krishna, and Kaveri. The first stage zoea larvae are washed down along with water current reaching the estuary and complete its all eleven larval stages. As soon as the larvae attain post-larval stage, they migrate towards freshwater environment in the riverine system leaving the saline zone. In this process, the species migrates up to a distance of 1400 km upstream in different riverine systems. The grow out culture of this species exists with the wild seed collected from natural riverine systems. The species requires 18-20 ppt salinity medium for its optimum growth and development during larval stages.

The culture trials made using hatchery produced seed in earthen ponds yielded 950-1125 kg/ha/year production under monoculture while over 2800 kg carps and 530 kg prawns /ha/yr were recorded under polyculture with carps (*Labeo rohita* and *Catla catla* at ratio 1:1). The details on grow-out culture are discussed in this paper.

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Effect of acclimation temperature on growth and metabolic responses in freshwater ornamental angel fish, *Pterophyllum scalare* juveniles

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In the ornamental fish rearing, growth and survival of fishes are very important. Hence, a study was conducted to understand the effect of acclimation temperature on growth and metabolic responses of freshwater ornamental Angelfish juveniles (*Pterophyllum scalare*). Three hundred and seventy juveniles of Angelfish were randomly distributed into six experimental aquarium tanks (15 juveniles/tank) in triplicates with thermostat heaters for temperature maintenance at 26 °C, 28 °C, 30 °C, 32 °C and 34 °C. The control group was maintained at ambient temperature (without heaters). The fishes were fed twice a day with tubifex worms throughout the experimental period. At the end of the experiment, the possible role of acclimation temperature on growth responses was assessed by evaluating growth parameters like percentage of weight gain, feed conversion ratio (FCR), feed efficiency ratio (FER), specific growth rate (SGR) and protein conversion ratio (PER). Further, metabolic responses were assessed in terms of enzyme activities of Glutamate oxaloacetate aminotransferase (GOT), Glutamate pyruvate aminotransaminase (GPT), Lactate dehydrogenase (LDH) and Malate dehydrogenase (MDH). Growth parameters and enzymatic activities were influenced significantly ($p < 0.05$) by the acclimation temperature. The highest weight gain %, highest SGR and lowest feed conversion ratio (FCR) were recorded in fishes acclimated at 28 °C and lowest weight gain %, highest SGR and highest FCR were recorded in fishes acclimated at 34 °C. The results in the present study indicate higher growth and metabolic responses in juveniles of Angelfish (*Pterophyllum scalare*) acclimated at a temperature of 28°C.

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Effect of different stocking densities of tiger shrimp, *Penaeus monodon* on water quality of shrimp ponds of Raigad district of Maharashtra

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Effective water management in shrimp ponds is one of the important factors contributing to the success of shrimp farming. Proper water quality management reduces the occurrence of diseases and enhances growth and survival. Therefore, understanding of the complex interaction between stocked organisms and water management is essential to increase the production and survival percentage. Hence, the prime importance is to maintain the water quality within the optimum limit. The study was conducted in eight shrimp ponds with four different stocking densities viz. 4, 5, 6 and 7 shrimp/m⁻² with an average size of 10–14 mm. The depth of water was maintained from 90 to 125 cm in all the experimental ponds during culture period of May to September. Water parameters such as dissolved oxygen, salinity, pH, dissolved organic matter, ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen were analyzed by adopting standard methods. Analysis of variance showed significant difference ($p < 0.05$) between different stocking densities for the water parameters such as salinity, dissolved oxygen, dissolved organic matter, ammonia-nitrogen, nitrite-nitrogen and nitrate-nitrogen. Significantly positive ($p < 0.05$) trend was observed for the water parameters such as ammonia-nitrogen, nitrite-nitrogen and nitrate-nitrogen. However the significantly inverse relationship ($p < 0.05$) was found between dissolved oxygen and stocking densities. Water parameters such as ammonia-nitrogen, nitrite-nitrogen and nitrate-nitrogen showed positive correlation with stocking density and found to be significant ($p < 0.05$). While, significant ($p < 0.05$) negative correlation was observed between dissolved oxygen and stocking density. There was no significant correlation of water parameters such as salinity,

pH and dissolved organic matter with stocking density. Linear multiple regression indicated that some water parameters were found to have significant relation with stocking density. The equation is given below: $Y = 1.794 + 0.197 X_1 + 2.709 X_2 + 10.823 X_3 + 0.856 X_4$ where, Y = Stocking density, X_1 = Dissolved oxygen, X_2 = Ammonia-nitrogen, X_3 = Nitrite-nitrogen and X_4 = Nitrate-nitrogen.

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Value addition of gold fish, *Carassius auratus* var. *comet* through colour enhancement

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Ornamental fishes are gaining popularity due to their aesthetic as well as commercial value. Commercial value of these ornamental fishes corresponds to their coloration pattern. Carotenoids are the pigments, which provide colouration in fish. Fish cannot synthesize these pigments/carotenoids in the body *de novo*, thus getting all its pigmentation from the available food. These carotenoids are widely distributed in nature occurring in plants and animals. They are also produced by all photosynthetic active microorganisms. Ornamental fish living in natural environment and feeding on natural live food get colouration very easily. Among carotenoids, xanthophylls are the pigments which provide red, orange and yellow colouration to fish. Xanthophylls synthesis in green materials starts in summer and changes to yellow/orange/red pigments of autumn leaves, fruits, flowers, roots and fungi such as marigold, tomato, pepper, maize, carrot, beetroot, mushrooms etc. Ornamental fish kept in captivity need to provide with the additional colour enhancing agents in the form of natural or synthetic pigments in the supplementary feed. In view of this, the present study was carried out for the value addition of gold fish *Carassius*



auratus var. *comet* by incorporating marigold petals (powdered) in the supplementary diet. Control (C) and experimental pelleted diets MG-1, MG-2 and MG-3 having 1 %, 2% and 3 % of powdered marigold petals respectively in control diet [rice bran (45 %), mustard cake (45 %) and fish meal (10 %)] were prepared. Molasses was added as binder @ 5 % in all the diets. The study was conducted in triplicate for 120 days. Water quality in terms of temperature, pH, dissolved oxygen, total alkalinity and hardness were analyzed at fortnight intervals. No significant differences were observed in water quality parameters among all the treatments. Growth was studied in terms of average total body length and average body weight at monthly intervals. Average final total body length was non-significant in all the treatments; whereas significant higher average final body weight was found in control and MG-1. Maximum number of coloured fishes were found in MG-2 (60%) followed by MG-1 (40%), control (20 %) and MG-3 (5%). Maximum survival of fish was also found in MG-2 (95 %) followed by MG-1 (70 %), MG -3 and control (50 % in each) respectively. Hence, it can be concluded from the present studies that value addition of ornamental fishes can be carried out by incorporation of powdered marigold petals @ 2 % to increase its commercial value.

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Competitive interactions between two marine benthic microalgae in mixed culture

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Benthic microalgae are commonly used as a food source for many commercially important marine invertebrates. Experiments were conducted to evaluate the comparative growth responses of two axenic strains of benthic microalgal species in their monoculture and mixed culture. For this, benthic diatom species *Nitzschia closterium* W. Smith 1853 and

Navicula transitans var. *derasa* (Grunow) Cleve 1893 were grown separately and in combination. In the monoculture, *N. transitans* var. *derasa* had significantly higher cell density (41.6×10^3 cells cm^{-2} on 18th day of culture) during the 24-days culture period compared to that of *N. closterium* (8.9×10^3 cells cm^{-2} on 15th day of culture). Throughout the experiment, *Navicula transitans* var. *derasa* was significantly higher in cell density when grown separately compared with the mixed culture with *N. closterium*. In both the species, enhanced settlement rate was observed at the bottom of the container than that of the vertical walls. In the mixed culture treatments, *N. closterium* dominated during the first nine days of the culture with a cell density of 5.21×10^3 cells cm^{-2} and growth rate of 0.50 ± 0.20

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Growth, survival and reproductive performance of captive broodstock of *Macrobrachium rosenbergii* reared at different densities

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Macrobrachium rosenbergii is one of the most important cultured freshwater prawns in India. Aquaculture production of this species in India has declined from 43000 t in 2005 to 6881 t in 2010. Poor quality of seed due to genetic deterioration of brood stock was thought to be the main reason for slow growth and poor production in grow-out. Hence, improving the quality of seed is an important area of research. As breeders are often collected from grow-out ponds, a study was conducted to evaluate the growth and reproductive performance of captive broodstock raised at different densities (2, 6 and 8/ m^2) in 0.04 ha earthen ponds. The study was conducted for one year. Hatchery raised post-larvae ($0.01 \pm 0.001\text{g}$) were stocked in six 0.04 ha earthen ponds at 2, 6 and 8/ m^2 . Two ponds



were allotted to each density treatment. Prawns were sampled at monthly intervals to determine growth and health. From the fourth month of sampling onwards, observations were also made on the male morphotype distribution, frequency of immature, maturing and egg bearing females.

Results revealed a significantly higher average daily growth in prawns stocked at 2/m² (0.11 ± 0.004 g) compared to those stocked at 6/m² (0.085 ± 0.006 g) and 8/m² (0.063 ± 0.004 g). Distribution of male morphotype showed a density dependent distribution with reproductively active and preferred blue claw morphotype as well as fast growing orange claw morphotype showing highest frequency in lowest density (2/m²) and slow growing and least preferred morphotype showing higher frequency in highest density evaluated (8/m²), indicating better chances of breeding success at 2/m² stocking density. Frequency of maturing females and egg bearing females (berried females) were significantly higher at lower stocking densities of 2/m² and 6/m². The fecundity (number of eggs per gram body weight of female) was highest (900.8 ± 58.5) in prawns stocked at 2/m² and lowest (858.4 ± 67.6) in females stocked at 6/m² and did not show any significant difference among density treatments. Low stocking density (2/m²) is appropriate for raising captive broodstock as growth and reproductive activity was higher in this density compared to higher densities.

AP-P 24

Evaluation of biofilm on different substrate in shrimp culture pond

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Shrimp farming is an emerging industry in tropical and subtropical regions around the world with current production estimated at 6.6 mmt /yr (FAO, 2010). A shrimp farm is an aquaculture business for the cultivation of marine shrimp or prawns for human

consumption. About 75% of farmed shrimp is produced in Asia, particularly in China and Thailand. Although there are many species of shrimp and prawn, only a few of the species are cultivated, all of which belong to the family of penaeids and within it to the genus *Penaeus*.

The present study deals with the comparative studies of biofilm diversity on different substrates like PVC pipe, paddy straw, coconut front, bamboo pole in shrimp culture pond. The size of the fish pond is 0.823 ha. The periphyton study was carried out during culture period of shrimp. The substrate was selected based on locally available degradable as well as non degradable substrate and each substrate has surface area of about 10x10cm². The Periphyton/biofilm was analysed by weekly sampling for about 60 days. The seeds of *Penaeus monodon* were stocked at the rate of three no/sq area. On regular basis manuring was applied and feed was broadcasted twice a day based on the body weight of shrimp. The weekly sampling was done and all physical and chemical parameters were monitored during the study period. The other biological parameters were also analysed. Results of the present investigation showed that autotrophic and heterotrophic production in water was much higher and stable than in substrate. The phytoplankton biomass in all substrates has increased at a faster rate due to more nutrients in biofilm, less grazing activity, low salinity and availability of more phosphorous which helped in proliferation of algae during their early stages. In later period, less chlorophyll-a could be due to more grazing and less nutrient which was exploited by phytoplankton during early succession. The major groups of phytoplankton recorded are the diatoms, blue green algae and green algae in the order of abundance (20,890 to 62,435 no/l), both in water and substrate. The plankton population was observed more on bamboo pole and by comparing all the substrates with all the parameters, bamboo pole was found to be most potential substrate among the degradable and non-degradable substrates tested.



AP-P 25**Breeding and seed rearing of Hungarian rospa scaly and felsosomogy mirror carp at experimental fish farm, Champawat, Uttarakhand**SURESH CHANDRA¹, S. K. SRIVASTAVA¹, S.K.GUPTA¹, N.N. PANDEY^{1*} AND P. C. MAHANTA²

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Trials at Champawat Experimental Field Centre to further evaluate breeding performance of 3+ years old of Hungarian Rospa scaly and Felsosomogy mirror carp named as Champa 1 and Champa 2 respectively were undertaken during last week of April to mid May, 2011 when water temperature ranged between 17.0-21.5 °C. Total five attempts were made with and without hormonal injections. Breeding response of both Hungarian and existing Bangkok strains in cloth hapas without hormone was not more than 10-15% while with hormonal (Ovatide) dose of 0.5 ml/kg in case of female brooders and 0.3 ml/kg of body weight in males. The average ovulation response was 70%, 100% and 100% in Champa-1, Champa-2 and existing scale carp of Bangkok strain, respectively. The latency period was 10-12 hours at water temperature of 17.5±2 °C in all the strains. Similarly the average fertilization rate was 65%, 80%, and 95% in Champa -1, Champa-2 and local variety respectively. Lower thermal regime in mid altitude areas like Champawat also had inherent limiting factors like fungal infestations due to prolongation of hatching period which adversely affected the normal spawn recovery. With a water temperature range of 17.0-21.5 °C hatching took place after 78 hours of incubation and was almost similar in all the strains. At the fry rearing period of 45 days, Champa -1 and 2 attained a size range of 10-40 mm with 48% of population above 20 mm whereas local variety of a common carp was in a size range of 10-30 mm with 80% population in size range of 10-20 mm under similar rearing conditions.

For egg attachment, in absence of commonly used aquatic weeds and other materials during

common carp breeding, dry and green spiny needles of pines were tried at Champawat field center in cloth hapas. Dry spiny needles were better suited and could be a good substitute as a substrate for adhesive eggs attachment in mid Himalayan areas, as aquatic weeds availability is extremely less. Due to lower temperature range during March-April, ovulation and hatching period is prolonged; however there was no decomposition of pine leaves in water and water quality remained normal in the hapas.

AP-P 26**Observation on the embryonic development of *Macrobrachium gangeticum***

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Diversification of cultivable freshwater prawn species in polyculture system is one of the desirable aspects for freshwater aquaculture. Although, a large number of freshwater prawn species available in the country, fast growing species being *Macrobrachium rosenbergii*, *M. malcolmsonii* and *M. gangeticum*. The later species recognized as the third largest growing indigenous freshwater prawn, naturally occurs in the Ganga River system and is commonly known as Ganga River prawn. Of late, comprehensive investigations on the breeding and culture of this species have been made by Central Institute of Freshwater Aquaculture (CIFA). However, records are not available on the embryonic development during incubation period of the fertilized eggs which is an important aspect for the prawn hatchery operators. In order to fill up the knowledge gap, study was carried out in captive condition using conditioned matured *M. gangeticum* brood stock in freshwater. Just after spawning, females were kept in separate aquarium containing saline water provision of aeration. After six hours of spawning, egg samples were collected from the berried females for immediate microscopic study of embryonic stages. Thereafter, using same berried females eggs were



collected at 24 hours intervals till hatching at water temperature of 26 °C to 28 °C. Photography of each embryonic stage was carried out at constant magnification. Preliminary account of embryonic development indicated that initially (after six hours of spawning) the translucent chorion was attached to the vitelline membrane. However, at this stage, embryonic structures were apparently not visible on the surface of eggs. After 30 hours of spawning, cleavage blastomeres were seen on the egg-surface. The germinal disc developed 54 hours. Development of numerous blastomeres evidently appeared like V shaped and germinal disc appeared clearly at the egg surface. Embryonic nauplius was formed from germinal disc. Three pairs of naupliar appendages were clearly seen in the developing embryos. In central region slight depression corresponded to stomodum. At these stages, caudal papillae was also demarcated. At 112 hours, the growth of embryos and optical lobes in cephalic region were recognized. Naupliar appendages developed and embryo were slightly bent into 'C' shape. After some hours of spawning, embryos grew in size and there was a vigorous movement inside the eggs. Increased size of embryos and their rapid movements exerted pressure on the egg membrane. Subsequently hatchlings emerged out from the eggs and led planktonic movement in 5 ppt saline water hatching medium. The study also provides insight to prawn seed producers in understanding the exact position of embryonic development during incubation period of the eggs carried by the berried females.

AP-P 27

Effect of intake water treatment system in shrimp hatchery for seed production

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The water source and the disinfection of the water in the hatchery are critical for the

successful seed production since it prevents the introduction and spread of infectious disease. Mostly the water source for the shrimp hatchery of brackishwater species is the sea water drawn from intertidal region and it requires appropriate disinfection and filtration system. To assess the effect of disinfection methods for effective and feasible biosecurity, an experiment was conducted with five treatments and three replication in a completely randomized design. The growth and survival percentage of *Penaeus monodon* from Zoea to PL 20 in different treated water viz. seawater (T1), chlorination@10ppm (T2), chlorination + sand filtration (T3), sand filtration + cartridge filtration @5 micron+ UV treated water (T4), and chlorination + sand filtration + cartridge filtration @5micron + Ozone treated water (T5) were observed. The statistical analysis using ANOVA revealed that the treatments were significantly different. The growth and survival was high in both T4 and T5 emphasizing the requirement for either UV unit or Ozonator in the hatchery. The water quality parameters viz., pH, salinity, temperature, ammonia, nitrite and bacterial load were also monitored daily. These results indicate that the concentration of ammonia and nitrite and the bacterial load decreased with filtration treatments and the bacterial load was almost nil after UV disinfection. Similar observation was found with the ozone treated water also. The results suggest that filtration system along with either UV unit or ozonator is very much essential for successful seed production and larval rearing.

AP-P 28

Indigenous technical knowledge in controlling predators in fish farms in Tripura

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Indigenous Technical Knowledge (ITK) is the evolved practical knowledge that a local community accumulates over generations of living in a particular geographical area and is generally



passed on through generations mostly by word of mouth. Indigenous Knowledge is a key element of the "social capital" of rural communities and the poor. These ITKs are seldom documented; such information is lost if not passed from generation to generation or protected and practiced by the local people. There are a limited number of studies focusing on ITKs in fisheries sector and few studies are available on fisheries of the North Eastern region of India. Documentation of ITKs of North Eastern region which is one of the hot spots of fish biodiversity is very important. This study, a part of the major work on ITK, was undertaken by a survey to document the ITKs in controlling predators in fish farms of Tripura. The following ITKs were documented: controlling otter using empty eggshell and lime, preventing otter and snake by planting turmeric, checking entry of otter by culturing *Labeo calbasu*, killing snake using *Anabus* and hook, catching kingfisher bird using jackfruit gum and checking entry of frog using ash. The respondents reported as much as 30% improvement in fish production when these ITK's were practiced diligently. The common practices and net addition to social capital formation in terms of an ITK database was found to be deteriorating in most of the locations studied. It is suggested that an electronic repository database may be developed to document, update, disseminate and interface ITK's across fisher communities of the north east in particular and the country at large for enhancing fish production. Most of the ITKs were found to be very much appropriate for further studies and validation.

AP-P 29

Water quality characteristics of some carp hatcheries of West Bengal

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The present study was carried out to find out the prevailing water quality of four carp

hatcheries situated in the three districts of West Bengal and also to assess the impact of water quality on breeding and hatching. Water of desired quality is the most important requirement of carp hatchery. During the investigation, the average temperature was found to vary between 29.0 °C and 36.3 °C in the breeding pool and in case of hatching pool it ranged from 28.7 °C to 35.0 °C in all four hatcheries. The range of pH was between 7.33 to 7.86 in breeding pool and 7.23 to 7.53 in hatching pool. The minimum and maximum dissolved oxygen in breeding pool was recorded as 5.53 and 6.53 mg/l and in hatching pool the respective minimum and maximum values were 3.43 and 5.80 mg/l. The highest total hardness in breeding and hatching pool were 724.0 mg/l and 785.33 mg/l respectively and the lowest values in respective pools were 175.50 and 190.86 mg/l. The turbidity level in breeding pool varied between 9.93 to 18.83 NTU and in hatching pool between 12.66 to 20.93 NTU. The average rate of fertilization was found to vary between 46% and 72% and the hatching rate ranged from 52 % to 77 % considering all the four hatcheries. Substantial mortality was observed during early stages. Fish eggs and spawn are very sensitive to environment and mortality increases considerably if rearing conditions are not optimum. From the results obtained during the investigation, it can be concluded that most of the water parameters were within the prescribed range. But in one of the hatchery; total hardness, total solid and turbidity were significantly higher than other three hatcheries. Probably this was the reason for lower rate of fertilization and survival rate in this hatchery. The findings indicate that water quality is one of the major factors influencing the breeding and survival of fish seed and also higher seed production from hatcheries.

AP-P 30

Influence of rearing system on survival and growth of Asian seabass, *Lates calcarifer* larvae in hatchery conditions

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Asian seabass *Lates calcarifer* seed production technology has been standardised and technology package for large scale seed production is being adopted in hatcheries. In the hatchery system, larvae are reared in differently shaded tanks constructed/fabricated with variety of materials varying light intensities, temperature etc. In the present investigation, an attempt was made to evaluate most suitable rearing containers and systems for seabass larval rearing in hatcheries. Hatchery produced seabass hatchlings were stocked in tanks made up of FRP material light blue and white shaded tanks and RCC tanks kept in open sheds and closed rooms. Hatchlings were stocked @20 nos/l initial density. The initial average size of the hatchlings was 1.47 ± 0.5 mm. In all the tanks, larvae were fed with rotifer *Brachionus plicatilis* @ 2-4 nos/ml for 9 days and in combination with *Artemia* nauplii 2-4 nos/l from 10th day to 15th day. In the rearing systems, water exchange (40%) was done from 5th day and made up with fresh filtered seawater and algal water. After 15 days of rearing, the growth and survival rate in the various rearing systems were assessed. In the white shaded tanks kept inside the closed room; the larvae after 15 days was of 6.6 ± 0.8 mm size with survival rate of 41.01 ± 0.38 ; in the light blue shaded tanks, it was 5.42 ± 0.6 mm with survival rate of 32.68 ± 0.26 %. However, in the RCC tanks, the larvae mean size was 4.8 ± 0.3 mm with survival rate of 29.8 ± 0.4 %. The results indicated that, light shaded FRP tanks are preferable compared to that of RCC tanks or darks substrate tanks for the early larval rearing stages of seabass

AP-P 31

Effect of stocking density on growth, survival and production of cage reared tiger shrimp, *Penaeus monodon* at Vellar estuary

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To find out optimum stocking density, effect of different stocking densities on growth, survival and production of *Penaeus monodon* was studied for 100 days. Five rectangular cages of uniform size (10x5x1.5m) were used for the respective stocking densities of 10, 20, 30, 40 and 50/m². Healthy juveniles of size ranging from 2.5 to 3.2 g were stocked as per the stocking densities. All these cages were changed at every 34 days interval to control auto entrants and fouling problems. Shrimps reared in all the cages were fed with Higashimaru Semi-intensive type feeds. Initially 10% feed were provided to shrimps of all cages and it was gradually reduced to 3-5% because of low auto entrant biomass in all the cages due to the exchange of cages at regular interval. Even though the higher growth of 31.8 g and survival rate of 95.5% was observed in the stocking density of 10/m², the maximum production rate of 1142.4 g/m² was reported in the stocking density of 50/m². From the present study, it is concluded that 50/m² stocking density is suitable for the culture of *P. monodon* in cages. It is also recommended that 120 days culture is economical to harvest larger size shrimps at higher stocking densities in cages. Further study may be needed to test the suitability of stocking density beyond 50/m².

AP-P 32

Effect of different stocking density on growth and survival of freshwater prawn *Macrobrachium rosenbergii*

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A study was conducted to evaluate the growth performance of freshwater prawn *Macrobrachium rosenbergii* under monoculture at different stocking densities. The experiment



was conducted in 200 m² earthen ponds in duplicate for a period of four months. The freshwater prawn post-larvae (mean weight 0.17 ± 0.06 g) were stocked at 20000, 30000 and 40000 numbers/hectare. The prawns were fed with commercial feed at the rate of 20% of the body weight for the initial 2 months and rest of the experimental period with 5% of the body weight. The sampling was carried out fortnightly to assess the growth of the prawn. Water quality parameters were also analyzed on a regular interval throughout the experimental period. The results indicate that the growth of the prawn was 20.20 ± 1.50 , 14.38 ± 1.41 , 12.35 ± 1.30 g at 20000, 30000 and 40000 no./ha respectively. The growth of the prawn was highest at the lowest stocking density (20,000 no./ha) and was significantly greater than other two stocking densities. In addition, the highest survival (55.30%) was recorded in lowest stocking density followed by 50.80% (30,000 no./ha) and 44.15% (40,000 no./ha). The results indicate that stocking density at 20,000 no./ha appear to be optimal in terms of survival and growth.

AP-P 33

Aquaculture based integrated farming system in coastal region of Nagapattinam district

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Aquaculture based integrated farming system for small and marginal farmers of the coastal region of Nagapattinam district was undertaken to increase production and earning. The integrated farming in model farms established at Valluvakudi village in 2010 continues to function even now. The fish farmers in these areas are following traditional culture practices without scientific knowhow. Initially they started fish culture in ponds (40x40m) under the government subsidy in order to utilize the water spread area effectively. The fishes used

for composite fish culture are a combination of Indian major carps and exotic carps. Generally 100 to 150 mm sized fingerlings of different species are stocked @ 5000 to 7500 numbers/ha. The stocking ratio followed is Catla 15 % (*Catla catla*), silver carp, 15% (*Hypophthalmichthys molitrix*), rohu, 20% (*Labeo rohita*), Mrigal, 15% (*Cirrhinus mrigala*), common carp, 20% (*Cyprinus carpio* var *communis*), and grass carp, 15% (*Ctenopharyngodon idella*). In spite of lack of clear scientific knowledge on fish culture, out of 16 interventions, a farmer obtained fish production of 3742 kg/ha/10 months, other than income from crops and animal husbandry. The net income earned was Rs. 90,000/- The details of these 16 interventions are explained in this paper.

AP-P 34

Effect of acclimation temperature on the thermal tolerance limits of freshwater ornamental angel fish, *Pterophyllum scalare*

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In the ornamental fish rearing, growth and survival of fishes are very important. Hence, a study was conducted to understand the effect of acclimation temperature on the thermal tolerance limits by using freshwater ornamental angelfish juveniles (*Pterophyllum scalare*). Three hundred and seventy juveniles of angelfish were randomly distributed into six experimental aquarium tanks (15 juveniles/tank) in triplicates with thermostat heaters for temperature maintenance at 26 °C, 28 °C, 30 °C, 32 °C, and 34 °C. The control group was maintained at ambient temperature (without heaters). The fishes were fed twice a day with tubifex worms throughout the experimental period. At the end of the experimental period, the possible role of acclimation temperature on the thermal



tolerance limits was assessed in terms of critical thermal maxima (CT_{max}), critical thermal minima (CT_{min}), lethal thermal maxima (LT_{max}) and lethal thermal minima (LT_{min}). The CT_{max} & LT_{max} were found significantly different ($p < 0.05$) in the treatment groups (acclimation temperature), compared to the control group (ambient temperature). There was an increase in the thermal tolerance limits with increasing acclimation temperature. At 34 °C acclimated temperature, CT_{max} and LT_{max} were 42.71 ± 0.16 °C and 44.00 ± 0.44 °C respectively. However, the CT_{min} & LT_{min} showed no significant differences between treatment groups and between control group and treatment groups.

AP-P 35

Management – the key of success in aquaculture

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Management is one of the most important aspects, needs to be considered for achieving maximum return from aquaculture practice. It includes planning, therefore while initiating aquaculture good planning is required and such planning is to be angled in different phases with time frame and targets which are to be monitored after completion of each activity. Moreover it is desirable that there should be healthy relationship between aquatic organisms and their surrounding environment. Conducive environment plays a vital role for any activity involved with living beings to survive well in addition to supply/addition of all other inputs required for successful aquaculture. Culture and breeding of fishes and/or prawns cover several aspects under management of aquaculture practice right from pond preparation, seed collection, seed quality, hygienic condition of both ponds and fishes, their stocking densities with ratios, healthy brood stock, proper feeding with formulated balanced diet both for larvae and adult fishes and prawns is maintenance and rearing of fishes and prawns throughout culture period,

harvesting, post-harvesting, transportation, labour-owner relationship and other related issues as well as constraints. Strict adherence of such aspects closely associated with aquaculture practice as per planning can contribute considerably in achieving better return against material and effort given as well as expenditure incurred therein. Good managerial ability, care, timely action taken and decision on the spot against problem identification and remediation etc. lead to success in aquaculture.

AP-P 36

Physiological responses of *Perna indica* to temperature and phytoplankton concentration

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Brown Mussel, *Perna indica* is one of the important molluscan resources in India. In the present study, the filtration rate of *P. indica* was determined by feeding *Chaetoceros* sp. in response to different temperatures (24, 27, 30 and 33 °C) and varying phytoplankton concentrations (1×10^5 , 1.25×10^5 , 1.50×10^5 and 1.75×10^5 cells/ml/animal). Filtration rate was found to increase as the temperature and phytoplankton concentration increased up to 30 °C and 1.50×10^5 respectively. However, there was a rapid decline in the filtration rate at 33 °C and also at phytoplankton density of 1.75×10^5 cells/ml/animal. The response of the experimental animals in terms of length as well as weight gain (%) are presented in the paper.

AP-P 37

Growth of groupers in fixed net cages in Karapad Bay of Tuticorin

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Groupers are highly priced marine food fishes usually cultured in floating net cages in the sea. Groupers were collected from the wild at different landing centres in and around Thoothukudi. After acclimatization in the hatchery, active groupers were transported to the cage. The growth of *Epinephelus malabaricus* was studied in fixed net cages of 1.8 x 1.8 x 1.1 m dimension in the Karapad Bay of Tuticorin. Growth was studied in groupers of size range 300-800 g for ten months. These were fed daily with trash fish, mainly sardines and squids at 5% of their body weight. Morphometric measurements were taken every month. The average weight and length increased from 507.85 g /30.96 cm to 1268.92 g/ 42.67 cm within 10 months. A growth rate of 76.1 g/ 1.17cm per month was attained for the fishes in captivity.

AP-P 38

Influence of dietary protein levels on growth and survival of honey gourami, *Trichogaster chuna* (Hamilton, 1822)

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Healthy growth and survival of any ornamental fish species depends on the feed provided and the utilization of this feed by the fish species. The aim of the study was to find the optimum dietary protein level for the growth and survival of juvenile of *T. chuna* using semi-purified diet with protein levels of 25%, 30%, 35%, 40%, 45% and 50% fed at the rate of 7% of the biomass. Length gain of juvenile differed significantly ($p < 0.05$) from that of T_1 , T_2 , T_3 and T_6 but did not show significant difference ($p > 0.05$) with T_4 . Weight gain of juveniles fed with diet T_5 differed significantly ($p < 0.05$) from T_1 , T_2 , T_3 and T_6 but did not show

significant difference ($p > 0.05$) with T_4 . SGR gain of juveniles fed with diet T_5 differed significantly ($p < 0.05$) from T_1 , T_2 , T_3 and T_6 but did not show significant difference ($p > 0.05$) with T_4 . The juvenile fed with 45% (T_5) dietary protein had the highest average length gain, weight gain, specific growth rate and survival indicating that the optimum level of dietary protein for juvenile of *T. chuna* is 45%.

AP-P 39

Stress response in lobsters under varying salinity with special reference to stress protein HSP70

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Lobsters display a variety of stress responses when their regulated physiological systems are extended beyond their normal range. Stress proteins, also known as heat shock proteins (HSPs), comprise a highly conserved class of proteins that display elevated transcription during periods of stress. One of the primary functions of the stress proteins is to aid in the recovery of damaged proteins by chaperoning their refolding. In the present study, we have examined the influence of altered salinity upon the HSP expression at the protein level. By means of western blotting, we observed an elevated expression of HSP70 at hypo-salinities (20 ppt and 25 ppt) and hyper-salinity (40 ppt). HSP70 induction is more pronounced at 48-96 h time period and the animals were found to acclimatize beyond this time period. Study reveals that elevated expression of HSPs are more significant under short term rather than under long term stress. We observed that lobsters responded to such acute stresses only briefly. Long term studies will be required to determine the utility of this work for such chronic stresses such as environmental pollution and global warming.





Nutrition and Fish Health

NH- O : Oral presentation
NH- P : Poster presentation

NH-O 01**Attractability and palatability of marine protein sources and their feeding value for Asian seabass, *Lates calcarifer***

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Effect of different marine protein sources viz., fish meal (FM), Acetes meal (AM), prawn head meal (PHM) and squid meal (SM) were evaluated for attractability and palatability in juvenile seabass (*Lates calcarifer*). Attractability and palatability studies were ascertained in specially designed FRP tanks. Results of the attractability and palatability studies revealed that PHM is having better attractability (11.66 seconds) and this was not significantly different with FM containing diets. AM and SM containing diets showed significantly lower attractability compared to PHM. Palatability effect as evidenced by percent of feed consumed among different protein sources revealed a non-significant difference among FM, AM and SM based diets. PHM based diets showed significantly poor palatability compared to the rest of the diets. The feeding value of these marine protein sources were assessed in a 45 day feeding experiment in a completely randomized design with three replicates for each diet and each replicate containing 10 animals (average initial body weight 15.90 ± 0.04 g). Significantly better performance in terms of FBW, weight gain, feed intake, SGR, and ADG was observed in groups fed with FM and AM containing diets, while the group fed with PHM based diets showed significantly poor performance compared to the rest of the diets. PHM fed group showed a significantly better FCR (1.39) compared to the rest of the diets. The survival among different treatments revealed a non-significant difference among FM, AM and SM based diets while PHM based diets showed a significantly lower survival than the rest of the treatments. The results indicate that PHM is a better attractant but has poor

palatability. FM and AM are potential marine protein sources in the diet of Asian seabass. However further studies are required to optimize the inclusion levels and nutritional utility of these protein sources.

NH-O 02**Development of live feed enrichment product for marine fish larviculture**P. VIJAYAGOPAL¹*, KAJAL CHAKRABORTY¹, G. IYYAPPARAJA NARASIMAPALLAVAN¹, M. K. ANIL², BOBY IGNATIUS¹, NEIL SCOLASTIN CORREYA³ AND K. K. VIJAYAN¹¹Marine Biotechnology Division, Central Marine Fisheries Research Institute, Kochi – 682 018, Kerala, India²Vizhinjam Research Centre of Central Marine Fisheries Research Institute, Vizhinjam, Thiruvananthapuram - 695 521, Kerala, India³National Centre for Antarctic Ocean Research, Goa, India

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Phytoplankton commonly used in finfish hatcheries in south India was profiled for their fatty acid content. Phytoplankton cultures of *Nanochloropsis oculata*, *Isochrysis galbana*, *Pavlova viridis* and *Dicrateria inornata*, obtained from the stock cultures of the Central Marine Fisheries Research Institute, Kochi were developed at a density of 1.2×10^6 cell/ml at a salinity of $30 \pm 5\text{‰}$, temperature $28 \text{ °C} \pm 1 \text{ °C}$ and pH 7.8 - 8.1 following standard protocols. It was found that *I. galbana* is the richest source of docosahexaenoic acid (DHA). *P. viridis* and *D. inornata* are rich in eicosapentaenoic acid (EPA). *N. oculata* is rich in EPA and arachidonic acid (ARA). DHA content recorded in *I. galbana* in our study was 9.75 % which was similar to that of *I. galbana* clone T-ISO reported elsewhere. When rotifers were enriched with *I. galbana* and analyzed for fatty acids at specific time intervals, DHA enrichment increased till 30 h and the maximum DHA content in enriched rotifers was found to be 1.13%. Subsequently, attempts were made to develop enrichment emulsions using sardine oil (90%) and fish roe (10%) as the major ingredients which are cost effective natural sources of DHA, EPA and phospholipids which are available round the year locally. DHA content of



39% and EPA content of 19% was obtained in this formulation which was used to enrich rotifers. The resultant enrichment level was 8.76% DHA and 3.17% EPA in six hours after which decline in the polyunsaturated fatty acid (PUFA) content was observed. Evidently *I. glabana* proved to be the richest source of DHA among the phytoplankton profiled. The enrichment formulation shows promise as an import substitute which requires refinement and further evaluation.

NH-O 03

Apparent digestibilities of mustard, sesame and sunflower oil cakes in Asian seabass, *Lates calcarifer*

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The apparent nutrient digestibility of three oilcakes viz., sunflower, sesame and mustard were estimated to evaluate their potentiality in Asian seabass (*Lates calcarifer*) diet. Three test diets were formulated with reference diet and individual oil cake at ratio of 70:30. Chromic oxide (0.5%) was used as an internal marker. Ten numbers of Asian seabass fingerlings (average body weight - 8.70 to 8.72 g) were randomly taken and stocked in FRP tanks holding 400 l of filtered dechlorinated brackishwater in four treatment groups in triplicate and were kept in static indoor condition. Four groups of fishes I, II, III and IV were fed with reference diet (RD), test diet with sunflower cake (TD-I), test diet with sesame cake (TD-II) and test diet with mustard cake (TD-III), respectively. Experiment was continued for 42 days. Total body weight gain and average daily gain were significantly ($p < 0.01$) higher in fishes fed with RD and TD-III as compared to that of TD-I and TD-II. Feed conversion ratio was significantly ($p < 0.01$) lower in fishes fed with RD and TD-III as compared to that of TD-I and TD-II. The apparent dry matter, crude protein and ether

extract digestibility (%) of mustard oil cake was significantly ($p < 0.01$) higher (84.49 ± 0.01 , 89.62 ± 0.10 , 91.01 ± 0.25 , respectively) as compared to that of sesame cake (73.31 ± 0.11 , 78.22 ± 0.08 , 84.76 ± 0.47) which was again significantly ($p < 0.01$) higher than that of sunflower oil cake (70.49 ± 0.19 , 76.54 ± 0.09 , 81.31 ± 0.05).

From the results of the study, it is concluded that among the three oil cakes, apparent nutrient digestibility of mustard oil cake was better as compared to that of sesame and sunflower oil cake in Asian seabass. This study will help in formulating practical diet of Asian seabass with these oil cakes.

NH-O 04

Body carcass composition and fillet fatty acid profile of Indian major carps fed vegetable ingredient diet at different feeding levels

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Farming of Indian major carps (IMCs) in ponds is generally a feed based practice. The feeds mainly constitute plant ingredients with very little reliance on ingredients of animal origin. However, the quantity to be fed in pond conditions without changing their body nutrient composition is a challenge. The aim of this study was to investigate the effect of feeding an all plant-ingredients based feed, at different levels to *Catla Catla* (catla), *Labeo rohita* (rohu) and *Cirrhinus mrigala* (mrigal), on their flesh proximate composition and fatty acid profile. A feeding study over 150 days was conducted with juvenile IMC stocked at a ratio of catla:rohu:mrigal, 35:35:30 with initial body weight 65.8 ± 3.6 , 64.7 ± 4.9 and 39.6 ± 2.4 g, respectively in twelve 0.06 ha earthen ponds. Fish were fed an all plant-based pelleted feed (30% crude protein and 6 % lipid) at 1, 1.5, 2



and 2.5% of their body weight, twice daily, in triplicate ponds. Ration size was adjusted on the basis of monthly sampling of fish. During feeding study all standard pond management practices were followed. Fish fed 1% of their body weight had significantly ($p < 0.05$) lower body weights in comparison to fish in other dietary treatments. At the end of the study, fish were sacrificed, fillets chemical composition were analyzed as per the standard methods (AOAC, 1998). Total lipids were extracted and prepared as per the method described by Folch *et al.* (1957). Fatty acid methyl esters (FAME) were prepared according to the method of Christie (1982) and analysed in Gas chromatograph. Protein content of catla fillets recorded were 17.90, 19.62, 20.01 and 20.00% when fed 1, 1.5, 2 and 2.5% diet, respectively and no significant effect ($p < 0.05$) was found in the fillet protein levels among the dietary treatments. The fillets protein percentage for rohu and mrigal were 18.32 and 19.14 for 1% feed, 18.78 and 19.22 for 1.5% feed, 19.66 and 20.01 for 2% and 19.20 and 20.92 for 2.5% feed, respectively and no significant difference was found in dietary treatments. Lipid, ash and moisture contents of fillets were also not statistically different among three species when fed diet at different levels. Saturated fatty acid percentage (SFA) was significantly lower ($p < 0.05$) and mono unsaturated fatty acid (MUFA) percentage was significantly higher at 1% feeding level in catla fillet. In rohu and mrigal fillets, no difference was found in SFA and MUFA percentage for four feeding levels. n-6 PUFA content (18.84%) of catla fillet was significantly lower ($p < 0.05$) at 1% feeding level but in rohu and mrigal, no significant effect was found among the dietary treatments. The n-3 PUFA content (19.52%) of catla fillet at 2.5% feeding level was significantly higher ($p < 0.05$) in comparison to other feeding levels. Eicosapentaenoic acid (C20:5 n-3) percentage was significantly higher in *C. mrigal* fillet at 2% feeding level and docosahexaenoic acid (C22:6 n-3) percentage was significantly higher in catla fillet at 2.5% feeding level.

NH-O 05

Synergistic effects of thyroxine and feeding regimes on the survival and biomass gain in indian magur, (*Clarias batrachus*, Linn.) larvae

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The larvae of Indian catfish magur, *Clarias batrachus* (av. wt. 15 + 2 mg) were exposed to five concentrations of thyroxine hormone along with three feeding regimes in a completely randomized block design experiment. Five test media 1.3 mg/l (T1), 2.2 mg/l (T2), 3.6 mg/l (T3), 6.0 mg l⁻¹ (T4), 10.0 mg l⁻¹ (T-5) of thyroxine hormone and a control (C) along with three feeding regimes: 1 d⁻¹ (feeding once a day), 2 d⁻¹ (feeding twice a day) and 3 d⁻¹ (feeding thrice a day) were maintained in duplicate sets in 36 5 l plastic troughs containing 2 l numbers of pre-settled borewell water. Each trough was stocked with 20 larvae of *C. batrachus* and fed freshly hatched artemia nauplii for 15 days. The larvae reared in the treatment media (T1, T2, T3, T4 and T5) with feeding regimes 1 d⁻¹, 2 d⁻¹ and 3 d⁻¹ showed 100% survival which was significantly high ($p < 0.05$) in comparison to control set, where survival rates observed were 60.5+0.7%, 64.5+0.7% and 71.0+1.4% respectively with feeding regimes 1 d⁻¹, 2 d⁻¹ and 3 d⁻¹. Net biomass gain was found significantly ($p < 0.05$) higher in all thyroxine treatment media in comparison to control, though a linear relationship did not exist amongst treatments. However, feeding regimes had a linear impact on gain in net biomass with feeding intensity in all treatment media and control. Net gain in biomass was found significantly higher ($p < 0.05$) in the feeding regimes 2 d⁻¹ (C, 146.5%; T1, 186.6%; T2, 122.7%; T3, 243.6%, T4, 200%, T5, 123.4%) and 3 d⁻¹ (C, 244.7%; T1, 305.7%;



T2, 217.5%; T3, 369.9%; T4, 371.4%; T5, 298.3%) in comparison to regime 1 d⁻¹. The synergic effects of thyroxine hormone, feeding regimes and their interaction evaluated through two-way ANOVA suggest that these values were significantly different ($p < 0.05$) and both thyroxine and higher feeding regimes performed altogether better and resulted in 100% survival and higher net weight gain. The present findings suggest that thyroxine and feeding regimes have significant effect on survival and growth of *C. batrachus* larvae.

NH-O 06

Role of nucleotides in the diets of *Macrobrachium rosenbergii*

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In the recent years, considerable importance has been given to health management in aquaculture. Use of drugs and antibiotics is discouraged in aquaculture in view of residual accumulation, destruction of gut microflora, development of resistant bacteria and other various harmful effects. Use of immunostimulants is practiced as a potential route for the reduction in the widespread use of antibiotics. Substances such as glucan, chitin, lactoferrin and levamisol, as well as vitamin C, B complex, growth hormone and prolactin are reported to have immunostimulatory effects. They have their direct positive influence on non-specific immune elements such as phagocytic cell activity, natural killer activity, lysozyme levels, complement levels and total immunoglobulin levels. Nucleotides, precursors of DNA replication, have long been recognized as important elements in mammalian nutrition. A study was carried out to evaluate the effect of dietary nucleotide on growth, survival, immunity and resistance to white muscle disease and *Aeromonas hydrophila* infection in freshwater prawn (*Macrobrachium rosenbergii*). The nucleotide was supplemented

at levels of 0, 1.5, 2.25 and 3.0 g/kg diet. The test diets were fed for 60 days in triplicate groups of prawns, which had initial weight of 0.27 g. At the end of the feeding trial, growth was recorded and non-specific immune parameters like, prophenol oxidase activity, super oxide anion production, total haemocyte count and total serum protein were studied in haemolymph samples.

Phenol oxidase activity and super oxide anion production were significantly ($p < 0.05$) higher in prawns fed nucleotide based diets (Table). Total haemocyte count and haemolymph were also higher ($p < 0.05$) in prawns fed nucleotide based diets. The relative percentage survival of prawn after the challenge test against white muscle disease was significantly ($p < 0.05$) higher in prawn fed nucleotide incorporated diets. However there was no significant effect of nucleotide supplementation on growth and survival of prawn.

Table. Prophenol oxidase activity, super oxide anion production, total haemocyte count and total serum protein recorded in different treatments.

Treatments	T ₀	T ₁	T ₂	T ₃
Prophenol oxidase activity	0.212 ^a	0.477 ^d	0.422 ^{bcd}	0.455 ^{cd}
Super oxide anion production	0.08 ^a	0.171 ^{bc}	0.18 ^c	0.108 ^a
Total haemocyte count x 10 ⁶ /ml	6.67 ^a	8.43 ^b	10.85 ^c	11.25 ^d
Total serum protein (mg/ml)	13.85 ^a	15.68 ^{ab}	18.77 ^{bc}	20.54 ^c

NH-O 07

Chicken waste meal as a replacer of fish meal in the diet of Asian seabass, *Lates calcarifer*

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An 8 week growth trial was carried out to study the effect of replacement of fish meal with processed chicken waste meal (CWM) in



the diet of Asian seabass, *Lates calcarifer*. Analysis of CWM showed that it has 53% crude protein and 32% of crude lipid. Effect of replacement of FM with CWM was carried out by including CWM at 0, 5, 10, 15 and 20% levels replacing fish meal (w/w) in an isonitrogenous (40%) and iso lipidic (10%) diets. The experiment was carried out in a completely randomized design with three replicates for each treatment and each replicate containing 10 animals (average initial body weight of 3.09 ± 0.04 g). The results showed that there was no significant difference in final body weight (FBW), absolute weight gain, weight gain %, feed intake, FCR, CF and average daily gain (ADG) in the fish fed with diets containing CWM up to 10%. Inclusion of CWM at more than 10% showed a significant reduction in the above growth parameters compared to control diet. There was no significant difference in survival rate among the fish fed with different experimental diets (93.3% – 80%). Similarly, Hepato-somatic qs well as viscero-somatic indices showed non-significant difference among the treatment groups. The result from this study infers that CWM is a potential ingredient in the feed for Asian seabass, *L. calcarifer* and it can be included up to 5-10.0% replacing fish meal. However further studies are needed to conclusively tell the optimal level of CWM in the diet of seabass.

NH-O 08

Effect of early co-feeding EPA/DHA enriched diet and *Artemia*, on growth, survival and fatty acid profile of *Tor khudree* fry

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A study was conducted to delineate the effect of supplementation of polyunsaturated fatty acids on *Tor khudree* fry through enriched *Artemia* nauplii. The experiment was conducted

for a period of 60 days at a temperature range of 22-24 °C in which 20 fry with average weight of 0.407 ± 0.003 g to 0.492 ± 0.021 g were stocked in plastic rectangular tubs with initial water level of 50 l. The experimental design comprised of four treatments (T0, T1, T2 and T3) with three replicates each. Formulated diet was prepared with purified feed ingredients which contained 5% cod liver oil (CLO) as a source of eicosapentanoic acid (EPA) and docosahexanoic acid (DHA). For the enrichment of live feed *Artemia*, oil emulsion was prepared with CLO and vitamin E was added as antioxidant. Treatment groups were fed with un-enriched formulated diet (T0), enriched formulated diet (T1), enriched formulated diet along with un-enriched *Artemia* (T2) and un-enriched diet supplemented with enriched *Artemia* (T3). Growth was significantly higher in treatment groups ($p < 0.05$) of which T3 group had highest weight gain followed by T2 group. Biochemical analysis revealed a better growth performance in terms of higher AST and ALT values in enriched *Artemia* groups (T3) than other groups. Survival percentages of mahseer fry fed with PUFA enriched *Artemia* nauplii was highest in T3 group (98.33%) and lowest in individuals fed with control diet (78.33%). Fatty acid profile of *Artemia* (enriched and un-enriched), formulated feed (enriched and un-enriched) were analysed. Both EPA and DHA levels were higher in enriched *Artemia* and feed. Similarly, the PUFA level of mahseer fry fed with PUFA enriched *Artemia* was higher than groups fed with un-enriched *Artemia* and formulated diet. The treatment groups fed with enriched *Artemia* showed better immunological function in terms of higher TLC, TEC, Hb and NBT values. Digestive enzyme functions were also better in T3 group followed by T2, T1 and T0 groups. The overall result revealed that supplementing dietary PUFA through *Artemia* enrichment and its co-feeding with formulated diet has positive influence in terms of growth enhancement, survival, fatty acid profile, immune and digestive functions in *T. khudree* fry.



NH-O 09**Effect of starvation on the digestive enzymes and growth in Asian seabass, *Lates calcarifer* (Bloch) larvae**

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One of the most important factors causing mortality during the larval stages of fish species is non-availability of appropriate feed in adequate quantity. Starvation would lead to lack of digestive enzymes secretion resulting in poor digestion and absorption as well as accumulation of undigested food material, metabolic waste and putrefied fecal matter in the intestinal tract. As the digestive process deteriorates further, decreased energy, fatigue, general malaise and reduced resistance to infections may be noticed. It is thus useful to understand the activities of digestive enzymes due to starvation in order to obtain insights into the digestive physiology of the fish. In the present study, an attempt was made to investigate the digestive enzyme activities of seabass (*Lates calcarifer*) larvae during starvation. The activities of digestive enzymes such as amylase, total protease, trypsin, chymotrypsin and lipase under starved and well fed conditions were evaluated. Two sets of experiments were conducted for two age groups of seabass larvae (0-15 day post-hatch, (dph) and 16-30 dph. In the first set, the newly hatched healthy seabass larvae were stocked @ 8 nos/l in 60 l FRP tanks filled with filtered UV treated seawater. Larvae in starved group tanks were not fed and those in control group tanks were fed with live feeds such as rotifers from 2 dph and from 8 dph, *Artemia* nauplii along with rotifer up to 15 dph. In the second set of experiment, 16 dph seabass larvae reared were subjected to starvation and well fed conditions with *Artemia* nauplii upto 30 dph. In the first age group (0-15 dph), the larvae were in the size of 2.12 ± 0.04 mm total length under starved condition on the 8 dph and in fed condition it was 3.35 ± 0.29 mm. Poor body

weight was recorded in the starved group with 0.25 ± 0.08 mg on 8 dph while it was 0.94 ± 0.32 mg in the fed group. All the larvae reared under starved group died on 9 dph. In the first age group, the digestive enzyme activities of amylase, protease, trypsin, chymotrypsin and lipase also reduced drastically under starved conditions, compared to those in the well fed seabass larvae. In the second age group, the starved larvae reached a total length of 7.70 ± 2.11 mm and it was 19.64 ± 1.46 mm in under feeding conditions after 15 days rearing. Poor body weight with 4.93 ± 5.45 mg was recorded after 15 days rearing in the starved group and it was 69.90 ± 2.44 mg in fed conditions. A survival rate of $15.0 \pm 1.5\%$ was noticed in the starved group and it was $72.0 \pm 1.5\%$ in the fed group at the end of experimental period. The enzymes activities decreased in the starved group as compared to that in the fed group. The results of the investigation indicated that seabass larvae could survive without exogenous feed upto 9 days and starved larvae would be poor in health.

NH-O 10**Fatty acid profile of native *Tetraselmis* strains (Prasinophyceae) isolated from Indian subcontinent as a live feed in mariculture**

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Among the many important microalgal live feeds, *Tetraselmis* sp. is widely used for hatchery rearing of larval forms of shrimps, prawns, bivalves etc. Nutritional value of microalga depends on several factors like size, shape, digestibility and biochemical composition (protein, polyunsaturated fatty acids-PUFAs, vitamins etc.). In the evaluation of the nutritional composition of an algal species, the content of PUFAs, in particular eicosapentaenoic acid (EPA, 20:5n - 3), arachidonic acid (AA, 20:4n - 6) and docosahexaenoic acid (DHA, 22:6n - 3) is



of major importance. PUFAs are important for healthy growth and survival of the larvae due to their role in fecundity, fertilization and hatching rates of fishes, crustaceans and molluscs. Many commonly used *Tetraselmis* spp. (*T. suecica*, *T. striata*, *T. gracilis* etc.) are reported to have high concentrations of EPA, but relatively very small amount of DHA (less than 1%). We have studied lipid content and fatty acid profile of five new strains of *Tetraselmis* isolated from west and east coasts of India and two commonly used live feed strains, *T. gracilis* and *Tetraselmis* sp. Considerable amount of lipid and fatty acids were found in all isolates under normal growth conditions, with lipid - 4.13% to 20% and total PUFAs - 41.09 to 62.12%. EPA was 8.39 to 15.07% while DHA was also high with 1.55 to 10.36%. The essential fatty acids like ALA (α - Linolenic acid), BLA (β - Linilenic acid) and Linoleic acid were also found in good quantity - 2 to 15.94%, 0.35 – 18.64% and 2.96 – 15.67% respectively. Compared to the two traditional isolates of *Tetraselmis*, based on growth, lipid content and fatty acid profile (especially in DHA), the new isolates showed better results revealing their potential use as live feed in mariculture. The strains were observed to be morphologically and genetically varying from each other and taxonomic characterization of the isolates is in progress.

NH-O 11

Phytochemical and nutrient investigation of maize cob as co-dietary energy source in carp feed

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Maize cob was assessed for phytochemical and nutrient value after subjecting to different processing methods with the purpose of using it as a co-energy source in carp feed. The maize cobs collected were divided into five different portions and given the following

treatments: A – untreated maize cob served as the control, B - boiled for 30 min. in water, C- Fermented naturally under laboratory condition for 24 h, D - fermented naturally under laboratory condition for 24 h and E - oven-dried at 80 °C for 6 h. The maize cobs were analyzed for phytochemical composition and nutrient values. The results of the experiment showed variation in the phytochemical compositions of the untreated maize-cobs and those given various treatments. The maize-cobs oven-dried and those fermented for 48 h recorded loss of some phytochemicals. There was increase in the crude protein, crude lipid and ash in the treated maize cobs as compared to untreated maize cobs. Reduction in crude fibre value was recorded in all the treated maize cobs compared to untreated. The results of the present study as well as that of the foregoing research indicated that maize cob which is an agro-waste could be a reliable co-dietary energy ingredient in herbivores fish.

NH-O 12

Effect of omega-3 fatty acid incorporated diets on growth, survival and body composition of *Labeo rohita* (Hamilton, 1822) fingerlings

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Essential fatty acids such as omega-3 fatty acids (EPA and DHA) play vital role in fish nutrition. To understand the role of the dietary omega-3 fatty acids in fingerlings of *Labeo rohita*, a 60 days experiment was carried out. Fingerlings of rohu (300 ± 20 nos.) were randomly distributed in five treatment groups consisting of three replicates each. Five isonitrogenous (protein 19.60 g) and isocaloric (337 k cal/100 g) experimental diets viz., control (basal diet), T1 (basal + 1% ω -3 fatty acid), T2 (basal + 3% ω -3 fatty acid), T3 (basal + 5% ω -3 fatty acid) and T4 (basal + 7% ω -3 fatty acid)



were prepared with graded levels of omega-3 fatty acids. These were fed to rohu fingerlings (average body weight 1.793 ± 0.022 g) twice a day. The results indicated that the fishes which received the feed T1 (127.4 ± 0.1) consisting of 1% of ω -3 fatty acid showed significantly increase of average body weight and specific growth rates (SGR) compared to control and other treatments T2 (120.1 ± 0.3), T3 (112.6 ± 0.3) and T4 (109.0 ± 0.3). Significant differences were not observed in feed utilization amongst the treatment groups, but the muscle tissue composition showed significant increment in all the treatments. Omega-3 fatty acid content of muscle tissues were higher in T4 (7% ω -3 fatty acid) group than those in the T1, T2, T3 and control groups. T1 and T2 groups showed increase in length, weight and specific growth rate compared to T3, T4 and control. These growth studies revealed that increase of ω -3 fatty acid levels beyond 3% has no effect. The survivability studies showed that 100% survival of rohu fingerlings was recorded during the experimental period. The changes in level of omega-3 fatty acid percentages did not show any effect on survivability of the fishes. It is concluded that, under the experimental conditions, the increase of dietary omega-3 fatty acid levels beyond 1% had no beneficial effects on growth, survival and body composition.

NH-O 13

Determination of chemical composition and carcass indices of the rainbow trout, *Oncorhynchus mykiss* fed animal protein sources containing biogenic amines

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In this study, the possibility of the N-nitroso di alkane amines existence in diets containing animal protein sources and its effect on growth performance and carcass traits of the rainbow trout *Oncorhynchus mykiss* fed experimental diets was examined. A total of 640 rainbow trout fish

with average weight of 100 g (40 in each pool) were used and randomly distributed in 16 octagon pools each with 1x1x1 m having standard discharge and physicochemical conditions. Four experimental diets were formulated for this study. The energy and crude protein contents of the control diet (commercial) were 6.3 μ cal/kg and 40%, respectively and it contained 50% fish meal as the only protein source of the diet. The first diet was regulated on the basis of 24.66% fish meal, the second had 16.14% fish meal and the third diet contained 0% fish meal. The design was completely randomized with four replications of four treatments in 74 days. The data of each biometry were analyzed with SAS software. The results indicated that increasing fish meal percentage in experimental diets and the consequent increase in the concentration of biogenic amines led to an increase in hepatic weight and hepatic index. It was also observed that feeding rainbow trout, by replacing plant protein sources and decreasing the fish meal level, hepatic weight and hepatic index were improved and significant differences were observed with control group ($p < 0.05$). On the other hand, increasing or decreasing the fish meal level did not have any influence on traits such as final weight, viscera index, carcass weight and the carcass chemical composition ($p < 0.05$).

NH-O 14

Assessment of the dynamics of carotenoid pigment during ontogeny of rosy barb, *Puntius conchoni*

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Rosy barb (*Puntius conchoni*) is one of the potential indigenous ornamental fish species



having considerable high commercial value. The bright orange and yellow colour of the fish is the consequences of ingestion and metabolism of the carotenoid pigment, which the fish cannot synthesize *de novo* but acquires from food. In order to determine the principal carotenoid pool during ontogeny both in terms of quality and quantity, the present study was carried out from hatching to 30 days post-hatch (dph) at 28-31 °C. The presence of α -carotene, α -carotene, α -carotene-5,6-epoxide, α -carotene-5,6:52 62 -diepoxide, echinenone, canthaxanthin, β -cryptoxanthin, zeaxanthin and astaxanthin were estimated and quantified. The quantity of all the carotenoids varied considerably from hatching to 30th dph. Among the carotenoids quantified, astaxanthin showed highest value in different days, revealing it to be a major carotenoid in pigmentation of rosy barb. The rapid decrease of astaxanthin content was recorded immediately after hatching in comparison to egg and a progressive increase was found thereafter from 9th dph with a peak on 24th dph. The significance of these results with special reference to the dynamics of carotenoid metabolism during ontogeny is discussed which could be used as predictive indicator for persistent colour improvement of the species during larval rearing.

NH-O 15

Effect of spirulina *Spirulina platensis* and marigold, *Tagetes erecta* fortified diets on growth, body composition and total carotenoid content of *Barilius bendelisis*

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The effect of *Spirulina platensis* and *Tagetes erecta* at different incorporation levels of 0, 3, 5, 7, and 10 % was tested on growth, body composition and total carotenoid content in *Barilius bendelisis* (an endangered upland fish

species) for a period of 60 days in triplicate. An overall reduction from 3.29 (control- T_0) to 1.57 (7% marigold- T_3), 1.49 (5% spirulina- T_6) and 1.34 (10% spirulina- T_8) in FCR was observed with increase in either spirulina or marigold in the diet. Further, RGR (%) increased from 93.37 (T_0) to 191.17 (T_3), 203.09 (T_6) and 224.359 (T_8) while SGR (%) from 1.09 (T_0) to 1.77 (10% marigold- T_4), 1.84 (T_6) and 1.96 (T_8) for both the additives. In case of proximate and mineral composition, crude protein increased from 14.9% (T_0) to 16.93% (for both T_6 and T_8) while, potassium from 1115 mg/100 g (T_0) to 1276 mg/100 g (T_6). Proximate and mineral composition of the fish was significantly affected by spirulina (especially for T_6), while marigold did not showed any significant impact. On the other hand, total carotenoids were much significantly affected by marigold and it was improved from 2.09 μ g/g (T_0) to 4.58 μ g/g (T_4) than the spirulina. *B. bendelisis* fed on 5% spirulina fortified diet improved the growth as well as enhanced its total carotenoid content. However, marigold was found to improve the total carotenoid content of the fish with least significant impact on growth and body composition.

NH-O 16

Innovative lactic acid fermentation technique to prepare marine single cell detritus (MSCD), an innovative marine larval feed

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Fermentation of seaweed to produce feed is being tested in the field of marine fish larval development sector. Marine single cell detritus (MSCD), a seaweed based fermented product is an ideal dietary material for shrimp larval feeding. This innovative method deals with enzymatic and microbial degradation techniques for the preparation of MSCD. *Ulva reticulata*, a green seaweed, was chosen as the base material and



enzyme standardisation was carried out with different types of cellulase enzymes. The cellulase enzyme Deniwash 1000 l at 750 μ l produced 2.84×10^7 particles / ml, highest number of particles at 60 min was used for the degradation of seaweeds into single cell units. Prior to fermentation, standradisation to arrive at the concentration of lactic acid bacterium *Lactobacillus plantarum* (LAB) and *Saccharomyces cerevisiae* was carried out and it was found that both the organisms at a concentration of 10^4 CFU/ml each was found to produce a high level of lactic acid which was at a rate of 1.64 g / l and pH was observed to be reducing to 3.7. Fermentation of seaweed at 10 l in-situ fermentor was also carried out by *Lactobacillus plantarum* (LAB), *Saccharomyces cerevisiae*, potato powder (sugar substrate) and soya powder (nitrogen substrate). The process of fermentation was monitored continuously by estimating the lactic acid concentration, pH, microbial propagation rate and also the odour. The microbial propagation pattern for a period of 60 days also has been studied to assess the keeping quality of the product.

NH-O 17

In vitro fibre and starch degradation of different aquafeed ingredients inoculated with *Bacillus subtilis*, isolated from gut of *Chanos chanos*

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Bacillus subtilis, a potential amylolytic bacteria isolated from gut of brackishwater fish, *Chanos chanos*, was evaluated for its starch degrading ability on seven locally available low cost feed ingredients viz., rice bran, sunflower cake, sesame cake, *Leucaena* leaf meal, sugarcane bagasse, mustard oil cake and *Azolla*. Each ingredient was fermented with the bacterium at different moisture levels (40, 50, 60 and 70%) and different inoculum levels (0.5, 0.75, 1.0 and 1.25%) for different time intervals (0, 24, 48, 72 and 96 h) in triplicate, in order to

optimize fermentation conditions required for enrichment of nutrients in the ingredients. Dry matter, protein, starch, cellulose and free glucose content of feed ingredients were measured before and after the incubation to estimate the *in vitro* degradation of starch and cellulose.

After fermentation of all the ingredients, 50-60% moisture level, 1-1.25% (v/w) inoculum and 48 h of incubation were found to be optimum for fermentation of the seven locally available low cost fibrous feed ingredients using *B. subtilis*. It was also found that *B. subtilis* was able to reduce starch level 9.86- 17.02% and cellulose level 0.35 – 25.96% in different feed ingredients. It could also increase the protein level 2.11 – 10.46% when fermented with optimum moisture level for the optimum period. The results of the *in vitro* study indicated that *B. subtilis* could degrade starch and cellulose at substantial level when optimum condition was provided.

NH-O 18

Enrichment of the rotifer *Brachionus* “Cayman” with iodine and selected vitamins

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Brachionus “Cayman” is widely used live feed in fish larviculture. Our previous studies indicated that these live feeds may not fulfill the exact nutritional requirement of marine fish larvae. The present study was aimed to enrich rotifers with the micronutrients thiamine, vitamins C, A, E, and iodine up to the levels found in copepods, the natural feed for fish larvae in wild. Various levels of these micro-nutrients were supplemented along with the basal diet: Baker’s yeast-pronova oil-live *Chlorella* (65:25:15 DW). Rotifers were cultured with these supplemented diets for 4 days.

Maximum thiamine level (81 mg kg⁻¹ DW) was observed in rotifers fed with diet-3 containing 705 mg kg⁻¹ DW thiamine which is higher than the copepod level. Dietary thiamine reflects in



rotifers. Rotifers were fortified up to 262 mg kg⁻¹ DW, with Stay C as vitamin C source, which is below copepod level but much higher than the larval requirement reported by NRC (1993). More than 4 times higher than the copepod vitamin E level were achieved in rotifers. Dietary vitamin A was not reflected in rotifers. Retinol content reached only up to 7 mg kg⁻¹ DW in rotifers fed with highest booster diet which is around 3 times higher than the requirement reported by NRC (1993). All vitamins except vitamin A showed correlation with dietary content and rotifers content. Iodine content reached up to 64 mg kg⁻¹ DW which is in the range of copepod level (50-350 mg kg⁻¹ DW) and much higher than the requirement for the marine fish as reported by NRC (1993). The results of the study indicated that *Brachionus* can be fortified with vitamins and iodine except vitamin A, simultaneously, up to copepod levels or to satisfy marine fish requirement. Further studies are needed for the vitamin A enrichment.

NH-O 19

Purification and characterization of trypsin from the digestive tract of the rohu, *Labeo rohita*

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The endoprotease trypsin was purified from the digestive tract of the Indian major carp *Labeo rohita* by acetone fractionation followed by Ion exchange chromatography using DEAE-SephadexA-50. The purification obtained from acetone fractionation and ion-exchange chromatography were 3 and 11 folds respectively. The reaction was found to be linear up to 20 min.. The temperature of incubation was 50 °C. Two pH optima were obtained. The first one at 7.5 and the second between pHs 9.5 and 10. The enzyme retained about 80% activity above pH 4.0

and thus was found to be stable over a wide range of pH from 4 to 10. Trypsin enzyme was found to be stable to heat treatment up to 50 °C for 10 min. At 60 °C the enzyme retained only 10% of its activity. Thermostability property revealed the enzyme to be quite stable retaining complete activity for a period of 120 min at 30 °C. At 40 °C, the enzyme lost 36% of its activity in 120 min and the same extent was recorded in 60 min at 50 °C. The enzyme retained only 16% of activity at 60 °C in 15 min. Metal ions such as Cu⁺⁺ (32%), Zn⁺⁺ (53%), Hg⁺⁺ (45%), Bi⁺⁺ (89%), Pb⁺⁺ (56%) and Ag⁺ (77%) inhibited trypsin. Trypsin inhibitor Type II-S (Soybean) (5 mg /ml), sodium meta bisulphite, EDTA (10 mM) and Para methyl sulphonyl fluoride (PMSF) inhibited the enzyme strongly by 94, 49, 60 and 25% respectively. Parachloro mercury benzoate inhibited the enzyme by 88%. The kM and Vmax of the trypsin were calculated to be 0.083 mM and 414 nmoles.mg.min. Substrate staining technique through Native Gel electrophoresis revealed two isomers of trypsin in the purified fractions and the molecular weights of the trypsins were calculated to be 32 and 17 KD.

NH-O 20

Characterization and identification of phytase-producing bacteria associated with the digestive tract of *Channa punctatus* (Bloch) and *Oreochromis niloticus* (Peters)

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Isolation and characterization of phytase-producing bacterial flora in the digestive tract of carnivorous murrel, *Channa punctatus* and omnivorous Nile tilapia, *Oreochromis niloticus* have been carried out using selective modified phytase-screening medium (MPSM). The phytase activity was measured both qualitatively and quantitatively. Among the strains isolated from the gut of each fish, strains CPF6 and CPH6 isolated from the fore and hind gut,



respectively of *C. punctatus* (0.992 ± 0.05 U and 0.553 ± 0.05 U, respectively) and ONF2 (1.105 ± 0.05 U), isolated from the foregut of *O. niloticus* exhibited maximum phytase activity. One phytase unit (U) was defined as the amount of enzyme per ml of culture filtrate that released 1 μ g of inorganic phosphorus per min. Pure cultures of these strains were selected for morphological, physiological and biochemical characterization. The strains possessed some common phenotypic characteristics. All the strains are motile and Gram-positive rods and can grow in anaerobic condition also. They are capable of producing endospores. Both are capable of utilizing citrate, L-albinose and malonate. The strains show better temperature ($25-42^\circ\text{C}$) and pH (5-9) tolerance. Among the selected strains, ONF3 can tolerate NaCl concentration of 2.5 to 9.5% in growth medium. Strains CPF3 and CPH6 can tolerate NaCl concentration of 2.5-6.5% and 2.5-8.5% in the growth medium.

The chosen strains were further identified by 16S rRNA gene sequence analysis. All the three strains were identified as *Bacillus licheniformis* showing 99% similarity with *B. licheniformis* strain LCR32 (Accession No. FJ976541.1). This preliminary study clearly indicates the presence of phytase-producing bacteria in the gastrointestinal tract of fish. It is also necessary to conduct further research to characterize the phytase activity of the bacterial strains and its regulation, if any, as well as to isolate bacteria from fish gut with higher phytase activity.

NH-O 21

Enumeration of phytase producing gut microbiota in selected freshwater teleosts for probable application in aquafeed formulation

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Isolation and enumeration of phytase producing microbiota from the gastrointestinal tract of 14 fish species, namely, *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Labeo calbasu*, *Hypophthalmichthys molitrix*, *Cyprinus carpio*, *Labeo bata*, *Puntius sophore*, *Anabas testudineus*, *Oreochromis niloticus*, *Mystus vittatus*, *Heteropneustes fossilis*, *Gudusia chapra* and *Channa punctatus* have been carried out. The intestinal homogenates were inoculated on trypton soya agar and modified phytase screening medium by spread plate method for enumeration of culturable heterotrophic and phytase producing autochthonous microbial population. Heterotrophic population was maximum in the distal intestine (DI) of *G. chapra* followed by DI of *H. molitrix*; whereas phytase producing microbiota was highest in the proximal intestine (PI) of *G. chapra* followed by PI of *L. calbasu* (CFU 8.9×10^3 and 6.95×10^3 g^{-1} intestinal tissue respectively). Out of 95 phytase producing isolates, 32 isolates were randomly selected for quantitative phytase assay. The strain LBH isolated from *L. bata* showed highest phytase activity (2.33 ± 0.006 U/ml) followed by the strain GCF (2.19 ± 0.018 U/ml) isolated from *G. chapra*. Morphological, physiological, biochemical characterization and 16SrRNA gene sequencing followed by nucleotide blast in the NCBI GenBank and Ribosomal Database Project (RDP) revealed that the strain LBH was similar to *Bacillus subtilis* (GenBank Accession no: HM 352551), however, the strain GCF was similar to *Bacillus atrophaeus* (GenBank Accession Number: HM 246635).

Preliminary study revealed that *in vitro* processing of plant ingredients by phytase producing bacteria through solid state fermentation was effective in reducing phytate and other antinutritional factors, and subsequent enrichment of the raw materials. Therefore, autochthonous phytase producing bacteria detected in the present study might be used in processing of phytate rich plant feedstuffs for formulation of aquafeed.



NH-O 22

Preliminary study on growth performance and sex manipulation in *Clarias gariepinus* (Burchell, 1822) fed dietary genistein under laboratory conditionsO. A. SOGBESAN¹* AND Y. M. AHMED²¹Central Institute for Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, Odisha, India²Department of Fisheries, Federal University of Technology, Yola, Nigeria

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This study was carried out to evaluate the effect of ethanol extracted dietary genistein from soybean on the growth and sex in *Clarias gariepinus*. Four 40% isoproteic and isocaloric diets :diet A (GNC, but no genistein and SBM), diet B (GNC, SBM but no genistein), diet C (GNC and genistein but no SBM) and diet D (GNC, genitsein and SBM) were formulated and fed to *C. gariepinus* fry for 42 days. The fish were stocked in triplicate at the rate of 15 fry per 50 l plastic tanks in semi-flow through system under laboratory conditions. They were monitored for survival, growth and sex manipulations. The result of the experiment showed that fish fed diet B had the best mean weight gain of 2.64 g/fish, specific growth rate of 2.57%/day and relative growth rate of 1100.3%/fish followed by diet A with 2.41 g/fish, 2.41%/day and 926.9%/fish respectively while the least was recorded in fishes fed diet D with mean weight gain of 2.27g/fish, specific growth rate of 2.01%/day and relative growth rate of 597.4%/fish. The best FCR and highest PER of 1.20 and 1.96 respectively were also recorded in fish fed diet B. The sex differentiations showed that fish fed diet A gave 11 females and 7 males, diet B gave 13 females and 5 males, diet C, 12 females and 3 males while diet D gave 6 females and 13 males. The results of the experiment indicate that foregoing masculinization is possible in *C. gariepinus* when fed diets with overdose of dietary genistein.

NH-O 23

Biochemical characterization of trypsin purified from the viscera of rohu, *Labeo rohita*

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Indian major carp *Labeo rohita* (rohu) is one of the commercially important fish species. Nutrition plays key role in the sustainable production of this species. Digestion of ingested food is regulated by various digestive enzymes. Serine protease trypsin plays significant role in this stomachless fish. The present study aimed to purify and characterise trypsin from digestive system of adult rohu. Trypsin from the digestive system of rohu was purified by ammonium sulfate (30-50%) fractionation followed by DEAE (diethylaminoethyl)-cellulose ion exchange chromatography and affinity chromatography. Yield of trypsin obtained was 3.84% with 46.65 fold purification. Purified fraction obtained from affinity chromatography showed one single band in sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE). The molecular mass of the purified trypsin was 22.46 kDa by SDS-PAGE. The purified enzyme was partially inhibited (58.29%) by EDTA (ethylenediaminetetraacetate, 20 mM), and completely inhibited by SBTI (soybean trypsin inhibitor, 250 mM), PMSF (phenylmethylsulfonylflouride, 100mM) and TLCK (N- μ -p-tosyl-L-lysine chloromethyl ketone, 10 mM). The purified enzyme was active between pH 7.0 and 9.0. The optimum pH for trypsin activity was 7.6. Highest enzyme activity was found at 40 °C. The K_m , K_{cat} and catalytic efficiency values of purified enzyme were 0.104 mM, 44.25 s⁻¹ and 427.54 s⁻¹ mM⁻¹, respectively with N- μ -benzoyl-DL-arginine-p-nitroanilide (BAPNA) as substrate. The protease was inhibited by the following ions in decreasing order: Hg²⁺ > Al³⁺ > Li⁺ > Mg²⁺ > Cd²⁺ > Co²⁺ > Zn²⁺ > K⁺. All these information may be useful for the better understanding of the digestive physiology of carp.



NH-O 24**Use of herbal products as feed attractants for rohu, *Labeo rohita* (Hamilton)**JOYDEV MAITY^{1*}, JOYDIP MAHINTAMANI¹ AND BIDHAN C. PATRA²¹Fisheries Research Laboratory, Department of Aquaculture Management and Technology, Vidyasagar University, Midnapore – 721 102, West Bengal, India²Aquaculture Research Unit, Department of Zoology, Vidyasagar University, Midnapore – 721 102, West Bengal, India

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Feed attractants are defined as any type of compound that could be added as feed ingredients to a diet to help enhance the overall palatability of the diet. Adding attractants can improve acceptability of artificial diets by fish fry and fingerlings, increasing intake of unpalatable feeds and improving growth rate, while reducing feeding time and feeding wastes. Several herbal products have been in use for alluring fish during harvest and angling by traditional fishermen in different parts of India. This study was aimed to evaluate the effects of levels of inclusion of different attractants of plant origin on the performance of the Indian major carp, rohu (*Labeo rohita*) fingerlings (16 ± 0.58 g). Experiment was conducted in glass aquaria having 45 l water holding capacity. Initially, a survey was conducted in different parts of south West Bengal, India to identify the different feed attractants used by fishermen as bait for angling. Mainly they used the locally available plant origin and animal origin components like "Ekangi" rhizome dust, "Coco" dust, "Bakery waste", "Amada", "Turmeric plant", "Kharbaj/kasturi", "Ant egg", "Haria" etc. For laboratory experiment, three feeds were prepared using Ekengi (*Kaempferia galangal*) rhizome dust (D1), Kharbaj/Kasturi (*Quassia amara*) root dust (D2) and Marigold (locally known as "Ganda") flower (*Tagetes patula*) dust (D3) along with one control (C) diet. Fishes were fed at 4% body weight twice daily and gradually increased up to 8% of body weight as per need. From the 15 days experimental trial, it was observed that the responding time of *L. rohita* fingerlings to

the diet D2 (210 ± 10 second) is lower as compared to D1 (558 ± 08 seconds), D3 (1260 ± 12 seconds) and control (1520 ± 13 seconds). Water quality parameters were more or less same in all the aquaria and were within normal limits. Kharbaj/Kasturi showed better performance as compared to other attractants tested in the present study. The results of the study provided evidence that feed attractants are able to enhance feed intake in fish. The maximum feed intake of 8% was recorded for kharbaz with the minimum responding time.

NH-O 25**Effect of partial replacement of live food by formulated feed, on the growth and spawning performance of *Betta splendens***SAGAR C. MANDAL^{1*}, PRANOJ DAS², DEBTANU BARMAN³ AND MUNILKUMAR SUKHAM²¹Department of Aquaculture, College of Fisheries, Central Agricultural University, Lembucherra - 799 210, Tripura, India²Central Institute of Fisheries Education, Versova, Mumbai-400 061, Maharashtra, India³Laboratory of Aquaculture and Artemia Reference Center, Ghent University, Belgium

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Formulated feed (FF) was partially replaced with live food (LF) in the diets of *Betta splendens* to evaluate the effect on growth, survival and spawning performance. Three hundred *B. splendens* fry of uniform size (mean body weight 0.19 ± 0.01 g) were equally distributed in 5 different groups, each group with three replicates, in glass aquaria of 35 l capacity. *B. splendens* fry were offered diets at different ratio of LF and FF viz., T1 (control) - 100% LF; T2 - 75% LF, 25% FF; T3 - 50% LF, 50% FF; T4 - 25% LF, 75% FF; and T5-100% FF. Highest ($p < 0.05$) body weight gain (% BWG) (67.1 ± 1.03) and specific growth rate (% SGR) (2.34) were observed in T2 group. Best feed conversion ratio (FCR) was also found in T2 (2.40), which was not significantly different with T1 and T3 groups. Highest survival rate (%) was recorded in T1, T2 and T3 groups (97%), which did not differ with T4 group. Highest gonadal weight (0.12 ± 0.01 g) and gonadosomatic index



(% GSI) (15.17%) was observed in T3 group during 1st spawning sampling. Highest gonadal and GSI values during 2nd and 3rd samplings were observed in T2 (0.15 ± 0.01 ; 17.77%) and T1 (0.187 ± 0.01 ; 13.97%) groups, respectively. During 1st spawning sampling, highest fecundity, fertilized eggs and fertilization rate were recorded in T2 group. However, their highest value in 2nd sampling was found in T1 group. T4 group registered highest fecundity and fertilized eggs at the end of 105 days of experiment did not differ with T2 group. Therefore, from the present study, it can be concluded that live food can be replaced successfully up to 25% with formulated feed without any adverse effect on the growth, survival and spawning performance of *B. splendens*.

NH-O 26

Fermented seaweed, *Kappaphycus alvarezii* as ingredient in the formulated diet of the giant freshwater prawn, *Macrobrachium rosenbergii*

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The evaluation of raw and fermented *Kappaphycus alvarezii* as feed ingredients in giant freshwater prawn *Macrobrachium rosenbergii* was carried out by incorporation at three levels of 10%, 20% and 30% in diets. The digestibility experiments were conducted for a period of 15 days to assess the apparent digestibility coefficient (ADC) of dry matter, apparent protein digestibility (APD) and apparent lipid digestibility (ALD). The growth experiments were carried out for a period of 45 days to assess the biogrowth parameters viz., mean weight gain, FCR, FCE, PER, ADG, mean feed intake and ANPU. In digestibility experiments, among the raw and fermented seaweeds incorporated diets, the freshwater prawn fed with fermented *K. alvarezii* (FK) at 10%, showed maximum apparent digestibility

coefficients for dry matter (96.46%), APD (94.54%) and ALD (94.69%). In the growth experiments, prawn fed with FK at 10 % showed maximum mean weight gain (3.38 g), SGR (2.23), mean feed intake (4.47 g), percentage weight gain (173.69%) and PER (1.43). The best FCR value of 1.1424 was observed in prawn fed with FK at 10 % incorporation followed by FK at 20 % incorporation (1.15). The highest ADG value of 0.0753 g was recorded in the prawn fed with FK at 10% incorporation. The ANPU values was maximum (69.64%) in prawn fed the diet with FK at 10% incorporation. Nutritional improvement in seaweeds after fermentation was observed. Considerable increment in protein content of fermented *K. alvarezii* was observed (23.86%). The slight increment in the lipid contents was observed in all the three fermented seaweeds. Marginal reduction in ash contents and drastic reduction in crude fiber contents were observed in fermented *K. alvarezii*. The crude fiber content in fermented *K. alvarezii* was 5.20%. The gross energy in fermented seaweed was marginally increased as compared to the raw seaweeds. The whole body composition of prawns fed the raw and fermented seaweeds incorporated diets did not show any variations in moisture, protein, lipid and ash. The present investigation has demonstrated that seaweed can be a potential feed ingredient in the juveniles of freshwater prawn *M. rosenbergii*. The results of the study suggest that raw *K. alvarezii* could be incorporated in freshwater prawn diets up to 20% level and fermented *K. alvarezii* could be incorporated up to 30% level without compromising growth, digestibility and flesh quality.

NH-O 27

Growth of the freshwater prawn, *Macrobrachium rosenbergii* post-larvae on formulated feeds supplemented with fruits wastes

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The present investigation was carried out on the growth and production of *Macrobrachium rosenbergii* post-larvae (PL) fed with fruits wastes supplemented feed. Soybean meal, groundnut oilcake, horse gram and wheat flour were used as basal ingredients (Table). Dried and powdered fruits wastes, such as mango seed, banana peel and papaya peel were separately taken at 10% concentration and mixed with basal ingredients equated to 35% protein. Sunflower oil was used as lipid source. Egg albumin and tapioca flour were used as binding agents. Vitamin B-complex was also mixed. Feed without any fruit waste served as control.

PL of *M. rosenbergii* (length 1.2-1.4 cm; weight 0.09-0.13 g) were fed with these feeds for a period of 90 days. The following parameters were analyzed: morphometry (length and weight); food indices (survival rate, weight gain, food conversion ratio and protein efficiency ratio); energy utilization (feeding, absorption, conversion, ammonia excretion and metabolism); proximate composition of biochemical constituents (total protein, amino acid, carbohydrate and lipid); profiles of amino acids and fatty acids; levels of non-enzymatic antioxidants (vitamin-E and vitamin-C); activities of digestive enzymes (protease, amylase and lipase); and concentrations of electrolytes (sodium and potassium). The overall results observed in these parameters suggest that among the three fruits wastes tested, mango seed incorporated feed resulted in better performance in terms of survival, growth and various biochemical parameters followed by banana peel and papaya peel when compared with control. Therefore, this study suggests that these fruits wastes can be incorporated as supplements in low cost feed formulation for developing sustainable aquaculture practices of freshwater prawns.

Table. Proportion of ingredients in formulated feeds (g/100g)

Ingredients (g/100 g)	Feed-1 Control (BI)	Feed-2 (BI+ MS)	Feed-3 (BI+ MS)	Feed-4 (BI+ PP)
Soybean meal	30	32	32	32
Groundnut oilcake	20	23	23	23
Horse gram	20	20	20	20
Wheat flour	20	5	5	5
Tapioca flour	5	5	5	5
Egg albumin	3	3	3	3
Sun flower oil	1	1	1	1
Vitamin mix	1	1	1	1
Mango seed	-	10	-	-
Banana peel	-	-	10	-
Papaya peel	-	-	-	10

BI: Basal ingredients; MS: Mango seed; BP: Banana peel; PP: Papaya peel

NH-O 28

Use of *Cannabis sativa* leaf in formulated fish feed as growth enhancer for ornamental fish

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Cannabis sativa leaves and flower buds contain terpeno-phenolic compounds called cannabinoids. Two such compounds are cannabidiol (CBD) and Δ^9 -tetrahydrocannabinol (THC). Among these, THC has proven psychoactive effects and is used as human medicine. Administration of THC increases the heart rate, blood circulation and hunger in human beings. Based on this medicinal property, formulated fish feeds were prepared with air dried and powdered leaves of *C. sativa* (5% w/w), along with other ingredients such as rice bran, wheat flour, fish meal, ground nut oil cake, mustard oil cake, binders, preservatives, vitamin and minerals in definite quantities. Standard feed mill setup was used to extrude



the feed pellet and the pellets were hot air dried for 10-12 h at 45 °C. The water stability of the formulated feed was about 5-6 h when used in aquarium. Water quality parameters were tested at every 7 days interval. Water parameters maintained during the experimental period were: Temperature 29 °C, pH 8.0, Phosphate (PO₄) 0 ppm, Nitrate (NO₃) 25 ppm and Nitrite (NO₂) 0.05 ppm. The formulated feed was fed to gold fish (*Carassius auratus*) fry for 30 days @ 25% of their body weight and the effect of the feed on growth and behaviour was recorded closely in comparison with the control group fed on normal commercial fish feed. Results showed that gold fish fry fed *C. sativa* incorporated feed were more agile and had better appetite as compared to control fish fed with commercial fish feed. Average body weight and average body length were recorded at 10 days interval. Analysis of data showed that *C. sativa* incorporated diet fed fish had better food conversion ratio (FCR) of 2.5 as compared to the FCR of 3.1 recorded in control fish. Nutritional analysis also indicated better food value for the *C. sativa* incorporated diet. Formulated feed with *C. sativa* had moisture 10%, fat 4%, protein 28%, carbohydrate 30%, where as the control feed had moisture 10%, fat 3%, protein 28% and fibre 4%. As the present experiment was limited to prefix the level of incorporation of *C. sativa* in the feed, there is need for further investigations with different levels of *C. sativa* for optimisation of the results.

NH-O 29

Effect of *Azolla* based feeds on growth and flesh quality of Indian major carps

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A 210-days feeding trial was conducted to assess the efficacy of *Azolla* (an aquatic fern) based diets in a semi-intensive carp polyculture system. Carp fry (*Catla catla*, *Labeo rohita* and

Cirrhinus mrigala) were fed diets containing sun-dried *Azolla* at 10% (D2), 20% (D3), 30% (D4) and 40% (D5) level by replacing basal diet - D1 (de-oiled rice bran and mustard meal in the ratio 1:1). Effect of *Azolla* based diets on physico-chemical parameters of water, pond productivity and survival, growth and flesh quality of fish were monitored and the results are discussed in the paper.

NH-O 30

Health management issues in mariculture of finfish and shellfish: an Indian perspective

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In India, sea farming or mariculture of finfish and shellfish is in its initial phase and has been identified as an alternative to the traditional fishing from the wild. Successful technology development and demonstration of bivalve farming and finfish cage farming, by Central Marine Fisheries Research Institute (CMFRI), has given the much needed impetus for expansion. Farming of green mussel (*Perna viridis*) has recorded an impressive growth in the past decade, with an annual production of about 20,000 t in 2011. However, the health management issues in mariculture has not been given the required focus, considering the experience in Indian shrimp farming sector, where the crop loss due to disease outbreak, contributed to the economic failure of the entire sector.

Preliminary studies by CMFRI on the finfishes such as cobia, snapper, seabass and grouper broodstocks sourced from wild and reared in cages have showed the presence of disease causing organisms belonging to helminths, crustaceans and acanthocephalans in significant levels. Parasites such as monogeneans and sealice affect the health status of the broodstock, leading to secondary



bacterial infections resulting in septicemic conditions. High levels of acanthocephalan infection has been recorded in all species of finfish which may lead to physiological dysfunction. Noda virus, one of the first virus infection reported from Indian seabass is also traced to hatchery produced seeds, suggesting a transmission of pathogen through horizontal/vertical route. Report of the OIE listed pathogen, *Perkinsus* spp, among farmed edible oysters and pearl oysters along southern India is a major concern, especially with the intensification of farming activity of bivalves such as green mussel. Pathogen profiling among the broodstocks of candidate species is imperative, in the management of pathogens and disease problems in the rearing system. This information is to be generated at the species and geographic level, as profile of pathogens can vary widely on the basis of species and farming locations. Development and use of novel diagnostic tools with high specificity and sensitivity for non-lethal detection of broodstock pathogens is also to be developed for successful fish health management.

NH-O 31

Comparison of probiotic effect of fish gut microbiota with commercial preparation of lactic acid bacteria (LAB) and yeast cells on the growth performance of rohu, *Labeo rohita* (Hamilton) fingerlings

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The present experiment was designed to compare the growth performance and nutrient utilization of rohu, *Labeo rohita* fingerlings fed commercially available probiotics supplemented *Lemna polyrhiza* leaf meal incorporated diets with that of fish fed *L. polyrhiza* leaf meal supplemented with two autochthonous bacterial strains isolated from fish gut. The bacterial strains, *Bacillus subtilis* CY5 and *Bacillus circulans* TP3 were isolated

from the gastrointestinal tract of *Oreochromis mossambica* and *Cyprinus carpio*, respectively. Four isonitrogenous (35% crude protein approximately) and isocaloric (4.27 kcal/g approximately) diets (D1 to D4) were formulated incorporating *L. polyrhiza* leaf meal at 30% level with other feed ingredients. Diets D1, D2, D3 and D4 were supplemented with lyophilized lactic acid bacteria (LAB; 'Lactobacil', Intercare Ltd., Mehsana, Gujarat, India), lyophilized baker's yeast (Burns Philip India Pvt. Ltd., Kolkata, India), *B. circulans* TP3 and *B. subtilis* CY5, respectively at the rate of 107 cells per 100 g feed. A reference diet (RD) was formulated without leaf meal and microbial supplementation. The diets were fed to rohu fingerlings (average weight: 3.24 ± 0.04 g) at a fixed feeding rate of 3% body weight per day for 60 days and fish performance was studied. There were three replicates for each dietary treatment.

Fish fed *L. polyrhiza* leaf meal incorporated diets supplemented with baker's yeast (diet D2) performed significantly ($p < 0.05$) better in terms of % live weight gain, SGR and PER. Fish reared with *B. circulans* TP3 supplemented diet (diet D3) followed the dietary group D2 in terms of overall growth performance. Fish fed diets D3 and D4 supplemented with *B. circulans* TP3 and *B. subtilis* CY5, respectively performed significantly ($p < 0.05$) better than the groups of fish fed diet D1, supplemented with LAB and the reference diet (RD). The apparent digestibility of protein was highest for diet D2 followed by diet D3. The carcass protein content increased from the initial value in all dietary groups, the highest being in the group of fish reared with diet D2. Although yeast cells at the rate of 107 cells per 100 g of feed were found to be effective in better performance of rohu fingerlings, the supplementation of autochthonous bacterial strains of *Bacillus* sp. was found to be superior as compared to that of commercial preparation of LAB. The results indicate potential for the use of autochthonous bacterial strains from fish gut as probiotic supplement in aquafeeds.



NH-O 32**Impact of probiotics on shrimp culture practices - a farm based study**

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India occupies 5th position in cultured shrimp production and farmed shrimp contributes about 60% by volume and 82% by value of total export. Shrimp farming is an important component of the Indian aquaculture industry and about 75% of the farming area is culturing the species *Penaeus monodon*. Shrimp aquaculture production plays a pivotal role in developing the economy of India. It provides employment directly to about 0.3 million people and indirectly to 0.6 to 0.7 million people mainly in states bordering the east coast states of Andhra Pradesh, West Bengal, Tamil Nadu and Orissa since a decade. At present, both area and production are the highest in Andhra Pradesh (79,760 ha; 51,230 mt) accounting for 50.57% and 50% of total cultured shrimp area. The yield from shrimp production started declining since 1992 due to diseases outbreaks, water quality problems etc. The indiscriminate usage of antibiotics and therapeutic agents by shrimp farmers, were unable to control these problems and posed another serious threat to environment such as antibiotic residues. The probiotics approach came as an alternative to these problems with an immense potential in aquaculture. In spite of the usage of different commercial probiotics, there were mixed results in terms of output. Keeping in view of this background, the present study was designed to evaluate the impacts of the different types of probiotics used by the shrimp growers who are holding 0-2 ha culture area. A farm based study was carried out during the first crop of 2011, at three mandals (taluka's) viz., Putcha kurthivari palem, Matlapudi and Karlapalem of Guntur district of Andhra Pradesh. The respondents were identified using simple random sampling.

The interview schedule was conducted with the aid of well structured and pre-tested questionnaires containing 33 items including both open and closed ended questions. The results showed that all (100%) of the shrimp farmers were using commercial probiotics such as Pro-B Active A, Biocult, Avant grow, Avant Bact, Black solve, Prob solve, Soil pro BR, MicroPS and EnvironAC etc., comprising of water, feed and soil probiotics. Out of the 25 farmers surveyed 44% were using water probiotics, 44% using feed probiotics and 12% of the farmers using soil probiotics. The results clearly indicated that the usage of probiotics yielded increased benefits in all aspects which includes shrimp survivability, reduction of total cost of average production, reduction of disease prevalence, improved water quality and pond bottom conditions and recorded a better feed conversion ratio (FCR). The results also showed that there was correlation between usage of probiotics and shrimp growth. All (100%) the collected samples of 10 different types of commercial probiotics used by sampled respondents were analyzed for the presence of genuine bacterial strain. All (100%) the analysed probiotics showed the presence of bacterial strains as per the labeling. The present study concluded that the usage of different types of commercial probiotics showed positive impact on shrimp grow-out production.

NH-O 33**Effect of *Vibrio* bacterial product 'CIBASTIM' administration on productivity in commercial tiger shrimp, *Penaeus monodon* culture ponds in Gujarat**H. G. SOLANKI¹, J. H. BHATT¹, C. GOPAL², P. K. PATIL² AND S. M. PILLAI^{2*}¹Soil and Water Management Research Unit, N.A.U. Navsari, Gujarat, India²Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu, India

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A study was conducted to evaluate the effect of *Vibrio* bacterial product 'CIBASTIM' an immunostimulant, on production



of *Penaeus monodon* culture in five commercial shrimp farmers' ponds in Navsari District of Gujarat. The immunostimulant was administered at a concentration of 2×10^6 CFU/kg pelleted feed as a feed top dressing using a commercial binder for two consequent days in a week throughout the culture period. In each farm, equal numbers of ponds were kept as control without administering the immunostimulant and uniform management practices were followed in all the treated and untreated ponds. The abiotic (pH, salinity, temperature) and biotic (average body weight, average daily gain) parameters were recorded fortnightly. Significant improvements in the average body weight (3.57-33.33%), survival rate (11.61-44.83%), FCR (7.14-11.11%) and the production per ha (16.67-50.00%) was recorded over the control ponds of the same farm. The results clearly showed that administration of CIBASTIM at the above dose, significantly improved *P. monodon* production. This is the first report of the performance of CIBASTIM in commercial shrimp culture operations in farmers' ponds.

NH-O 34

Dietary *Bacillus circulans* and fructooligosaccharide application improves growth and immune function in *Labeo rohita* (Hamilton, 1882) juveniles

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The present investigation examines the effect of dietary symbiotic combination of *Bacillus circulans* and prebiotic fructooligosaccharide (FOS) on growth and immune responses of juvenile *Labeo rohita* (average weight 11.5 ± 0.68). Eight diets were formulated to contain graded levels of *B. circulans* at 10^6 and 10^8 cfu g^{-1} , FOS at 1% 2%, four combinations (*B. circulans*+FOS) and a control. Each diet was randomly assigned to

triplicates of 10 numbers of rohu juveniles. On termination of the experiment, growth and immune responses were assessed in terms of specific growth rate (SGR), feed conversion ratio (FCR), lysozyme activity, bactericidal activity (SBA), superoxide dismutase (SOD) and blood WBC, RBC, haemoglobin, glucose and respiratory burst activity (NBT). Results using two way ANOVA showed that supplementing dietary *B. circulans* and FOS improved growth as defined by significantly higher SGR and lower FCR compared with control. However, interaction between the two components was not significant. Significantly higher WBC, RBC, haemoglobin, lysozyme, NBT, SOD and low glucose was observed as compared to control owing to dietary supplementation of probiotic and prebiotic. Highest value was recorded in combination diet and interaction between the two dietary components was significant. Overall result implies that synergistic effects of the biotic components on immunomodulation exist in *L. rohita* juveniles. Growth and immune retardation occurred at higher dose of prebiotics which needs further investigations.

NH-O 35

Probiotic based diets for freshwater prawn, *Macrobrachium rosenbergii*-a case study

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With the rapid population growth and requirement for fish protein as food, the modern aquaculture system began. During the past 50 years, numerous trials were conducted with microorganisms known as 'probiotics' in order to improve cultivability of food animal, and to improve human health and welfare. 'Antibiotics' have been used as therapeutic agents and growth promoters in the animal feeds since 1950. However, excess use of antibiotics led to development of antibiotic resistance to some bacterial pathogens. The



Swann committee restricted the use of antibiotics as growth promoters, leaving these antibiotics only for use in the treatment of disease. This situation paved the way for the search for an alternative to the antibiotics in livestock production systems. This gap was filled through the use of beneficial bacteria to fight pathogenic bacteria (by competitive exclusion), i.e., 'probiotic' which was an acceptable practice in animal husbandry. The most commonly used probiotics in animal nutrition are lactic acid bacteria (LAB). The beneficial effects of probiotics include higher growth and feed efficiency, prevention of intestinal disorders and pre-digestion of anti-nutritional factors present in the ingredients. Hence, probiotics in aqua-feed can also be tested for their efficacy as have already been demonstrated in animal production systems. Unlike animal production practices, use of probiotics in aqua-feeds may have limitations due to water exposure. Therefore, selection and screening of suitable probiotics in the aqua-feeds is needed. The present experiment was designed to study the response of commercially available probiotics in the diet of *Macrobrachium rosenbergii*.

In the present investigation, experimental trials were conducted to investigate the impact of two commercial probiotics (Prosol and Improval) in supplementary diets of *M. rosenbergii* post-larvae and juveniles. The experiment was conducted in tanks of 350 l capacity for a period of 105 days. For each dietary treatment, triplicates were maintained. Ten experimental diets were formulated with different levels of probiotics. Significantly higher growth ($p < 0.05$), for final body weight, net body weight gain and specific growth rate were recorded in prawns fed diet containing 2-3% of probiotic 'Prosol' and 4% of 'Improval'. In addition, the apparent feed conversion ratio and protein efficiency ratio in dietary treatments having probiotic were significantly better ($p < 0.05$) than control diet. The results of our study suggest that the addition of probiotics as growth promoter in the diet may be useful for profitable culture of *M. rosenbergii*.

NH-O 36

Optimization of *Saccharomyces cerevisiae* for better survival, growth and production of *Macrobrachium rosenbergii*

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The present study was conducted for optimization of the level of incorporation of the probiotic, *Saccharomyces cerevisiae* on the survival, growth, biochemical constituents and energy utilization in post-larvae of *M. rosenbergii*. *S. cerevisiae* was incorporated at 1%, 2%, 3% and 4% levels in the diet (basal ingredients: fish meal, soya meal, groundnut oil cake, corn flour, cod liver oil; binding agents: tapioca flour, egg albumin and guar gum). Vitamin B-complex was also supplemented. PL-30 of *M. rosenbergii* was fed with *S. cerevisiae* incorporated diet for a period of 90 days. Leaching of these diets varied between 14-15% in 8 h duration. The survival rate, total weight gain (WG), specific growth rate (SGR), feed efficiency rate (FER) and protein conversion efficiency (PCE) were found to be higher in 4% *S. cerevisiae* incorporated pellet fed PL when compared with other tested groups. The proximate biochemical composition, such as total protein, amino acid, carbohydrate, lipid and ash contents were also higher in 4% *S. cerevisiae* incorporated diet fed PL. The energy utilization parameters, such as feeding, absorption, conversion and metabolism were all found to be higher in PL fed 4% *S. cerevisiae* incorporated diet. Among different concentrations of *S. cerevisiae* tested, 4% was found to result in better survival, growth and production of *M. rosenbergii*.

NH-O 37

Control of pathogenic bacterial population by application of probiotics in *Penaeus monodon* culture in India

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The most important shrimp species used for culture in Indian aquafarms for the past two decades is *Penaeus monodon*, though in the recent couple of years *Litopenaeus vannamei* culture has been taken up in Andhra Pradesh and Tamil Nadu states. During recent times, due to various problems like non-availability of good quality post-larvae, low export price and regular disease incidence, the culture productivity is reduced in the ponds of coastal Andhra Pradesh. The application of probiotics has been accepted as an important management approach for controlling diseases as well as for management of water quality and plankton population in Indian shrimp farms in recent years.

The present study was undertaken to evaluate the effect of selected probiotics in controlling pathogenic bacterial populations and in management of water quality, as well as plankton population, in *P. monodon* culture ponds. The study was conducted in four experimental ponds along with two control ponds located at Amplam and Kaikalur areas of coastal Andhra Pradesh during the first crop from January-April, 2011. The commercial probiotic used was a product having combination of *Bacillus* species and *Pediococcus* species at 4 Billion cfu/g. The changes in bacterial dynamics of both pathogenic and non-pathogenic bacteria and incidence of pathogenic colonies of *Vibrio* sp. with difference in the frequency of application of probiotics at intervals of 7 and 15 days in the experimental ponds were compared with that of the control ponds. The study showed interesting and significant results in the management of plankton, prevention of pathogenic bacterial problems and also better performance of shrimps in terms of growth and survival in the probiotic treated ponds.

NH-O 38

Probiotic effect of a marine *Streptomyces* sp. on growth of the Indian white shrimp *Fenneropenaeus indicus*

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A strain of *Streptomyces* sp., isolated from the mangrove rhizosphere was evaluated for its potential use as a probiotic for the Indian white shrimp, *Fenneropenaeus indicus*. Probiotic effect was checked both via feed and water. The water quality parameters and the microbial load in the experimental tanks were checked once in every five days for a period 30 days. Shrimp growth was recorded before commencement and also on termination of the experiment. Survival and growth of *F. indicus* fed the probiont, *Streptomyces* species during the 30 days experimental period was higher as compared with non-treated shrimps. In addition to this, shrimps treated with water probiotics showed better growth response than shrimps supplemented with feed probiotics. It is inferred from our results that *Streptomyces* species improved water quality and also produced inhibitory compounds against shrimp pathogens. Hence, this strain may be used to inhibit pathogenic bacteria and also to promote growth and survival of the shrimps in aquaculture.

NH-O 39

Control of disease and growth of koi carp, *Cyprinus carpio carpio* using probiotics

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An experiment was conducted to evaluate the effect of selected probiotics (*Lactobacillus acidophilus* and *Bacillus subtilis*) against four bacterial species viz., *Aeromonas hydrophila*, *Pseudomonas aeruginosa*, *Staphylococcus arizone* and *Vibrio parahaemolyticus* by *in vitro* techniques. Microbial analysis of normal aquarium water was done and the incidence of harmful bacterial



species was noted. Prepared probiotic was applied in the above aquarium tanks and after 48 h, only the probiotic bacteria used was found to be present in the water. During the experimental period, some diseased koi carps (*Cyprinus carpio carpio*) were bought from Howrah district, West Bengal, which were treated by the said prepared probiotic and were found quite normal after ten days of treatment. Probiotic was applied directly in water and through feed to the aquarium containing diseased koi-carps for three months consecutively to test the development of immunity against the common pathogens. Satisfactory results were recorded and the experimental fishes were found healthy, energetic and found no trace of hazard within the confined water body.

NH-O 40

Immunostimulatory effect of artificial feed supplemented with indigenous plants in *Clarias gariepinus* against *Aeromonas hydrophila*

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Control artificial feed and artificial feed supplemented with 5% powder of *Ficus baghensis* (prop-root), *Leucaena leucocephala* (pod seed) and mixture of *F. baghensis* (prop-root) and *Aegle marmelos* (1:1) were prepared. Juvenile *Clarias gariepinus* were acclimatized to laboratory conditions and fed with respective feeds for 20 days. Immunomodulatory response of supplementary feed was studied by challenging the fishes at weekly intervals with *A. hydrophila* through intraperitoneal injections. One set of non-challenged fishes was used as a negative control to analyze the effect of supplementary feed.

Blood samples were collected at weekly intervals for a period of four weeks and serum samples were analyzed to evaluate the damage caused by *A. hydrophila* in target organs. The increased levels of SGOT and SGPT in positive control group indicated the damage of liver, however

the levels did not vary significantly in fishes fed with experimental diets as compared to negative control group. Nitric oxide, SOD, ALP and lipid peroxidase levels indicated lower stress level in experimental diets fed fishes compared to controls. Fishes fed with supplementary diet showed increased total protein level, lysozyme activity and phagocytic index indicating the increased non-specific immune response. Antibody in serum was detected by Ouchterlony double immunodiffusion and dot blot. The immunoglobulin levels in serum analyzed by sandwich ELISA showed higher antibody production in fishes fed with supplementary feed. The results of the current study suggest immunostimulatory role of *F. baghensis* (prop-roots), *L. leucocephala* (pod seed) and mixture of *F. baghensis* and *A. marmelos* in *C. gariepinus* when supplemented in artificial feed.

NH-O 41

Molecular characterization of Toll-like receptor 22 gene, and analysis of its signaling cascades in inducing innate immunity in rohu, *Labeo rohita*

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Toll-like receptors (TLRs) are one of the key components of innate immunity. Among various types of TLRs, TLR22 is unique in fish that recognize bacterial LPS, and double-stranded RNA virus mimicking molecular structure poly I:C, and after binding, it triggers myeloid differentiation primary response gene 88 (MyD88)-dependent signaling pathway to induce pro-inflammatory cytokines. We analyzed the expression profile of TLR22 and its associated downstream signaling molecules like MyD88 and tumor necrosis factor (TNF) receptor associated factor (TRAF) 6 in rohu



(*Labeo rohita*), the most important Indian Major Carp species in the Indian subcontinent. Tissue specific expression analysis of this gene by quantitative real-time PCR (qRT-PCR) revealed their wide distribution in various organs and tissues. Modulation of TLR22, MyD88 and TRAF6 gene expression, and the induction of innate immune cytokines were analyzed in various organs by qRT-PCR following LPS stimulation, poly I:C treatment and bacterial infections. In the treated fish, majority of the tested tissues exhibited significant induction of TLR22, activation of adaptor molecules, and the expression of cytokines. These findings suggest the important role of TLR22 in augmenting the innate immunity in fish in response to pathogenic invasion.

NH-O 42

Tissue specific expression profile of Toll like receptors 20 and 21 in *Heteropneustes fossilis* in response to *Aeromonas hydrophila* infection

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Due to high nutritional value, there is a constant demand for increased production of catfish in India. The major limiting factor in the success of catfish production is prevalence of pathogenic microorganism in culture systems causing disease outbreaks. Haemorrhagic septicaemia, an important disease affecting cultured catfish is mostly caused by the bacterial pathogen *Aeromonas hydrophila*. Since adaptive immunity is not very well developed in catfishes, innate immunity plays the major role in its defense mechanism. Toll-like receptors (TLRs) are evolutionarily conserved pathogen recognition receptors (PRRs) that function in innate immunity through recognition of the conserved pathogen associated molecular patterns (PAMPs) of an invading pathogen and eliciting inflammatory and immune responses. Using semi-quantitative

PCR, the relative transcriptional levels of two toll-like receptors (TLR20 and TLR21) were studied in the different tissues viz., liver, gill, head kidney, spleen and intestine of the catfish, *Heteropneustes fossilis* in control and treated [with 8.5×10^6 CFU of *Aeromonas hydrophila* (strain PB-19)] fishes at 24 h post-injection (hpi). Expression of TLR 20 and TLR 21 in different tissues of the control and infected fish was analysed by densitometry after normalizing the expression of both the genes in each tissue with respect to that of β actin expression. In control fish, the TLR 20 and TLR 21 gene expression were in the order of spleen > intestine > head kidney > gill > head kidney > liver > spleen > intestine, respectively. In treated fish, a quantifiable upregulation of 0.21 and 0.16 fold of TLR 20 gene expression were observed in spleen and intestine respectively. TLR 21 gene upon infection showed a peculiar expression pattern with a significant down regulation in liver, head kidney and intestine to the tune of 0.33, 0.32 and 0.14 fold respectively, while a tremendous upregulation was observed in intestine and spleen to the tune of 0.45 and 0.61 respectively with respect to control fish. There was no detectable change in expression of TLR 20 in head kidney and gill of treated fish relative to that of control fish. TLR 20 expression was not observed in liver. Our results showing significant regulation of TLR mRNA in response to pathogenic infection suggest that TLRs are important components in the immune system in the catfish, and their transcriptional regulation might be important in protection from *A. hydrophila* infection in catfish.

NH-O 43

Implications of the virulence variations and genomic stability of white spot syndrome virus

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White spot syndrome virus (WSSV) has become an enzootic pathogen in the



cultured and wild caught shrimps in India. Onsets of overt clinical infections are still capable of completely destroying the crop with near 100% mortality. The virus is found to have multiple crustacean and other invertebrate hosts, many of which are found to act as carriers. Specific instance of massive mortality was also observed in a crab culture farm in south India with apparently no external signs including the white spots.

We observed the presence of multiple strains of WSSV among the cultured shrimp populations of India, which differed in their variable number of tandem repeats in ORF 94, ORF 125 and ORF 75 or exhibited deletion variations in the variable regions (ORF 14/15) of the genome. Analyses on the association of the different strains of WSSV with age of the cultured shrimps or geographic location of farm showed no integral relationship. Our investigations on the pathogenicity variations among these isolates revealed the biological variation of the WSSV isolates in terms of virulence to juvenile *Penaeus monodon*. While some of the strains killed the shrimps instantly (in less than 10 days) others did not cause any mortality to juvenile shrimps of same cohort in experimental infections. This was also further proved in a subsequent study where the cumulative death time of the entire experimental animals varied from 22 h to 136 h for different isolates of WSSV. Our experiments also proved that the infectivity of the isolates vary independent of the viral load in several cases. This finding indicated the presence of virulence variations among the isolates of WSSV. Induction of variation in virulence and alteration in the genomic organization was also observed when the virus has to pass through different crustacean hosts. Although the environmental factors may be playing a significant role in the onset of WSSV infection in the field conditions, virus virulence may also have a prominent role in the WSSV outbreak, which could probably linked with specific genomic characteristics. Our investigations on variable regions or deletion regions of the virus did not yield any conclusive

link to a genomic marker and virulence of WSSV. However, the presence of multiple strains of WSSV in the field and their ability to change the genomic and virulence characteristics show potential threat posed by this virus to the farmed shrimps, at the same time highlights the evolution of low virulent WSSV strains which could probably delay overt infection by a virulent WSSV strain.

NH-O 44

Evaluation on the efficacy of the toxin gene knockout mutant live vaccine of *Aeromonas hydrophila* in *Labeo rohita* by challenge studies

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An experiment was conducted to evaluate the haemolysin gene knockout mutant live vaccine of *Aeromonas hydrophila* using mobile group II introns, by intraperitoneal (i.p) injections. Vaccine would enhance the immune response and disease resistance against infections of *A. hydrophila* (Ah1) in *Labeo rohita* fingerlings. Hence, haemolysin gene knockout mutant live vaccine of *A. hydrophila* suspension in phosphate-buffered saline through i.p injection was administered to the fingerlings of *L. rohita* and 0.1 ml PBS was injected to control fishes. At weekly intervals, different serum biochemical and immunological parameters of fish were evaluated during the immunization trail of 28 days. Control group and immunized group were challenged with virulent strain of *A. hydrophila* (Ah1) through i/p injection at 0.1×10^6 CFU/ml. There was 100 % mortality in control group by end of 8 days while only 20 % mortality was recorded in immunized group. Relative percentage survival was 80 % recorded on 21st day post challenge. Most of the immune parameters such as leucocyte count, differential leucocyte counts, total serum protein, albumin, globulin and A/G ratio and lysozyme activity were significantly ($p < 0.05$) enhanced during



immunization. Multiple injections of haemolysin knockout mutant live vaccine of *A. hydrophila* might have maintained the activation of phagocytic cells for a long period which in turn would lead to protection in fishes. Histopathology of samples from the gill, liver, heart and kidney of dead fish and surviving fish were studied at the end of the experiment on day 21 post-challenge. The results are discussed in the light of the available literature.

NH-O 45

Antioxidant level response in Asian seabass, *Lates calcarifer* early stages under vaccination for Noda viral disease and on challenge

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Quality seed production of Asian seabass (*Lates calcarifer*) is an important pre-requisite for good growth and healthy fish production in culture systems. Seabass farming has shown promising results for intensification. With the intensification of farming, there will be likelihood of outbreak of diseases like Noda viral infection affecting the culture of the fishes. To meet the probable challenges, a programme for the viral vaccine against Noda virus (NV) has been initiated. In the present investigation, an attempt was made to evaluate the antioxidant levels in Asian seabass juveniles up on vaccination using heat killed Noda virus both by immersion and oral means followed by homologous challenge of the vaccinated fish with the virus. The antioxidant levels recorded in the experimental fish prior to vaccination were : glutathione peroxidase 117.33 ± 1.25 nmol/min/ml, glutathione transferase 63.67 ± 0.94 nmol/min/ml, superoxide dismutase (SOD) 6.15 ± 0.01 unit/min/mg protein, total glutathione 82.00 ± 1.63 unit/l, catalase 24.77 ± 0.40 nMH₂O₂/min/mg protein, lipid peroxidase 2.10 ± 0.01 nM/mg protein, SGOT

57.67 ± 0.58 , SGPT 75.33 ± 1.15 and alkaline phosphatase 104.67 ± 1.15 in the control (normal) fish. The antioxidant levels were found to decrease in immersion as well as orally vaccinated fishes as compared to that of control group, except SGOT and SGPT which showed slight increase. When the vaccinated fishes were subjected to homologous challenge, marginal increase in the levels of the antioxidants was observed as compared to that of vaccinated fishes and slightly lesser than the control animals. The results of the preliminary investigation indicated that vaccination is effective in reducing the stress caused due to the virus in the fish and revealed that heat killed viral vaccine could be used for controlling Noda viral infection in Asian seabass.

NH-O 46

Prevalence of transferable oxytetracycline resistance factors in *Aeromonas hydrophila* of Indian major carp and African catfish hatcheries

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The distribution of motile aeromonads and prevalence of transferable oxytetracycline resistance factors in *Aeromonas hydrophila* of Indian major carp and catfish hatcheries in West Bengal, India were studied. A wide variation in the motile aeromonads counts of source water (log 0.70 - log 3.67 /ml) was recorded. While the counts of motile aeromonads in carp hatching pool water (log 4.23 - log 4.54 /ml), carp larval rearing water (log 3.36 - log 3.93 /ml) and catfish larval rearing water (log 5.41 - log 5.85 /ml) of different hatcheries did not vary much. The motile aeromonads counts in the range of log 2.81 - log 4.28 /carp larva and log 6.08 - log 6.69 /g catfish larvae were recorded. The sensitivity of 48 *Aeromonas* strains to six antibiotics was observed to be in the following descending order: gentamycin, chloramphenicol, ciprofloxacin, nitrofurantoin,



oxytetracycline and co-trimoxazole. The incidence of multiple antibiotic resistance (MAR) in motile aeromonads was significantly high ($p < 0.05$) in catfish hatcheries (95%) than in carp hatcheries (41%). The prevalence of MAR in *A. hydrophila* (69%) was high, but insignificant ($p > 0.05$) than in *A. caviae* (55%). The mutation frequency of *A. hydrophila* strains to oxytetracycline (25 µg/ml) was in the range of 6.71×10^{-9} - 1.60×10^{-6} . The oxytetracycline resistance factors of size 20.13 and 25.41 kb from *A. hydrophila* were transferred to *Escherichia coli* K12 at a frequency of 2.70×10^{-6} - 5.35×10^{-3} . These bacteria carrying resistant factors may be the source of spreading antibiotic resistance to other environmental and pathogenic bacteria, which share the same aquatic environment.

NH-O 47

Histopathological changes associated with vibriosis in cobia, *Rachycentron canadum*

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The occurrence of vibriosis in sea cage farming of hatchery produced cobia juveniles was recorded at Regional Center of Central Marine Fisheries Research Institute, Mandapam Camp, Tamil Nadu. The mortality of juveniles occurred from May to October 2010. The cobia juveniles at 100 day post-hatch with an average weight and length of 44 g and 19 cm respectively were transferred from nursery tanks to grow-out sea cages. Initial mortality of 25 numbers occurred during May and the length and weight of dead fishes were 30-70 g and 20-23 cm respectively. The infected fishes exhibited clinical signs of anorexia, sluggish swimming and frequent surfacing. In acute cases bilateral exophthalmia with extensive congestion was noted followed by mass mortality. Gills were

pale with profuse mucous secretions. Petechial haemorrhages were observed in base of the dorsal fin and tail region, the liver was often pale with petechiae, spleen was dark reddish in colour with severe congestion. Abdomen was distended with peritoneal fluid accumulation. Histologically, the heart showed infiltration of polymorphonuclear cells into the endocardium, mild congestion and degeneration of myocytes. The eyes revealed congestion and polymorphonuclear cells aggregation in the choroid layer and the pigmented epithelial cells were disintegrated and distorted. Acute glomerulonephritis was observed in kidney. The kidney parenchyma showed brownish-yellow round metallic sheet, as haemochromatosis deposits in the entire glomeruli indicating the intravascular haemolysis. The proximal convoluted tubules revealed degeneration and losses of brush borders and the entire tubular epithelium was degenerated. The gastric mucosa showed engorged capillaries and loss of tubular glands in the gastric pit. The bacterial pathogen *Vibrio alginolyticus* was isolated from lesions of infected cobia fingerlings and it was confirmed by biochemical and PCR method. The cause of mortality was mainly due to *V. alginolyticus* infection and source of the pathogen could be attributed to the carrier sea bass fishes, cultured nearby in which the vibriosis outbreak was reported two months before this occurrence. No mortality was observed after October and the mortality rate was successfully reduced by proper management.

NH-O 48

Effect of temperature and salinity on the infectivity pattern of white spot syndrome virus (WSSV) in giant tiger shrimp, *Penaeus monodon*

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The white spot syndrome disease (WSD) pandemic caused by the lethal white spot syndrome virus (WSSV) continues to be the major cause of mortality among the farmed tiger shrimp in India and elsewhere resulting in an annual loss of about 4-6 billion US\$. Among the environmental variables, temperature and salinity of the rearing water are considered to be the major triggering factors for white spot disease outbreak, mostly followed by mass mortality and emergency harvests. In order to characterize the effect of salinity and temperature on the pathogenicity of WSSV infection in giant tiger shrimp, *Penaeus monodon*, a laboratory challenging study was conducted at different levels of temperature (16, 25, 27, 28, 30, 32 and 36 °C) and salinity (0.5, 5, 10, 15, 30 and 45 g/l), with virulent white spot syndrome virus. A significant influence ($p < 0.05$) of temperature over the percentage mortality and time to death in shrimps affected by the virus was observed, whereas salinity did not show any effect.

Significantly higher survival rate was recorded in animals exposed at 32 °C (37%) and 36 °C (14%) after 21 days post-challenge. Further, there was a statistically significant difference in the mean lethal time (LT50) between treatment groups held at 32 °C and all other treatment groups ($p > 0.05$). All the shrimps challenged at other temperature levels, however, died after 21 days of post-challenge. The shrimp exposed to higher experimental temperatures of 32 and 36 °C, were found to be carrying virus when tested with 2nd step polymerase chain reaction (PCR) whereas the animals exposed to lower temperatures were first step PCR positive. These results demonstrate a preference of WSSV for lower temperatures. The present observation may help to explain the increased WSSV inflicted mortality during the lower temperature regimes during the winter crop and fairly lower mortalities during periods of higher water temperatures during the summer crop, from the Indian shrimp farming areas. This also suggests a management option in the control of WSSV inflicted mortalities by selecting favorable hyperthermic rearing conditions for the shrimps

NH-O 49

Seasonal influence on hematological parameters and prevalence of white spot disease among wild tiger shrimp, *Penaeus monodon* (Fabricius) population in Sunderban, West Bengal

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Effect of seasonal variations on hemato-immunological parameters and prevalence of white spot disease (WSD) in wild-caught tiger shrimp, *Penaeus monodon* was studied. A total of 210 numbers of *P. monodon* samples were collected from the Sunderban estuarine mangrove ecosystem during pre-monsoon (March to May) and monsoon (June to September) seasons of 2010. The animals were sexed, measured (total length and carapace length) and weighed. The hemato-immunological parameters such as total hemocyte count (THC), granular hemocyte (GH) and nongranular hemocyte (NGH) count, phenoloxidase activity and serum protein levels were analyzed. The animals were diagnosed for WSSV by nested polymerase chain reaction (PCR). Significant difference in THC, GH and NGH count was observed between seasons in both sexes. However, no significant statistical difference was observed in serum phenoloxidase activity and serum protein levels in both sexes between seasons. None of the diagnosed animals were first step PCR positive for WSSV throughout the study period. However, few samples diagnosed in September were second step PCR positive. No significant difference was observed in any of the hemato-immunological parameters between second step positive and negative samples. The absence of significant changes in the hemato-immunological parameters in the WSSV second step PCR positive animals suggests that level of infection might not influence the immunological parameters.



NH-O 50**Susceptibility of *Penaeus monodon* post-larvae to *Vibrio harveyi* at various levels of salinity**ELIZABETH CAROLIN¹* AND R. MADHAVI²¹Central Institute of Fisheries Technology, Kochi - 682 029, Kerala, India²Department of Zoology, Andhra University, Visakhapatnam - 530 003, Andhra Pradesh, India

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Among the bacterial diseases, luminescent bacterial disease caused by *Vibrio harveyi* is the most devastating disease causing huge losses to the shrimp hatchery production systems. Experiments were conducted to know the effect of salinity on the susceptibility of *Penaeus monodon* post-larvae (PL 15) to varying doses of *V. harveyi* (isolate recovered from luminescent vibriosis affected larvae of *P. monodon*). The various levels of salinity tested were 5, 10, 15, 20, 25, 30, 35 and 40 ppt. and *V. harveyi* test doses (10^1 to 10^5 CFU/ml), with a control at each salinity level without any bacterial inoculation added. Post-larvae acclimatized to the required salinity were used for each level of testing. Each test dose was replicated thrice. The LC50 values of *V. harveyi* in *P. monodon* post-larvae at different levels of salinity are given in Table.

Table. LC 50 values (log CFU/ml) of *Vibrio harveyi* in *Penaeus monodon* post-larvae at different salinities

Duration (h)	Salinity (ppt.)							
	5	10	15	20	25	30	35	40
24	*	4.59±0.37	4.43±0.39	4.28±0.48	4.02±0.49	3.64±0.52	3.82±0.49	*
48	*	3.84±0.49	3.66±0.52	3.09±0.60	2.48±0.62	1.74±0.61	1.83±0.62	*

*total mortality

The 48 h LC 50 values estimated, shows a decreasing trend with increasing salinity, with the infectious dose of *V. harveyi* required being 2 logs lower at 35 ppt (1.83 log CFU/ml) than at 10 ppt (3.84 log CFU/ml), indicating that the post-larvae of *P. monodon* are more susceptible to *V. harveyi* at 35 ppt than at 10 ppt. This leaves the possibility of manipulating seawater salinity

in controlling the intensity of luminescent bacterial infection especially in postlarvae.

NH-O 51**Histopathological and bacteriological studies of monodon slow growth syndrome (MSGs) affected shrimp**P. JANAKIRAM¹*, L. JAYASREE², B. SIVAPRASAD¹, G. K. GEETHA¹ AND M. VEERENDRAKUMAR¹¹Department. of Marine Living Resources, Andhra University, Visakhapatnam - 530 003, Andhra Pradesh, India²Central Marine Fisheries Research Institute, Karwar Research Centre, Karwar- 581 301, Karnataka, India

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Shrimp affected with monodon slow growth syndrome (MSGs) were collected from culture ponds of Amalapuram and Bhimavaram areas of Andhra Pradesh during the year 2009-2010. MSGS affected shrimps were subjected to bacteriological and histopathological studies and identified *Vibrio alginolyticus*, *Vibrio fluvialis* and *Vibrio harveyi* as the dominant bacterial isolates. Major histopathological changes were noticed in hepatopancreas, gut and gill, besides revealing the presence of monodon baculo virus (MBV) and hepatopancreatic parvo-like virus (HPV) in hepatopancreatic tissues. fifty percentage of the sampled shrimps were found infected with MBV and 20% infected with HPV whereas the rest 30% with double infections of MBV and HPV.

NH-O 52**Loose shell syndrome (LSS) of cultured *Penaeus monodon* : microbiological and histopathological studies**L. JAYASREE¹*, P. JANAKIRAM², G. K. GEETHA², B. SIVAPRASAD² AND M. VEERENDRAKUMAR²¹Karwar Research Centre of Central Marine Fisheries Research Institute, Karwar -581 301, Karnataka, India²Department of Marine Living Resources, Andhra University, Visakhapatnam - 530 003, Andhra Pradesh, India

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Investigations were undertaken on loose shell syndrome (LSS) of cultured *Penaeus monodon* during the period 2009 - 2010. The infected



shrimps were collected from culture ponds of East and West Godavari districts of Andhra Pradesh, India and were subjected to histopathological and microbiological studies. Four species of *Vibrio* were isolated from the diseased shrimp and were identified as *V. harveyi*, *V. alginolyticus*, *V. metschnikovii* and *Vibrio fluvialis* based on morphological and biochemical characterization tests. Histopathological studies revealed the presence of occlusion and inclusion bodies of Monodon Baculovirus, Hepatopancreatic Parvo-like virus, Infectious Hepatopancreatic Parvovirus and Reo-like virus in the sections of Hepatopancreatic and gill tissues. All the diseased shrimps collected during the present study were found infected with *V. harveyi* infection but the infections of other *Vibrio* species were observed in 40% of infected shrimp. Prevalence of Infection with WSSV, MBV and HPV was comparatively lesser than the *Vibrio* infections. Granuloma formation was observed in the affected tissues due to bacterial infections. Multiple viral infections in association with *Vibrio* sp. were also observed in 2% of LSS affected shrimps.

NH-O 53

Antibacterial activity in the extracts of accessory nidamental gland of the Palk bay squid, *Sepioteuthis lessoniana* Lesson

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The present study illustrates the antibacterial activity in the extracts of accessory nidamental gland of *Sepioteuthis lessoniana*. Different maturity stages (immature, maturing, ripe and spent) of accessory nidamental gland (ANG) were extracted using different solvents viz., acetone, ethanol, butanol and methanol. The antibacterial activity was evaluated in all the extracts by disc-diffusion and four

pathogenic strains of bacteria (*Escherichia coli*, *Aeromonas hydrophila*, *Staphylococcus aureus* and *Bacillus megaterium*) were used. The extracts of different maturity stages (immature, maturing, ripe and spent) showed antibacterial activity against the tested bacterial strains except in *B. megaterium*. The extracts from immature stage ANG did not exhibit any antimicrobial activity but in mature stage (ANG), pronounced activity was found. Among the four extracts, butanol extract showed the maximum antibacterial activity followed by methanol extract, except immature stage. Maximum antibacterial activity was found in ripe stage especially in butanol extract against *E.coli* (10.1 mm) and minimum inhibition was found in ethanol extract against *A. hydrophila* (3 mm) in maturing stage. The present study revealed that the ANG extracts of *S. lessoniana* exhibited antibacterial activity in all maturity stages except immature stage.

NH-O 54

Screening of Actinobacteria with potential antagonistic activities against aquaculture pathogens from marine and mangrove sediments of the Southwest coast of India

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In view of emergence of multidrug resistant pathogens, it is imperative to explore novel sources of microorganisms as a viable alternative for use in aquaculture. Microorganisms including Actinobacteria harboring marine environment are known to be highly resistant against several species of deleterious microorganisms and are therefore novel sources to isolate antibacterial secondary metabolites. Approximately two third of thousands of naturally occurring antibiotics have been isolated from Actinobacterial species. The objective of the present study was, therefore, to isolate and identify Actinobacterial population from mangrove and marine habitats of south-



west coast of India, and to screen their antagonistic activity against aquaculture pathogens. Colonies of Actinomycetes were purified by repeated streaking on specific agar medium. The population density of Actinobacteria varied with sample treatment and different culture media used for isolation. Colony size of the isolates varied from small to medium, powdery, and color varied from chalky white, grey and pink. Among several Actinobacterial strains screened for antagonistic properties, MV20, 29, 30, and 36 isolated from mangrove sediment was found to be promising source of antibacterial metabolites.

Thirteen out of the forty isolates were found to be potentially active against aquaculture pathogens with inhibition zone ranging from 15-30 mm. These isolates exhibited broad spectrum activity, and were therefore selected for further characterization. The Actinobacteria were identified by morphological and biochemical characterization as *Saccharopolyspora* spp. and the results were validated with PCR analyses with specific primers. Further purification of active principles from these candidate Actinobacterial species are being carried out to identify the bioactive compounds for use against pathogenic *Vibrio* and *Aeromonas* spp.

NH-O 55

In vitro* antimicrobial activity of crude extract from Sundarban mangrove plants *Acanthas ilisifolius*, *Bruguiera gymnoriza* and *Xylocarpus granatum

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Medicinal plants are rich sources of antibacterial agents. *Acanthas ilisifolius*, *Bruguiera gymnoriza* and *Xylocarpus granatum* are commonly used medicinal plants in Sundarban, West Bengal.

Extracts from the leaves of *A. ilisifolius*, *B. gymnoriza* and seed, fruit outer and inner layer of *X. granatum* were screened for their antimicrobial activities. For this purpose leaves and fruits of these plants were collected from Jharkhali, Sundarban during February - May. Leaves were shade dried and powdered before being soaked in solvents. The extraction process was carried out in rotary evaporator at reduced pressure below 50 °C and methanolic extracts were lyophilized. *In vitro* antibacterial activity of crude extracts were tested by Kirby-Bauer disc diffusion method at concentrations of 200 µg/ml, 400 µg/ml, 600 µg/ml, and 800 µg/ml in nutrient agar plates against two strains of fish/shellfish pathogenic bacteria viz., *Aeromonas hydrophilla* and *Vibrio parahaemolyticus*. The plant extracts showed significant antibacterial activity against the two pathogens. The results of the present study provide scientific basis for the potential use of these plants for controlling bacterial infections in fish.

NH-O 56

Inhibitory activity of marine *Bacillus* sp. isolated from Visakhapatnam coast on the shrimp pathogen *Vibrio harveyi*

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An investigation was undertaken during the period August 2008 to July 2010 to collect and study the antagonistic activity of *Bacillus* sp. isolated from coastal waters of Visakhapatnam, Andhra Pradesh against the shrimp pathogen, *Vibrio harveyi* (MTCC 3438). Total bacterial loads of Visakhapatnam coastal waters ranged from 0.06 X 10³ to 2.16X10³ CFU/ml. A total of 320 isolates were collected during the study period, out of which 270 isolates were identified as Gram positive



endospore forming rods belonging to *Bacillus* sp. All the *Bacillus* isolates were tested for their antagonistic activity against the pathogen in question. Five among 270 isolates belonging to *Bacillus* sp. exhibited antagonistic activity with *Vibrio harveyi* as evidenced by cross streak and agar well diffusion methods. One (BC-4) among the five *Bacillus* isolates exhibited maximum antagonistic activity, with an inhibition zone of 8.5 mm dia against the pathogen tested.

NH-O 57

Antibacterial activity of three marine invertebrates of sunderban coastal area on *Aeromonas hydrophilla*

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Invertebrates of Sunderban coastal area are potential source of bioactive compounds that can be tested for development of drugs for controlling several diseases in aquaculture. The purpose of the present study was to test the antibacterial activity of tissue extracts from selected aquatic invertebrate species of Sunderban area, against the fish pathogenic bacterium, *Aeromonas hydrophilla*. Three species of organisms viz., *Scylla serrata*, *Fenneropenaeus indicus* and *Saccostrea cucullata* were experimented for their antimicrobial activity on *A. hydrophilla*. The tests were carried out on isolated bacteria as well as on ATCC strains. Antibacterial activity (*in vitro*) of methanolic crude extracts of these three fauna were tested by disc diffusion method against *A. hydrophilla*. The results showed that the maximum inhibition zone for *S. cucullata* and *F. indicus* were 6 mm and 5.5 mm respectively, where as *S. serrata* gave maximum zone of 5 mm, when tested at four different concentrations. Antibacterial activity of the above said fauna were also confirmed through

some accessory tests like TLC and HPLC. These organisms could be considered as good candidate species for further investigations in order to develop natural compounds for controlling diseases in aquaculture.

NH-O 58

Incidence of helminth parasites in fishes of Utra Lake, Manipur

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This study was conducted to investigate the incidence of helminth infections in fishes from Utra Lake, Manipur. A total of 457 samples of fishes were collected from Utra Lake during the months of June 2009 to May 2010. Out of these samples, 313 were found to be infected with different kinds of helminth parasites. These parasites belonged to the groups trematoda, nematoda and acanthocephala. The encountered parasite species include *Camallanus anabantis*, *Paragendria* sp., *Paraquimperia manipurensis*, *Clinostomum complanatum*, *Astiotrema reniferum* and *Pallisentis ophiocephali*. The incidence of infection by the *Camallanus* sp. (nematode) seemed to be the highest (50), while the lowest incidence was observed in *Channa orientalis* by *Haplonema* sp. (nematode).

NH-O 59

Nematode parasite infections in the freshwater fishes of Dolu Lake, Silchar, Assam during different seasons of the year

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A total of 749 fishes of different species from Dolu Lake in Silchar were examined for parasitic infections. Out of the 749 fishes examined, 53 (7.07%) fishes were found to be parasitized by nematodes. The highest intensity observed was 62 in *Mastacembelus armatus*. The highest percentage of infection recorded was 81.81% in *Notopterus notopterus* in autumn and the lowest was 5.9% recorded in *Channa punctatus* during winter. The overall percentage of infection was found to be highest in summer and lowest in spring.

NH-O 60

Studies on helminth parasites of freshwater fish *Channa striatus* of Loktak Lake, Manipur

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This paper discusses the findings from the study on helminth parasites infecting the freshwater fish *Channa striatus* of Loktak lake, Manipur. The study was undertaken during April 2010 to March 2011. The findings includes nematode namely *Camallanus anabantis*, *Spinitectus*, Trematodes include, *Allocreadium handia* and *Astiotrema reniferum* and acanthocephala i.e., *Pallisentis ophiocephali*. No cestodes were recorded during the study period in *C. striatus* from Loktak lake.

NH-O 61

Evaluation of CIBASTIM-an immunostimulant in shrimp culture pond - a farmer's experience

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CIBASTIM – an immunostimulant developed by the Central Institute of Brackishwater Aquaculture, Chennai was used by a farmer in two tiger shrimp (*Penaeus monodon*) culture ponds of 1 ha area each in the Bucharwada village of Diu district. The ponds were stocked with PL 15 @ 6.6 pcs/m². One pond (P1) served as control and in the treatment pond (P2) CIBASTIM was applied along with feed from 65 DOC onwards. At the start of the treatment, the average body weight (ABW) of shrimps were 9.65 and 9.55 g in control and the treated ponds respectively. Fortnightly analysis of water quality parameters viz., salinity, pH, DO, turbidity and temperature were carried out during the study period. Regular sampling with cast netting showed exceptionally high degree of sturdiness of the shrimp with fully opened uropod, flipper movements and good body coloration from 2nd week of application in the treatment pond. Additionally, the shrimps in treated pond showed lower percentage in antennae cut (3%), tail rot (1%) and *Zoothamnium* sp. infestations (1%) compared to the control pond (60%, 19% and 17% respectively). Administration of CIBASTIM in feed till harvestable size (130 DOC) recorded continuous improvement in shrimp with higher average body weight (16.18%) and average daily gain (17.1 %) as observed during subsequent samplings which ultimately lead to higher production, count (24) and low per kg cost of production (6.54 %) and higher yield (7 %) over the control at harvest. The farmer expressed his happiness with the positive performance of CIBASTIM in producing healthy shrimp.

NH-O 62

Effect of dietary *Bacillus circulans* and fructooligosaccharide supplementation on serum biochemical characteristics in *Labeo rohita* (Hamilton, 1882) fingerlings

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The effect of dietary supplementation of *Bacillus circulans* and fructooligosaccharide (FOS), used singly and in combination, on the serum biochemical characteristics of *Labeo rohita* fingerlings were assessed. Basal diet (control), Basal diet+1%FOS (T1), Basal diet+2%FOS (T2), Basal diet+ 1×10^6 cfu.g⁻¹ *B. circulans* (T3), Basal diet+ 1×10^8 cfu.g⁻¹ *B. circulans* (T4), Basal diet + 1% FOS + 1×10^6 cfu.g⁻¹ *B. circulans* (T5), Basal diet+2% FOS+ 1×10^6 cfu.g⁻¹ *B. circulans* (T6), Basal diet+1%FOS + 1×10^8 cfu.g⁻¹ *B. circulans* (T7), Basal diet+2%FOS+ 1×10^8 cfu.g⁻¹ *B. circulans* (T8) were fed to a total of 324 fingerlings distributed into 8 experimental groups and a control group for 60 days. At the end of the trial, serum total protein, albumin (A), globulin (G), A/G ratio, aspartate aminotransaminase (AST), alanine aminotransaminase (ALT), triglyceride, phospholipid, cholesterol, high density lipoprotein (HDL)-cholesterol and low density lipoprotein (LDL)-cholesterol were analysed. Fishes fed 1%FOS with 1×10^6 cfu.g⁻¹ *B. circulans* PB7 supplemented diet had significantly higher serum total protein and globulin than fishes fed either FOS or *B. circulans* alone ($p < 0.05$). Serum phospholipid was highest in groups fed 1% FOS and 1×10^6 cfu.g⁻¹ *B. circulans*. Individual effect and interaction of dietary FOS and *B. circulans* PB7 on serum phospholipid was apparent. Serum total cholesterol decreased due to FOS supplementation and increased with *B. circulans* supplementation signifying the hypocholesterolemic and hypercholesterolemic effect. Serum HDL-C increased significantly ($p < 0.05$) and highest value was observed in fishes fed 1% FOS and 1×10^6 cfu.g⁻¹ *B. circulans*. From the present study, it can be concluded that dietary supplementation of 1%FOS and 1×10^6 CFU/g *B. circulans* enhanced the immune function in *L. rohita* fingerlings due to synergistic effects of both *B. circulans* and FOS supplementation.



NH-O 63

Development and characterization of cell line from *Pristolepis fasciata*, (Bleeker, 1851) ornamental fish endemic to the Western Ghats

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The Western Ghats of India is one among the 34 biodiversity hotspots of the world harboring 289 primary freshwater fish species. Among these, the native ornamental fishes form the most important component of the regional biodiversity. Many of these are in high demand in both domestic and international markets and being exploited from the wild in large quantities and exported. During the transboundary movement of ornamental fish, there are possibilities of inadvertent introduction of pathogens such as viruses, bacteria and fungi. Viruses that have caused serious disease outbreaks in ornamental fish include aquareoviruses, coronaviruses, rhabdoviruses, herpesviruses, poxviruses and iridoviruses. Little work has been carried out on the viral diseases of endemic fishes of the Western Ghats of India due to lack of suitable cell lines from respective fish species. The present study describes the establishment and partial characterization of cell line from fin tissue of important ornamental fish *Pristolepis fasciata* endemic to the Western Ghats. A new cell line designated as PFF, were established from the caudal fin of the fish. These cell lines have been subcultured in Leibovitz's L-15 medium with 10% fetal bovine serum for more than 40 passages at 28°C. The morphology of all the cells was fibroblast-like. The PFF cells were susceptible to ECP of *Vibrio cholerae* MTCC 3904. Polymerase chain reaction amplification of mitochondrial 16S rRNA and CO1 gene and karyotype confirmed the species identity and origin of these cell lines.

NH-O 64

Antagonistic efficacy of aqueous extract of *Allium sativum* against luminescence disease causing marine *Vibrio harveyi* and its virulence

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Allium sativum bulbs were extracted with sterile water and tested against the luminescence disease causing marine *Vibrio harveyi* isolated from the shrimp larvae. The aqueous garlic extract (AGE) was checked for antagonism and the filtered garlic extract (FGE) gave better inhibition zone against *V. harveyi*. The FGE (100 mg/ml) showed arbitrary unit (53.33) as zone of inhibition against *V. harveyi* (OD 2.039) through "well diffusion assay". The antibacterial activity of FGE against *V. harveyi* was ascertained by adding as media component in the LB broth. The growth was reduced to 1.93 OD as compared to control (2.38 OD) on the fifth day. The efficacy of the garlic extract against the virulence factors such as proteolysis, lipolysis, phospholipase, extracellular products, bacteriocin and thermonuclease production was also investigated. The FGE showed greater reduction in proteolysis, lipolysis as determined through agar spot assay. The bacteriocin production was reduced to 0.26 OD as compared to control (1.59 OD). Other virulence tests like salt aggregation (SAT) and bacterial adhesion to hydrocarbons (BATH) also exhibited moderately hydrophobic values as compared to their strong hydrophobic nature. Therefore, the garlic extract without organic solvent tested in the present study may be used to control luminescence disease causing *V. harveyi* in shrimp larviculture. This may be used as a biotherapeutic agent to control even other aquatic pathogens and could be considered as an alternative for antibiotics for use in aquaculture.

NH-O 65

Report of loose shell syndrome (LSS) and its relation to banana shrimp, *Fenneropenaeus merguensis* grow-out pond environment in Tamil Nadu

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Incidence of loose shell syndrome (LSS) has been extensively reported in tiger shrimp *Penaeus monodon* culture from different brackishwater culture areas of India. The occurrence of LSS in Banana shrimp *Fenneropenaeus merguensis* culture ponds from Pattukottai district of Tamil Nadu is reported in this study. Two ponds of 1.11 ha and 0.87 ha each were stocked @ 10 nos/m² with *F. merguensis* seed and standard culture practices were followed including regular monitoring of abiotic as well as biotic parameters and evaluating the microbial quality of pond water. At 33 days of culture (DOC), sudden mortality was noticed in one of the ponds (1.11ha) and detailed clinical and laboratory examination were conducted. Clinical observations of the moribund and dead animals revealed poor feed intake, sudden drop in daily feed ration, empty gut, partially detached carapace, reddish hepatopancreas and soft body with hard rostrum. The shrimp at this point showed average body weight of 7.82 ± 1.87 g in LSS affected and 12.48 ± 3.62 g in unaffected pond. Detailed investigations of the abiotic parameters in LSS affected pond revealed very low DO (2.94 to 3.25 mg/l during early hours) and redox potential (-245 mv) with high organic carbon (1.23%), ammonia (2.088 ppm) and nitrate (0.2784 ppm) concentration followed by low phosphate (0.1219 ppm), indicating poor water quality and natural productivity. The microbiological studies based on biochemical and *in vivo* infectivity assays showed higher total bacterial and *Vibrio* counts dominated by colonies of pathogenic *Vibrio harveyi* and *Vibrio*



anguillarum. A vitamin based micronutrient mixture when applied @ 2 g/kg in feed resulted in improving the health status of the shrimp within 48 h. Continuation of the treatment upto five days lead to complete recovery of the affected shrimp and restoration of normal feeding activity. The results of the study showed that deteriorating pond environment conditions act as a predisposing factor in the occurrence of LSS which could lead to vibriosis by opportunistic *Vibrios* causing severe mortality. This is the first report of LSS and its successful control by nutritional management in grow-out culture of banana shrimp *F. merguensis*.

NH-O 66

Drug possibility from algal extract for fish disease

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Algae are host for different bacterial communities in marine ecosystems. On the other hand, they are source of bioactive compounds, which have antibacterial activity against pathogenic bacteria. In the present investigation, selected marine algae viz., *Catenella impudica*, *Enteromorpha intestinalis*, *Ulva lactuca*, *Phormidium tenuii*, *Phormidium valderianum*, *Cladophora* sp. etc. as well as the fresh water alga *Lyngbya* sp. of Sunderban area of West Bengal were tested for their bioactivity through *in-vitro* tests. The above-mentioned algal genera were collected during the months of February – April 2011, shade dried and stored in cool dry place for further use. Selected bacterial strains isolated from water/aquatic animals namely, *Escherichia coli*, *Aeromonas hydrophilla*, *Vibrio parahaemolyticus*, and *Shigella dysenteriae*, which are common disease causing organisms in human beings or aquatic organisms were used to test the algal extracts through *in vitro* assays. The bacterial strains used are either isolated,

identified and maintained at ARHMC, Pailan, or procured from ATCC. Solvents used were Acetone, Methanol and Ethanol as well as hot and cold water. Antibacterial activity of the above said algae were also confirmed through some accessory tests like TLC, HPLC as well as spectrophotometric analysis. Results obtained from the experiments are encouraging as significant inhibition zones due to antagonistic activity was exhibited by some of the algal species. which can be considered as good candidate species for further investigations in order to develop a cost effective as well as eco-friendly natural compound for fish farmers who often frequently or haphazardly use different chemicals and antibiotics to control disease in aquaculture systems.

NH-O 67

Occurrence and intensity of nematode parasites infecting *Mystus bleekeri* (Day) in Oinam Lake, Manipur

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The present paper discusses the results of the study on incidence and intensity of occurrence of four nematode parasites - *Paragendria* sp., *Spinitectus* sp., *Philometra* sp. and *Parascaphis* sp. in the catfish, *Mystus bleekeri*. These parasites were observed to have quite low prevalence in the species and the infestation was even absent during certain months of the investigation period.

NH-O 68

***Mothocya renardi* (Bleeker, 1857), a parasitic cymothoid parasitizing the banded needlefish, *Strongylura leiura* (Belonidae) from the Malabar coast, India**

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The present study reports the occurrence of *Mothocya renardi* (Bleeker, 1857), an isopod (Crustacea, Isopoda, Cymothoidae) parasitizing the banded needlefish, *Strongylura leiura* (Belonidae), from the Malabar coast. This cymothoid species was already reported parasitizing *S. leiura* from the Indo-West Pacific (Bruce, 1986). Fifty seven fish species belonging to 22 different families, including Stromateidae, Scombridae, Carangidae, Terapontidae, Ambassidae, Engraulidae, Belonidae, Clupeidae

and Dasyatidae were examined. Among these, *S. leiura* was the only species found to be parasitized with *M. renardi* which implied a high degree of parasitic specificity. Such parasitic infestation was observed throughout the year without any significant seasonal fluctuation. The prevalence reached 97.21%. Interestingly, *M. renardi* was found in pairs, each partner settling separately in one of the branchial cavities of the host. Females were relatively large. They showed a high site specificity, attaching only on the wall of the branchial cavity close to the gill, their cephalon facing the host mouth. All the collected females are either ovigerous with developed brood pouches or non-ovigerous with ovaries in active maturation. The present paper also discusses the branchial tissue damage induced by *M. renardi*.

NH-P 01**Research progress towards lobster culture – understanding and formulating phyllosomal diets**

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The feasibility of lobster mariculture can be increased if the hatchery and nursery phases are shortened and larval viability improved. Lobster larval nutrition has been conventionally utilizing enriched and encapsulated *Artemia* strains. Research programs at the lobster culture laboratory of the Central Marine Fisheries Research Institute at Kovalam, Chennai are aimed at identifying natural diets of phyllosoma of the different species of spiny and scyllarid lobsters available along the coast. The suitability of different live feed diets have been tried and tested through several trials using live plankton (Hydromedusae, Heteropoda, Appendicularians, Siphonophora, Ctenophora, Thalacea and Scyphomedusae) collected at various depth and time regimes from the coastal waters off Kovalam. Spiny lobster phyllosoma show preference for arrow worms in the initial stages, while sand lobster larvae prefer comb jellies particularly in the final larval stages. Smaller scyllarids have been found to prefer shrimp nauplii and crab zoea. Enrichment of live feeds with algae and different sources of proteins and fatty acids were found to increase consumption rate and survival in early larval stages.

While the role of live feed components remains vitally important for lobster larval rearing, the development of a new generation of sophisticated inert co-feed and replacement diets has enabled intensification of the larval rearing process. Extensive research carried out

in the laboratory on larval rearing in *Thenus* sp. has identified substitute diets from other animal sources such as the clam *Meretrix casta*. The soft hepatopancreas and gonad tissues from these clams are found to be acceptable and efficient in sand lobster larval rearing. Adding these ingredients as dry powders or as a paste with select binders to keep the molecules cohesive to the size and shape designed, has given a major advantage over the entry of pathogenic microbes into the culture systems through live and fresh feeds. The primary live feeds can be loaded with the essential nutrients, harvested and processed and stored for formulations. A soft-gel pellet bound with micronized ingredients and shaped to the required diameter and texture is being developed for co-feeding the phyllosoma with the identified raw and live feeds.

NH-P 02**Effect of dietary protein in formulated diets on the growth and survival of juvenile spiny lobster, *Panulirus homarus* (Linnaeus)**

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A suitable feed is paramount for the ongoing success of spiny lobster culture. An experiment was conducted to evaluate the effect of dietary protein level on the growth and survival of juvenile spiny lobster *Panulirus homarus* with pellet diets containing three different protein levels of 34% (Diet A), 40% (Diet B), 46% (Diet C) and a control diet of clam meat with 47% protein (Diet D). The duration of the experiment was 90 days. Three different pellet feeds viz., A, B and C were prepared with different ingredients including fish meal, shrimp meal, soybean flour, starch, attractants and binders,



tested and compared with control diet of raw clam meat. The Protein Energy Ratio (PER) was almost equal for all diets. A closed recirculatory system was used to conduct the experimental trials in spiny lobsters in duplicate at Kovalam Field Laboratory, Chennai. The survival was 100% for the lobsters fed on diet C, followed by A (95%), B (85%) and control - D (60%). Diet C gave the highest growth rate of 37% (± 0.32), followed by diet B with 33% (± 0.13) and Diet A with 30% (± 0.56), in comparison to the natural clam Diet (Diet D) with 51% (± 0.19), which indicated that next to clam meat diet C with 47% protein level gave highest growth rate. The specific growth rate (SGR) was 0.41 (± 0.03), 0.36 (± 0.03), and 0.33 (± 0.01), respectively for the Diets C, B and A, in comparison to the SGR of natural clam diet (Diet D) with 0.66 (± 0.05). The Diet C with protein level of 46% gave good survival, SGR and FCR next to clam meat diet (D). Though the wet flesh weight conversion rates are much higher for clam diets, access to these raw diets may not be feasible in all cases. The acceptance of formulated diets by the spiny lobsters and positive growth factors indicate that other than natural feeds, spiny lobsters can be grown successfully on pellet feeds with improved survival rates.

NH-P 03

Manipulation of lipids in the estuarine clam *Meretrix casta* for use as food in larval rearing of scyllarid lobsters

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The estuarine clam *Meretrix casta* is one of the major food organisms used in the larval rearing of the scyllarid lobster, *Thenus* spp. However, the nutritional quality of the clam tissues is highly subject to seasonal variations. This variation is related to the food availability, mainly microalgae, which is influenced by

environmental conditions such as water temperature, salinity etc. In order to compensate these seasonal variations, an investigation on the effect of supplemental feeding with specially reared microalgae on nutritional profile of clams was carried out under controlled conditions. The microalgal species *Isochrysis* sp. was chosen for this purpose because it is relatively easy to produce in large quantities and possesses a typical fatty acid composition characterized by a high content of n-3 polyunsaturated fatty acids (PUFA) believed to be essential to crustacean larval development. Thus, significant changes in the fatty acid composition can be expected by feeding clams with this microalgal species.

For the study, the clams were divided into two groups of 200 animals each and maintained under conditions of constant temperature, salinity and continuous aeration. One group fed only with phytoplankton present in seawater was used as the control, while the experimental group was fed with *Isochrysis* sp. of microalgae at a daily rate of 2×10^8 cells/clam. The duration of the experiment was one week, following which the overall lipid profile and fatty acid composition of tissues from control and experimental clams were investigated using gas chromatography (GC). The salient result obtained was the increase in concentrations of polyunsaturated fatty acids (PUFA), in particular docosahexaenoic acid (DHA, C22:6n3) and C18:2n-6 in clams supplemented with *Isochrysis* sp. Changes in monounsaturated fatty acid (MUFA) composition were less marked and were related to the increasing proportions of C18:1 after supplementation. Further, supplementation with *Isochrysis* sp. induced a decrease in the proportion of saturated fatty acids which was related to a decrease in proportions of both C16:0 and C18:0. Although the fatty acid composition showed significant differences, the gross lipid content of the clam tissues did not seem to be excessively influenced by the algal feeding. In general, the fatty acid composition of the algae (*Isochrysis* sp) was reflected in that of the tissues from the experimental clams. Tissues from clams



supplemented with *Isochrysis* sp. are being evaluated as feed for sand lobster larval trials.

NH-P 04

Development of cost effective, nutritious grow-out feed for rainbow trout

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Grow-out feeds (floating pellets) were formulated with 3 levels of protein (45, 40 and 35%) with uniform lipid level of 14% using fish meal (sterilized having >60% protein), solvent extracted soybean meal, mustard oil cake, wheat flour, starch, fish oil, brewer's yeast powder, linseed oil cake and vitamin mineral mixture. Proximate composition of all the 3 diets was analyzed. Experiment was conducted in six nursery raceways (size-10 x 3 x 0.7 m) under outdoor conditions at Experimental Fish Centre, Champawat. Data on growth performance and nutritional value showed that, CTF1 (Champa Trout Feed 1) having 45% protein and 14% lipid, is the best among all the tested diets. There was no significant difference between CTF1 and CTF2 (40% protein) in terms of growth, survival and FCR. Although, CTF3 (35% protein) was found to be inferior in respect of nutritional value, it was found cost effective with feed cost of Rs.78/- per kg. and the feed cost to produce 1 kg fish as Rs. 105. High protein level in the diet always resulted in increase of unwanted ammonia excretion. In case of CTF1 and CTF2 fed fish, it was noted as 0.12 mg/l and 0.08 mg/l respectively in the drain water. But, lowest level of ammonia as 0.05 mg/l was noted in the pond fed with diet CTF3 having low level of protein. Therefore, for further refinement and to develop a more environmentally friendly, cost effective, nutritious diet for trout, CTF4 was formulated with the same composition as CTF3 with additional inclusion of 40% SESM and 60% fish meal as protein supplements, 0.4% papain powder, 0.1% turmeric powder as anti-microbial and 2

g/kg asafoetida as appetizer for improving feed intake. CTF4 was found an environmentally friendly, cost effective, nutritious diet for trout, with low level of protein and good FCR of 1.26.

NH-P 05

Use of mast tree *Polyalthia longifolia* seed meal as an alternative carbohydrate source in the diet of rohu, *Labeo rohita* fry

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As the demand on common feed ingredients increases from different animal husbandry sectors, search for alternate feed ingredients for fish feeds has become research priority. Mast tree (*Polyalthia longifolia*) is a tropical avenue plant found all over India. The seed of mast tree is an untapped resource, presently available in plenty at nominal cost. The crude protein, ether extract, crude fiber, ash and nitrogen free extract of the mast tree seed (MTS) is 13.93, 5.54, 3.44, 20.7 and 43.61%, respectively on dry matter basis. Moisture content of dry seed is about 4.0%. Therefore, in the present study the possibilities of use of raw MTS as a feed ingredient of rohu, *Labeo rohita* fry was investigated. Incorporation of MTS meal at 27% was tested for survival and growth of rohu fry. Two iso-nitrogenous (27% CP) diets (control and test) were prepared (Table 1). Sunflower oil cake, rice bran, vitamin-mineral mixture and binder were used at 70, 27, 1 and 2% levels respectively in the control diet. Rice bran was completely replaced by MTS meal in the test diet and the other ingredients remained the same as that of control diet. The experimental diets were fed to rohu fry (1.08 ± 0.04 g) for a period of 30 days in triplicate tanks (40 l capacity fibre-reinforced plastic tanks) with provision for continuous aeration. In each tank, 20 rohu fry were stocked. The results indicated that there was no significant difference ($p > 0.05$) in survival (%),



weight gain and specific growth rate (% day⁻¹) of fish fed control and test diets (Table 2). Hence, the MTS meal can be used as a suitable low-cost alternate carbohydrate source, completely replacing rice bran in formulating diet for rohu fry.

Table. Chemical composition of the experimental diets

Feed	CP	EE	Ash	CF	NFE
Test diet	27.80	9.96	5.39	16.5	40.35
Control diet	27.23	10.24	7.27	14.5	40.76

Table 2. Growth performance of rohu fry fed experimental diets

Growth parameter	Test diet	Control diet	p value
Survival (%)	96.67 ± 1.67	93.33 ± 4.41	p > 0.05
Av. Wt. gain (g)	1.29 ± 0.09	1.26 ± 0.	p > 0.05
Wt. gain (%)	109.35 ± 8.18	128.27 ± 12.8	p > 0.05
Specific growth rate	0.46 ± 0.04	0.56 ± 0.16	p > 0.05

NH-P 06

Efficacy of giant duckweed, *Spirodela polyrrhiza* (L. Schleiden) incorporated diets in semi-intensive carp polyculture system

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Supplementary feeding is the most critical and major input for augmenting fish production. Due to increase in cost and demand for protein from conventional feed resources like rice bran, rice polish, oiled/ de-oiled cakes, fish meal etc., it is becoming difficult for the small farmers to afford supplementary feeds for higher productivity. Hence, there is need to develop cost effective fish feeds by substituting the conventional ingredients with low cost locally available non-conventional ingredients with a sole aim of reducing the production cost.

Aquatic plants, generally referred as “aquatic weeds”, contain high amount of quality protein and less fiber as compared to terrestrial forage plants, which makes them a valuable feed resource for livestock including fish. Among aquatic plants, duckweeds have emerged as the most promising plant protein supplement for substituting fish meal, meat meal and soybean meal in fish feeds. Duckweeds are small, floating aquatic plants belonging to the family Lemnaceae and four genera viz., *Lemna*, *Spirodela*, *Wolffia* and *Wolffiella*. Among the different duckweed species, *Spirodela* is the largest and more promising in terms of nutritive value and productivity. However, very little work has been done to assess efficacy of *Spirodela* incorporated diets on growth performance of carps under polyculture conditions.

The present study was taken up to develop duckweed based low cost diets by incorporating sundried *Spirodela* in traditionally used farm made feeds, generally prepared by mixing rice bran and mustard meal in the ratio of 1:1 by fish farmers in north-west India. An outdoor feeding experiment was conducted to assess efficacy of giant duckweed (*Spirodela polyrrhiza* L. Schleiden) incorporated diets in a semi-intensive carp polyculture system. Experimental diets were prepared by 10% (D₁), 20% (D₂), 30% (D₃) and 40% (D₄) replacement of control diet (de-oiled rice bran and mustard meal in the ratio 1:1) with sundried *Spirodela* and were fed to carp fry (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*) for 210 days under polyculture conditions in outdoor cemented tanks. *Spirodela* incorporation did not adversely affect the survival of fish and water quality in any of the treatments. All the species fed on *Spirodela* diets exhibited significantly higher weight gain, better condition factor and superior flesh quality than fish fed on diet without *Spirodela* (control diet). Although *C. catla* exhibited maximum growth with diet D₁, *L. rohita* and *C. mrigala* recorded maximum growth with diet D₃. Higher yield was supported up to 40% *Spirodela* inclusion level (D₄); however maximum yield (43.11% higher than the



control) was recorded at 30% *Spirodela* inclusion level (D_3) and among the different species, *L. rohita* registered maximum weight gain followed by *C. mrigala* and *C. catla* with 16.19, 19.44 and 12.58% higher muscle protein content, respectively. Better FCR (1.53-1.56) was recorded with diets D_1 , D_2 and D_3 (10, 20 and 30% *Spirodela* inclusion levels) as compared to D_4 (1.79) and control (1.69) diets. The results revealed that sundried *Spirodela* can be incorporated in carp diet upto 30% level for formulating low cost eco-friendly diets for higher productivity and better flesh quality.

NH-P 07

Chitin supplementation in the diet enhances growth and survival of giant freshwater prawn, *Macrobrachium rosenbergii* (de Man)

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The experiment was carried out to investigate the effect of chitin on the growth, survival and nutrient digestibility of *M. rosenbergii*, fed four test diets viz., T_0 (0%), T_1 (0.5%), T_2 (0.75%) and T_3 (1%). All the four diets were evaluated in three replicate groups. Increase in length and weight of prawns under different treatments and control during experimental period were recorded. Weight gain and survival of the treatment groups were observed to be highest in the chitin supplemented diet at 0.75% (Table 1). Proximate composition of prawn muscle showed that, protein and fat contents were higher in the chitin supplemented diet at 0.75% but moisture and nitrogen free extract (carbohydrate) level was lower (Table. 2). This indicates that prawn fed 0.75% chitin diet had higher protein, lipid digestibility, survival rate and weight gain.

Table 1. Details of survival and mean weight of prawns recorded in different treatments.

Treatments	Survival (%)	Weight gain (%)
T_0	73.0	368
T_1	74.0	360
T_2	77.0	372
T_3	76.0	364

Table 2. Proximate composition of prawn muscle different treatments.

Treatment		Moisture (%)	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	NFE (%)
Before commencement of experiment	Initial	79.23* (0.07)	20.77 (0.07)	13.88 (0.07)	1.57 (0.07)	2.47 (0.03)	2.85
T_0	Final	76.56 (0.20)	27.50 (0.01)	16.02 (0.20)	2.05 (0.09)	2.52 (0.14)	2.85
T_1	Final	74.32 (0.28)	26.42 (0.15)	17.56 (0.14)	3.35 (0.18)	2.74 (0.05)	2.03
T_2	Final	73.92 (0.19)	26.92 (0.13)	17.95 (0.11)	4.61 (0.07)	2.37 (0.05)	1.15
T_3	Final	75.10 (0.19)	26.55 (0.11)	16.23 (0.19)	4.32 (0.14)	2.32 (0.06)	2.03

NH-P 08

Dietary protein requirement of stunted fingerlings of catla, *Catla catla* during grow-out period

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The present investigation was conducted to find out the protein requirement of stunted fingerlings of *Catla catla* during grow-out period. Experiments were carried out in soil based, manured cement cisterns of 25 m² area. Stunted catla fingerling of average weight of 7.10 g were stocked at the rate of 5600 nos./ha (14 nos./25 m²) in duplicate and fed at 2% of the body weight with the three experimental diets having a protein content of 20% (T_1), 25% (T_2), and 30% (T_3) in triplicate and groups without feed served as control (T_0). The experiment was carried out for a period of 120 days. The cement cisterns were manured with cow dung at the rate of 2000 kg/ha initially and at the rate of



1000 kg/ha subsequently once in a month. Water quality parameters monitored in different treatments were within the optimum range. The protein efficiency ratio (PER) showed significant inverse relation with protein level of diets. The final average weight gain was highest in T_2 followed by T_1 , T_3 and T_0 . Further, higher growth in terms of weight as well as specific growth rate (SGR) and higher hepato-somatic index (HSI) were also noticed in the treatment (T_2) fed with diet containing 25% protein, whereas the treatment without feed (T_0) showed higher viscero-somatic Index (VSI). Survival studies also showed better results (96.43%) in the treatment T_2 . The weight gain was slightly higher in T_2 fed with 25% of crude protein. The carcass body proximate composition also indicated higher crude protein in the tissue of fishes treated with diet containing 25% protein. Hence, it can be concluded that the stunted fingerlings of *C. catla* shows better performance when fed with diet containing 25% protein.

NH-P 09

Evaluation of mannan oligosaccharide (MOS) on growth and survival in rohu, *Labeo rohita*

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Effect of mannan oligosaccharide (MOS) on growth and survival in Indian major carp, *Labeo rohita* was investigated for 120 days. The basal diet in all trials contained 35% protein with different dosages of MOS at 0.0, 0.15, 0.30 and 0.45% in triplicates. Uniform sized fish fingerlings averaging 1.3 g were used for the experiments. Significant differences were evident in growth parameters between treatment groups ($p < 0.05$) with 0.15% MOS fed fishes showing higher mean weight gain of 11.40 ± 0.24 g. No significant differences were evident in specific growth rate (SGR), feed conversion ratio (FCR) and survival rate of fish between the treatments. However, fish fed with 0.15% MOS incorporated

diets showed highest SGR of 1.80 ± 0.02 , lowest and best FCR of 2.33 ± 0.07 and highest survival rate of $84.00 \pm 2.3\%$ as compared to control and other treatments. Among the tested doses, 0.15% MOS showed better results than 0.30% and 0.45% MOS inclusion in the fish diet.

NH-P 10

Growth of rotifer *Brachionus rotundiformis* in different nutrient media

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The dominant marine algal species are good food sources for rotifer growth. The rotifer, *Brachionus rotundiformis* was cultured in four different nutrient media to find out the most suitable medium for growth. Fifty rotifers/l was inoculated in 2 l conical flasks in four different media containing *Nannochloropsis*, *Nannochloropsis* with vitamin B12, *Nannochloropsis* with thiamine and *Nannochloropsis* and *Chlorella* with vitamin B12 and thiamine, with three replicates. Nine million cells/ml of *Nannochloropsis* and *Chlorella* and 0.1 ml/l of vitamin B12 and thiamine were used for the experiment. The variations observed in growth and multiplication of rotifers in different media were highly significant ($p = 0.00$). Number of rotifers were counted every week and it was found that the highest rate of growth of 104.7 rotifer/ml in the third week was in cultures grown in *Nannochloropsis* with *Chlorella* and extra vitamins.

NH-P 11

Activities of protease and trypsin during ontogenic development of golden mahseer, *Tor putitora* larvae

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Analysis of digestive enzymes activities is an easy and reliable methodology that can be used as indicator of digestive processes and



nutritional condition of fish larvae. Samples of mahseer larvae of different age groups viz., 0 day after hatching (0 DAH), 3 DAH, 7 DAH, 15 DAH, 21 DAH, 30 DAH and 45 DAH were collected from DCFR mahseer hatchery, Bhimtal. Whole larvae (till age 21 DAH) and dissected larvae (30 and 45 DAH) were homogenized with 5 % chilled 0.25 M sucrose solution. The homogenized samples were centrifuged (6000 g for 10 min) and supernatants were collected and used for protease and trypsin assay. The protease activity in mahseer larvae was observed even on 0 DAH and this activity was consistent till 3 DAH. On 7 DAH, the protease activity increased by 10% and from 7 DAH onward, the activity sharply decreased (2 fold) to a minimum on 30 DAH. Again, a sharp increase was evidenced on 45 DAH. The presence of trypsin activity in mahseer larvae was evidenced from 0 DAH and there was no significant difference ($p > 0.05$) in its activity till 7 DAH. Activity significantly ($p < 0.05$) decreased and became minimum on 15 DAH and then a four fold increment was observed on 21 DAH. Again there was two fold decrease in its activity on 30 DAH and remained same until 45 DAH. Results on the ontogenic activities of protease and trypsin reveal that mahseer larvae may have the capacity to digest protein diet from an early stage. Data obtained from the present study give an insight on the development of the larval digestive functions with respect to protein utilization, which can be made use for formulation of a compounded diet suitable for mahseer larvae.

NH-P 12

Dietary supplementation of L-tryptophan ameliorates thermal tolerance and mitigates oxygen consumption rate in *Cirrhinus mrigala* fingerlings

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A 60 days feeding trial was conducted using *Cirrhinus mrigala* fingerlings to determine

the effect of dietary L-tryptophan on their thermal tolerance and oxygen consumption rate. Four hundred eighty fingerlings were distributed into eight experimental groups. Each group, i.e., the low density group (10 fishes/ 75 l water) or the high density group (30 fishes/ 75 l water) was fed with a diet containing either 0, 0.68, 1.36 or 2.72% L-tryptophan in the diet, thus forming eight experimental groups viz., low density control (LC) (basal feed + 0% L-tryptophan); LT1 (basal feed + 0.68% L-tryptophan); LT2 (basal feed + 1.36% L-tryptophan); LT3 (basal feed + 2.72% L-tryptophan) high density control (HC) (basal feed + 0% L-tryptophan); HT1 (basal feed + 0.68% L-tryptophan); HT2 (basal feed + 1.36% L-tryptophan); and HT3 (basal feed + 2.72% L-tryptophan) were fed at 3% of the body weight with isonitrogenous (34.33 ± 0.23 to 35.81 ± 0.18 CP%) and isocaloric (423.49 ± 1.76 to 425.85 ± 0.31 k cal/100 g) purified diets. The possible role of dietary L-tryptophan on oxygen consumption rate and thermal tolerance was assessed in terms of CT_{max} , CT_{min} , LT_{max} and LT_{min} . The CT_{max} , CT_{min} , LT_{max} and LT_{min} were found to be significantly higher ($p < 0.05$) in the treatment groups CT_{Max} 42.95 ± 0.096 (LT₂); LT_{Max} 43.18 ± 0.070 (HT₃); CT_{Min} 10.47 ± 0.088 (LT₂) and LT_{Min} 9.42 ± 0.062 (HT₃) whereas, the control group showed lower tolerance level. The same trend was found in the higher density group (CT_{Max} 42.09 ± 0.066 (LT₃); LT_{Max} 43.23 ± 0.067 (HT₃); CT_{Min} 11.00 ± 0.059 (LT₂) and LT_{Min} 9.74 ± 0.037 (HT₃). However, gradual supplementation of dietary L-tryptophan in diet significantly reduced the oxygen consumption rate in both low density group ($Y = -35.659x + 296.63$, $r^2 = 0.9158$) and high density group ($Y = -36.625x + 329.5$, $r^2 = 0.8923$). Hence, dietary supplementation of L-tryptophan at a minimal level of 1.36% concomitantly improved the tolerance level and reduced oxygen consumption rate in *C. mrigala* fingerlings. Though 2.72% dietary tryptophan also improved the tolerance level and reduced oxygen consumption rate, 1.36% level appears to be cost effective.



NH-P 13**Proximate composition of selected indigenous fishes of northeast India from River Brahmaputra**

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Most small and medium-sized indigenous fish species occurring in River Brahmaputra are relished by the people of Northeastern India and are usually preferred over bigger fishes. Proximate composition of some selected indigenous fishes of the river was determined in the present study for assessing their nutritional values. Samples of *Aspidoparia morar*, *Chanda* sp., *Ailia coila*, *Gudusia chapra*, *Anabas testudineus*, *Channa striatus*, *Labeo gonius* and *Labeo bata* were collected from Uzanbazar landing centre of Brahmaputra during October to December, 2010 for determining their nutrient composition. Among these species *A. testudineus* was found to have significantly higher ($p < 0.01$) amount of protein (18.38% on dry weight basis), lipid (12.48%) and ash (8.03%) contents along with lowest moisture content (59.79%). *C. striatus* was also found to have higher protein content (16.78%) compared to other species. Proximate composition of different sizes of *A. morar*, *Chanda* sp. and *A. coila* were compared. Moisture content decreased with increasing size in all the three species with just the opposite trend in case of lipid content. However, protein contents were similar among the species except in case of *A. coila* where larger fishes showed significantly ($p < 0.01$) higher protein content. It could be concluded that the small indigenous fishes are a rich source of protein food having 11-19% crude protein, high quality fats ranging from 2.33 to 12.5% and also rich in mineral content (2.18 to 8.03% ash). Among the selected fish species, *A. testudineus* commanded the highest wholesale price (Rs. 300-350/kg) followed by *A. coila* (Rs. 200-250/kg), *G. chapra*

(Rs. 180-200/kg), *C. striatus* (Rs. 150-200/kg), *A. morar* (Rs. 120-150/kg), *L. gonius* and *L. bata* (Rs. 100-140/kg) and *Chanda* sp. (Rs. 100-120/kg), the scientific basis for which needs to be studied by assessing taste and flavor giving components.

NH-P 14**Comparative evaluation of *Tubifex* worm production using three different waste products**

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An experiment was conducted on production of tubifex worms using three waste products viz., raw cow dung (RCW), dairy sludge (DS) and rice mill sludge (RMS). The entire experiment comprised of three phases of culture period : 10 d, 20 d and 30 d. Two different procedures of tubifex culture was tried (i) biomass production and (ii) number increment of individuals. Biomass production experiment was conducted in FRP tanks (each 1.6 m²). A total of 9 tanks were set up for one phase of experiment comprising 3 wastes each with 3 replicates. Similarly, in the experiment on number increment, 9 plastic pots were used for one phase of culture period. In each plastic pot, 10 individuals of tubifex worms were released and three wastes as food sources, each with three replicates. The entire experiment was conducted under water flow through system having flow rate @1.2 l/min.

Results showed that there were significant difference ($p < 0.05$) in biomass production between the different culture periods, using the three wastes with the highest production being recorded with RMS, followed by DS and then RCW. In number increment experiment, there was no significant ($p < 0.05$) difference between 10 days and 30 days culture periods, except in



the case of 20 days period. When the degree of rate of biomass production was calculated, it showed that production of biomass in 10 days period, harvested at 10th day was higher as compared to those of 20 days and 30 days period. Results indicate that maximum tubifex production can be obtained in 10 days period as compared to 20 days and 30 days culture period.

NH-P 15

Metabolic and anti-oxidative enzyme activities during starvation in *Labeo rohita* (Hamilton) fingerlings

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An experiment was set up to study the effect of starvation on metabolic and anti-oxidative enzyme activities in *Labeo rohita* fingerlings (av. wt. 3.41 ± 0.07 g). Fish were distributed in four plastic tanks of 150 l capacity (30 fish/ tank) and kept under starvation. Sampling was done every 15 days to measure activities of metabolic enzymes namely hexokinase, malate dehydrogenase (MDH), lactate dehydrogenase (LDH), glucose-6-phosphate dehydrogenase (G6PDH), aspartate amino-transferase (AST) and alanine amino-transferase (ALT) and anti-oxidative enzymes namely catalase (CAT) and superoxide dismutase (SOD). Starvation inhibited the hexokinase and G6PDH enzyme activity. The MDH and LDH enzyme activity of both liver and muscle initially increased up to 30 days of starvation (dos) and then decreased. The liver ALT activity increased linearly up to 30 dos, become stable at 45 dos and then decreased slightly after 60 dos, suggesting metabolic adaptation of the enzyme to provide substrates for gluconeogenesis and carbon skeleton for energy up to 45 dos. In the muscle, the major source of amino acid substrate for gluconeogenesis seems to be oxaloacetate and glutamate as the muscle AST was maintained

up to 30 dos and then increased at 45 and 60 dos. The anti-oxidative enzyme activities increased up to 30 dos after which the anti-oxidative capacity of the fish reduced. It could be concluded that rohu fingerlings were able to combat starvation up to 30 days based on majority of the metabolic and anti-oxidative enzymes assessed.

NH-P 16

Effect of phyto-genetic feed additives on the growth performance and responses of antioxidant activity in *Heteropneustes fossilis* (Bloch)

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Hydro-methanolic extract of leaves of *Euphorbia neriifolia* (Linn), a common hedge plant was used as a phyto-genetic feed additive in the formulated diet of *Heteropneustes fossilis* (Bloch). The phenol and flavonoids content in the extract was estimated by Folin-Ciocalteu and aluminium chloride assay. A total number of 225 fish (18 – 20 g) were divided equally among five groups with three replicates each. The fish were fed with formulated diets supplemented with four levels (10, 20, 30, and 40 mg/kg of diet) of phyto-genetic compounds for 60 days. The control groups were free from phyto-genetic compounds. The result revealed that the treatment groups showed significantly ($p < 0.01$) higher weight gain, digestibility and lower mortality rate than the control. The major antioxidant enzymes, catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPx) increased significantly ($p < 0.01$) as compared to the control groups. The phytochemical study revealed that the extract was rich in phenolic and flavonoid compounds. In conclusion, the extract of *Euphorbia neriifolia* can be used as an effective phyto-genetic feed additive in aquaculture as it contains useful bioactive compounds.



NH-P 17**Water stability and shelf-life of treated tadpole meal as substitute for fish meal in the diet for catfish**O. A. SOGBESAN¹* AND A. A. UGWUMA²¹Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, Orissa, India²Department of Zoology, University of Ibadan, Ibadan, Nigeria

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The introduction of animal source non-conventional ingredients has always been faced with the problem of leaching of nutrients or shelf-life apart from availability; hence this experiment was conducted to provide possible solution to this problem. Five diets, isonitrogenous at 42.5% crude protein, isocaloric at 1900 kJ/100 g and protein to gross energy ratio (P:GE) of 44.7 mg protein/kJ/100 g diets were formulated in which boiled tadpole was used to substitute fishmeal at various inclusion levels of 0% (control), 25%, 50%, 75% and 100%. 2.5g of each experimental diet was weighed and placed in muslin cloth of mesh size 250 μ m made of rayon material. This was suspended by a string on a retort stand and slowly immersed in 250 ml beaker filled with 150 ml of water and left for 30 min to determine the water stability of the diet. Another 5 g of each of the experimental diet was put in a corked bottle labelled according to each of the diet code. One set was stored in a refrigerator at 8 °C with the code A while the other set was stored under ambient room temperature of 28-31 °C in the laboratory and given the code B. Routine checking was done bimonthly for the physical, biochemical and microbial evaluations for a duration of 10 weeks. Data generated were statistically analyzed using SPSS 13 (2007) package.

The results showed that the inclusion of boiled tadpole meal in fish feed recorded water stability range of 72.32% to 76.88% against 74.11% from the control. In physical examination, highest hedonic scale 7, was recorded for mould appearance in all the unskinned-boiled tadpole

meal feeds stored in refrigerator while the lowest value of 3 was for flavour/odour in 75% and 100% unskinned-boiled tadpole meal stored at room temperature. The chemical assessment showed that 50% unskinned-boiled tadpole meal diet stored at 8 °C had the highest final crude protein of 43.53% while the control feed stored at room temperature had the lowest value of 42.64% which was not significantly different ($p>0.05$). An insignificant correlation ($r=0.728$, $p>0.05$) also existed between the final protein levels at the two temperatures. Highest final lipid level of 14.55% was recorded in 100% unskinned-boiled tadpole meal diet stored at 8 °C while lowest value of 10.51% in 25% unskinned-boiled tadpole meal stored at room temperature. Significantly different correlation of $r=0.998$, ($p<0.05$) was recorded between the final lipid levels of unskinned-boiled tadpole meals stored at the two temperatures. The 100% unskinned-boiled tadpole meal also had the highest fungi count of 29.33×10^7 CFU/ml followed by 28.73×10^7 CFU/ml in 75% unskinned-boiled tadpole diet both stored at room temperature while the lowest fungal count of 15.33×10^7 CFU/ml was recorded in the control diet stored in the refrigerator. The inclusion of the boiled tadpole as animal protein source and storage of the diets for about two months at 8 °C are recommended for improvement of the nutrient stability.

NH-P 18**Isolation of probiotic bacteria from fish gut and their application as feed supplement for growth and prevention of disease of Indian major carps**ARCHANA SINHA¹* AND SUBHDEEP GHOSH²¹Central Institute of Fisheries Education. Powarkhed Centre, Hoshangabad-461 110, Madhya Pradesh India²Visakhapatnam Regional Centre of Central Marine Fisheries Research Institute, Visakhapatnam, Andhra Pradesh, India

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The use of probiotics in aquaculture began with commercial preparations meant for terrestrial animals. With increasing intensification in commercial aquaculture, many products are



being made available for aquaculture purpose with varying degree of success. *Bacillus subtilis*, a probiont isolated from the intestine of *Cirrhinus mrigala* (Hamilton), was incorporated in fish feed at three different concentrations (4×10^5 , 4×10^6 , 4×10^7 cells/ml) and fed to the three species of Indian major carps - catla (*Catla catla*), mrigal (*Cirrhinus mrigala*) and rohu (*Labeo rohita*) for a period of 90 days. The growth parameters, proximate composition of whole body, digestive enzymes and gut microbiology were monitored at regular monthly intervals. The increments in length and weight and the survival were significantly higher ($p < 0.05$) and the values of food conversions were significantly lower ($p < 0.05$) in fishes fed the probiotic feeds. The administration of *B. subtilis* in diet resulted in an increase ($p > 0.05$) in body ash and protein content and in the specific activity of protease and amylase in the digestive tract of all the fishes. The counts of total heterotrophs, motile aeromonads, presumptive pseudomonads and total coliforms were significantly lower ($p < 0.05$) in the gut of the probiotic fed fishes. *Bacillus subtilis* persisted in the fish intestine and in the feed in high numbers during the feeding period.

The study reveals that probiotics can be used as protein source in fish feed. The high survival and low infectivity recorded in the probiotic feed fed fishes when challenged by immersion assay with the pathogenic *Aeromonas hydrophila* demonstrated that the probiotic strain confers disease resistance in fishes. A probiotics concentration of 10^6 to 10^8 cells g^{-1} is adequate for improved growth performance as well as survival and for healthy gut microenvironment and use of higher concentration of the probiont did not always lead to significantly better results. The findings showed that an isolated probiont *B. subtilis*, when compounded with feed, improved the growth performance and survival of all the three species of Indian major carps. The increase in specific activities of digestive enzymes coupled with the substitution of pathogenic microbial population by beneficial probiont population in the intestine of probiotic feed fed fishes led to enhanced digestion and increased absorption of food, which in turn contributed to the improved survival and growth in carps, including improved FCRs and SGRs.

NH-P 19

Effect of 'biogut' on growth performance of *Cyprinus carpio* (Linn.) fingerlings

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The study evaluated the effect of three varying levels of the probiotic product 'biogut' on growth performance of common carp fingerlings. Biogut was incorporated into a formulated diet (protein level: 35%), at 0.5, 1.0 and 1.5% of the diet and designated as T_1 , T_2 and T_3 and the fourth group, without biogut served as control (T_0). The diets were fed for 60 days to common carp fingerlings stocked at 10 nos./tank with three replicates. Results indicated that the common carp fingerlings fed with the diets containing biogut exhibited higher growth than those fed with the control diet. The survival was 100% in all the groups, the average weight and length of common carp were maximum in 0.5% biogut treated group. Specific growth rate, protein efficiency ratio, RNA/DNA ratio and protease activity were also highest in the group fed on biogut at 0.5%. The results clearly exhibit the advantage of incorporation of biogut, in the diet of common carp fingerlings.

NH-P 20

Effect of 'biogut' on growth performance and feed utilization in Deccan mahseer, *Tor khudree* (Sykes) fingerlings

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Probiotic microbial feed supplements are gaining wide acceptance in livestock production as well as in aquaculture. The present study was conducted to examine the efficacy of



the probiotic product 'biogut' on growth in fingerlings of Deccan mahseer, *Tor khudree* (Cyprinidae). A total of 120 fingerlings with an average weight of 1.2 g, stocked at 10 nos./ tank, were divided into four groups and then fed on biogut. Experimental diets had biogut at 0% (T_0), 0.5% (T_1), 1.0% (T_2), and 1.5% (T_3) inclusion levels. The experiment was conducted for 60 days. The survival was 100% in all the groups. The growth performance and nutrient utilization - specific growth rate, protein efficiency ratio and food conversion ratio were significantly ($p < 0.05$) higher in the biogut treated groups than the control. RNA/DNA ratio and protease activity were highest in the group treated with the probiotic at 1.5%.

NH-P 21

WSSV induced host protein expressional variations in tiger shrimp, *Penaeus monodon*

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White spot syndrome virus (WSSV) has proven to be by far the most serious virus to affect the penaeid shrimp industry during the past decade with its sudden onset, rapid replication, high mortality and ability to infect over 40 species of crustaceans. Viral infection cycles involve numerous interactions between viral proteins and host proteins. These interactions range from the initial binding between host membrane receptor and viral coat proteins, to the take-over of the host transcription machinery by replacing specificity-determining host factors by viral proteins. To date, virus-host interactions of WSSV have been studied only at transcription level, focused on lymphoid organ cells and hemocytes which are not the primary WSSV targets and therefore, their cellular pathways are not necessarily representative of the host cells in which virus replication occurs. Understanding the interaction between host and pathogen will be

helpful in developing control strategies for the diseases. The present study investigates the protein expressional variations in tiger shrimp *P. monodon* inoculated with WSSV, in a time course manner. All the experimental animals except the control were injected with viral inoculum ($50 \mu\text{l}$, 6×10^7 copies) between the second and third tergal plates of the lateral side of the tail using a 1ml syringe (30G). The challenge dose was optimized to ensure 100% mortality within 4 days of infection. The tissues like hepatopancreas, muscle and gills were then excised from infected and control shrimps at 6, 12, 24, 36 and 48 h post-injection (hpi). Mitochondrial, nuclear and total proteins were isolated from these tissues of both infected and control shrimps. SDS PAGE was performed and a known protein molecular weight marker mix (Bio-Rad) with proteins ranging from 14.4 to 97.4 kDa, was co-electrophoresed to determine the molecular weights of the proteins. The molecular weights of the proteins resolved by the SDS PAGE were identified using Quantity One software (Bio-Rad).

The gill which is one of the main target organs of WSSV showed up-regulation of 24 proteins and expression of three novel proteins after infection. The new proteins observed in the total protein fraction of gills were 24 kDa and 144 kDa. While the expression of the former started from 6 h onwards, the latter was observed at 48 h only. The expression of a 64 kDa nuclear protein was also noticed from 6 onwards. The shrimp hepatopancreas has been used as a monitor organ for the overall assessment of the health and well-being of the organism. In the hepatopancreas, 20 up-regulated proteins and six novel proteins were observed following infection. Among the new proteins, 77 kDa was in the total protein fraction, the expression of which commenced at 48 h. The newly expressed nuclear proteins in the hepatopancreas were of 148, 114, 82, and 47 kDa. While the expression of the 82 kDa protein was from 6 h to 24 h post-infection, 47 kDa was from 12 to 24 h. Expression of the 114 and 148 kDa proteins were observed from 24 h. The sixth one was a



mitochondrial protein of 64 kDa which was highly expressed at 48 h. The muscle showed up-regulation of 11 proteins and one new protein. The expression of a new protein which is a mitochondrial protein of 34 kDa was observed in the muscle from 12 h after infection, and was highly expressed at 48 h. The protein profile resolved in the study provide a rich source of information on proteins in shrimp which may be involved in antiviral response.

NH-P 22

Comparative analysis of immunoglobulin molecules from catfish, *Clarias batrachus*, *Clarias gariepinus* and *C. batrachus* ♀ x *C. gariepinus* ♂ hybrid

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A comparative study among the immunoglobulin molecules of *Clarias batrachus*, *Clarias gariepinus* and their F₁ hybrid (*C. batrachus* ♀ x *C. gariepinus* ♂) was undertaken. The fishes were immunized with bovine serum albumin (BSA) and the immunoglobulin molecules were purified from the immune sera, separately from each species by affinity chromatography on BSA-Sepharose 4B. In native PAGE analysis, the purified immunoglobulins demonstrated single bands with approximate molecular weights of 863 kDa for *C. batrachus*, 864 kDa for the hybrid and 860 kDa for *C. gariepinus*. The SDS-PAGE analysis revealed two heavy (H) chain bands of ~66 and ~59 kDa, ~76 and ~66 kDa, ~86 and ~77 kDa, respectively. The light (L) chain bands however, were two for *C. batrachus* and the hybrid with molecular weights of ~27 and ~26 kDa and one for *C. gariepinus* with a molecular weight of ~27 kDa. In western blot from SDS-PAGE gel, the rabbit anti *C. batrachus* Ig serum was shown to react with immunoglobulins of *C. batrachus* as well as the hybrid but not with the immunoglobulin of *C. gariepinus*.

NH-P 23

Demonstration of age of antibody production in *Catla catla* by monoclonal antibody based histochemistry

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Neonates hatch into a pathogenically hostile environment when their immunological capacity is still severely limited. Immunological competence occurs sometime later with the formation of cells in the lymphoid organs. Therefore vaccination in the earliest possible time could be an important immune prophylactic measure for fish health management during larval stages. The success of vaccination largely depends on the structural and functional maturity of the immune system at the time of vaccination.

Against this background, age of antibody production in catla (*Catla catla*), an economically important Indian major carp species has been studied employing MAAb based histochemistry. It was found that in catla, head kidney appeared by 2 day post-hatch (dph). Appearance of thymus and spleen was observed by 3 dph and 5 dph respectively. Mature lymphocytes were first detected on day 4, 10, 10 and 15 dph in kidney, thymus, gut associated lymphoid tissue (GALT) and spleen respectively. Appearance of immunoglobulin (Ig) positive cells could be noted in kidney by 8 dph followed by thymus and GALT by 10 dph. Spleen developed Ig positive cells by 15 dph. Thymus, kidney and spleen matured with the development of Ig positive cells by 21dph. Upon challenging the immunized fish with *Aeromonas hydrophila*, spleen and kidney reacted intensively by producing large number of Ig positive cells. It can thus be concluded that catla can be vaccinated by 21 dph, when their immune system is completely matured with the maturation of kidney, thymus, GALT and spleen.



NH-P 24**Kinetics of antibody response to *Aeromonas hydrophila* antigen in *Channa striatus***

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The teleost humoral immune system, like higher vertebrates produce specific antibodies in response to antigenic stimulations and the antibodies have much more flexibility and are much more potent in their defense ability. In the present investigation, an attempt was made to study the kinetics of specific antibody response in a freshwater fish, *Channa striatus* to formalin-killed *Aeromonas hydrophila* antigen was undertaken using an indirect ELISA. Apparently healthy *C. striatus* fishes were injected with formalin killed *A. hydrophila* (10^9 cfu/ fish) suspended in PBS and emulsified with equal volume of Freund's complete adjuvant (FCA). The immunized fishes were distributed into 3 replicate groups and blood samples were collected at different time intervals i.e., 0, 2, 4, 6, 10, 14, 21, 28, 35 and 42 days. The separated sera were used in an indirect ELISA to determine the specific antibody titer. For ELISA, the 96-well polystyrene ELISA plate was coated with formalin-killed *A. hydrophila* whole cell suspension to which *C. striatus* serum was added. Then the rabbit antiserum developed against purified *C. striatus* immunoglobulin was added followed by HRP conjugated anti-rabbit antibody. After treatment with the substrate (TMB/ H_2O_2), the reaction was stopped with H_2SO_4 and the color reaction was read on an ELISA plate reader at 450 nm. The antibody titer was expressed as P/N values, where P represents the OD_{450} of immunized sera samples of different time periods and N , the OD_{450} of control (0 day). A kinetic curve was plotted with time period vs. P/N value and one-way ANOVA followed by DMRT was performed to find out the significant difference among the antibody titers at different time intervals using SPSS18 software.

ELISA test showed there is a significant increase in antibody titer from day 2 onwards and such early rise in titer possibly indicates the previous exposure of the animals to *A. hydrophila* or related organisms. The titer reached the peak at day 14 ($P/N = 2.69$), which is significantly higher compared to the titers of all other time intervals. Subsequently, the antibody titer was dropped from day 21 ($P/N = 1.8$) till the completion of the experiment at day 42 ($P/N = 1.53$), but was at significantly higher level than the control. Understanding the antibody kinetics would be helpful in studying the impact of vaccination or pathogenic microorganisms on *C. striatus* health.

NH-P 25**Differential expression of Toll-like receptors (TLRs) in gold fish, *Carassius auratus* infested with the freshwater lice, *Argulus* sp.**

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Toll-like receptors (TLRs) play a major role in the activation of innate immunity and development of antigenic acquired immunity against invading pathogens. TLRs are pathogen recognition receptors (PRRs) that recognize pathogen-associated molecular patterns (PAMPs). As there is no report on TLRs that are involved in the recognition of the ligands of parasites, this study was carried out with an objective to assess the role of the six different TLRs (TLR2, TLR3, TLR4, TLR7, TLR9 and TLR22) based on their expression in, parasite (*Argulus* sp.) infested gold fish, *Carassius auratus*. Expression of TLRs in various organs of healthy and parasite infested fishes were compared. The results showed that there are differential expressions of TLRs in various organs of healthy and parasite infested gold fish. The results of this study show that specific TLRs are involved in activation of immune response to parasitic infestation in fish.



NH-P 26**Multiplex polymerase chain reaction (PCR) for simultaneous detection of viral pathogens infecting tiger shrimp, *Penaeus monodon* in india**

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Monodon baculovirus (MBV) and Hepatopancreatic parvovirus (HPV) infections in shrimps have been reported to cause poor feeding; reduced growth and predispose the stock to various infections resulting in production and economic losses in shrimp culture operations. Screening of shrimp brood stocks and post-larvae by PCR for MBV and HPV helps to avoid vertical transmission of these viral diseases to the offspring and their horizontal transmission during shrimp culture operations respectively. PCR assays for individual detection of MBV and HPV and multiplex real time PCR assay have been reported from various countries. In this study, a conventional PCR based multiplex PCR assay was developed for simultaneous detection of MBV and HPV infecting *P. monodon*. The advantages of this assay are specificity and sensitivity in detecting MBV and HPV, saves time, chemicals and template DNA and detects false negatives by its internal control. Hence, this multiplex PCR assay developed for simultaneous detection of MBV and HPV will be a useful tool for routine screening of shrimp broodstock and seed. The multiplex PCR assay was specific in amplifying the targets with a good sensitivity.

NH-P 27**Comparative evaluation and application of PCR and realtime PCR for rapid detection of viral hemorrhagic septicemia and Koi herpes virus in fish samples**S. S. MISHRA¹*, M. DHIMAN² AND S. M. GOYAL³¹*Regional Centre, Central Inland Fisheries Research Institute, 24, Panna Lal Road, Allahabad – 211 002, Uttar Pradesh*²*Department of Zoology, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna-485 001, Madhya Pradesh, India*³*Department of Veterinary Population Medicine, College of Veterinary Medicine, University of Minnesota, Saint Paul, Minnesota – 55018, USA***e-mail : ss_mishra60@yahoo.co.uk*

Viral hemorrhagic septicemia (VHS) is a deadly infectious fish viral disease of international importance, caused by the Viral hemorrhagic septicemia virus (VHSV). It afflicts over 50 species of freshwater and marine fish in several parts of the northern hemisphere. Koi herpes virus (KHV) has been recognized as the cause of mortality in populations of koi fish, *Cyprinus carpio koi* and common carp, *Cyprinus carpio carpio*, in carp aquaculture industry worldwide. In 1998, KHV was confirmed for the first time in carp (*Cyprinus carpio*) in Israel and soon after the disease was reported in many parts of the world. In USA, KHV has emerged in recent years causing mortality rates of up to 90% in koi fish. Intensive fish farming along with domestic and international trading in the absence of proper quarantine and health certification measures, has led to rapid spread of this disease. It is known that the virus is highly contagious and typically causes disease outbreaks, especially in young koi, when water temperatures are between 72 °F and 81 °F. Signs of KHV are often non-specific and mortality can begin before symptoms are apparent.

Common diagnostic methods used for detection of VHSV and KHV are isolation of virus on specific cell lines, by gross and histopathology, detection of viral antibodies using ELISA and by PCR assay. Among these, PCR assay is shown to be sensitive but has the disadvantage with respect to quantification of virus in the tissue sample. The TaqMan realtime PCR assay using dual labeled probe has been used and tried for detection and quantification of VHSV and KHV in tissue samples received by Veterinary diagnostic laboratory, University of Minnesota, USA. In the present study, realtime PCR was standardized and evaluated for its suitability in detection of VHSV and KHV using FAM-TAMRA labeled probe. The amplified PCR product (78 bp) was cloned in to TOPO TA



plasmid cloning vector, screened and purified. The plasmid copies were estimated and different dilutions of plasmid ranging from 2×10^{11} copies to 2 copies in sample were checked using ABI 7500 realtime PCR system and corresponding Ct values were noted. Significant amplification and detection was noted up to 20 copies, indicating high sensitivity of the reagent. The number of viral copies in fish tissue samples were estimated which ranged from 5×10^8 to 2×10^6 . The Realtime PCR tests were found to be more sensitive than PCR for detection of VHSV and KHV. The detailed methods used and results obtained have been discussed in the present paper.

NH-P 28

Identification and molecular characterization of *Aeromonas* and *Vibrio* isolates from fish

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Among the groups of microorganisms affecting fish and shellfish, *Vibrios* and *Aeromonas* are responsible for devastating economic losses both in hatchery and aquaculture farms. Various *Vibrio* spp. have been implicated in major mortality cases in juvenile penaeid shrimp. *V. parahaemolyticus* and *V. alginolyticus* have been isolated from cases of septicemic vibriosis, black spot and shell necrosis disease in shrimp. *Vibrios* and *Aeromonas* are regarded as members of the normal bacterial flora of shrimp, often acting as opportunistic pathogens under stressful conditions inflicting mortalities up to 100% Both *Aeromonas* and *Vibrios* are of public health significance, responsible for gastroenteritis in humans, warranting methods for their control. So far fifteen species have been considered, among which, six are considered to be pathogenic for human, while nine are non-pathogens or "environmentals". Among *Aeromonas* species,

A. hydrophila, *A. caviae*, *A. veronii*, *A. eucrenophila*, *A. popoffii* and *A. culicola* are predominating species isolated from human cases where as *A. hydrophila*, *A. sobria*, *A. veronii* b.v. *sobria* have been found in fish samples.

It has been shown that the identification of *Aeromonas* and *Vibrios* at species level is very difficult because of the wide variability of these strains. Since these bacteria were recognized as important pathogens for aquatic animals and significant opportunistic pathogen for humans having public health significance, many efforts were dedicated to find methods for accurate identification and classification of these microbes. *Aeromonas* spp. and *Vibrios* are known to be phenotypically, serologically and genetically quite diverse and the conventional methods of identifying these microorganisms like microbiological culture, biochemical tests, protein analysis, serotyping etc. give contradictory results. Alternative specific genomic fingerprints have been proposed as diagnostic tools by means of amplification of interspersed repetitive DNA sequences present in bacterial genomes, referred to as rep-PCR (Rademaker and Bruijn, 1997) or by amplification of random sequences by arbitrary primers, RAPD (Williams et al., 1990). Different methods used for molecular typing of *Aeromonas* and *Vibrio* species and their application in identification, differentiation and characterization of species have been elaborated in the present paper.

NH-P 29

Gill pathology of Asian seabass, *Lates calcarifer* (Bloch) infected with monogenean fluke, *Diplectanum* sp. in open sea cage culture

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Asian seabass (*Lates calcarifer*) is a promising species for open sea cage culture in India. Presence of monogeneans on a range of cultured



fish species has been reported to be responsible for mortalities or a reduction in the health of fish. Natural infestation of Asian seabass reared in open sea floating cages off Karwar, south India with monogenean flukes is reported. Fish (600 ± 120 g mean weight; 30 ± 2 cm mean length) were found to be infected with flukes during July to September 2011 with occasional mortality, when the water salinity was low (6 ± 1.2 ‰). The salinity during the rest of the rearing period was 26 ± 3.6 ‰. The stocking density was 25 fish/ m². Gill infestation with monogenean flukes was not observed when the stocking density was 20 fish/m².

Random sampling of gill impression smears of externally healthy fish revealed presence of monogenean flukes of about 6 per 100X microscopic field. The flukes were identified as *Diplectanum* sp. based on morphology. Impression smears of the gills showed that the flukes were attached to gill filaments. Histologically, haematoxylin and eosin stained gill sections revealed opisthoaptor of the fluke penetrating deep into the basement membrane and connective tissue of the primary lamellae causing destruction of the secondary lamellae leading to detachment of gill cells. Cellular debris was observed in the close proximity to the body of the parasite. Proliferation of the epithelial cells resulting in fusion of secondary lamellae was noted at the vicinity of the opisthoaptor. The importance of these parasites in affecting the growth and productivity of cultured fish in open sea floating cages has been emphasized.

NH-P 30

Parasitic infections in brood stock of clown fishes at Vizhinjam, Thiruvananthapuram

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Large scale breeding and rearing programme for clown fishes is ongoing at Vizhinjam Research Centre of CMFRI. Brood stock of 8 species of clownfishes is being maintained here. Parasitic infections were noticed in the case of brood stocks of orange clown (Nemo) (*Amphiprion ocellaris*) and blackfinned anemonefish or Maldives anemonefish (*Amphiprion nigripes*). An incidence of brooklynellosis (clownfish disease) was observed in orange clown (*A. ocellaris*). Few fishes died and the symptoms included thickening of the mucus on the skin; so much so that the fish appears to have a rough white coating. This thickening of the mucus layer may become severe in some individuals and mucus strands trail behind the fish as it swims. Often the scales are loosened in the infected area and may fall off from the fish when it is caught in a net. Such fishes become weak and lethargic. Microscopic examination of skin and gills revealed the infection of *Brooklynella hostiles* in them. Fresh water bath dislodged most of these parasites. The treatment trials improved the health, further preventing mortality and the spread of infection.

Adult fishes of *Amphiprion nigripes* were collected from the local dealers for brood stock development and breeding. In the process of development, few fishes were found weaker and showed abnormal swimming behaviour. Freshwater dip could not improve their health condition. Fishes did not show any characteristic symptom of microbial diseases. The scales were loosened and few fishes became less active. Four fishes died within a span of 2 weeks. Postmortem examination revealed heavy infection of metacercariae of a digenean *Proisorhyncus* sp. in gills and muscles. Infection was almost 100%. Both fins and gills were heavily infected. In some cases almost all the gill filaments were infected by the parasites. Treatment trials and controlled water quality parameters improved the health condition and further mortality was prevented.



NH-P 31**Observations on black gill discoloration in farmed *Litopenaeus vannamei* and its mitigation using a pond sanitizer**

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The white leg shrimp, *Litopenaeus vannamei* (Boone, 1931) has been considered as a revolutionary species in shrimp farming industry in the recent past in India. There has been a marked shift from the farming of indigenous black tiger shrimp, *Penaeus monodon* to the culture of exotic white leg shrimp, *L. vannamei* in India from the beginning of this century. Intensification of shrimp farming poised several problems including the sporadic occurrence of diseases in the farms. In addition to the most widely occurring viral and bacterial diseases, a number of less prevalent disease manifestations also were observed in shrimp farming sector. The present study deals with the observations on a black gill discolouration in farmed *L. vannamei*. The results indicated that the excess feeding and unused feed in the shrimp farm causes bottom pollution which in turn led to the black/brown discolouration in shrimps. This specific problem could be overcome by the application of KMnO_4 , an oxidising agent that reduces the organic load to safer levels and the shrimps recovered to normalcy within a few days.

NH-P 32**Response of juvenile tiger shrimp, *Penaeus monodon* challenged with virulent *Vibrio harveyi*, to antimicrobial biogenic silver nanoparticles**D. INBAKANDAN¹*, V. SIVAKUMAR¹, A. RAVIKUMAR REDDY¹ AND S. AJMALKHAN²¹Center for Ocean Research, Sathyabama University, Chennai- 600 119, Tamil Nadu, India²Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai-608 502, Tamil Nadu, India

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Shrimp cultivation is an important sector of the Indian aquaculture industry in which production losses can result from disease outbreaks caused by luminous *Vibrio harveyi*. Though lot of aquaculture medicines and management options are available to control vibriosis, a proper remedy has not been achieved so far. Use of silver nanoparticles for biomedical application is the current trend in the field of nanobiotechnology. On this back drop, the present research work focused on the biogenic silver nanoparticles with antibacterial property to control the infectious vibrio load in the host as well as in the aquatic environment. As part of the study, (i) response of juvenile *P. monodon* to antimicrobial biogenic silver nanoparticles, (ii) response of juvenile *P. monodon* challenged with a virulent *V. harveyi* and (iii) response of juvenile *P. monodon* challenged with a virulent *V. harveyi* to antimicrobial biogenic silver nanoparticles were studied. Shrimps were exposed to silver nanoparticles for a period of 48 h. The responses were assessed by analyzing total glutathione-S-transferase assay (GST), lipid peroxidation assay (LP) and histopathological investigations. The activity of GST was elevated in control shrimps at 6, 24 and 48 h. When, the shrimps were infected with pathogenic vibrios, the GST level was depleted at 24 h compared to the initial 6 h, which could be to overcome the oxidative stress due to the pathogenic infection. At 48 h, the GST level was increased which could be due to the decreased virulence of vibrios and the innate immunity of the host. In the case of infected shrimps challenged with silver nanoparticles, GST level was significantly elevated at 6, 24 and 48 h, indicating no utilisation of GST which could be attributed to antimicrobial effect of silver nanoparticles. No significant variations in LP levels were noticed in control shrimps. When the shrimps were exposed to vibrios, LP levels increased at 6, 24 and 48 h which could be attributed to the pathogenicity of the vibrios. In the case of infected shrimps challenged with silver nanoparticles, the LP level elevated during the initial hours and declined in the later hours. This indicates that nanoparticles could control proliferation of vibrios leading to low levels of LP.



NH-P 33**Effect of medicinal plant crude extracts on the health of *Channa striatus* fingerlings**

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The use of medicinal plant products as an alternative to the drugs, chemicals and antibiotics to combat fish diseases in aquaculture is attracting the attention of many researchers globally. Several workers have focused on the use of medicinal plant products as potential therapeutic measures for modulating the immune response and to prevent and control fish diseases. In view of this, a preliminary study was conducted during winter months to know the effect of medicinal plant crude extracts on growth, survival and health status of *Channa striatus* fingerlings. The aqueous paste was prepared separately from the leaves of *Ocimum sanctum* (Tulsi), and *Aegle marmelos* (stone apple) and rhizome of *Curcuma longa* (turmeric) and kept in sealed polybags under refrigeration. The experiment was conducted in circular cisterns having 500 l of water in duplicate, containing 15 numbers of *C. striatus* fingerlings (6.15 ± 0.2 g). The crude extracts of three medicinal herbs viz., *O. sanctum* (T₁), *C. longa* (T₂), *A. marmelos* (T₃) were mixed @ 5% to the weight of boiled and minced poultry viscera and fed @ 4-5% of fish body weight for a period of 60 days. The control group (C) was fed the same feed but without herbal extract. Fishes were sampled fortnightly for assessing growth, survival, gross health and bacterial load in the intestine and gills.

Treatment group T₂ showed significantly higher ($p < 0.05$) survival (93.33%) in comparison to control and other treatment groups. Growth was higher in control group in comparison to treatment groups. *C. striatus* is a highly carnivorous fish and prefers to take live feed or feed of animal origin with meaty flavour. Hence,

slight change in flavor due to presence of herbal extract might have resulted in reduction in palatability of feed which could be seen as slower growth in treatment groups. Gross morphological examination showed that fishes of treatment groups were healthy having shiny body surface, intact fins, more active etc. in comparison to control group. The microbial studies revealed that *O. sanctum* fed fishes (T₁) contains significantly less ($p < 0.05$) number of bacteria in gut in comparison to fishes of other treatment or control groups. Similar result were observed in gills. The present study suggests that the herbal crude extract could be used as a prophylactic measure to keep fishes healthy and also to enhance survival during fingerlings rearing.

NH-P 34**The protective effect of chitin against white tail disease (*Macrobrachium rosenbergii* nodavirus and extra small virus) in freshwater prawn *Macrobrachium rosenbergii***

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Macrobrachium nodavirus (MrNV) is the causative agent of white muscle disease of cultured fresh water prawn which is a major threat to fresh water prawn culture. To control white tail disease (WTD), several efforts were made but there is no single solution for it. In the present investigation, chitin was used as an immunostimulant to control WTD in prawn because this biopolymer has given promising results in respect to the human and shrimp diseases. Chitin acts as an effective immunostimulant by enhancing non-specific immune system during viral, bacterial and parasitic diseases in shrimp and prawn by activating prophenoloxidase (Ppo) enzyme and enhancing respiratory burst. In the present study, freshwater prawn *Macrobrachium rosenbergii* were reared for



90 days by incorporating chitin in the experimental diet at varying concentrations (0.5%, 0.75%, and 1%). The prawns were then experimentally infected with purified MrNV by intramuscular injection. The MrNV infection was confirmed by RT-PCR and nested PCR. The immunological parameters such as Ppo activity and respiratory burst were significantly higher in prawn fed chitin supplemented diet. Chitin at 0.75% level showed significantly stimulated Ppo and NBT. Incorporation of chitin in feed at 0.75% was found effective in this study, giving rise to enhanced immune response as well as survival in *M. rosenbergii*, with the highest relative percentage survival (RPS) of 63.4% against MrNV infection.

NH-P 35

Green synthesis of silver nanoparticles using *Citrus limon* (lemon) extract and their antibacterial effect

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Metallic nanoparticles are traditionally synthesized by chemical reduction methods but the chemicals used are mostly toxic and hazardous to living system. The green synthesis of nanoparticles by using different plant extracts is gaining importance due to its simplicity, cost effectiveness and eco-friendliness. Silver has been used as an antimicrobial agent for centuries but in recent years its nanoparticulate form has attracted intensive research interest due to its strong antimicrobial activity. Therefore, in the present study, silver nanoparticles were synthesized from silver nitrate (AgNO_3) solution using the extract of *Citrus limon* (lemon) in the ratio 3:2 (vol/vol), as reducing as well as capping agent. The concentration of lemon extract was standardized to find out the optimum reduction of silver nitrate to form silver nanoparticles of appropriate size and shape. The formation of silver nanoparticles was confirmed by Surface Plasmon Resonance

as determined by UV-visible spectroscopy. Silver nanoparticles in the average size range of 30 nm with spherical shape were observed by Transmission Electron Microscopy. Their antibacterial activity was studied against a wide range of bacterial fish pathogens [Gram positive (*Bacillus* sp., *Staphylococcus* sp., *Streptococcus* sp.) as well as Gram negative (*Aeromonas hydrophila*: 10 different strains, *Edwardsiella tarda*, *Aeromonas salmonicida*, *Flavobacterium columnare*, *Pseudomonas fluorescens*, *Vibrio* sp.)] by *in vitro* antibacterial assays showing strong antibacterial activity as comparable with chemically synthesized silver nanoparticles.

NH-P 36

Field assessment of polyherbal product for immune enhancement in growout rearing of *Penaeus monodon*

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The use of herbs has become an alternative way to control diseases of fish by enhancing the activity of non-specific defence mechanisms without environmental hazards. A herbal mix comprising *Aloe vera*, *Ocimum sanctum*, *Curcuma longa*, *Withania somnifera*, *Embilica officinalis*, *Phyllanthus niruri* and *Allium sativum* fermented with *Saccharomyces cerevisiae* was incorporated in the feed at 0.9% level and fed to *Penaeus monodon* for the first 60 days of growout rearing. Growout rearing was carried out in earthen ponds for 150 days at a stocking density of 12 nos./m². The growth parameters were recorded at the end of grow-out period. There was no incidence of diseases in the experimental group fed with herbal mix. An increase in production of shrimp to a level of 30.19% was recorded in the treatment group as compared to control. In field assessment, the herbal mix was found to be effective in immunity enhancement and it also proved as a growth promoter.



NH-P 37**Polyherbal product enhances disease resistance in tiger shrimp, *Penaeus monodon***

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Polyherbal formulation containing *Aloe vera* (10%), *Ocimum sanctum* (10%), *Curcuma longa* (20%), *Withania somnifera* (20%), *Embellica officinalis* (20%), *Phyllanthus niruri* (10%) and oil of *Allium sativum* fermented with *Saccharomyces cerevisiae* [at 1:1 ratio for 3 days] (10%) showed enhanced disease resistance in tiger shrimp against White Spot Syndrome Virus (WSSV) and secondary *Vibrio* pathogen. The herbal formulation was incorporated into shrimp feed at 0.9% level and administered to *Penaeus monodon*. After 60 days of administering this test diet, the experimental shrimps were subjected to *per os* challenge (by way of continuous input of WSSV infected tissues to the experimental animals) from 61st day onwards. At the end of 72 h after initial challenge, 100% mortality was observed in control, whereas the herbal preparation administered shrimp group showed only 50% mortality. This herbal formulation administered shrimp also showed maximum protection (100% survival) when challenged with *Vibrio anguillarum* (isolated from WSSV infected shrimp) at a dose of 0.1 ml per animal at 6.4×10^9 cfu/ml concentration. On the other hand, the control group exhibited only 33.33% survival when subjected to the pathogenic bacterial challenge. Statistical analysis showed that there was significant difference (at 5% level) in disease resistance among the treatment groups.

NH-P 38**Isolation of pathogenic fungi from coldwater fish and their environment**

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An attempt was made to isolate pathogenic fungi from body tissue and eggs of cold water fish as well as from their habitat water. Fungal load was more prominent in ponds with stagnant water than the running water raceways. The inferior water quality of the stagnant fish ponds supports growth of fungi. The exotic carps being reared in these ponds showed heavy mucus production, especially in the winter months, which supports the presence of fungal pathogens in the pond water. Similarly, golden mahseer and chocolate mahseer showed high intensity of infection in cement tanks than in the earthen ponds and lakes. In most of the samples from fish farms, elongated tapering zoosporangia were noticed at the tips of somatic hyphae which were appearing darker and more granular. Pear shaped primary zoospores were present. The zoospores in the zoosporangia were multi-rowed. They were motile which clearly indicated the presence of flagella in the zoospores. The oogonia present on the terminus of the somatic hyphae were somewhat round in shape and pluriovulate (multiovulate) while some intercalary oogonia were also present in between the somatic hyphae, which is a characteristic feature of members of family saprolegniaceae. Antheridial cells were observed as hypogenous. On placing the pieces of the grown colony contained in the cottony growth in sterile water under aseptic conditions, asexual and sexual structures were observed after 3-4 days of incubation at room temperature. On the basis of the above findings, the fungi isolated were characterized as *Saprolegnia parasitica*, *Saprolegnia diclina* and *Saprolegnia ferax*. *S. diclina* infection was more common in winter months, whereas *S. ferax* occurred predominantly in the spring and autumn. In the water samples from the lake and trout farm Bairangna, no freely floating primary zoospores were observed and secondary oocytes appeared at the sporangium opening, which is a characteristic of *Achlya* spp. as well as *Aphanomyces* spp.



NH-P 39**Histopathological changes in *Catla catla* due to textile effluents in Kanchipuram, Tamil Nadu**R. KOWSALYA^{1*}, M. DEECARAMAN¹, C.M. KARRUNAKARAN² AND A. UMA³¹Dr. M. G. R. Educational and Research Institute, Maduravoyal, Chennai – 95, Tamil Nadu, India²Department of Biomedical Engineering, SMK Fomra Institute of Technology, Kelambakkam, Chennai -103, Tamil Nadu, India³Shrimp Disease Diagnosis Laboratory and Water Quality Analysis Lab, TANUVAS, Madhavaram Milk Colony, Chennai -51, Tamil Nadu, India

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Dyeing and printing of textiles being a traditional industry of Kanchipuram town, a good number of textile industries along with dyeing and printing clusters have come up in the area. The dyeing units in Kanchipuram municipality and the surrounding villages are under constant threat of ground water contamination. Untreated textile dyeing effluents released from the textile industries on open land, seeps in to the aquifer and increases the concentration of pollutants in the ground water. The ground water quality in this vicinity has resulted in the damage of agricultural crops and aquatic organisms such as fishes. The effluent of about five litres were collected in polythene containers from a textile industry in Kanchipuram. Histopathological effects of textile effluent on the gills of freshwater fish *Catla catla* were observed at different time intervals (24 h, 48 h, 96 h and 1 week) with three different concentrations - 25 ml/l, 50 ml/l and 100 ml/l. The toxic effects of textile effluents on gill showed degeneration, edema, desquamation, lamellar fusion, haemorrhage and epithelial lifting of primary and secondary lamellae.

NH-P 40**Incidence of Dactylogyrosis in fry of Ropsa scaly and Felsosomogy mirror carp reared at high altitude raceways system, Champawat, Uttarakhand, India**SURESH CHANDRA^{1*}, AMIT PANDEY¹, SUMANTA MALLIK¹, S. K. SRIVASTAVA¹, R. S. PATIYAL¹, S. K. GUPTA¹ AND P. C. MAHANTA²¹Chirrapani Experimental Field Centre of Directorate of Coldwater Fisheries Research, Champawat, Uttarakhand-262 523, India²Directorate of Coldwater Fisheries Research, Bhimtal - 263 136, Nainital, Uttarakhand, India

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Occurrence of various monogenetic trematodes leads to large scale mortality of fry, fingerlings and adults of various fish species mainly due to damage of gills, causing major economical loss in fish farms. Present communication reports the outbreak of dactylogyrosis in 35-40 days old fry of Ropsa scaly and Felsosomogy mirror carp (Hungarian imported strains) reported to be fast growing compared to existing Bangkok strain of common carp. The study was undertaken at Champawat Experimental Field Centre of Directorate of Coldwater Fisheries, located at an altitude of 1620 m above sea level. Three common carp strains i.e., Ropsa scaly, Felsosomogy mirror carp and existing Bangkok strain were bred at a temperature range of 17-21 °C, and stocked @ 250/m² in raceways. The average water temperature of nurseries during entire two months fry rearing period was 20.5±3.5°C. Outbreak of dactylogyrosis was observed, when the average water temperature of 23±1 °C was recorded in the raceways. Emaciated growth, excessive mucus secretion, pale coloration of gills with minute hemorrhages and large scale fry mortality were the clinical signs observed during the infection. The outbreak was spontaneous and infection lasted for about one and half weeks. Prevalence varied significantly (p<0.05) with respect to host size in terms of length. Maximum prevalence (48%) was observed in the host size class of 10 to 20 mm followed by size class of 20 to 25 mm (20%). Bigger size group fry above 25 to 40 mm had least infection (2%). Highest number of parasites were recorded in the gills of size class 10 to 20 mm. Mortality rates of 46.6% was observed in infected raceways. The existing Bangkok strain of common carp fry having size range of 10-20 mm reared at the farm under similar rearing condition did not show signs of dactylogyrosis, probably showing greater tolerance to this infection.



NH-P 41**Establishment of cell lines from various tissues of the honeycomb grouper, *Epinephelus merra* (Bloch, 1793)**

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In vitro cell culture systems are necessary for the isolation and characterisation of viruses, development of diagnostic reagents, testing of therapeutics and for the production of material for immunological and vaccination studies. Fish cell lines have also found widespread application in cytogenetics; as *in vitro* models for studying cellular and physiological processes, to evaluate the toxicity of pollutants and also in transgenics. The present study envisaged to develop and characterise cell lines from the honey comb grouper, *Epinephelus merra*. *E. merra* is one of the smaller fish species in the *Epinephelus* genus, widely-distributed and common to the waters of the Indian and Pacific Oceans. Groupers are popular marine food fish of high market value in many parts of the world including the Gulf and South East Asian countries. Central Marine Fisheries Research Institute (CMFRI) has achieved success in development of broodstock and laboratory scale spawning and larval rearing of *E. merra*.

Tissues from various organs such as fin, gill, caudal peduncle, heart, liver, spleen, kidney and brain of *E. merra* were evaluated for deriving cell lines by explant as well as trypsinisation method. The culture medium used was Leibovitz L-15 supplemented with 20% foetal bovine serum (FBS). Among the different organs, cells from spleen, brain, gill, heart, fin and caudal peduncle were found to have better potential

for attachment, growth, multiplication, formation of confluent monolayers and successful subculturing. Beyond 10 passages, the serum concentration was gradually reduced. Six successful cell lines have been derived (Table) which are at passage levels ranging from 40 to 70. Chromosome mapping of metaphase spreads from the cell lines revealed that the modal chromosome number is 48. All the 6 cell lines derived have been successfully cryopreserved and the viability of cells were found to be >85% when revived after 6 months of storage in liquid nitrogen.

Table. Cell lines developed from *Epinephelus merra*

Cell line	Tissue of origin	No. of passages
HC2H2 Ex	Heart explant	70
HC2G1 Tr	Trypsinised Gill	67
HC2Cp Tr	Trypsinised caudal peduncle	64
HC2Sp Ex	Spleen explant	54
HC2F3 Ex	Fin explant	51
HC2Br Tr	Trypsinised brain	40

NH-P 42**Effect of salinity and pH on bacteriophage therapy for luminous vibriosis in *Penaeus monodon* (Fabricius, 1798)**

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Luminous vibriosis caused by *Vibrio harveyi* is one of the major diseases for penaeid larvae in hatcheries and juveniles in farms. Bacteriophage therapy is a viable proposition for controlling luminous vibriosis in shrimp aquaculture. Various environmental factors enhance the growth and activity of phages followed by increased efficiency in controlling bacterial diseases. A total of 7 *V. harveyi* phages were used in this study and their efficiency was checked at different levels of pH and salinity. Of the seven *V. harveyi* phages used, phage V was found to be best for biocontrol of luminous vibriosis due to its wide



host range. Out of the two parameters studied, the activity of phage was best at a salinity of 25 ppt and at neutral pH. It has been suggested

that at varying salinity and pH, different volumes of phage (indicative of different pfu) need to be used for best results.





Genetics, Breeding and Biotechnology

GB- O : Oral presentation
GB- P : Poster presentation

GB-O 01

Fine mapping of QTL involved in viral resistance in rainbow trout and search for candidate genes

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Viral haemorrhagic septicaemia disease is a major problem in rainbow trout aquaculture. Understanding the intrinsic genetic factors determining the variation in disease resistance has their applications in selective breeding programmes for improved genetic resistance. Present study has been aimed to dissect the QTL affecting the VHS resistance, in order to find polymorphic markers and candidate genes that contribute for the variation in resistance among the individuals. Genomic tools facilitated the systematic fine mapping of QTL both in molecular and in-silico methods. Through molecular fine mapping, seven new SNPs and one microsatellite were identified. A total of 4 microsatellites were genotyped in the members of the QTL reference family and further linkage mapping of these microsatellites validated the assembly of regional physical map. These results guided us to select the appropriate whole BAC sequences near QTL region for further in-silico analysis. Genes spanning in individual BACs were identified by means of BLAST search in rainbow trout EST contig database and gene prediction method. Genes having functional role in immunological pathway has been prioritized. 'C1q-like adipose specific protein' in BAC 425H10 and in BAC 125H06, 'Interferon-gamma receptor 2' and Cytokine receptor family b5 are the genes expected to have a functional role in immune mechanism against virus. Further confirmation of their candidacy and identifying the polymorphism involved in these candidate genes may play a significant role in future selective breeding programmes for improved resistance in rainbow trout.

GB-O 02

Development of genic SSR markers in *Labeo rohita* using next generation sequencingC. CHHOTARAY¹, P. DAS^{1*}, N. ROBINSON², M. BARANSKI², K. D. MAHAPATRA¹, J. MISHRA¹, J. N. SAHA¹, H. K. BARMAN¹, S. DAS¹ AND P. K. SAHOO¹¹Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, 751 002, Odisha, India.²Nofima Marin, P. B. No. 5010, 1432 Ås, Norway.*e-mail : pdas77@hotmail.com

Simple sequence repeats (SSR) were identified from the contigs generated through next generation sequencing of transcriptome by selective RNA pooling from seven different organs (liver, muscle, kidney, spleen, gill, brain and fin) of *Labeo rohita*. De-novo assembly and clustering of short reads generated by Illumina Solexa platform produced 137,629 contigs which were screened for the presence of tandem repeat sequences using 'Repeat Finder' software. With minimum of 7 motifs for di-, 5 for tri-, 4 for tetra- 3 for penta- and hexa-nucleotide repeats as search criteria, 996 microsatellite containing contigs were identified having enough flanking region for primer design. Out of 996, 380 (38.1%) were di-nucleotide repeats, 358 (35.9%) tri-nucleotide repeats, 68 (6.8%) tetra-nucleotide repeats, 93 (9.3%) penta-nucleotide repeats and 97 (9.7%) were hexa-nucleotide repeats. For polymorphism study, a panel consisting of three individuals from a mapping pedigree and other eight (four each) from resistance and susceptible lines of rohu was selected. A total of 110 loci (25 each from di, tri, tetra and hexanucleotide repeats and 10 from penta-nucleotide repeats) were randomly selected for PCR-genotyping using the above animal panel. PCR products initially separated on 3% agarose gels resulted in 22 polymorphic microsatellite markers with tetra-nucleotide repeats being highest in frequency (9/25) followed by hexa-nucleotide (6/25), di-nucleotides (4/25) and tri-nucleotide repeats (3/25).



GB-O 03**Enrichment, characterization and *in vitro* propagation of spermatogonial stem cells of farmed carp, *Labeo rohita***

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Spermatogonial stem cells (SSCs) have the intrinsic ability to self-renew throughout the life-time to produce spermatozoa. It is difficult to study SSC behaviour *in vivo*. *In vitro* culture of SSC will be useful to study developmental stages of gametogenesis. The aim of this study was to isolate and characterize pure population of SSCs from the testis of commercially important carp, *Labeo rohita* (rohu). Testicular tissues were dissociated with collagenase and purified by two-step: ficoll-gradient centrifugation followed by MACS using either Thy1.2 (CD90.2). The two-step purification protocol dramatically heightened recovery rate for spermatogonial cells. The efficiency of enrichment was marked higher in the tune of 28%. A majority of enriched cell population represented a Vasa⁺, Pou5f1⁺, Ssea-1⁺, Tra-1-81⁺, Plzf⁺, Gfra1⁺ and c-Kit⁺ as detected by immuno-cytochemical and/or quantitative RT-PCR (qRT-PCR) analyses. Thus, Thy1⁺ SSCs were enriched with greater efficiency from the mixed population of testicular cells. The enriched cells proliferated *in vitro* for more than two months with mitotic divisions, as revealed by BrdU incorporation assay, forming colonies characteristic of SSCs in a medium containing L-15, 10% FBS, 1% rohu serum and other nutrients at 28°C. The proliferative rate was determined by the growth curve, while the number of live or dead cells was examined by trypan blue dye exclusion test. The survival rate was higher during initial two months of culture period. Thirty days after plating, the cell number increased by about two-fold, whereas cells grew relatively faster from 30 days to 60 days (increased by ~3.6-fold). The doubling time of the cells was around 18 days. A population of

enriched spermatogonial cells could be cultured in an undifferentiated state since most of the cells was immuno-positive for Vasa (96%) rather than cKit (12%), and expressed marked higher levels of *pou5f1* and *plzf* transcripts instead of *c-kit* as evidenced from the qRT-PCR analyses; while rests committed towards differentiation to produce fertile sperms. Additionally, few novel transcripts preferentially expressed in spermatogonial cells were identified from the generated EST library and these transcripts are likely to be associated with germ cell development. The full length cDNA sequence information of Plzf involved in stem cell maintenance and proliferation was generated its expression in spermatogonial cells was documented. The phenotypic and genotypic signatures for identifying rohu spermatogonial cells, while propagated *in vitro*, have also been documented. The availability of rohu SSC has provided the basis of undertaking basic research and germ-line manipulations so as to assist in carp industry.

GB-O 04**Molecular phylogeny of commercially important lobster species from Indian waters deduced from mitochondrial and nuclear DNA sequences**N.S. JEENA¹*, A. GOPALAKRISHNAN¹, E.V. RADHAKRISHNAN², LIJO JOHN¹, JOE.K. KIZHAKUDAN², V. S. BASHEER¹, SHOBA J. KIZHAKUDAN², P. K. ASHOKAN² AND J. K. JENA³¹National Bureau of Fish Genetic Resources Kochi Unit, CMFRI Campus, Kochi 682 018, Kerala, India²Central Marine Fisheries Research Institute, P.B. No. 1603, Kochi - 682 018, Kerala, India³National Bureau of Fish Genetic Resources, Canal Ring Road P. O. Dilkusha, Lucknow-226 002, Uttar Pradesh, India

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Lobsters are widely distributed along the coasts of India. Though 11 species are commercially important, two species [*Thenus unimaculatus* and *Panulirus homarus homarus* (*microsculpta*)] form the major share of lobster landings in India. Molecular studies have not been carried out to deduce their phylogeny from the region. In the present study, sequence data derived from mitochondrial COI (655bp),



16SrRNA (549bp), and 12SrRNA (608bp) and nuclear 18SrRNA (938bp) genes were used to generate molecular signatures and determine phylogenetic relationships among 11 species of commercially important lobsters. Eight species belonging to the family Palinuridae (*Panulirus homarus homarus* (microsculpta), *P. ornatus*, *P. polyphagus*, *P. versicolor*, *P. longipes longipes*, *P. penicillatus*, *Puerulus sewelli*, *Linuparus somniosus*) and three to Scyllaridae (*Thenus unimaculatus*, *T. indicus*, *Petrarctus rugosus*) were studied. In view of the species revision of the shovel-nosed lobsters, morphological as well as molecular level analyses clearly indicated that the fishery of *Thenus* sp., from all the major landing centres of the Indian coast consists mainly of *Thenus unimaculatus*, while *T. indicus* forms minor part of fishery along the east coast. Neighbour-joining and maximum likelihood analysis based on combined 1804 mt DNA characters recovered the most resolved phylogeny with >85% bootstrap support for associations among species and supported independent monophyly of Palinurid and Scyllarid lobsters. The K_2P pair-wise genetic distance value showed the maximum range with 12SrRNA (5.6-44.01%) while 18SrRNA showed minimum values (0.4-8.71%) among species. The results also support the phylogenetic hypothesis of Achelata and evolution hypothesis within family Palinuridae.

GB-O 05

Isolation and characterization of antioxidant compounds from *Acanthophora spicifera* and *Padina gymnospora* collected from Gulf of Mannar

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The methanolic extract and different solvent fractions obtained from seaweeds *Acanthophora spicifera* (Rhodophyta) and *Padina gymnospora* (Pheophyta) from Gulf of Mannar of southeastern coast of Indian subcontinent were

evaluated for antioxidant activities and total phenolic contents. A higher level of phenolic content was observed with the fractions of *A. spicifera* especially for ethyl acetate fraction (119.28 GE/g) than that of *P. gymnospora*. Ethyl acetate extract of *A. spicifera* registered significantly higher ($p < 0.05$) activities with respect to ABTS.⁺ radical scavenging (37.8%), Fe²⁺ chelating (61.58%), and reducing abilities (Ab_{700nm} 1.46) than *P. gymnospora*. The ability of ethyl acetate fraction of *A. spicifera* to inhibit the formation of TBARS and to scavenge OH radical were significantly higher (4.21 MDEC/kg and 66.6%, respectively) than that of *P. gymnospora*. Bioassay guided purification of the fractions from *A. spicifera* led to the isolation of propyl 4-acetyl-2-(dimethyl-2-hexenyl) benzoate that was found to be highly effective (51.35%, IC₅₀ 0.55 mg/mL) followed by 3-acetyl-dihydroxy-dioxohexahydrobenzofuranyl hydroxy-3-oxobutanoate (32.20%, IC₅₀ 0.66 mg/mL) towards DPPH radical scavenging activity. Dichloromethane fraction of *P. gymnospora* yielded methylallyl oxoocta-dienoate (IC₅₀ 0.37 mg/mL) and was found to be effective to scavenge DPPH free radical. The present study provides valuable information regarding the potential of these seaweeds, especially *A. spicifera*, as natural sources of antioxidants for food supplements, for increasing the shelf-life of food industry, as nutraceuticals and/or functional foods and combating carcinogenesis and inflammatory diseases.

GB-O 06

Mitochondrial DNA variation in peninsular riverine population of Indian carps

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GB-O 07

As part of a network program on fish genetic stocks, natural populations of Indian carps viz. *Labeo rohita*, *Cirrhinus mrigala* and *Labeo fimbriatus* were studied for genetic variation using three mitochondrial genes. In total, 270 individuals collected from three peninsular riverine systems of India were analyzed with respect to mitochondrial DNA variation in 614 bp of ATPase-6, 288 bp of Cytochrome b (Cyb) and 692 bp of Control region (CR) genes. *Labeo rohita* collected from three riverine sources exhibited eight haplotypes in total (two unique haplotypes from Mahanadi, one from Godavari and three from Krishna) with respect to Cyb gene, seven haplotypes (one unique each from Mahanadi and Godavari, four from Krishna) in ATPase-6 and 42 haplotypes (7 unique haplotypes from Mahanadi; 11 from Godavari and 16 from Krishna) in Control region. Similarly, *Cirrhinus mrigala* had eight Cyb haplotypes (two unique from Mahanadi and four from Krishna), 10 ATPase-6 haplotypes (no unique haplotype found from Mahanadi, one from Godavari, four from Krishna) and 45 CR haplotypes (16 unique haplotypes from Mahanadi, nine from Godavari and 16 from Krishna). *Labeo fimbriatus* had eight cytb haplotypes (three unique haplotypes from Mahanadi, four from Krishna and one from Kaveri), seven ATPase-6 haplotypes (two unique haplotypes from Mahanadi, three from Krishna and one from Kaveri) and 16 CR haplotypes (eight unique haplotypes from Mahanadi, two from Krishna and five from Kaveri). Rohu and mrigal exhibited haplotype sharing between populations where as *L. fimbriatus* showed population specific haplotypes with respect to Cytochrome b gene. Molecular diversity indices of each species with reference to three gene haplotypes indicated that haplotype number and diversity are more in mitochondrial control region compared to that of ATPase-6 and Cytochrome b region. Findings of this investigation would help in furthering research on phylogeographic distribution of Indian carps in peninsular region.

Molecular taxonomy of diatoms isolated from the coastal plains of India using 18S rDNA and COX1 genes

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Diatoms, a widely distributed group of photosynthesizing microscopic algae, are unicellular but commonly appear as chains of diverse morphology. Identification of diatom by morphological method is very difficult due to the limited morphological differentiation and also due to the variation of morphological characters with different culture conditions. Most recently, the applications of molecular taxonomy on diatoms has revealed more variations and play an important role in the discovery and delimitation of diatom species. Present study mainly focused on the application of molecular methods, combined with morphology, for the identification of diatom isolated from the coastal regions of India and cultured under laboratory conditions.

Water samples were collected from the coastal plains of India, and diatoms were isolated and maintained as monoculture in f/2 medium under laboratory conditions. Morphological characters such as shape and size of the cell, length and arrangement of the setae, number and arrangement of external processes etc. were analyzed with a phase contrast microscope. Molecular identification was done by sequencing and analysing 18SrDNA and COX1 gene with diatom specific primers. A total of 30 pure strains were identified up to genus level by morphology followed by molecular taxonomy. These isolates were consisting of centric and pinnate diatom with nine genera belonging to five different families. The common diatoms identified were coming under the genera *Chaetoceros*, *Thalassiosira*, *Coscinodiscus*, *Skeletonema*, *Cyclotella*, *Phaeodactylum*,



Navicula, *Nitzschia* and *Cylindrotheca*. The study revealed the use of molecular taxonomy approach in the identification of marine diatoms at the genus level. However, a better DNA barcode for the species level identification of diatom is essential for overcoming the existing barrier in the diatom taxonomy.

GB-O 08

Muscle proteome of the Indian major carp, *Catla catla*

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The Indian Major Carps catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) are the major cultured species in India and contribute significantly to aquaculture production in the country. Omics science, i.e. genomics, transcriptomics and proteomics is being increasingly employed in biology for analyzing the molecular blue prints of different species of organisms for harnessing the benefits through application of biotechnology. However, this is yet to find the desired application in Indian fisheries and aquaculture sector and therefore, little information is available on the genomic and proteomic aspects of any fish species in India. Technical advances in high-throughput screening of peptides by mass spectrometry have established new ways of identifying entire cellular proteins in one swift analytical approach. Muscle is the major edible tissue and constitutes the major biomass in fish body. In many species of fish, muscle tissues provide a natural model system to study the molecular changes resulting from remodeling of tissues. The present study was undertaken to generate complete proteomic information on the muscle proteome of *Catla catla*. We generated the muscle proteome of IMC *Catla catla* and have, thus far, identified about 75% of the proteins using a combination of proteomic tools like 2-D GE, immunoblotting, MALDI-TOF-MS and LC-MS-MS. The protein

spots identified include glyceraldehyde-3-phosphate dehydrogenase, creatine kinase M1, creatine kinase M2, phosphoglycerate kinase, phosphoglucomutase, apolipoprotein, enolase, aldolase A, β -actin, glutamic-oxaloacetic transaminase, pyruvate kinase, α -1 antitrypsin, phosphorylase, triosephosphate isomerase, lactate dehydrogenase, transferrin variant F, zgc protein, novel protein similar to vertebrae desmoplakin (DSP), Novel protein similar to vertebrae Rho guanine nucleotide exchange. This is the first such information for any major aquaculture species in India and thus, would provide the base line information for stimulating further research on proteogenomics of Indian major carps and other fish species for better fish health and disease management.

GB-O 09

Investigation on the hematological and biochemical parameters in the female black king fish cobia, *Rachycentron canadum* at different maturity stages

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Black king fish cobia (*Rachycentron canadum*) is a potential candidate fish for farming in the coastal waters in cages owing to its fastest growth rate and better market demand. Efforts are underway to develop comprehensive technology for breeding and seed production of cobia. In the present investigation an attempt was made to understand some of the biochemical and hematological parameters in different stages of maturity in the female cobia fish. Blood samples were collected from cobia caught from the wild at different maturity stages and the hematological parameters such as hemoglobin content, Total Erythrocyte Counts (TEC), Total Leucocytes Count (TLC) and hematocrit value; biochemical parameters such as blood glucose, serum, protein, cholesterol and triglycerides were analyzed. The



hemoglobin level was found to be 15.7 ± 0.15 g/dl in immature female, 14.57 ± 0.92 g/dl in matured female and 11.63 ± 0.12 g/dl in spent fish. The hematocrit value also show similar trend with 46.6 ± 1.15 , 45.34 ± 3.45 and 34.67 ± 0.58 in immature, mature and spent one respectively. The total RBC count was 5.40 ± 0.1 ml/cm³ in immature, 5.2 ± 0.24 ml/cm³ in mature and 3.83 ± 0.12 ml/cm³ in spent fish. The WBC count also showed a similar trend of 16.30 ± 0.1 cells/mm³, 15.83 ± 0.34 cells/mm³ and 11.57 ± 0.12 cells/mm³ in immature, mature and spent fishes respectively. No significant change was observed in the blood glucose level in all the stages of maturity. The serum cholesterol level was significantly higher in immature fish (291.67 ± 1.00 mg/dl) than matured (204.0 ± 0.89 mg/dl) and spent fish (203.67 ± 1.0 mg/dl). The results of the present investigations indicated higher metabolic activity in immature fishes than matured and spent fishes and also indicated gradual mobilization of vital blood parameters during the process of maturation and subsequent reduction in the spent stage.

GB-O 10

Biochemical responses of algal genera exposed to metallic gold solution with special reference to biosynthesis of gold nanoparticles

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Nanogold is a hot issue at present as it finds various applications especially in the field of medicine and cosmetics. Aqua-resource especially algae has a huge potential for synthesizing such particles. Intracellular bioconversion of auric ion (Au³⁺) to gold nanorod (Au⁰) by the algal filament of *Lyngbya majuscula* has been observed in laboratory condition. The gold nanoparticles were produced within the cell after exposing the

healthy growing filaments to 15 mg l^{-1} gold (III) solution (pH 4.5) for 48 h at 20°C. The algal biomass turned purple within 48 hours of incubation indicating intracellular reduction of Au (III) to Au (0) and subsequent formation of gold nanoparticles. The gold nanoparticles were extracted with sodium citrate solution and were subjected to UV-Visible spectroscopy. The characteristic surface-multiple plasmon bands at 529 and 680 nm were observed. Change of the position of absorption peak (red-shift) was observed with increasing particle diameter ($\lambda_{\text{max}} = 517, 521, 533, \text{ and } 575 \text{ nm}$ for the 9, 22, 48, and 99 nm particles). The size of gold crystals was observed after a long exposure of 7 days by SEM study. The nature and size of the particles were determined by transmission electron microscopy (TEM). TEM studies confirmed the presence of nanoparticles of varying sizes (5-60 nm) which were of hexagonal in shape. Furthermore, it was observed that the cell-free extract of the algae was also capable of reducing aqueous chloroaurate ions to produce gold nanoparticles as it becomes purple in color after one week. The formation of the AuNP was further investigated by UV-vis spectroscopy and the plasmon resonance band appeared at about 530 nm characteristic of colloidal gold.

Estimation of primary and secondary metabolites from metal exposed that biomass is a common practice to determine the growth performance in metal stress condition. *L. majuscula* showed gradual decrease in chlorophyll content after 48 hrs of exposure. Total protein content in metal exposed cell indicates the metabolic status of the cell in stress condition. Algal enzyme systems take active part in metal detoxification process. In this study, *L. majuscula* showed a gradual increase in lipid peroxidation during 3-24 hours exposures followed by a decrease. Catalase activity was observed to increase till 24 hours but at 48 hours enzyme activity becomes nil. Au treatment decreased cellular glutathione content in *L. majuscula* cells. The amount of proline increased gradually in treated *L. majuscula*



indicating metal stress. *Anabaena*, *Nostoc* and *Phormidium* also showed a good result in nanogold formation in our laboratory and their enzymatic activity will be studied.

GB-O 11

Molecular taxonomy of bacterial groups associated with the marine sponge *Halichondria nigrocutis* from the west coast of India

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Sponges are associated with a large number of bacterial species embedded within their matrix. Cultivation and cultivation-independent techniques were employed to provide insights into the microbial diversity associated with the marine sponge, *Halichondria nigrocutis* collected from the west coast of India. In the present study, bacteria belonging to *Bacillus* sp., *Acinetobacter* sp. and *Vibrio* sp. were recorded as prominent isolates by cultivation method. These isolates were also confirmed by amplifying and sequencing 16SrDNA genes and grouped under the groups of *Firmicutes* and *Proteobacteria*. The phylogenetic affiliation of sponge-associated bacteria was also assessed by cultivation independent approach by cloning and sequencing 16SrDNA gene. The community structure of *Halichondria nigrocutis* was found to be extremely diverse with representatives of the *Alpha-proteobacteria*, *Gamma-proteobacteria*, *Delta-proteobacteria*, *Cyanobacteria*, *Actinobacteria* and *Firmicutes*. The sponge associated bacterial isolate TSNC63 belonging to *Bacillus* sp. displayed remarkable antimicrobial activity. SDS-PAGE of the bacterial supernatant and ammonium sulphate precipitate displayed the protein profile of the isolate TSNC63. This is the first report on

phylogenetic identification of cultured and uncultured bacteria associated with the sponge and also the phylogenetic identification of secondary metabolites producing bacteria associated with sponge from Indian waters.

GB-O 12

Therapeutic role of recombinant *Penaeus monodon* antiviral (rPmAV) protein against WSSV in *Penaeus monodon*

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PmAV is the first antiviral gene identified from *Penaeus monodon*. Although, the antiviral mechanism of PmAV protein has been well established, no studies were conducted to evaluate its efficacy as a therapeutic molecule. Therefore, the present study was performed to evaluate the therapeutic role of rPmAV in combating WSSV in *P. monodon*. The therapeutic efficacy of rPmAV was tested in three different forms viz., purified rPmAV protein expressed in a fish cell line, naked plasmid DNA construct constitutively expressing rPmAV (pcDNA-His-PmAV) and rPmAV expressing plasmid DNA encapsulated with chitosan nanoparticles. Survival analysis was carried out using Kaplan Meier analysis (SPSS V.16). The challenge studies showed that pcDNA-His-PmAV, Chitosan-pcDNA-His-PmAV nanoparticles and rPmAV protein (23.5 kD) injected intramuscularly into *P. monodon* gave survival rates of 27.8%, 83.3% and 66.7%, respectively on fifteenth day post WSSV challenge. The purified rPmAV protein gave high survival rate during the initial experimental period followed by a sudden decline owing to its shorter shelf life. On the other hand, chitosan conjugated pDNA construct gave superior protection of 83.3% amongst all the treatments due to its high stability. Thus, it can be concluded that the rPmAV can be used as an effective therapeutic



agent against WSSV in *P. monodon* provided the economically viable delivery strategies are developed.

GB-O 13

Correlated response in PUFA profile of *Artemia franciscana* from the Indian salinas following quantitative genetic manipulation for nauplii size reduction

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The present study evaluates the correlated selection response in nutrient profile of *Artemia franciscana* from the Indian salinas following selective breeding for nauplii size reduction. Thirteen generations of selection was carried out in a strain of *Artemia franciscana* collected from an Indian salina. The primary trait under selection was naupliar length and a criterion of selection was small size. While 12.4 per cent reduction was realized in the trait under selection from 13 generations (from $517.0 \pm 39.8 \mu\text{m}$ to $452.2 \pm 25.0 \mu\text{m}$), substantial increase in the PUFA content was realized as correlated response. The polyunsaturated fatty acids (PUFA) content showed a steady increase during the selection viz., the PUFA percentage in G2, G4, G6, G9, G11 and G13 generations were 21.43, 27.96, 27.19, 33.27, 36.98 and 37.25 respectively compared to 18.04% in the base generation. The content of essential polyunsaturated fatty acids such as 20:5n-3 and 22:6n-3 were high in the selected generations indicative of their nutritional superiority when compared to the base generation. The smaller nauplii with an enhanced level of PUFA, especially the essential polyunsaturated fatty acids in strain developed from selective breeding in the present work make it a promising live feed for the larviculture of marine species. Field trials are required to validate the performance of the strain.

GB-O 14

Controlled breeding of black king fish cobia, *Rachycentron canadum* using pond reared broodstock

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Black kingfish, cobia, (*Rachycentron canadum*) is identified as one of the most promising candidate species for cage farming in India. Owing to faster growth rate and better market demand, development of seed production technology is identified as one of the priority area and limited success has been achieved in Central Marine Fisheries Research Institute and Rajiv Gandhi Centre for Aquaculture using broodstock maintained in open sea net cages. At Central Institute of Brackishwater Aquaculture, land based captive stock of Cobia have been raised in earthen pond and RCC tanks. Wild caught fishes (2-20 kg in size) were procured and transported to the holding facility. After quarantine and acclimatization, they were stocked in the holding facility @1kg/m³ and fed with forage fishes like sardine and tilapia @5% of the body weight once a day. Daily Water exchange of 50-70% with seawater brought from inter tidal bore well was carried out. Water quality parameters were monitored regularly. The water temperature ranged between 25 and 32 °C; D.O. varied between 3.8-5.4 ppm; Ammonia from BDL to 0.8 ppm and pH was recorded in the range of 7.6-8.4. Broodstock which were maintained from February 2010 showed gonadal maturity from the month of March 2011. The female fishes with ova diameter above 680 μm were selected for induction of spawning through exogenous hormonal administration. HCG hormone @300-350 IU/kg body weight for females and half the dose for males was administered intramuscularly. Fishes spawned spontaneously after 28-36 hours of hormone administration. Successful fertilization was achieved in three cases



out of eight spawning cases and subsequent hatching and rearing was recorded in two cases. The captive maturation of pond broodstock has opened a new horizon in simplifying hatchery operation protocol of cobia seed production.

GB-O 15

Effect of nanopheromones in reproductive performance of *Clarias batrachus*

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Pheromones are compounds secreted by one member of an animal species which can influence the behavior or development of another member of the same species. It carries chemical signals between members of the same species for communication and has a great potential to be useful in fish reproduction. As pheromones are species-specific and are used only in small quantities, their use is more environmentally acceptable. These pheromones can be used for inducing fish breeding. But for using these pheromones which is available in minute amount, it needs to be encapsulated for enhancement in amount and longer effective life. Micro encapsulation has mean particle size of 1-5 microns with the drawback of sinking to the bottom to form a coagulum. Nano encapsulation or nano conjugation is the effective alternate for encapsulating small amount of pheromones. Though several advantages that make nano-scale particles useful in aquaculture and other fields, there are no reports on application of nano conjugated pheromones for fish breeding. Therefore, the present study was initiated to understand the role of nanopheromones in fish breeding for which understanding of the physiological change or hormonal change is important. The study describes the effect of nanopheromone in increasing the level of FSH and LH in *Clarias batrachus*. Nanoparticles of chitosan were developed and characterized using particle size

analyzer. Chitosan nanoparticles were conjugated with two fish pheromones viz. 17 α 20 β dihydroxy-4-pregnen-3-one (17 α 20 β) and Prostaglandin F 2. The chitosan conjugated pheromones were analyzed and characterized using particle sizes analyzer. These nanoconjugated pheromones were administered to female species of *C. batrachus* and the level of FSH and LH were analyzed using commercially available ELISA kit at 3 hrs, 7 hrs and 24 hrs after the injection. The result showed that even after 24 hours of administering nanopheromones, there was increase in the level of FSH and LH; where as the ovaprim injected fishes showed declining level of FSH and LH after 7 hours. This preliminary study indicates the possibility of using nano conjugated pheromone for reproduction of *Clarias batrachus*.

GB-O 16

Antagonistic properties of marine *Vibrio* sp. isolated from a solitary ascidian, *Microcosmus exasperatus*

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Marine ascidians are known to produce bioactive compounds and the bacteria associated with them are often reported to be involved in their biosynthesis or the true sources of those metabolites. The antibacterial activities of the bacteria associated with *Microcosmus exasperatus*, a solitary ascidian and that of the ascidian alone were evaluated.

Ninety five isolates of heterotrophic bacteria were purified and characterized to the generic level, of which 17 (17.9%) showed antagonistic property against highly susceptible indicator bacteria. However, only three isolates, two belonging to the genus *Bacillus* and one



belonging to *Vibrio* exhibited antagonism against human and shrimp pathogenic bacteria. *Vibrio* sp. was characterized as *Vibrio alginolyticus* (16s rRNA sequence showed >96% similarity) and showed marked inhibition against *Pseudomonas aeruginosa* (MTCC 27853) and *Vibrio harveyi* (Shrimp larval isolate) by cross streaking assay and also against *E.coli* (MTCC 443), *Salmonella Typhi* (clinical isolate) and *Vibrio cholerae* (clinical isolate) by well-diffusion assay. Although the crude extract of extracellular products (ECP) prepared by ammonium sulphate precipitation did not show any marked inhibition; the ethyl acetate extracts of both cells and spent media exhibited a remarkable inhibitory activity against all the tested pathogenic bacteria. However, the crude ethyl acetate extracts of the ascidian showed inhibition only against *Salmonella typhi* and *Pseudomonas aeruginosa* and the effect was very poor when compared to the activity exhibited by the *Vibrio* sp. Although, no direct relationship could be arrived at on the antagonistic property of the ascidian with that of the associated bacteria, the antagonistic *Vibrio* sp could be used for bio control of pathogenic bacteria.

GB-O 17

Primers to amplify ATPase6/8 region of mtDNA in *Macrobrachium rosenbergii* stocks from west of the Huxley's Line

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Macrobrachium rosenbergii is one of the commercially important and widely cultured freshwater crustaceans across the world. The species is distributed from Pakistan to Vietnam along west of Huxley's Line. Natural genetic resources form the basis for selection of founder stocks for stock improvement programmes and for this, information on population history and distribution of genetic

diversity within and among populations through genetically controlled markers is essential. Mitochondrial DNA is extensively used for molecular identification and population genetic studies in fishes. Depending on whether mitotyping is used for species identification or population characterisation, different genomic regions are used, since the mutation rate of mitochondrial genes or regions is highly variable and dependent on genomic location. Rapidly evolving sequences of the mitochondrial genome like the ATPase6/8 are useful for high-resolution analyses of population structure. However, universal primer pairs are not available for amplification of ATPase regions in crustaceans and even the primers from closely related *Macrobrachium australiense* were not effective in amplifying the same region in *Macrobrachium rosenbergii* stocks from west of the Huxley's Line.

In the present study, primers for ATPase (ATPase 8 and 6) region were designed based on the complete mtDNA sequence of *Macrobrachium rosenbergii* available on NCBI (Accession no: NC 006880) using online software Primer3 (v. 0.4.0). The oligonucleotide primers of 20-22 bp in length and having a GC content of 45 to 60% were designed and PCR conditions standardized. Full length of ATPase gene (including ATPase6 and ATPase 8; 827bp) sequences were generated for *Macrobrachium rosenbergii* stocks from west of Huxley's Line, using the above primers and therefore these are useful in population studies of this species.

GB-O 18

Development of polymorphic EST-SSR markers in *Macrobrachium rosenbergii* by data mining

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Expressed sequence tags (EST) provide a valuable and cost effective source of



developing simple sequence repeat (SSR) markers. In the present study, microsatellite markers were developed for *M. rosenbergii* through data mining of EST databases. A total of 3,256 ESTs of *M. nipponense* and 2,151 ESTs of *M. rosenbergii* were downloaded from the GenBank. Clustering of the EST sequences with web based software CAP3, a total of 4921 unigenes were found in both the species. Ninety-nine sequences (3%) of *M. nipponense* were found to contain repeat motifs out of which 64 loci had sufficient flanking region for designing primers. Fifteen loci (23.4%) produced unambiguous PCR products when cross amplified in *M. rosenbergii* and only one locus showed polymorphism. Similarly, out of 129 (5.9%) SSR positive sequences of *M. rosenbergii*, 109 loci were good for primer designing. Ninety four loci (86.2%) were successfully PCR amplified out of which, 20 showed polymorphism. These results indicated that data mining of EST sequences is an effective and feasible approach to develop microsatellite markers in *M. rosenbergii*.

GB-O 19

Gonad Inhibiting Hormone (GIH) of giant tiger shrimp, *Penaeus monodon*: preliminary characterization and expression profile of GIH transcript during ovarian maturation

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Farming of giant tiger shrimp is one of the most important and relatively recent coastal food production industries in India. Although great strides have been made in the zoo techniques for the shrimp husbandry in grow out system, management of reproduction in the captivity has not kept pace. Although several hormones are involved in the crustacean

reproduction, the inhibitory effect of GIH is thought to be more intense than any other hormones. As an essential component of understanding the reproduction of *P. monodon*, characterization of the expression pattern of GIH in the sinus gland in relation to the female gametogenic cycle was carried out. A 633 bp sequence was cloned from the eyestalk of *P. monodon*. The sequence comprises an open reading frame (ORF) of 291 bp that encodes a protein of 96 amino acids. The deduced protein was used to search the Genbank database using BlastP. Protein alignment with all known crustacean GIH revealed that homology of *P. monodon* GIH shares 61, 48, 46, 46 and 35 percent identity with *Metapenaeus ensis*, *Nephrops norvegicus*, *Homarus americanus*, *Rimicaris sp.*, and *Armadillidium vulgare* respectively. The RT PCR analysis showed that GIH mRNA is expressed mainly in the eyestalk of female. The expression of GIH in the eyestalk of males was reported for the first time. Expression profile of GIH during different reproductive cycle *P. monodon* female was characterized in four major stages of maturation using light/electron microscopy and morphological characteristics. GIH from eyestalk was expressed in all stages of maturation, although the expression of GIH mRNA changes during the different stages of vitellogenesis. In animals with immature ovary, the quantity of GIH was found to be less and the quantity was peaked in previtellogenic phase and diminished in subsequent phases. Low GIH level during the immature (oogonial) phase is particularly intriguing and has application in the commercial aquaculture to select the brooders.

GB-O 20

Effect of aromatase inhibitors on sex differentiation in common carp, *Cyprinus carpio* (L)

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Common carp *Cyprinus carpio* is an important food fish being cultured throughout the world and its production is the most important freshwater aquaculture domain. Aromatase enzyme (arom P450) being synthesized in ovary or in brain (cyp 19) has been shown to play a pivotal role in sex differentiation. Sex control for aquaculture and research purposes have been attempted in many species including common carp, tilapia, *Tor putitora* and *Clarias gariepinus*. Our earlier study has demonstrated possible involvement of pineal melatonin in ovarian development and function. Therefore, present study was specifically designed to find out *in vivo* production of melatonin during manipulation of the sex in common carp using aromatase inhibitors (fadrozole and anastrozole, Sigma Chem Co., USA). Effect of fadrozole and anastrozole on the specific-growth rate (SGR%^{day}), gonado-somatic-index (GSI), sex-differentiation (morphological and histological studies of ovary and testes), gonadal and serum protein and lipid, endogenous production of serum as well as gonadal 17 α oestradiol (E₂) and testosterone (T) levels were studied in sexually undifferentiated *Cyprinus carpio*. The treatment of common carp with fadrozole and anastrozole suppressed the 17- α oestradiol (E₂) production whereas testosterone level was elevated significantly (P<0.05). The level of plasma melatonin was also estimated in the aromatase exposed common carp using ELISA technique and was found that changes in the gonadal steroidal levels modulated the pineal melatonin secretion *in vivo*. It is concluded that pineal melatonin is involved in the process of sex differentiation in common carp and the biosynthesis of aromatase is influenced by pineal secretory activity.

GB-O 21

Captive breeding and embryonic development of threatened snakehead, *Channa gachua* (Hamilton, 1822)

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Channa gachua (Hamilton–Buchanan) has witnessed a drastic decline due anthropogenic stress and is listed under vulnerable (VU) category. Captive breeding was undertaken in *C. gachua* collected from wild by injecting three different intramuscular doses (1000IU, 2000IU and 3000IU/kg body weight) of Human Chorionic Gonadotropin (HCG). Distinct spawning behaviour was noticed in the brooders injected with the hormone. Total number of eggs spawned was estimated as 2740 and the fertilized eggs were spherical in shape (1.16mm \pm 0.05 mm), floating and pale yellow in colour. Fertilization rate varied from 62% - 70%. The eggs hatched out between 24 – 36h after fertilization and about 1,420 hatchlings were produced from one set. Newly hatched larvae measured 4.23mm \pm 0.03 mm length and 0.037g \pm 0.008 g in weight and the mean diameter of yolk sac was 1.1 \pm 0.08 mm. Yolk sac was absorbed after three days and the percentage survival of hatchlings varied from 40% - 56 %. Preflexion larvae showed a large head with a conspicuous occipital melanophore and terminal mouth. The head, oil globule and the yolk sac together appeared as a bulb like structure. Melanophores were scattered on the yolk and a few were present on the unpaired fin. The length of the young one at flexion stage was 6.2-7.1 mm from day 8-14 (n = 29). Caudal fin began to separate; faint pigmentation of eyes was noticed, alimentary tract was distinct and pectoral fin bud appeared. During Post flexion stage the length of the larvae was 7.1-14.0 mm from day 14-30. The development of pectoral and pelvic fins was completed on day 26 (11.3mm), whereas caudal fin completed its development on day 16 (7.2mm). The number of rays in pectoral, caudal and pelvic fins were 14, 13-15 and 6-7 respectively.



GB-O 22**Population genetic structure analysis using protein and DNA markers in the fish *Labeo gonius* from Nanaksagar Reservoir of Uttarakhand**

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The present study was carried out to explore the population genetic structure of the fish, *Labeo gonius* (Kursa) in Nanaksagar Reservoir of Uttarakhand by applying protein and DNA markers. This fish contributes significantly to commercial catches from the reservoir through self recruitment without stock supplementation from outside. The study of genetic diversity of this fish was undertaken with the objective for developing efficient management and conservation plans for sustained fishery of this species in the reservoirs of the state. Allozyme and Random Amplified Polymorphic DNA (RAPD) markers have been used for genetic characterization of this species. The allozyme analysis was conducted for 18 enzymes but only 10 enzymes showed their presence with scorable activity that are aldehyde oxidase, esterase, glucose 6-phosphate dehydrogenase, glucose phosphate isomerase, lactate dehydrogenase, malate dehydrogenase, malic enzyme, phosphoglucumutase, superoxide dismutase and xanthine dehydrogenase. All 10 allozymes yielded overall 19 scorable loci, out of which 11 loci were found to be polymorphic in the population. The percent of polymorphic loci for overall population was 57.89 %. The observed heterozygosity ranged from 0.49 to 0.53 and expected heterozygosity for the same population was from 0.51 to 0.56.

For RAPD study, DNA was isolated from fin tissue by using SDS-phenol / chloroform method. Eighty decamer (20 from each series of OPA, OPB, OPC and OPY; Operon Technologies, Alameda, USA) were used out of which, only 15 primers i.e. OPA-01, OPA-05, OPA-13, OPA-14, OPA-15, OPC-07, OPC-08, OPC-11, OPC-15, OPC-18, OPY-

05, OPY-13, OPY-14, OPY-15 and OPY-20 were selected for the present study on the basis of repeatability, sharpness and intensity of the bands. The PCR was carried out following RAPD protocols and the RAPD profile was computed by using the software POPGENE Version 1.31. Total 3829 amplified DNA fragments were detected consistently with 15 Operon primers, out of which 3329 fragments were polymorphic (86.94%). Other genetic diversity parameters i.e. Nei's genetic diversity ($H=0.3980$) and Shannon's information index ($I=0.5727$) revealed considerable heterozygosity in the population. Thus population genetic data generated for *L. gonius* is indicative of a high level of polymorphism and heterozygosity for Nanaksagar Reservoir.

GB-O 23**Growth performance of new strain of common carp under polyculture in Karnataka**

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Trials were conducted to evaluate growth performance of new strain of common carp-Amur. This particular strain was identified as genetically superior compared to the existing common carp stocks available in the country. The performance of Amur and existing stock of common carp (Big bellied) was evaluated under polyculture across Karnataka representing different agro-climatic zones. The present study covered five districts representing central dry, transition and coastal regions of Karnataka and trials were conducted in nine locations. All the trials were undertaken in farmer ponds ranging the size from 600 – 5000m² over a period of 7-8 months. Polyculture comprised of common carp (Amur and locally existing strains in equal numbers), catla, grass carp and silver carp in the ratio of 4:4:1:1 with a stocking density of 5000 fingerlings/hectare. Results indicated that



Amur and local strain of common carp attained mean body weight of 583.03 ± 18.36 g and $484.60 \text{ g} \pm 19.69$, respectively. The specific growth rate (% day⁻¹) of Amur was higher (2.64) than the local strain (2.59). The mean body weight of Amur at harvest was significantly higher than that of local strain ($p < 0.05$) and registered 20.31% faster growth over existing strain. There was no significant difference in the survival rates of two strains. The Amur strain consistently showed better growth performance over existing strain in all the locations. Thus, the Amur strain of common carp has greater practical significance in low-input aquaculture systems due to its better growth rate than the existing strain.

GB-O 24

Mining of salt tolerant genes from *Dunaliella salina* under hyper saline stress

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Dunaliella (Chlorophyceae, Volvocales) is one of the most studied unicellular microalgae in both general and applied biology for its higher tolerance level to extreme conditions of salinity, light intensity, temperature and pH as well as for their richness in natural carotenoids, glycerol, biofuel and many other bioactive compounds. This genus naturally inhabits saline and hyper saline waters and has a cosmopolitan distribution. *Dunaliella salina* is reported as the most halotolerant photosynthetic eukaryote with a remarkable degree of halotolerance ranging from 0.5 M – 5.0 M (ca. 30-300 ppt) salt concentration.

In the present study, an isolate of *D. salina* from the salt pans at Kelambakkam, Tamil Nadu was acclimatized to laboratory conditions and cultured in F/2 media with 1.5 M NaCl concentration. Salinity stress was given to the exponentially growing *Dunaliella* culture by increasing the salt

concentration to 3 M by adding NaCl. Poly A⁺ mRNA purified from the tester and driver cultures after 12 hrs was used for developing the cDNA library of differentially expressed genes under salinity stress by performing suppression subtractive hybridization (SSH). A total of 1440 clones were picked, out of which 300 were sequenced and analyzed using bioinformatics tools available online. Sequence homology analysis showed similarity with genes such as fructose-1,6-bisphosphatase (FBP), glyceraldehyde 3-phosphate dehydrogenase (GAPDH), 2-oxoglutarate-dependent dioxygenase (AOP), aspartic protease, 60S ribosomal protein and some hypothetical proteins; but few clones showed no significant similarity. The results showed that the library represented salt responsive genes for metabolic enzymes with a few clones containing hypothetical/ unknown genes that differentially expressed under salt stress; and a few genes had miscellaneous functions. Further characterization and validation of potential halotolerant genes would be useful in the development of transgenic crop plants and animals capable of survival under elevated saline conditions.

GB-O 25

Level of protein, carbohydrate and lipid in the body wall of *Holothuria spinifera* Theel with respect to reproductive stages

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Holothurians are exploited commercially for the raw body-wall or viscera, but mostly for processed dry product called 'beche-de-mer', which is an important item of trade among the developing countries in the Indo-Pacific region. The edible part of the sea cucumber is the loose connective tissue unlike the muscular tissue of vertebrates. From the nutritional point of view, sea cucumber is an ideal tonic, high in protein and low in fat. It also contains essential amino acids and trace elements. Recent studies indicate their greater



importance in biomedical research as a rich source of a polysaccharide - 'chondroitin sulfate'. The body wall of commercial sea cucumber *Holothuria spinifera* in each reproductive stage was pooled for biochemical analysis, after drying in hot air oven at 80 °C for 48 hours. The protein, total carbohydrate and total lipid content were estimated by standard procedures. The mean values of protein, carbohydrate and lipid content in the body wall of *H. spinifera* were 17.8%, 2.8% and 1.3% respectively. The highest concentration of these organic constituents was observed during the maturing stages and their decline during the post-spawning periods indicated their role as the source of energy during gametogenesis. The one-way ANOVA on the differences in the mean protein, carbohydrate and lipid content in the body wall with respect to reproductive stages indicated high level of significance ($P < 0.001$).

GB-O 26

Comparative evaluation of the biochemical characteristics of milt from the land based captive broodstock of black kingfish cobia, *Rachycentron canadum* and Asian seabass, *Lates calcarifer*

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Land based broodstock of cobia (*Rachycentron canadum*) and Asian seabass (*Lates calcarifer*) were maintained in pond/tank system under controlled conditions. Fishes were fed with forage fishes (oil sardine, Tilapia) @ 5% of body weight once a day. The broodstock was monitored regularly to understand the maturity of the captive males. The milt was collected and the parameters (spermatozoa concentration, sperm motility, spermatocrit values with seminal plasma indices, albumin,

protein, glucose, urea, creatinine, uric acid, cholesterol, triglycerides, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cl⁻, aspartate amino transferase, alanine amino transferase, pH, osmolality, sperm motility, duration of the motility and milt volume) were recorded. The sperm concentration in seabass was $31.17 \pm 6.4 \times 10^6 \text{ ml}^{-1}$ and it was $24.33 \pm 7.07 \times 10^6 \text{ ml}^{-1}$ in case of cobia. The major organic substance; glucose concentration was 35.33 ± 1.21 and $27.18 \pm 1.25 \text{ mg.l}^{-1}$ and albumin content was very low with the mean value of 0.40 ± 0.06 and $0.88 \pm 0.4 \text{ mg.l}^{-1}$ in cobia and seabass species respectively. The inorganic ion concentration was moderately higher in seabass milt compared to that of cobia and correlated with sperm motility, duration of the motility and milt volume. The result of the present study suggests that the rate of fertilization may be higher in seabass compared to that of cobia.

GB-O 27

Isolation and characterization of anti-inflammatory principles from green mussel *Perna viridis*

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Inflammation is a process involved in the pathogenesis of several disorders viz., arthritis and cardiovascular disease. Traditional drug treatments for relieving the pain and swelling of inflammation include cyclooxygenase-1 (cox-1) non-steroidal anti-inflammatory drugs (NSAIDs) used to reduce the untoward consequences of inflammation. The green mussel, *Perna viridis*, a bivalve mollusc, forms a part of fishery in south west coast of India, and there is a tradition of consuming mussel meat as a remedy for arthritis among indigenous people. Considering the adverse effects of synthetic NSAIDs, the present work was envisaged to isolate anti-inflammatory principles from *P. viridis* for use against inflammatory disorders. A group of anti-inflammatory principles were isolated/



characterized and their bioactivities investigated by *in vitro* and animal model studies to determine their inhibitory potencies. An active fraction (GMAI₁₁) purified from the mussel extract was found to contribute a major share of *P. viridis* bioactive components. GMAI₁₁ realized higher inhibition COX₁ (>54%), than aspirin (52%) and indomethacin (46%) indicating its efficiency over NSAIDs. In the animal model study, the carrageenan administered animals experienced severe swelling at 5th h, and the swelling was maintained until 6th h. Animals challenged with GMAI₁₁ significantly mitigated the carrageenan-induced inflammation in rats till 6th h. GMAI₁₁ showed 66% (250 mg/kg) inhibition during the 4th h reaching 79% after the 6th h as compared to ~80% for aspirin. It was interesting to note that the activity of GMAI₁₁ persisted throughout the period of study, and the activity improved with time, indicating the potential to release the active principle over an extended period, unlike aspirin, which showed a deceleration in activity after 4th h. GMAI₁₁ shares comparable molecular features with arachidonate/coxibs. There is, therefore, a possibility to develop a drug candidate from the anti-inflammatory templates of *P. viridis*, to substitute the COX₁/NSAIDs available in the market.

GB-O 28

Reproductive behaviour and embryonic development of the rock lobster, *Panulirus homarus*

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The order Decapoda of the class crustacean occupies an important position because of its diversity, abundance in different habitat, food value etc. Organisms such as lobsters, prawns, crab and crayfish are commercially important crustaceans. Lobsters occupy an important place by virtue of their magnitude in fishery and demand and lobsters, valued as one of the prime seafood all over the world; stand next to prawns in their

landings and export. A study on the reproductive behavior of a fish species is an important link in aquaculture.

The present study has revealed that *Panulirus homarus* is a continuous breeder with peak breeding season during the monsoon and post-monsoon periods. Experiments conducted in the aquaculture laboratory have revealed that copulation took place between a post-moult female and an intermoult male, when the male lobster deposited spermatophore on to the abdomen of the female; the grayish sperm plug appeared hard and the female opened the plug by means of the pointed and hooked fifth pair of walking legs. Subsequently, the female spawned 6-38 days after copulation. Fertilization was external and the fertilized eggs were seen attached to the ovigerous hairs of the female on the abdomen. The female lobster lays 70,000 - 1.0 lakh eggs at each time depending on their size. Twelve developmental stages were noticed before the egg hatched into the phyllosoma larva. It was observed that the egg took 4-7 days before initiation of cleavage. Cleavage and development were confirmed as temperature dependent and 27 - 32 °C was considered ideal with duration of 9-16 days for embryonic development and hatching. Salinity also played crucial role with egg development taking place in the salinity range of 29-35 ppt. Various details of the embryonic development including the morphological and cellular differentiation along with the organic material usage during various developmental stages with reference to temperature were also recorded.

GB-O 29

Sterilization of animal and tissue for mantle explant tissue culture of the abalone, *Haliotis varia* Linnaeus

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The role played by depuration of test animals and sterilization of tissues has been greatly



felt in tissue cultures so as to control contamination and to ensure viable cultures. The effect of depuration and the optimum dose of antibiotics for sterilization of mantle tissue in abalone mantle tissue culture and their effects in cell yield have not been reported with reference to cell proliferation and its survival. Abalone cell culture is being given importance in order to develop a technology for in-vitro pearl production, as the cultured pearls are highly valuable in terms of high quality. Separate studies were conducted to evaluate the effect of depuration and to formulate the optimum dose of antibiotics. Mantle tissue from depurated and non-depurated abalones (*Haliotis varia*) was used simultaneously to study the effect of depuration in cell yield. The cell yield was found to be more in non-depurated mantle (75.04%) than the depurated ones (24.96%). During the study, contamination was found to be more in depurated tissues than in non-depurated ones. Role of antibiotics such as streptomycin and penicillin on cell proliferation and contamination was also studied by incorporating three doses in washing solution for tissues prior to culture. Washing of tissue in 1000 µg/ml of streptomycin and 2000 IU/ml of penicillin yielded more cell proliferation with less contamination. Fungizone was incorporated along with streptomycin and penicillin to minimize the fungal contamination and found that the combination of streptomycin, penicillin and fungizone at a rate of 1000µg/ml, 2000 IU/ml and 200µg/ml resulted in better cell proliferation and less contamination than other doses.

GB-O 30

Water requirement and efficacy of specialized hatchery for selective breeding of carp

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A specialized hatchery was constructed at Central Institute of Freshwater Aquaculture

(CIFA), Kausalyaganga, Bhubaneswar, India to produce spawn of fullsib families of rohu carp (*Labeo rohita*) and mass production of genetically improved rohu spawn. While following combined selection method, fullsib families have to be produced and reared separately from fertilized egg to fingerlings (10-15g) i.e. till taggable size for individual tagging. Mass scale spawn productions have been undertaken for dissemination of improved rohu. Water requirement study was performed for full sib family production as well as for mass scale spawn production and it was worked out to be 10.54 and 81.07 m³ for one fullsib family and a million of spawn, respectively. The specialized hatchery improved the production of fullsib families and spawn recovery percentage to a greater extent. Recovery of fullsib families increased from 70-82% to 94-100% in different year classes. Efficacy of the hatchery for fullsib family and mass scale spawn production in selective breeding of rohu program for last 12 years was studied. The same model of hatchery can also be utilized for any other carp selective breeding programme.

GB-O 31

Development of polymorphic SSR markers from ESTs of *Labeo rohita*

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The Indian major carp (*Labeo rohita*) is an economically important aquaculture species in India. The development of expressed sequence tag (EST) in aquaculture species has provided a useful source for mining novel simple sequence repeat (SSR) markers. Present study mainly aimed at identifying SSRs from ESTs generated by cDNA library sequencing of rohu. Two thousand ESTs generated from sequencing of brain and liver libraries were screened for presence of SSRs using repeat finder software. Analysis of these SSRs revealed that the dinucleotides (90), trinucleotides (66), tetra-



nucleotides (18) penta-nucleotides (01) and hexanucleotides (01) were the major motifs that accounted for 51.13%, 37.05%, 10.22%, 0.56% and 0.56% of the total, respectively. CA/TG was the most frequent motif (32%), followed by GA/TC (11%). One hundred and twenty nine SSR-containing ESTs that had sufficient flanking sequences of good quality were chosen for primer designing out of which sixty seven percent (87 nos.) loci could be successfully amplified. PCR-genotyping of these loci using 36 unrelated individuals resulted in 20 polymorphic loci with the allele number ranging from two to six. These polymorphic loci would be useful for population genetic analysis and in breeding programs of Indian carps.

GB-O 32

Detection of toxigenic strains of *Aeromonas hydrophila* by multiplex PCR

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Multiplex PCR (MPCR) assay was developed for the detection of toxigenic strains of *Aeromonas hydrophila* using *ahh*, *aerA*, and *ast* genes, as *A. hydrophila* has been considered as food-borne human pathogen. It is also regarded as fish pathogen causing epizootic ulcerative syndrome in freshwater fishes. Genomic DNA was extracted from the control strain of *Aeromonas hydrophila* (MTCC 1739) by Phenol-choloroform-isoamyl alcohol method. The genes *ahh* encodes for hemolysin, *aerA* for aerolysin, and *ast* for heat stable enterotoxins produced by *Aeromonas hydrophila*. These toxins are responsible for the pathogenicity in human beings, when they consume the foods contaminated with the *A. hydrophila*. The product sizes of the selected genes were 130bp, 309bp, and 536bp, respectively. The developed MPCR assay was

found to be specific, as the assay was negative for *Vibrio cholerae* and *E. coli*. The MPCR assay was sensitive and reliable in identifying the toxigenic strains of *A. hydrophila*.

GB-O 33

Use of random amplified polymorphic DNA for typing of *Nitrosomonas* sp. isolated from freshwater fish ponds

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Autotrophic oxidation of ammonia to nitrite, the first stage in nitrification, is of major importance in the global cycling of nitrogen in aquatic ecosystems. Furthermore, molecular techniques provide a comprehensive overview of species diversity of natural microbial populations. In freshwater environment, *Nitrosomonas* bacteria are generally the predominant Ammonium Oxidising Bacteria (AOB) group, as evidenced from the bacterial genera present in the freshwater fish pond. *Nitrosomonas* species isolated from fish pond was subjected to DNA fingerprinting studies using Random Amplified Polymorphic DNA (RAPD) analysis. Decamer random primers of OPC series (20 primers) were used for screening from which 13 primers showed amplification of the genomic DNA of *Nitrosomonas* species. DNA fingerprinting pattern of *Nitrosomonas* species showed 2-6 polymorphic bands and there were 2-3 unique prominent bands of each primers amplified where their molecular weight ranged from 120-1700 bp. There were common bands found in a series of primers i.e. fragment size of 458 bp in OPC-7 and OPC-16; 770bp in OPC-10 and OPC-16; 700bp in OPC-2 and OPC-18; 1100bp OPC-8 and OPC-11 and 340bp in OPC-2 and OPC-18. Thus RAPD profiles of *Nitrosomas* (DN-1) strain will be useful for environmental monitoring of this genus for further nitrification studies.



GB-O 34**Extensive use of alien *Artemia* strains in larviculture industry in India: impact on native *Artemia* biotopes**

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In India, *Artemia* has been used as live food in the hatcheries since the early eighties and presently the Indian aquaculture industry consumes approximately 200 tones of *Artemia* annually, which has been met through imports. To study the impacts of exotic *Artemia* strains in the native *Artemia* biotopes, an extensive survey was carried out in the hypersaline habitats, inland salt lakes and salt pans covering seven States and three Union Territories in India. Water and soil samples, cysts and biomass samples were collected to test the occurrence of *Artemia* and identify the species. Morphological observations and molecular analysis using the Internally Transcribed Spacer-1 (ITS-1) sequence of the *Artemia* populations collected from Vedaranyam, Tamaraikulam, Marakkanam, Nanganvadi, Mithapur, Kelambakam and Tuticorin regions showed 99% homology with the exotic *Artemia franciscana*. The pairwise genetic distance results of ITS 1 sequences revealed the genetic resemblance of Indian *Artemia* populations with the non-native invasive species *A. franciscana*.

Protein fingerprinting of the whole cell proteins of the *Artemia* strains from Indian salinas vis-à-vis reference *A. franciscana* indicated minor variations with respect to homomeric polypeptide band numbers, molecular weight, and intensity. Nei's genetic identity and genetic distance analyses of the polypeptide bands apparently indicated that the present *Artemia* strains collected from Indian salinas have more similarity with *A. franciscana* than *Artemia salina*. Extensive use of imported *Artemia* cysts paved the way to its spread and establishment

in the different hypersaline habitats of India, by various physical and biological agents. Invasion by non-native species is second only to habitat loss as a threat to global biodiversity with a huge economic impact, and has had its greatest impact in aquatic ecosystems. Present study concludes that the existing *Artemia* populations in Indian salinas are of *A. franciscana* and further studies are required to understand the changes brought by expanding populations in these ecosystems.

GB-O 35**Generation and functional annotation of expressed sequence tags from the normalized cDNA libraries for selected tissues of rohu, *Labeo rohita* (Hamilton)**

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Labeo rohita (Hamilton) is the most important fish among freshwater aquaculture species in Indian sub continent. But, there are very limited genomic resources available for this species, which hinders both genome mapping as well as post transcriptomic large scale functional genomics. Here, our objectives were primarily to construct cDNA libraries to initiate EST sequencing and to generate *Labeo rohita* genomic resources. In this study, five normalized cDNA libraries were constructed from brain, liver, pituitary, ovary and testis of adult male and female rohu of different phases of reproduction throughout the year. About 6,000 random clones from these libraries were sequenced using Sanger's method and 4,500 (75.00%) high quality sequences were obtained. The ESTs were assembled into 3,028 (67.28%) unique sequences composed of 657 contigs and 2,371 singletons and found 236 putative microsatellites showing maximum TG repeats. 743 (22.65%) of the total 3,028 unique sequences had significant BLASTX matches within the Uniprot database with a cut-off



e-value of 10^{-5} to 10^{-100} , and total of ~1825 (60.27%) sequences had significant BLASTN hits with nr database called (un-annotated sequences) and ~460 (15.19%) sequences had no match with the any database at all. Further Gene Ontology (GO) annotation of the BLASTX hit genes were carried out for functional annotation. The highest number of annotations came from the biological process category followed by molecular function and cellular component. In biological process category, 516 genes and 481 genes were related to cellular and metabolic processes respectively, in molecular function category, the vast majority of genes (575) were involved in binding (86%), whereas under cellular component category, 587 genes were from cell and 437 genes corresponded to membrane bound proteins. Enzyme Commission (EC) numbers were obtained and used to putatively map unique sequences to specific biochemical pathways. The highest number of KEGG mapping was extracted from oxidative phosphorylation and ribosome pathways with 81 and 53 sequences respectively. The sequencing of 6,000 ESTs will significantly increase the EST resources in *Labeo rohita* which will be utilized for future genomic research.

GB-O 36

Heritability and genetic correlations of body traits at harvest in giant freshwater prawn, *Macrobrachium rosenbergii*

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Heritability estimates were obtained for three body traits (harvest weight, carapace length and standard length) in a captive population of giant freshwater prawn *Macrobrachium rosenbergii*. A total of 2545 individuals from a 3 × 3 diallele cross produced over two mating

batches: 979 from batch 1 (progeny of 27 sires and 30 dams) and 1566 from batch 2 (progeny of 13 sires and 30 dams) were included in the analysis. Fixed effects fitted in the model were: grow-out ponds within spawning batch (pond 1 and 2 for batch 1, and pond 3 and 4 for batch 2), cross combination (9 crosses), sex (male or female), and the cross by sex interaction. Age at harvest was fitted as linear covariate. Additive genetic effect, maternal and common environmental effects were included as random effects in the model. Due to skewed distribution of body weight, it was transformed to natural logarithms prior to analysis. The heritability was 0.14 ± 0.2 for harvest body weight and 0.03 ± 0.17 and 0.08 ± 0.18 for carapace length and standard length, respectively. The common environmental effect was 0.06 ± 0.08 , 0.10 ± 0.08 and 0.09 ± 0.08 for harvest weight, carapace length and standard length respectively. High genetic correlations (0.97-0.99) were observed among three harvest body traits. The heritability estimates obtained in the present study were lower than those reported in literature for marine shrimps. More data are required to obtain parameter estimates with greater accuracy.

GB-O 37

Multiple induced breeding of albino magur, *Clarias batrachus* without sacrificing the male

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Asian catfish *Clarias batrachus*, is highly popular as an expensive table fish for its nutritional value and good taste. Recently, it has made an entry in the ornamental fish world as 'Walking Cat fish' and the albino variety is a regular exportable item as ornamental fish. Induced breeding of albino magur without sacrificing the male for milt was carried out and the detailed outcome was recorded for three



consecutive occasions at the ARHMC, Pailan, using the same male but different female in each case during August-September, 2010. Physicochemical parameters and other information including time of injection, stripping & fertilization, hatching, percentage of fertilization and hatching, first feeding of larvae, the size of larvae and at different growth stages etc were recorded. Synthetic gonadotropic releasing hormone analogue & domperidone (OVAPRIM) was used as inducing agent with the appropriate dose as per body weight of the brooders. Injected fish were placed in a fiber tank of 5' X 2' dimension with 10" water height in the evening. Stripping was done after 18 hours of injection on the next day. The eggs were flushed onto the male vent directly during stripping procedure followed by washing with 0.5% saline solution in to a 2'x 1'x 8" plastic tray for proper mixing and then incubated in running water with 2.5" water level. In general, water temperature ranged between 29 °C to 30 °C; water pH – 8; male weighed 48 g and females weighed between 60g and 80g, number of eggs obtained per female ranged between 750 to 1000, hatching percentage varied between 4% to 15%, hatching time was between 20 to 22 hours and 1st feed was given after 72 hr post hatching. The present attempt of breeding albino magur without sacrificing the male broodstock and obtaining magur seed by using the same male in multiple breeding is quite significant.

GB-O 38

Captive maturation of moon fish, *Monodactylus argenteus* under laboratory condition

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Moon fish (*Monodactylus argenteus*) is one of the highly prized ornamental fish inhabiting coastal waters. It is a euryhaline fish which can be maintained in freshwater, brackishwater and seawater. The information on the reproductive physiology of this fish is scanty. In the present investigation, an attempt was made to study the maturity of moon fish under controlled conditions. Sub adults (Mean weight= 7.0 ± 0.45 g) caught from Ennore backwater were transported to the CIBA fish hatchery at Muttukadu. After acclimatization and quarantine they were transferred to 10 tonne FRP tank and reared for one year from January 2010 to December 2010. Year round physico-chemical parameters of water such as dissolved oxygen, pH, salinity, temperature, total ammonia and nitrite nitrogen were monitored. Frozen artemia biomass and formulated diet (32% crude protein, 8% lipid) were used as maturation feed. Monthly sampling was done for recording the biological parameters like standard length (SL), total length (TL), wet weight (TW) and condition factor (K). The gonad weight and length were recorded for determination of Gonado-somatic Index (GSI). Histological analysis of gonad was done for the microscopic examination of sex and stage of maturity. Results of the present study showed that both male and female attained their sexual maturity at the mean standard length of 13.16 cm ± 0.05 (mean weight = 51.2 gm ± 0.27). The GSI of matured male was 0.62 and it was 0.72 in maturing female. The value of GSI increased with the advancement of maturation in both the sexes (male 0.21 to 0.62; female 0.23 to 0.72), which was in accordance with the histological observation. Regression analysis showed that the relation of GSI with total length and wet weight was linear.

GB-O 39

Rapid and cost effective development of SSR markers in rohu, *Labeo rohita* using next generation sequencing

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Development of species-specific simple sequence repeat (SSR) markers using conventional approaches like partial and enriched genomic library screening are costly and time consuming. Next generation sequencing is a promising alternative for acquisition of abundant microsatellites from the genome. In an effort to expand the existing microsatellite database for generation of marker map in *Labeo rohita*, Roche-454 GS-FLX sequencing platform was used and results compared with the conventional enriched library screening. A library enriched for 'GT' repeat motif was prepared and screened using Sanger sequencing whereas Roche-454 GS-FLX Titanium platform offered by Ecogenics GmbH, Switzerland was used for high throughput sequencing. Screening of enriched library produced 1718 clones resulting in only 238 sequences having enough flanking region for primer designing which took six months to one year. However, sequencing a fraction of rohu genome, enriched for two repeat motifs such as 'CT' and 'AGG', using Roche- 454 GS generated about 10mb raw data resulting in at least 387 microsatellites repeat sequences in just two weeks. The results of the present study demonstrated the high throughput platform, Roche 454 to be substantially more rapid, effective and economical than other methods.

GB-O 40

Detection of bacterial pathogens from fish and shrimp by the amplification of 16SrDNA

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Many bacteria living in aquatic systems have been reported to cause diseases in fish as

well as in human beings. Identification of bacteria based on conventional biochemical methods is time consuming, laborious and at times misleading due to the existence of variants among bacterial strains. Extremely fastidious pathogenic bacteria can be identified by the use of 16SrDNA amplification technique without the need to culture them. This technique was applied in our studies for the identification of bacterial isolates from fish and shrimp under laboratory culture systems. The results showed that the bacterial isolates belonged to *Aeromonas hydrophila*, *Vibrio harveyi* and *Vibrio alginolyticus*, respectively. 16SrDNA amplification, sequencing and comparison helped in the accurate identification of the culturable and non-culturable microorganisms from biological samples with high accuracy.

GB-O 41

Copy number estimation of integrated transgene in zebra fish copper biosensor and response to heavy metals

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The number of transgene copies can greatly influence the level of expression and genetic stability of the target gene. Many primary transformants must be analyzed because the new DNA is randomly inserted into the fish genome, often leading to a generation of fishes with multiple transgene copies integrated into one or more chromosomal locations. The number of copies of the exogenous gene inserted into the genome is one of the reasons for transgenic silence: Usually, fishes with one or two integration events yield high-level expression of the exogenous gene; whereas, lower and/or unstable transgene expression and transgene silencing has been associated with high numbers of copies. Since it is directly relevant to the effectiveness of transgenic event and data interpretation, transgene copy number determination is usually an essential part of transgene studies.



The mature individuals of F_0 generation of zebrafish were screened for true transgenics and the ones with the transgene integrated in the gonad were selected. The F_1 generation produced by mating such individuals with wild type carries the transgene integrated at the same site as the parent in all tissues. For Southern blot analysis, the DNA samples were digested with restriction enzyme *HindIII*. A Southern blot of the DNA gel was hybridised with a fluorescent reporter probe and which was hybridised with 200 bp fragment of reporter gene. The intensity of each band was quantitated, and copy numbers of the transgenes were calculated by using Gene Tool software. Results showed that transgene copy number depends upon the integration of transgene in zebrafish genome.

GB-O 42

Detection and determination of shikimic acid from marine plants through biochemical method

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Shikimic acid is the principle precursor for the synthesis of aromatic amino acids, phenylalanine, tryptophan and tyrosine and other compounds such as alkaloids, phenolics and phenyl propanoids and used extensively as a chiral building block for the synthesis of a number of compounds in both pharmaceutical and cosmetic industries. In the recent past, the focus on shikimic acid has increased, as it is the key precursor for the synthesis of Tamiflu, the only drug against avian flu caused by the H5N1 virus. In the present study, presence of shikimic acid in marine plants collected from Gulf of Mannar and Palk Bay was determined biochemically. Seaweeds such as *Grateloupia lithophila* (red algae), *Sargassum muticum* (brown algae), *Gracilaria edulis* (red algae), *Ulva reticulata* (green algae), *Sargassum*

tenerrimum (brown algae), *Sargassum ilicifolium* (brown algae), *Sargassum turbinaria* (brown algae), *Gracilaria corticata* (red algae), *Padina gymnospora* (brown algae), *Ulva fasciata* (green algae), *Ulva lactuca* (green algae), *Ulva rigida* (green algae), *Turbinaria ornata* (brown algae); halophytes such as *Suaeda monoica* and *Salicornia virginica*; seagrass *Halodule wrightii* and the mangrove *Avicennia marina* were screened for shikimic acid. The seaweeds *Grateloupia lithophila*, *Sargassum muticum* and the halophyte *Suaeda monoica* contained shikimic acid. Farming of these plants is proposed as an alternative source of livelihood for the fishing folks of the area.

GB-O 43

Development of polymorphic EST markers in Indian white shrimp, *Fenneropenaeus indicus*

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The Indian white shrimp, *Fenneropenaeus indicus*, is one of major commercial shrimp species of the world. It is the dominant shrimp species in the shallow water shrimp fishery along the west and east coasts of India and cultivated in Pokkali paddy fields (paddy-cum-prawn farming) in the wetlands of Kerala. It also forms a major fishery in African coast (Mozambique, Tanzania, Kenya), Sri Lanka, Red Sea and Persian Gulf. Long-term growth pattern, simplicity in hatchery-reared seed production and the adaptability to grow in hypersaline conditions make it a promising species for aquafarming in India. Even though the social acceptance and economic benefits of *F. indicus* is less attractive compared to the tiger shrimp (*Penaeus monodon*), large-sized *F. indicus* from southeast coast of India (popularly known as "Tuticorin White") fetches a higher price in countries like Japan and China. But there is no much information on genomic resources of



F. indicus till date that will be of use in population genetic studies and linkage mapping.

Expressed sequence tags (ESTs) are type I molecular markers with known functions which provide gene candidates for production traits and are important components in genome mapping projects. In this study, we developed 28 expressed sequence tags (ESTs) for genome mapping and other genetic studies of *F. indicus*, through cross-amplification from related species like *P. monodon* and *Litopenaeus vannamei*. These EST sequences contained simple sequence repeats (SSR) and were found to be polymorphic in a small testing panel of *F. indicus*, indicating their useful in genetic stock identification and linkage mapping studies.

GB-O 44

Molecular characterization of differentially expressed gene (O- Methyl transferase) in shrimp, *Penaeus monodon* during salinity stress

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Biotic and abiotic factors have a huge impact on the shrimp aquaculture. In the present study, gene expression in shrimp gill tissue exposed to varying salinity conditions was analyzed. Subtracted cDNA libraries of *Penaeus monodon* under low and high salinity stress conditions were constructed by suppression subtractive hybridization (SSH) method. The sequence analysis of the SSH clones revealed differentially regulated genes such as O-Methyl transferase (OMT), transposase and lysyl hydroxylase which are related to salinity stress tolerance in shrimps. OMT was identified as one of the differentially expressed genes of shrimp *P. monodon* subjected to low and high salinity stress. The full length cDNA of OMT cloned from the gills of *P. monodon* consists of 666 bp open reading frame, encoding 221 amino acids. The

deduced amino acid sequence of OMT exhibited high sequence identity (92%) with COMT class of protein from *F. chinensis*. Real time PCR analysis of the shrimp samples at 3 ppt revealed significant increase in expression of OMT transcripts in gills suggests a possible role of this gene in salinity stress tolerance in shrimps under low salinity conditions.

GB-O 45

Molecular characterization of differentially expressed gene (Acyl CoA binding protein) in shrimp, *Penaeus monodon* during salinity stress

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Salinity as an abiotic stress factor has an impact on the growth, molting, metabolism and survival of shrimp (*Penaeus monodon*). In the present study, suppression subtractive hybridization (SSH) was carried out to identify the genes that are differentially regulated in *Penaeus monodon* exposed to high salinity stress (55 ppt). Acyl CoA binding protein (ACBP) was identified by SSH as one of the differentially expressed genes of the shrimp . *monodon* subjected to high salinity stress. The full length cDNA of ACBP cloned from the gut of *P. monodon* consisted of 273 bp open reading frame, encoding 90 amino acids. The deduced amino acid sequence of ACBP exhibited high sequence identity (97%) with ACBP from *Fenneropenaeus chinensis*. Real time PCR analysis of the shrimp samples exposed to high salinity conditions (55 ppt) revealed significant increase in expression of ACBP transcripts (1.4 fold) at 6 h. The differential expression level of ACBP at various time intervals in gut tissue suggest a possible role of this gene in salinity stress in shrimps under high salinity conditions.



GB-O 46**Assessment of genetic diversity in *Labeo calbasu* wild population across the Indian rivers using nuclear and mitochondrial DNA markers**

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Labeo calbasu, an Indian major carp (family: Cyprinidae, subfamily: Cyprininae) is natural inhabitant of rivers of Indo-Gangetic plain, in addition to some rivers from peninsular India such as Mahanadi, Godavari and Krishna. Over the years, there has been a distinct reduction in its population as evident from catches from open waters. The present study was undertaken to identify suitable polymorphic nuclear (allozyme and microsatellite) and mitochondrial DNA (mtDNA) markers and to determine the distribution and pattern of genetic variation in the native distribution of *L. calbasu*.

A total of 415 individuals of *L. calbasu* collected from 11 rivers belonging to the Satluj, Ganges, Bhima, Mahanadi and Godavari basins were investigated using three markers. Seven polymorphic allozyme loci (*EST-1**, *2** & *3**, *GPI**, *GPDH-2**, *XDH** and *G₆PDH**) revealed 19 loci with mean number of alleles per locus for form 1.45 to 1.65 whereas, nine polymorphic microsatellite loci (*R1**, *R3**, *R12**, *Lr28**, *Lr29**, *Lr38**, *Lro23**, *Lro 25** and *MFW11**) yielded 105 alleles for genotyping. The 5' end of the Cytochrome *b* mtDNA region was amplified (307 bp) for a total of 55 individuals that described 10 different haplotypes. The F_{ST} estimates and AMOVA results indicated that the *L. calbasu* populations are moderately sub-structured. Based on the distribution of genetic differentiation detected by three markers, different genetic stocks of *L. calbasu* across its natural distribution could be identified. The results of genetic divergence through combined

use of mtDNA, microsatellite and allozyme markers may be utilized in the fishery management, aquaculture and stock conservation of this species across its natural habitat.

GB-O 47**Complete mitochondrial DNA sequence of two Indian catfishes, *Pangasius pangasius* and *Clarias batrachus***

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Catfishes are commercially important for both fisheries and aquaculture industry. Two freshwater catfishes, *Pangasius pangasius* and *Clarias batrachus*, belonging to families Pangasidae and Clariidae, respectively, are endemic to South-Asian Region and are considered as endangered species due to their a reduced abundance in wild. For genetic characterization, the complete nucleotide sequence of the mitochondrial genome of these two species was determined. In *P. pangasius* and *C. batrachus*, complete mitochondrial DNA is of 16476 and 16571 bp, respectively. The base compositions in both the species are as follows: *P. pangasius* T=25.1%, C=28.7%, A= 30.5%, G=15.7% and *C. batrachus* T=25.0%, C=27.4%, A=32.3%, G=15.4%, and the mean genetic distance between the two species was found to be 0.1755. The mitochondrial genome of both species contained 13 protein-coding genes, two ribosomal RNA and 22 transfer RNA genes, and a non-coding control region. The observed gene order was identical to that reported in most other vertebrates. Most of the genes were found in the heavy strand, with the exception of ND6. The data reported here could be a resource for comparative analysis of mitochondrial genomes of two catfishes for phylogenetic and functional genomic applications.



GB-O 48**Molecular phylogeny of Indian catfishes**

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Siluriformes is one of the richest fish orders in number of families and genera. India is home to a wide variety of catfishes belonging to different families. Most of them are confined to freshwater but some inhabit marine waters also. The relationship between various catfish families has been studied on the basis of morphological and osteological structures, however, much remain to be done to attain a satisfactory knowledge about Indian catfish phylogeny.

Studies on molecular genetic divergence in prioritized Indian catfish group was carried out for 129 individuals of 28 species belonging to eleven families under the order Siluriformes. For finer resolving the phylogeny, polymorphism of two mitochondrial regions, the fast and medium evolving 16S and Cytochrome *b*, respectively, was analyzed. For all the samples, mtDNA genes were amplified using total genomic DNA and bi-directional sequencing was carried out. With both the markers, it was observed that in the subfamily Bagrinae of family Bagridae, the two species of *Sperata*, i.e., *S. seenghala* and *S. aor*, which were earlier included in the genus *Mystus* were found to form a separate cluster from rest of the five *Mystus* species. Similar pattern was observed with RAPD markers also. The newly named family Horabagridae consisting of *Horabagrus brachysoma* and *Horabagrus nigricollaris*, which was earlier in subfamily Bagridae, formed a totally separate cluster from Bagridae. It was also observed that the cluster of subfamily Ritinae including *Rita rita* and *Rita pavimentatus* of family Bagridae is significantly distinct from that of rest of the families. For the eleven catfish families studied, five main clusters were observed- one containing

Bagridae and Siluridae, in second Sisoridae, Horabagridae, Chacidae and Schilbeidae, third Pangasiidae, Heteropneustidae and Clariidae while in fourth and fifth falls the Plotosidae and Ariidae, respectively. The phylogeny of Indian catfishes is discussed based on these observations.

GB-O 49**Genetic structure of wild *Clarias batrachus* population in India: Evidence from partial Cytochrome *b* and ATPase 6/8 mtDNA genes**

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The sequence variation in mitochondrial cytochrome *b* (307bp) and ATPase6/8 (842 bp) gene to establish the pattern of genetic variation among *Clarias batrachus* samples (n=205) from fourteen different localities spread across the Ganga, Brahmaputra basin. For cytochrome *b* region, the sequence of a 307 bp partial segment at the 5' end of the cytochrome *b* mtDNA gene was determined. A total of 19 variable nucleotide sites were found, 12 of which differed by transitional substitution, 7 differed by transversional changes, 288 positions were conserved with 19 haplotypes and 15 parsimony informative sites. The average frequencies of four nucleotides for all the samples of *C. batrachus* were A: 26.7%; T: 30.3%; C: 26.7%, G: 16.3%; Nucleotide sequences of cytochrome *b* were A+T rich (57.0%) with transition to transversion ratio was 2.668. For ATPase 6/8 region, total of 842 bp of ATPase 8 and ATPase 6 mitochondrial gene amplified, was analyzed to determine genetic variation.. ATPase 8 region was detected from 1-165 bp of the sequence and ATPase 6 region spanned from 159-842 bp. An overlapping region of 7 bp was also seen from 159-165 bp.



The two regions have been analyzed together for variation in this study. The alignment of the sequences revealed nine different haplotypes defined by ten divergent nucleotide sites six of which differed by transitional substitution and four differed by transversional changes. For 842 bases, 832 were constant 8 variables with parsimony informative and 2 singletons. The average frequencies of four nucleotides for all the samples of *C. batrachus* are A: 33.4%; T: 26.7%; C: 29.1%, G: 10.8% Nucleotide sequences of cytochrome b were A+T rich (60.1%) with transition to transversion ratio was 1.644. The analysis of results clearly depicted the population structuring of the *C. batrachus* population.

GB-O 50

Bioactive sterol from the Gulf of Mannar brown algae *Sargassum longifolium*

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S*argassum longifolium*, a brown seaweed commonly and abundantly found in the Gulf of Mannar region is the source of a valuable sterol of fucosterol along with an aliphatic acid as could be ascertained from the exploratory study. The ethanolic extract was found to be slightly active against *Vibrio alginolyticus* and fractionation of the same by bioassay guided mode to get these two compounds by column chromatography. The compounds were found out to be active against *Vibrio parahaemolyticus*, *Pseudomonas fluorescens*, *Vibrio vulnificus*, *Vibrio harveyi*, *Aeromonas hydrophilla* and *Pseudomonas fluorescens*. The compounds were spectrally characterized using ¹H NMR and Mass spectra.

GB-P 01**Genetic variation of *Labeo fimbriatus* populations using heterologous primers**

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Labeo fimbriatus, popularly known as podosi, native to lower peninsular region of India and has great economic and ecological importance. Knowledge of the genetic diversity of this species is important to support management and conservation programs which will subsequently help in sustainable consumption of this species. DNA markers, especially microsatellite markers are excellent tools to evaluate genetic variation of populations. However, development of these markers from each species is time consuming and a bit costly affair. Therefore, it was attempted to evaluate usefulness of heterologous primers in assessing the genetic variation of three populations of *L. fimbriatus*. Thirty microsatellite loci originally isolated from *Labeo rohita* were selected based on their polymorphic information content, for cross-amplification in *L. fimbriatus*. Fifteen loci produced PCR products with unambiguous band pattern with clarity in allele scoring. The above selected primers were used to characterize 110 samples of *L. fimbriatus* collected from the Rivers Krishna (n=30), Kaveri (n=50) and Mahanadi (n=30). Out of fifteen loci, only three were found polymorphic in all the populations with allele size range of 2-3 and remaining 12 loci were found to be monomorphic. Values of expected heterozygosities for these polymorphic loci ranged from 0.602 to 0.613. The mean genetic diversity values were also low. From the result of the present

study, it may be concluded that use of heterologous primers in this species may not be a suitable strategy for genetic variation study. Comparison with the markers originally from the above species will provide more information on utility of heterologous primers for genetic variation study.

GB-P 02**In vitro profiling of melanin and immune genes and their interaction in head kidney cells of Atlantic salmon, *Salmo salar***

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A part from light manipulation capacity of melanin, they have also significant role in antimicrobial immunity. Melanin deposition has been observed on tumor cells and inflammatory cells in gut of Atlantic salmon. It raises question regarding role of melanin and its interaction with immune system. Aim of the present study was to understand the interaction of melanin genes (tyrosinase and dopochrome tautomerase) with immune genes such as interferon, MHC II and heat shock protein genes in response to bacterial infection. Salmon head kidney cells were stimulated in triplicates with CPG-B (modified oligonucleotide) which acts as bacterial DNA at different temperatures such as 10 °C and 20 °C. Extractions of tRNA from cells were collected at different time intervals (0, 24, 48 and 72 hrs). Gene expressions were profiled through real-time PCR and statistical significance of differential regulations was assessed. At 48 hrs and 74 hrs, co-expression of tyrosinase, heat shock protein and MHC II was observed and meantime, dopochrome tautomerase was down regulated substantially. Results of the above study provide substantial information regarding correlation between immune and melanin gene expressions and further *in vivo* study in this direction may validate the correlation among genes.



GB-P 03**Generation and annotation of a few transcripts from cDNA libraries of the Indian freshwater pearl mussel, *Lamellidens marginalis*, with reference to nacre formation**

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Among the bountiful resource of freshwater mussels of India; *Lamellidens marginalis*, *L. corrianus* and *Perryisia corrugata* play significant role in indigenous pearl production. The mantle epithelial cells are directly responsible for pearl formation by the deposition of aragonitic CaCO₃ crystals and the secretion of an organic protein matrix, conchiolin, to hold them. However, the cellular mechanism of nacre secretion signaling is yet to be fully elucidated. Recent findings revealed that nacrein gene, codes for a shell matrix protein and expressed in the pearl oyster mantle. Sequence of nacrein or similar type of pearl proteins are not available from any freshwater mussel and the primers designed from the nacrein sequences available for marine species like *Pinctada fucata*, *Mizuhopecten yessoensis*, *Crassostrea nippona*, *P. maxima* failed to amplify the similar sequences in Indian pearl mussel (*L. marginalis*). RNA was isolated from the implanted and non-implanted mussels and (SSH) cDNA libraries specific to the nacre of freshwater pearl mussel was prepared. About 1000 clones were picked and grown in LB- ampicillin media and verified by colony array using adaptor specific nested primers showing clones having inserts of various sizes. The repeatability was verified by slot blot hybridization and 90 clones were selected out

of 336 as non-redundant. The transcripts were assembled into 55 unique genes composed 14 contigs and 41 singletons. BLAST-X and BLAST-N searches produced 18 and 31 significant (E - value < 10⁻³) hits and further Gene Ontology (GO) annotation of these genes found that the highest number of annotations from the cellular component (30) followed by biological process (27) and molecular function (13) categories. In the biological processes category, nine genes each were related to cellular and metabolic processes, respectively; under cellular component category 10 genes were from cell, whereas molecular function category had majority of genes involving structural molecular activity.

GB-P 04**Immunomodulatory activities of the marine sponge *Halichondria panicea* (Johnston 1842) available off Mumbai coast**

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Bioactivities of extract from the marine sponge *Halichondria panicea* collected in the Arabian Sea were studied. The crude toxin was obtained by methanol, chloroform: methanol (2:1) and aqueous extraction and subsequently lyophilized. The protein content of the crude extract was 0.096 mg/ml, 0.192 mg/ml and 0.124 mg/ml for the methanolic, chloroform: methanol and aqueous extracts, respectively. Crude methanolic and chloroform:methanol extracts of the sponge were found to be lethal while the aqueous extract was found to be highly lethal, when injected intraperitoneally to 20 ± 2 g Kasauli strain male albino mice. The partially purified fractions, viz., elutes of 0.2 M, 0.4 M, 0.6 M, 0.8 M and 1.0 M NaCl, of methanolic and aqueous extracts were also lethal to mice.



The symptoms of toxicity observed in the mice indicated that the toxin affected the central nervous, cardiovascular and urinary systems. Histopathological study revealed hemolysis in blood vessels, occasional necrosis and accumulation of fluid in kidney, lungs and liver. Impact of sponge methanolic extract on Na⁺ K⁺ ATP-ase and Mg⁺⁺ ATP-ase was also analysed and it was observed that sponge methanolic and aqueous extracts were found to be increasing the activity of Na⁺ K⁺ ATP-ase and Mg⁺⁺ ATP-ase at 50ml. In the case of chloroform:methanolic extract, higher concentrations increased AchE activity. The methanolic and chloroform:methanol extracts exhibited hemolytic activity on chicken (333.33 HT/mg, in each case) as well as human erythrocytes (20.83 HT/mg, and 10.41 HT/mg respectively), whereas, the aqueous extract failed to elicit any hemolytic activity. The crude sponge extract failed to exhibit antibacterial property when tested for inhibition of the growth of nine pathogenic bacteria. Methanol and aqueous extracts had immunostimulating effect at lower concentrations.

GB-P 05

Complete mitochondrial genome sequence of Indian major carps: A phylogenetic consideration

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Whole mitochondrial genome (mt-genome) sequencing in animals plays a crucial role in evolutionary, ecological and conservation perspectives. The complete mt-genome of Indian major carps, *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* have been sequenced and compared. The genomes consist of 13 protein coding genes, two ribosomal RNA genes, 22 transfer RNA genes and a non-coding region exhibiting similar pattern in organization. The (A+T)% were 56.52, 57.13 and 55.79 in protein

coding genes, 54.68, 53.62 and 54.81 in ribosomal RNA and 54.43, 54.81 and 54.56 in transfer RNAs respectively in rohu, catla and mrigal. With respect to codon usage pattern of protein coding genes, the 1st positions were in the order of A>C>T, the 2nd positions T>C>A>G and 3rd positions A>C>T>G in rohu, catla and mrigal, respectively. Phylogenetic analysis with representatives from nine families and six orders of class Pisces revealed close relationship among rohu and catla and mrigal forming a sister clade. This phylogenetic analysis supported the previously established fish phylogeny.

GB-P 06

Genetic characterization of four cyprinids using random amplified polymorphic DNA (RAPD) markers

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Information on the genetic structure of important fish groups is essential for studying molecular systematics and optimizing fisheries management and aquaculture. The usefulness of random amplified polymorphic DNA was examined as a potential tool to differentiate four genus viz., *T. putitora*, *S. richardsonii*, *G. gotyla* and *B. bendelisis*. (Cyprinidae: Pisces) of Kumaun (K) and Garhwal (G) regions of Uttarakhand. Species specific markers were observed through the experiment conducted using 10 mer random primers through RAPD-PCR assay. The statistical analysis of RAPD was performed using POPGENE version 1.31. The 15 RAPD primers generated 155 consistently scorable bands with size ranging from 250 -3000 bp. Nei's genetic diversity (h) was ranged from 0.3555 to 0.2811, highest in *T. putitora* (K) with 0.3555 followed by 0.2976, 0.3134, 0.3178, 0.3496, 0.2811, 0.3387 and 0.3281 in *S. richardsonii* (K), *S. richardsonii* (G), *B. bendelisis* (K), *B. bendelisis* (G), *G. gotyla* (K), *G. gotyla* (G) and *T. putitora* (G) respectively.



The total gene diversity (H_1) of populations and species was 0.4469 and the genetic differentiation (GST) of all populations and species was 0.2778 with a gene flow (Nm) value of 1.2997. The genetic distance data showed that the genetic distance was high between *B. bendelisis* (K) and *G. gotyla* (G) (0.2842) and low between *S. richardsonii* (K) and *B. benedelesis* (K). The dendrogram based on UPGMA was constructed which consisted two major clusters. One cluster included *S. richardsonii* and *B. benedelesis* and another one with *T. putitora* and *G. gotyla*. The present investigation could be a valuable tool for studying molecular systematics and establishing the taxonomic position among cyprinid coldwater fish species of India.

GB-P 07

Characterization of *Pseudomonas stutzeri* from the skin of four lined terapon, *Pelates quadrilineatus*

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Pseudomonas stutzeri plays an important role in denitrification, nitrogen fixation, metal cycling and degradation of biogenic and xenobiotic compounds (oil derivatives-aromatic and nonaromatic hydrocarbons and biocides). Furthermore, some strains have been shown to be naturally transformable and have been studied extensively for their capacities. *Pseudomonas* spp. are frequently associated with fish and are reported from eggs, skin, gills and intestine of fishes. A denitrifying bacterial strain T-S3 was isolated from the skin of *Pelates quadrilineatus*, a marine fish collected from Thoothukudi coast (N- 08°, 46.872'; E- 078°, 09.562'), Tamil Nadu. The strain was able to utilize nitrate and could convert nitrate to ammonia gas. The colonies on nutrient agar were off-white, opaque, round and flat with entire margin. The strain was gram-negative, alkali-tolerant, halophilic, spore-forming and penicillin sensitive, non motile rod. It was found

to be catalase and oxidase positive. While no H_2S production, citrate utilization, starch and cellulose hydrolysis was observed. The strain needed salt in the medium for growth. The isolate grew well in minimal media containing cellobiose, glucose, fructose and xylose. Based on the phenotypic characteristics and 16SrRNA sequence analysis, the strain was identified as *Pseudomonas stutzeri*. *P. stutzeri* has not expressed fluorescence pigments on King's B medium, which differentiated it from members of the fluorescent *Pseudomonas* spp. In the present study, *Pseudomonas stutzeri* strain T-S3 was screened for its ability to degrade aromatic hydrocarbons.

GB-P 08

Protease producing *Bacillus cereus* from the gastrointestinal tract of pick handle barracuda *Sphyarena jello*

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Screening of bacteria from the gastrointestinal tract of barracuda *Sphyarena jello*, collected from Thoothukudi coast, Tamil Nadu, led to the isolation of novel protease producing bacterial strain. It was gram-positive, alkali-tolerant, halophilic, spore forming, penicillin-sensitive, and non-motile rod. Colonies on nutrient agar were off-white, opaque, undulate, and flat with irregular margins. The strain was catalase positive, oxidase positive and did not produce hydrogen sulphide. Citrate utilization, starch and cellulose hydrolysis tests were negative. It could grow in the absence of salt and grew well in minimal media containing cellobiose, glucose, fructose and xylose. The strain was able to utilize casein as substrate and showed zones of clearance around its growth in skim milk agar medium. Due to these novel biochemical characteristics of the strain, molecular characterization by 16SrDNA sequencing was also carried out. Based on the phenotypic characteristics and 16SrRNA gene sequence



analysis, the strain was identified as *Bacillus cereus* (GenBank Accession Number: JN793477). By further analysis based on the level of protease activity, the strain can be used for industrial applications.

GB-P 09

Study of population genetic polymorphism and gene flow rate in Indian snow trout, *Schizothorax richardsonii*

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Genetic polymorphism and gene flow rate among Indian snow trout fish *S. richardsonii* population was studied from three different locations; Chirapani stream of Champawat district, Kosi and Gola river of Nainital district were assessed by employing twenty numbers of RAPD markers. The Overall percent of polymorphisms among these three populations were 14.76 with 6.56, 4.92 and 3.28 in Chirapani, Kosi and Gola river populations respectively. The Chirapani population is having higher proportion of polymorphic loci as compared to the Kosi and Gola. The primers of OPY 01, OPY 04, OPY 11 and OPY 16 had produced population specific banding patterns among these three populations with a total 61 repeatable bands. The higher value of genetic distance (0.1565) was recorded between Chirapani and Gola population and the lower value of genetic distance observed between Chirapani and Kosi (0.1058) river population. The cluster analysis revealed that the formation of two clusters, one consisted of Chirapani and Kosi and the other was of Gola fish population. The G_{ST} estimate among these populations showed some extent of homogeneity with lower genetic differentiation rate between populations and further suggested that the higher tolerance to mutation as expected that RAPD bands arise from both coding and non-coding DNA regions.

Present findings revealed the rate of gene flow in three populations seems to be very low and indicative of little migration among populations.

GB-P 10

Development of diagnostic biomarker using bioinformatics in the Dimua River prawn, *Macrobrachium villosimanus*

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Genetic characterization of the species is possible through the identification of DNA biomarkers using restriction endonuclease analysis technique. The species-specific biomarkers also known as diagnostic biomarkers are used to diagnose or identify a particular unknown species. RE analysis helps in determining the suitable candidates as biomarkers of a particular target species. The freshwater prawn (Dimua river prawn) *Macrobrachium villosimanus* has been used as an experimental target species, a natural inhabitant of the Brahmaputra river basin of North East region of India (in the surveyed states of Assam and Nagaland). Sequences of highly conserved 16SrRNA genes and COI mitochondrial genes of the 15 species of the genus *Macrobrachium* were retrieved from NCBI. Restriction endonuclease analysis was performed with the help of the computational tool Web cutter 2.0. This tool provides a map of the restriction enzymes in the target species and their recognition sites. The restriction enzymes of the target species were then compared manually with the restriction enzymes of the rest of the other selected species. The enzymes unique in COI genes were BbsI, Bbv16II, BpiI and BpuAI. Being the type II restriction enzymes and isochizomers with common prototype BbvII, can be considered as diagnostic biomarkers. In case of 16SrRNA



genes, the unique enzymes were AflII, BfrI, BspTI, Bst98I, MspCI and Vha464I; can be used as diagnostic biomarkers since these are isochizomers with the common prototype AflII. Validation of biomarkers was followed after biochemical means of identification. Being first of its kind, results of this study can help in better understanding of their biology and genetic complements which in turn can help in conservation of this species.

GB-P 11

Characterization of mahseers using cytochrome oxidase subunit 1 (Cox 1)

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The fishes of genus *Tor*, *Neolissochilus* and *Naziritor* (Teleostei: Cyprinidae) are referred as Mahseer. These are valued food as well as game fish in our country. At present 46 Mahseer species are known, of which 23 species are of genus *Tor*, 22 species belong to genus *Neolissochilus* and one species of genus *Naziritor*. A great deal of diversity is found between the different genera of Mahseer. The present study was carried for molecular identification and characterization of the two genera of Mahseer species by using mitochondrial Cytochrome Oxidase 1 gene sequence analysis. Samples of *Tor putitora* (Arunachal Pradesh), *Tor tor* (Uttarakhand), *Tor khudree* (Maharashtra) *Tor chelynoides* (Uttarakhand) and *Neolissochilus hexagonolopis* (Sikim) were collected. Fragment of Cytochrome Oxidase subunit 1 (cox-1) was amplified using universal primers and sequenced. The sequences were analysed using MEGA 4 and DnaSP 5 software. The length of Cox-1 in all five species of mahseer was of 628 bp. Among them 134, 108 and 26 bp was variable, singleton variable and parsimoniously informative sites respectively. A total of 20 haplotypes were identified. The nucleotide diversity ranged from 0.03329 to 0.06910 with

lowest between *T. khudree* and *T. tor* and highest between *T. khudree* and *T. chelynoides*. The findings from the present study have important implication in conservation and management of mahseer species.

GB-P 12

Cryopreservation of rainbow trout, *Oncorhynchus mykiss* spermatozoa using different cryoprotectants

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Rainbow trout is one of the important species in coldwater aquaculture. Breeding of rainbow trout in farmed condition is carried out using dry stripping method. Main constraint in breeding of the above species is that males mature earlier than the females. To overcome this problem, cryopreservation of milt can be undertaken as a viable solution. An experiment was conducted to standardize milt cryopreservation protocol of rainbow trout, *Oncorhynchus mykiss* using different combinations of cryoprotectants. The mature males of rainbow trout having average size 28.83 ± 0.55 cm and 340 ± 14.73 g were used in the present investigation. The volume of the fresh milt of individual rainbow trout was found to be 2.66 ± 0.30 ml with pH range of 8 - 8.4. The concentration of the spermatozoa in the fresh milt was observed to be $7.07 \pm 0.22 \times 10^6$ spermatozoa/ml. The motility of spermatozoa in the fresh milt was observed to be 91.73%. Among the extenders tested, Zhang and Liu, 0.6 M Sucrose and TRIS buffer extenders were found to be the most suitable extenders with higher motility percentages compared to the other extenders like fish ringer's solution, 0.9% NaCl and 0.3 M glucose. In the suitability study of cryoprotectants, Glycerol with 0.6 M Sucrose and DMSO with 0.6 M sucrose extender observed to have lower motility percentage than the other combination



of cryodiluent. Percentage of fertilization was found to be significantly ($p < 0.05$) highest in the combination of (10% DMSO + Zhang & Liu), (12% DMSO + Zhang & Liu) and (8% Glycerol + 0.6 M Sucrose) and it was found to be 90.27%, 89.21%, and 89.20% respectively. The higher percentage of hatching was observed in treatments of (8% DMSO + Zhang & Liu extender), (10% DMSO + Zhang & Liu) and (12% DMSO + Zhang & Liu) which was observed as 48.17%, 43.04% and 36.21% respectively. Present study suggests that the combination of DMSO + Zhang & Liu extender performed better than the other combination of cryoprotectants and can be used for cryopreservation of rainbow trout spermatozoa.

GB-P 13

Investigation for bioactive compounds of sea anemone, *Anthopleura midori* off Mumbai coast

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The bioactivities of the venom from a locally available sea anemone *Anthopleura midori* were studied. Crude venom was obtained with the protein content of 3.18 mg/g of tissue. The crude venom of sea anemone found to be lethal at 1.0 ml when injected intraperitoneally to 20 ± 2 g Kasuali strain male albino mice. Partial purification into 11 fractions indicated eight lethal factors. Out of these eight, one factor was unadsorbed fraction, indicating the concerned factor to be a non-protein. The symptoms of toxicity observed in the mice indicated that the venom affected the central nervous, cardiovascular and urinary systems. Histopathological study revealed hemolysis of erythrocytes in blood vessels, occasional necrosis and formation of vacuoles in kidney and liver. The crude venom also exhibited

hemolytic activity on chicken, sheep and human erythrocytes, which was estimated as 5 HU. The hemolytic titre was found to be 32 in all three cases, with specific hemolytic activity of 10.062 HT/mg. The crude venom exhibited neurostimulatory response on mouse brain AChE activity, which increased with increase in concentration. The crude venom stimulated the activity of $\text{Na}^{++}\text{ATPase}$ at $250 \mu\text{g}$ and inhibited the activity of $\text{Mg}^{++}\text{ATPase}$ at the same concentration. However, the crude venom failed to show analgesic or edema formation activity. Avil[®] and Dolonex[®] failed to negate the toxic activity. The present study thus reveals the pharmacological potential of the nematocyst toxin of *Anthopleura midori* in terms of cytolytic (antineoplastic) and CNS manipulation (paralysis/epilepsy) purposes.

GB-P 14

Evaluation of spawning performance of striped murrel, *Channa striatus* in simple plastic tanks induced with the synthetic hormone, ovatide

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The snake head, *Channa striatus*, commonly known as chevron snake head, striped murrel or shol has been considered as one of the high valued food fish species of India. Murrel production in India mainly comes from capture fisheries; the main reason is due to the scarcity of quality seed supply for culture, lack of breeding and larval feeding knowledge among farmers. In view of this, the present study was carried out to evaluate the spawning performance of striped murrel, *Channa striatus* in simple and small plastic tanks ($1\text{m} \times 1\text{m} \times 1\text{m}$). The fish were induced with ovatide, injected intramuscularly at varying dosages (0.4 and 0.6 ml of ovatide per kg body weight of fish) and the fish in control group were administered with saline (0.9% NaCl). Successful spawning was observed at



both the dosages. The latency period for 0.4 and 0.6 ml of ovatide per kg body weight of fish was found to be 29.27 ± 0.18 h and 30.37 ± 0.17 hr respectively. The total spawning fecundity ($14,717 \pm 775$ eggs/female) and spawning fecundity (48 ± 2.54 eggs/g female BW) in 0.4 ml kg^{-1} BW was found to be higher compared to 0.6 ml kg^{-1} BW. The average diameter of floating and non adhesive fertilized eggs ranged from 0.52 to 0.63 mm. The highest fertilization rate (90.54 ± 0.55) and hatching rate (92.49 ± 0.16) were observed at the ovatide dosage of 0.4 ml/kg BW.

GB-P 15

Isolation and characterization of bioactive compounds from marine bacteria

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Microorganisms have been recognized as an important resource for bioactive compounds. Majority of such compounds that are widely used are isolated from terrestrial sources. However, microorganisms isolated from marine sources are known to synthesize metabolites that are unique from the terrestrial counterparts. In the present study, a total of 1,11,277 isolates were screened and about 176 bacteria with antimicrobial property were isolated. Among them 64% were identified as *Bacillus* spp and 36% as *Pseudomonas* spp. Further screening of these 176 isolates based on zone of inhibition against two indicator bacteria (*Staphylococcus aureus* as a representative of gram positive bacteria and *Vibrio harveyi* as representative of gram negative bacteria) led to the selection of 28 that showed significant activity. The antimicrobial compounds produced by the strains SM 5

(*Bacillus* spp) and SK 9 (*Pseudomonas* spp) inhibited many pathogenic bacteria and the activity was maximum against *L. monocytogens*, *V. fischeri* and *V. parahaemolyticus*. Ammonium sulphate fractionation of culture supernatant revealed maximum activity in the 30% fraction. The dialyzed protein fraction extracted from the strain SM 5 also showed promising inhibitory activity against HeLa cell line. As the development of resistance to drugs by pathogenic bacteria is a major concern in the medical science in recent days, isolation of such antimicrobial compounds are very much essential. However, the compound isolated in this study needs further study to characterize its unique chemical and antimicrobial properties.

GB-P 16

Isolation and characterization of salt-tolerant bacteria using 16SrRNA gene sequence analysis from east coast of India

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The rRNA genes are essential for the survival of all organisms and are highly conserved in the bacterial and other kingdoms. Consequently, characterization of the 16SrRNA gene is now well-established as a standard method for the identification of species, genera and family of bacteria. The soil sediment, water and salt crystal samples were collected from salt pan areas i.e. Alampur and Deuli Bungalow of West Bengal and 22 salt tolerant bacteria have been isolated and identified on the basis of biochemical tests and 16SrRNA gene sequence analysis. The salt physiology study revealed that out of 22 salt tolerant bacteria isolated one bacterium; *Staphylococcus* sp. HaNA21 can tolerate 30% NaCl concentration in Tryptone Soya Broth (TSB) medium. In addition to that four bacterial isolates can tolerate in 20% and six bacterial isolates can tolerate 15% NaCl



concentration. All the isolated bacteria were genotyped using 16S rRNA gene sequence analysis and the phylogenetic relationships established.

GB-P 17

Captive induced breeding of *Heteropneustes fossilis* (Bloch) in control conditions at Raipur, Chattisgarh

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Heteropneustes fossilis is popularly known as Asian catfish. It breeds in natural waters and source of seed mainly depends on collection from natural resources. Demand for this fish is quite high because of its good taste, flavor and high market value. To overcome the scarcity and dependency of seed collection from natural resources, a modern cat fish hatchery was designed under the guidance of CIFE, Mumbai at the farm site of Department of Fisheries, Raipur, Chattisgarh. The hatchery is quite simple, low cost and based on water flow through system. During the experiment, 10 nos of female and 20 nos of male brooder were selected for induced breeding. The brooders were injected with ovaprim @ 0.5 – 0.8 ml/kg body weight. Breeding of *H. fossilis* was carried out successfully with average fertilization rate of 90%. The hatching results were encouraging with 90% survival from eggs to spawn stage while 70% larval survival under fry to fingerlings stage under three tier system. Total 25,000 fingerlings were produced from this hatchery. It was observed that post spawning mortality was negligible and larvae grew up to 10-20 mm in 12 to 15 days of rearing period in cement cistern. After yolk-sack absorption on 4th day, the larvae were fed with plankton, eggs custard and artemia naupli three times a day. The results of the present study would be useful in breeding of *H. fossilis* without sacrificing male and also to reduce the dependency of seed collection from natural resources.

GB-P 18

Assessment of population genetic structure and diversity among Indian snow trout, *Schizothorax richardsonii*

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In this study, the levels of genetic variability was estimated in *S. richardsonii* fish populations from three different locations viz., Chirapani stream (pop 1), Gola (pop 2) and Kosi River (pop 3) by using OPY Operon primers (n= 20) and 10 primers produced a distinct and repeatable amplification as well as polymorphic loci. The higher proportion of polymorphic loci was observed in Chirapani stream population as compared to other two populations and with the overall % polymorphism was 14.76. The OPY 01, OPY 04, OPY 11 and OPY 16 primers were found to be the population specific banding patterns among these populations. The Nei's genetic diversity (h) was found to be highest between pop1 and pop2 (0.24) and 0.2 between pop1 and pop3. The total gene diversity (H_t) among these populations was 0.2962, within sample gene diversity (H_s) of 0.2321 and genetic differentiation (G_{ST}) among the populations was 0.2164. The higher genetic distance (0.1565) was obtained between pop1 and pop2, whereas the least genetic distance was between pop1 and pop3 (0.1058), followed by pop3 and pop2 (0.1385). Further it is suggested that the levels of genetic identity and diversity obtained was very low and might be due to the less number of polymorphic loci and migration rate.

GB-P 19

Characterization of rainbow trout and snow trout using morphometric and genetic tools

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Rainbow trout, *Oncorhynchus mykiss* and Indian snow trout (*Schizothorax richardsonii*) are two important coldwater fish species in India. Characterization of these two species was done using analysis of morpho meristic characters, chromosomal analysis and RAPD techniques. The results of the present investigation showed distinct morphomeristic variations among these two species. The Karyological studies showed the clear difference in chromosome number, chromosome morphologies and chromosome formula. In Rainbow trout, diploid chromosome number was found to be $2n = 60$, karyotypic formula was $36 M + 6 Sm + 16 T$ and fundamental arm number (FN) was 208. In Snow trout, diploid chromosomes number was found to be $2n = 96$, karyotypic formula was $18 M + 16 Sm + 12 St + 50 T$ and fundamental arm number (FN) was 260. The RAPD analysis was carried out using five decamer primers of OPA series (OPA-01, OPA-02, OPA-04, OPA-05 and OPA-10). A total of 68 polymorphic loci were obtained of which 53 were polymorphic. Rainbow trout (17.65) had less percentage of polymorphic loci as compared to snow trout (35.29).

GB-P 20

Studies on some enzyme activities responsible for glycerol production in cold condition in *Barilius bendelisis* (Hamilton)

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Fish inhabits in polar and temperate oceans have a variety of freeze resistance adaptation. In winter, some species migrate to warmer or deeper water, where there is no risk of freezing. A few species accumulate a very high concentration of glycerol, which has a significant colligative effect on their freezing point. Indian Hill Trout, *B. bendelisis*, an indigenous coldwater fish is available in almost all hill aquatic resources where winter temperature drops down to 5-7°C and in

summer it thrives at 23-25 °C. In present study, investigations were made to understand the adaptability mechanism of this species to the temperature variation. The fishes were collected from wild resources and acclimatized under laboratory condition. They were subjected to the challenge of winter and summer temperatures i.e. 5-7 °C and 23-25 °C for 96 hrs. The sampling of blood and tissue like liver was done starting from 0 hours to 96 hrs with an interval of 24 hrs. Glycerol level and activities of different enzymes such as Glycerol-3-phosphate dehydrogenase, Phosphoenolpyruvate carboxykinase, Alanine aminotransferase, Aspartate aminotransferase were studied. It was found that the activities of all the enzymes were found to be increased in low temperature in comparison to the higher temperature. Also sodium and potassium level were increased in low temperature. Interestingly, it was observed that the fishes kept in 5-6 °C showed elevated levels of glycerol approximately two times more than the fishes kept in ambient temperature. Thus, the study indicated that glycerol plays an important role in cold adaptation whose level ultimately controlled by different enzymes.

GB-P 21

Low genetic diversity and absence of population differentiation of hilsa, *Tenualosa ilisha* revealed by mitochondrial DNA cytochrome b region in Ganga and Hooghly rivers

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mitochondrial DNA cytochrome b based genetic structure of anadromous clupeid hilsa, *Tenualosa ilisha* was investigated from Rivers Ganga and Hooghly. In the sample size of 240, six different haplotypes were observed with dominance of a single haplotype available in both the rivers. Analysis of molecular variance



(AMOVA) does not suggest existence of population structuring among Ganga and Hooghly populations. AMOVA conducted on the whole population from Ganga and Hooghly as a single group resulted in F_{st} negative value (-0.0041, $p > 0.05$). The mtDNA cytochrome *b* sequence data suggest existence of a single population, migrating to Ganga and Hooghly rivers through the estuaries for spawning and breeding.

GB-P 22

Chromosome preparation from olive barb, *Puntius sarana sarana* (Hamilton)

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Fishes have been the subject of a number of cytogenetic investigations. However, research has been hampered due to the large number of small chromosomes present in most fish species and the difficulty in obtaining good spreads of metaphase chromosomes from various fish tissues. The specimens of *Puntius sarana sarana* reared at fish farm of college of fisheries, Mangalore were used in this study. This technique explains an improved and simple method for obtaining good quality metaphase chromosomes in the olive barb. The chromosomes were obtained from gill and kidney tissues. The chromosome preparations were made using minimum essential medium eagle (Sigma) – colchicine - KCl – flame drying-Giemsa's stain technique. The diploid number of chromosomes in both sexes of *P. sarana sarana* was found to be 50.

GB-P 23

Molecular taxonomy and species identification of tunas from Indian subcontinent

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Fishes being the most diverse group of vertebrates owing to their high diversity and changes during their development poses difficulty in their accurate identification. Molecular tools are indispensable part of systematic and conservation studies which are very informative for different analysis. DNA bar-coding is a taxonomic method that uses a short genetic marker in an organism's DNA to identify it as belonging to a particular species. The intent of DNA bar-coding is to use large-scale screening of one or a few reference genes in order to assign unknown individuals to species and enhance discovery of new species, aid in resolution and strengthen the classical taxonomical identification system.

The present study mainly focused on the precise identification of nine different species of tunas caught from seas representing the Indian sub-continent. Tuna fish samples were collected from different parts of the Indian coast which falls under different stages; juvenile, semi-adult to adult. The morphological characters and images were recorded for further confirmation. The molecular identification was done by sequencing and analyzing the 655 bp Cytochrome Oxidase sub unit 1 gene (COX-1) using gene specific primers. The molecular taxonomy approach could identify accurately seven species of tunas namely *Auxis thazard* (Frigate tuna), *Auxis rochei* (Bullet tuna), *Euthynnus affinis* (Little tuna), *Katsuwonus pelamis* (Skipjack tuna), *Thunnus tonggol* (Long tail tuna), *Thunnus albacares* (Yellow fin tuna) and *Sarda orientalis* (Oriental bonito). There exists ambiguity in identification of *Gymnosarda unicolor* (Dogtooth tuna) due to high similarity of sequences with *Thunnus alalunga*. Large scale sequencing when integrated with the traditional taxonomical identification will contribute to the challenge of identifying different species of tunas and enhance the rate of discovering the biological diversity.



GB-P 24**Expression analysis of antioxidant genes involved in the innate immunity of pearl oyster, *Pinctada fucata***

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Pearl oyster *Pinctada fucata* is distributed over south coast of India and is the most important bivalve mollusc for seawater pearl production in India. Decline in pearl production is mainly due to mortality of pearl oyster mainly due to ocean pollution, disease outbreaks and stock degeneration. In order to control disease and enhance the yields and quality of seawater pearl, it is necessary to study the innate immune defense mechanisms of pearl oyster, which lacks the adaptive immune system. One strategy is to identify disease resistance genes and use them for genetic improvement of cultured stocks. Generation of reactive oxygen species (ROS) is an unavoidable consequence in most aerobic organisms. ROS are produced during metabolism, however, excessive ROS cause harmful damage to a number of cellular macromolecules including lipids, nucleic acids, carbohydrates and proteins. Superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione-S-transferase (GST) are the most important antioxidant enzymes. In the present study, nucleotide sequence of the various antioxidant genes of *P.fucata* like Cu/Zn SOD, GPx and GST was carried out. This is the first report of cytoplasmic

Cu/Zn SOD sequence from *P. fucata*. Expression analyses of the above genes (Cu/Zn SOD, GPx and GST) of *P. fucata* were also carried out.

Live individuals of adult *P. fucata* (with shells of about 4.5-5.5 cm in shell length and body weight 20-30 g) were subjected to LPS (lipopolysaccharide) challenging experiment. The haemolymph from the control and the LPS stimulation group were collected from the adductor muscles at the definite time interval (0, 4, 8, 12, 24 and 36h). Total RNA were extracted from haemocytes using standardized procedure and its quantity was determined. Total RNA was used to synthesize single-strand cDNA in accordance with the manufacturer's recommendation (Biorad). Primers for the genes under study were designed. The cDNA of these genes were amplified and their expression levels at different intervals were determined by semi quantitative PCR analysis. Housekeeping gene 18s was used as references for calculation of relative expression levels of target genes. The PCR product obtained was 471bp, and its nucleotide sequence showed high identities with other known SODs, especially the SODs from molluscs. Cytoplasmic Cu/Zn SOD family signatures were identified using InterProScan program. The expression levels of antioxidant genes in the LPS challenged and control group at different time intervals were quantified based on the gel band intensity using Image J analysis software. Expression levels of antioxidant genes viz, SOD, GPx and GST showed a marked up-regulation with slight variations among the different time periods. The present results may support the proper use of these genes as biomarkers and pave the way for investigation of the defense mechanism of the pearl oyster.





Environment Impacts and Aquatic Health

EH- O : Oral presentation
EH- P : Poster presentation

EH-O 01**Toxicity of manufactured metal nano particles on aquatic organisms**

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The unique characteristics of nanoparticles which are responsible for their myriad applications nevertheless also play an important role in producing toxicological effects, due to their massive surface area and surface reactivity, which make them a particularly serious environmental and occupational health risk. Main objective of the study was to assess the potential impact that metal nanoparticles may have on release in to freshwater and marine aquatic environment. Preparation and characterization of nanosized titanium dioxide ($n\text{TiO}_2$), fullerenes ($n\text{C}_{60}$), silver ($n\text{Ag}^+$), iron oxide ($n\text{Fe}_2\text{O}_3$) and zinc oxide ($n\text{ZnO}$) nanoparticles in different concentrations was carried out and exposed to *Artemia salina*, *Carassius auratus* and *Lates calcarifer* for 48 hours acute toxicity testing. $n\text{C}_{60}$ nanoparticles prepared through filtration with lower and more uniform particle sizes (at 30 nm range) showed maximum biological response, achieving 100% mortality at 1 to 1.5 ppm range where similar results were not obtained for sonicated nanoparticles even at 500 ppm. Preliminary findings pointed to a negative correlation between particle size and biological responses like mortality and behavioral characteristics like swimming pattern. The extent of morphological damage were in the order of $n\text{C}_{60} > n\text{Fe}_2\text{O}_3 > n\text{ZnO} > n\text{Ag}^+ > n\text{TiO}_2$. Further, fullerene nanoparticles showed more pronounced response than other nanoparticles prepared by similar methods. In order to investigate sublethal pathological effects, the fishes were exposed to nanoparticles of various concentrations (1 ppm, 5 ppm and 10 ppm) for 96 hours with parallel untreated control and positive control (hydrogen peroxide). At the end of exposure, destruction of neuronal cells

evidenced severe reduction of nissl bodies and vacuolation, the presence of binucleated cells were also observed with all exposed nanoparticles especially higher severity in Fe_2O_3 and Ag^+ exposed brains. Erosion of primary and secondary lamellae, curling of primary gill filament, desquamation, hyperplasia and epithelial lifting were greatest in gills corresponding with higher concentrations of AgNPs, indicating that gills were the most susceptible organ to AgNPs exposure. In addition, massive necrosis and total destruction of villi of intestinal wall and necrosis of muscle tissues were also seen. The intracellular generation of ROS was significant with $n\text{C}_{60}$, Ag^+ and $n\text{ZnO}$ but not with the other particles. These results demonstrated that various manufactured metallic nanoparticles could cause cell damages directly or indirectly. More detailed studies on the influence of size, structure, and composition of the nanoparticles are needed to better understand their toxic mechanisms.

EH-O 02**Assessment of marine ecosystem health in India: A case study on the evaluation of debris in the marine zone of North Vembanad lake, Kerala**

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With urbanization, marine debris has started making a negative impact on the coastal ecosystems and fisheries. The coastal region of Vemband lake, the largest brackishwater ecosystem in Kerala which opens to the Arabian Sea is one of most thickly populated regions of the state. The increased discard of non biodegradable wastes by the resident populace and the tourists has increased the quantity of marine debris which enters the coastal ecosystem. An assessment of non biodegradable waste (NBDW) in the northern part of Vembanad Lake in Kerala was done during 2011 using the quadrant method. The NBDW was categorized as floating (surface floating and column floating)



and submerged. The occurrence of NBDW in the high tide zone was also noted. The total area surveyed was 142 hectares and the intertidal shore line was 8.88 km which was divided into Zone I (marine region) and Zone II (central estuarine region) with eight stations. For each location, visual observations were made from quadrants. In the subtidal regions, submerged samples were taken by diving and the quantity of marine debris per unit area was weighed and qualitative analysis was done. Based on a grading system developed, the overall grading for the North Vembanad region was evaluated as 'impacted -25%'. To evaluate the quantity of NBDW flowing into the ecosystem and its effect on fisheries a targeted study was conducted involving the local fishers. Stake nets were operated according to tide and daily records of marine debris collected in the stake net along with the catch were recorded. The quantity of marine debris accumulating in the stake net was estimated. It was observed that the quantity of NBDW ranged between at 2 to 18 kg day⁻¹ and consisted of rubber tyres, bottles, metal plates, tin cans etc during the pre-monsoon period. The quantity of debris flowing into the coastal ecosystem was found to be considerably higher during the full moon and new moon period coinciding with the spring tides. From the daily estimates, the quantity of marine debris flowing to the ecosystem was calculated and the impact on fisheries was also assessed.

EH-O 03

Study on comparative toxicosis of chromium VI at different exposure periods on *Anabas testudineus* (Bloch)

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Comparative toxicosis of Cr (VI) at different exposure periods 7, 14, and 21 days was studied based on microanatomical, histological,

histochemical and enzymological changes of an air-breathing teleost, *Anabas testudineus* maintaining the water quality standards of the physicochemical parameters of the aquarium water during the period of treatment. The microanatomical structures of different organs like stomach, intestine and gill were shown increased alterations along with the extensions of exposure periods. Histopathological lesions were also of similar trends but the nature of changes in liver and kidney were different with increased exposure periods. The changes in hepatocytes and nuclear size were very specific for specific exposure periods. In kidney, glomerulus and tubules revealed different types of damages depending on the exposure periods, showing severe destruction at 21 days exposure. The intestinal villi including its absorptive columnar epithelial cells were prone to more serious damage in final exposure period. Profuse secretion of acid and neutral mucopolysaccharide from columnar epithelial cells of stomach and intestine was marked by the positive reaction of PAS-AB stain in different exposure periods. The enzymological results showed declining trends with increased exposure periods, but the amylase and lipase activity were reduced to 50% in 7 days in stomach and intestine and continued upto final 21 days. The maximum reductions of protease, lipase and amylase were very significant in stomach, intestine and liver.

EH-O 04

Fish diversity, fish habitats, fish disease and aquaculture in north-east India hotspot

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Ichthyological survey conducted in 54 Rivers in north-east India, hotspot of biodiversity since 1990 to 2011, revealed the occurrence of more than 250 species of freshwater fishes belonging to 67 genera, 24 families and



10 orders. Topographic maps (1970-71) and satellite imageries were georeferenced and mosaiced. Comparison of Topo maps with LISS IV satellite imageries (2007) have been viewed concomitantly. It revealed slight change detection in River Barak course during the last 40 years. Study of endangered Mahseer fishes using GIS tools revealed five species (four of genus *Tor* and one of genus *Neolissochilus*) from the Barak drainage. The habitat condition of the mahseer fishes was found degraded. The 'Beels' in Assam (1, 00,000 ha) form 49.5 % of the total wetland area in India. Out of 70,000 ha of Beel area, 19,000 ha is still good; 15,000 ha semi-derelict and, 35,000 ha is derelict. Assam beels fish yield 173 kg/ha/year. Sone Beel showed 103 kg/ha/year. Change detection of Sone Beel boundary with GIS tools showed shrinkage of 3,539.6 ha during 1880 to 1980. EUS has been causing large-scale mortality among the freshwater fishes since 1988. There are fluctuations in the intensity of the disease in relation to species affected. Low total alkalinity (TA) could be pre-disposing 'stress factor'. Sick fishes show low haemoglobin and polymorphs, but high ESR and lymphocytes. Communicative nature of EUS revealed variation in time gap between fish and infection in different species. Inoculation of microbes in the test animals did not reveal any sign of ulcerations for two years. Haemolytic *E. coli*, *Aeromonas hydrophila*, *Staphylococcus epidermitis*, etc., in the surface lesions as well as in the gut, liver, gills, heart, kidney and gonads were recorded from sick fishes. All these were sensitive to antibiotics. Fungal isolation revealed *Aphanomyces* sp. Histopathological (HP) studies showed focal areas of increased fibrosis and chronic inflammatory cell infiltration in muscles. Virus has been isolated using BF2 cell line. Electron microscopic studies with the ultra-thin sections of still-occurring EUS-affected fish tissues revealed the presence of virus-like particles (inclusion bodies). Preliminarily, virus like (30-40 nm) were identified by electron microscopy which needs to be confirmed by immunofluorescence assay and reverse

transcription PCR. Experimental study of initiation of EUS was done in fishes and fish lesions were formed in the experimental setup possibly due to the interaction of fishes with bacteria, the environment and possibly the viruses.

EH-O 05

Study of different hydrographic variables at Ennore and Chennai fisheries harbour region of Chennai

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The knowledge of hydrographic variables is very important in determining the abundant availability of fishes in a particular region. The important hydrographic variables that influence the fish abundance were studied. At Ennore, the salinity level was maximum in July (37ppt) with lowest temperature of 27 °C, highest temperature of 31 °C was recorded in September with the salinity level of 32 ppt. At Chennai fishing harbour, the lowest temperature recorded was 26.4 °C (Jan) and the highest temperature was 30 °C (April); lowest salinity level was 26.8 ppt (Feb) and highest salinity level was 38.5 ppt (July). The variations of hydrographic variables from two different locations viz., Ennore and Chennai fishing harbour were studied during the entire year. The interaction effect between the two locations was also studied.

Temperature, salinity, chlorophyll a, gross and net primary productivity, are non significant both at 5% and 1% level of significance at Ennore and at Chennai fishing harbour. The response optimization of the different hydrographic variables viz., temperature, 28.14 °C, salinity, 30.80 ppt, pH, 6.37, dissolved oxygen, 3.120 mg/l, and total soluble solids, 0.4 mg/l for a predicted response of chlorophyll a of 3.354



mg/m³ were recorded at Ennore and at Chennai fishing harbour region, the hydrographic variables viz., temperature, 30 °C, salinity, 26.80 ppt, pH, 6.38 dissolved oxygen, 2.859 mg/L and total soluble solids of 0.40 mg/l for a predicted chlorophyll a response of 1.883mg/m³ were recorded.

EH-O 06

Bioremediation of municipal waste water, sewage water and seafood processing plant waste water using mixed micro algal treatment

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Pollution of water is a major problem and day by day this problem is increasing with the rapid growth of industrialization and urbanization in all parts of the world. Nowadays, the use of micro algae is becoming an emerging technology for environmental cleaning. The objective of this study was to evaluate the nutrient removal efficiency of the mixed micro algae from different wastewaters such as municipal wastewater (W₁), sewage water (W₂) and seafood processing plant wastewater (W₃). Wastewater from different sources was collected from Thoothukkudi district and the experiment was carried out at four different dilutions such as raw (D₀), 25% dilution (D₁), 50% dilution (D₂) and 75% dilution (D₃). The mixed microalgae were inoculated at a rate of 10 v/v and the experiment was conducted for a period of 15 days. The maximum removal rate of NH₃-N was 96, 100 and 100% in W₁D₀, W₂D₃ and W₃D₁ respectively. The highest PO₄-P removal rate was observed in W₁D₃, W₂D₃ and W₃D₀ at the rate of 92, 86 and 81% respectively and the maximum BOD reduction rate of 60, 74 and 78% was noticed in W₁D₂, W₂D₂ and W₃D₁ respectively. The maximum algal growth rate of 2.6×10⁵, 5×10⁵ and 5.4×10⁵ cells/ml was observed in W₁D₂, W₂D₃ and W₃D₀ respectively

on 12th, 9th and 12th day of experimental period. The results of this study suggested that micro algae could grow well in all these three different wastewaters. The nitrogen and phosphorus required for algal growth can be utilized from different wastewaters and produced algal biomass can also be used as bio fertilizers for paddy crop or as animal feed after ascertaining toxicological aspects. This algal biomass can also be used for valuable bio fuel feedstock production.

EH-O 07

Impact of sewage discharge and wastes from fishing activities on the water quality variables off Tuticorin coast

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The effluent discharges from various industries, chemical plants, untreated sewage and wastes from fishing activities are the major sources of pollution along Tuticorin coastal waters. Studies were conducted to estimate the water quality variables in the coastal waters at three stations, i.e. Station 1 (St.1) : within the vicinity of municipal sewage discharge point; Station 2 (St.2): the bar mouth areas of Punnakayal fish landing centres and compared with that of an unpolluted Tharuvaikulam coastal waters (Station 3 - St.3) during the period 2008 -2010 to assess the impact.

The mean values of most of the water quality parameters were observed to be beyond the standard values, stipulated by EPA at the sewage discharge point (St.1). The low salinity (31.5 ± 0.7 ppt), very low dissolved oxygen concentration (0.93 ± 0.12 ml/l) even to anoxic condition on many occasions, high carbon dioxide (22.8 ± 3.9 mg/l), high ammonia (0.77 ± 0.12 mg/l) beyond toxic limit, high chlorophyll (23.9 ± 3.8 mg m⁻³), high nutrients



like nitrite ($13.23 \pm 3.4 \mu\text{g/l}$), phosphate ($13.7 \pm 1.6 \mu\text{g/l}$) and silicate ($0.21 \pm 0.13 \mu\text{g/l}$), high G.P.P ($3.1 \pm 0.74 \text{ mg C/l day}$) and N.P.P ($11.6 \pm 10.1 \text{ mg C/l/day}$) and high B.O.D ($1.8 \pm 0.6 \text{ mg. L}^{-1}$), high T.S.S (Total suspended solids) ($0.27 \pm 0.003 \text{ mg/l}$) and low pH (7.4 ± 0.006) indicated the alarming threats due to sewage pollution. Abnormal values of certain parameters at St.2 when compared with St.3 indicated the moderate extent of pollution from fishing activities. Statistically very high significant differences ($p < 0.001$) were observed in the variations of sea surface temperature, dissolved oxygen, carbon dioxide, salinity, pH, chlorophyll, ammonia, nitrite, phosphate and TSS between stations. Except in the annual variations of ammonia, chlorophyll, pH, salinity and sea surface temperature (SST), statistically no significant ($p > 0.05$) differences were observed among other parameters.

EH-O 08

Deterioration of water quality threatens fisheries in Bengaluru urban

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Bengaluru is one of the fastest growing cities of the world. As the city plagued with ever increasing population, new constructions and expansion of industries, pollution has crossed its threshold. The impact of pollution on waterbodies has threatened inland fisheries of the region. Fish death was observed in Yarandalli, Ibbloor, Giddanakere, Hilaligere, Bommasandra, Kondareddy and Madivala tanks of Bengaluru urban. Fish mortality is a frequent phenomenon in Bangalore urban district due to poor and uncongenial water quality. Water quality parameters viz., dissolved oxygen, water temperature, pH, turbidity, alkalinity, total dissolved solids, conductivity, ammonia and BOD were analyzed in order to determine the specific causes for the mortality.

Results indicated that the mass mortality of fish was due to poor dissolved oxygen ($0\text{-}1 \text{ mg/l}$), higher ammonia ($3\text{-}5 \text{ mg/l}$) and BOD levels ($14\text{-}24 \text{ mg/l}$). Causes for the deterioration of the water quality can be traced back to continuous inflow of sewage, industrial effluents and limited or no provision for water exchange. In addition, continuous accumulation of nutrients resulted in eutrophication in most of the water bodies which in turn creates obstructive environment for fish survival. To safeguard fish and fisheries in this region, focused efforts on proper water quality management is anticipated from government and public as well.

EH-O 09

Occurrence of *Noctiluca scintillans* bloom off Mangalore in Arabian Sea

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Adinoflagellate bloom of high magnitude consisting of *Noctiluca scintillans* (Macartney) was observed along the Mangalore coast on 12.05.2011. It extended from Mangalore bar mouth area to Sasihithlu spanning a distance of about 15 kilometers and to about two kilometers towards west rendering the sea surface a greenish tinge. During the intense period of the bloom the concentration of *N. scintillans* was around 10.5 lakh cells/l. Other plankton cells observed during the period were *Planktoniella* sp., *Cyclotella* sp., *Coscinodiscus* sp., *Pleurosigma* sp., *Gymnodinium* sp., *Ceratium* sp., tintinnids, copepods, chaetognaths, decapod larvae, lucifer, amphipods and gastropods. The lowest dissolved oxygen level was 2.98 ml/l. The bloom continued for the next couple of days showing a decreasing trend near shore, but had spread further towards north and into the river mouths up to 5-10 km in Kulur and Mulky due to tidal influence. The higher wind velocity during the period caused further movement and dispersion



of the bloom and its presence was observed in Karwar by 2.6.2011. A comparison of the nutrients of the water samples from Jan 2011 to May 2011 with that of 2010 showed that silicate, nitrate and total suspended solids was highest during March 2011. During the bloom period, the maximum silicate observed was $26.86 \mu\text{g-at/l}$, Chlorophyll-a $56.16 \mu\text{g-at/l}$ and phosphate $6.23 \mu\text{g-at/l}$.

The phytoplankton bloom in the Arabian Sea is strongly influenced by the seasonal wind shifts (monsoon) that dominate the area. It was observed that the wind velocity and sea level pressure was higher during May 2011 compared to May 2010. High nitrate in the range $30.72 \mu\text{g-at/l}$ to $59.4 \mu\text{g-at/l}$ was observed in the coastal waters in March 2011. It is evident that sudden shifts in wind velocity combined with increased coastal nutrient input due to anthropogenic activities could trigger changes in coastal nutrient levels and subsequent blooms. Observation during June 2011 off Mangalore showed that the count of *N. scintillans* and nutrient level in coastal waters had reached normal condition.

EH-O 10

Carbon nitrogen ratio manipulation in reducing ammonia nitrogen levels in shrimp aquaculture

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Shrimp farming is an important source of income for farmers in coastal districts of India. High margin of profit and availability of good quality seed, commercial feed and disease diagnostic techniques lead to rapid expansion of its culture in last twenty years. Maintenance of good water quality in shrimp culture ponds with low level of metabolites load is an important problem faced by the farmers. Yard experiment

was conducted in 100 l indoor FRP tanks in triplicate to evaluate the effect of different Carbon: Nitrogen (CN) ratios and application of molasses as carbohydrate source on rate of reduction of ammonia and its rate of transformation into useful microbial protein, biofloc. Four different carbon nitrogen ratios viz., 5, 10, 15 and 20 were manipulated by ammonia-N @ 4 mg/l using ammonium sulphate (21% nitrogen) as nitrogen source and molasses (25% carbon) as carbon source. Addition of molasses reduced ammonia-N concentration by 21 to 38% within 6 hours and 34.4 to 75.3% in 24 hours at different CN ratios. Biofloc production started when microbial load reached in the range between 10^6 to 10^7 cfu/ml. The level of ammonia reduction and biofloc production was significantly low ($p > 0.05$) in CN ratio, 5 and highest in CN ratio, 20. Negative correlation was observed between heterotrophic microbial load and biofloc volume with regard to ammonia level. The results showed that application of carbohydrate source to reduce the nitrogenous metabolites load will be an important remedy for solving the problem of water quality maintenance within the pond and eutrophication due to nutrient rich effluent from shrimp farms in coastal areas.

EH-O 11

Change in elemental composition of scale of *Channa punctatus* on treatment with mercury

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Heavy metals impose a major threat to the aquatic environment for the last few decades. Mercury is a highly toxic heavy metal that is found both naturally and can be introduced in the environment by anthropogenic activities. The present study was performed in order to investigate change in elemental composition of scale of *Channa punctatus* on



exposure to sublethal concentrations of mercuric chloride by electron probe microanalysis. LC₅₀ value was calculated (1.21mg/l) by probit analysis and its sublethal concentrations i.e. 0.08 mg/l, 0.10 mg/l, 0.25 mg/l, 0.40 mg/l and 0.55 mg/l were used to expose fishes for 15 days. The percentage composition of calcium was recorded to be maximum followed by phosphorus, aluminum and iron. When fish were exposed to these sublethal concentrations of mercury, an increase in the trend was observed in the percentage composition of phosphorus and aluminum, whereas reverse trend was noticed for calcium and iron on the focal and lepidontal regions. On the basis of standard deviation and standard error mean, it is concluded that in all the cases calcium is the most affected. Thus, calcium alteration can be termed as a true pollution indicator in quantitative analysis.

EH-O 12

A methodological study to generate a 3-D view of medium size reservoir using GIS: A case study

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Reservoirs are a prominent feature of the hydrology of river systems; where they are used to impound and store water for public water supply, flood control, irrigation, recreation, hydropower, wildlife habitat and fisheries. Natural process like erosion in the catchment area and its deposition in various parts of reservoir gradually reduce the capacity of the reservoir. Dead as well as live storages are affected by this. This sort of silt from the upland and surrounding areas poses threat to the aquatic environment in general and fisheries in particular. Information about the quantity of the silt and the consequent reduction in the capacity of the reservoir is necessary for all the planning and operational purposes and the

same can be estimated through scientific capacity surveys. It is also essential to know the bottom topography of the reservoir for sustainable management of fisheries. Present study highlights the conceptual methodology to develop the accurate 3-D view of reservoir of medium size in a GIS platform by carrying out hydrographic survey.

EH-O 13

Evaluation of efficiency of *Eichhornia crassipes* in phytoremediation of copper polluted water using *Clarias batrachus* as a bio-indicator

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The present investigation was carried out to study the effectiveness of *Eichhornia crassipes*, commonly called water hyacinth, in absorbing and accumulating copper in its tissues from copper polluted water using *Clarias batrachus* as a bio indicator. Experiments were conducted in glass jars in triplicates using 2ppm, 3ppm and 5ppm doses of copper salt containing only *C. batrachus* as test specimen in one set and *C. batrachus* and *E. crassipes* for the other one. Immediate mortality of fish occurred at 5 ppm copper salt treatment and mortality occurred within 24 hours in a case of 3 ppm copper salt treatment in the jars without water hyacinth. In the experimental jars with water hyacinth, fishes survived during entire experimental period in case of 5 ppm and 3 ppm copper salt treatment. In case of 2 ppm copper salt treatment, fishes survived for entire experimental period both in case of experimental set up with plant and without plant. However, accumulation of copper in different fish tissues in case of fish with water hyacinth in the experimental jars was significantly less than that in case of fish without plant in the jars. Copper accumulation was reduced by 49 % in



gills, 57% in liver, 79% in kidney and 33% in muscles tissues of fish in the jars which contained water hyacinth. It was also observed that there was maximum accumulation of copper in liver tissue of fish and minimum in the muscle tissues for all the doses of copper treatment.

EH-O 14

Laser-induced fluorescence imaging: A potential tool for early detection of coral bleaching

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Fluorescence spectra of corals gathered using point monitoring and imaging techniques have been utilised to study the stress induced changes in hard corals under *in situ* and laboratory environments. In this study, a Laser Induced Multi-Wavelength Fluorescence Imaging System (LIMFIS) was developed for fluorescence imaging of corals. The system consists of a Diode Pumped Solid- State Laser (DPSS) emitting at the seawater transmission window of 457 nm, with a CW power of 200 mW, for excitation of coral fluorescence and an intensified CCD (ICCD) camera for recording of fluorescence images. In order to capture the fluorescence images at specific emission wavelengths, the LIMFIS is incorporated with a Liquid Crystal Tunable Filter (LCTF) that can be tuned to any wavelength of interest between 400 and 720 nm with a spectral bandwidth of 20 nm. The ICCD camera is triggered by the laser pulse and gated to avoid interference from ambient light.

LIF imaging of corals was carried out in *Favia* sp, *Goniastrea* sp. and *Goniopora* spp. grown in a marine aquarium at the Central Marine Fisheries Research Institute, Vizhinjam,

Trivandrum. The fluorescence images of healthy and bleached samples were taken at 510, 680 and 720 nm. The 510 nm emission was the most intense followed by 680 and 720 nm. Moreover, the intensity of the host pigment emission at 510 nm was highest at the mouth region. The fluorescence image intensity ratios F510/F720, F510/F680, and F680/F720 of healthy and bleached corals were obtained from images captured using ANDOR Solis software. In order to understand the variance of fluorescence signatures with the progress of bleaching ratio images were computed from healthy (H), bleached (B) and its adjoining (A) region. For F680/F720 image ratios calculated, *Goniastrea retiformis* showed a variance of 4.12 % between H and A regions, and a variance of 2.06 % between H and B regions. *Favia mathaii* showed a variance of 6.12% between H and A regions, and a variance of 10.2% between H and B regions. A variance of 7.36% was observed in the F680/F720 ratio between a fully healthy and partially bleached sample. The application of the image ratio F680/F720 in detecting coral bleaching opens up the possibility of utilisation of this ratio to detect early stages of bleaching events in coral habitats.

EH-O 15

Bacterial contamination of green mussel, *Perna viridis* at Ennore estuary, south east coast of India

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Ennore estuary, the most polluted estuary along the eastern coast of Chennai has effluents of industrial and domestic sewage which led to the degradation of the biodiversity, affecting the ecosystem. Green mussel, *Perna viridis* is harvested commercially for human



consumption as they are rich in protein and fat, and are available throughout Indian coastal areas. As filter feeders, the bivalves *Perna viridis* can accumulate pathogenic and other bacteria from contaminated waters. Hence an attempt was made to isolate and enumerate faecal indicator bacteria such as *Escherichia coli*. The bacteria were isolated using selective and non-selective medium following the standard methods and confirmed by biochemical test. The predominant strains identified from water and green mussel, *Perna viridis* meat in Ennore estuary were *Escherichia coli*, *Klebsiella pneumoniae*, *Aeromonas hydrophila*, *Shigella flexnei* and *Yersinia rohdei*.

EH-O 16

Heavy metals in water, sediment and in some selected fish species of the Ennore estuary, Chennai, Tamil Nadu

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Mercury and arsenic were the toxic heavy metals found in water, sediment and in tissues of different species of fishes from Ennore estuary. The water, sediment and fish tissue were analysed for mercury and arsenic using standard procedure in atomic absorption spectrophotometry. The maximum mercury concentration in water was 0.020 ppb, in sediment 0.303 ppb, in tissue : Indian mackerel, *Rastrelliger kanagurta*, (0.255 ppb), *Nemipterus* spp. (0.540 ppb), *Parapenaeopsis maxillipedo* (0.584 ppb), *Metapenaeus dobsoni* (0.345ppb), *Perna* sp.(0.612 ppb) and *Sepia* sp.(0.724 ppb) and *Loligo* sp. (0.383 ppb) in the first quarter, Jan-Mar 2009. In second quarter (April-June 2009), the lowest mercury content recorded was in *Rastrelliger kanagurta*, (0.357 ppb). During 2009 lowest arsenic content was in *Rastrelliger kanagurta* (3.850ppb) followed by threadfinbream,

Nemipterus spp (6.100ppb), squid, *Loligo* sp. (26.094 ppb), shrimps, *Metapenaeopsis maxillipedo* (34.723 ppb), *Parapenaeopsis maximillipedo* (43.840 ppb), *Sepia* spp. (52.099 ppb) and bivalve, *Perna* sp (60.136 ppb). Among the fish species selected for study during Apr-June '09, the second quarter, the lowest arsenic content was recorded in *Rastrelliger kanagurta* (4.354 ppb).

EH-O 17

Decadal changes in the transparencies of Indian coastal waters

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Fishes are visual predators and depending on their prey they are classified as piscivores and planktivores. Piscivores feed on larger fish compared to planktivorous, which feed on much smaller prey such as zooplankton. Hence, clarity or transparency of water is an essential parameter as it may impair their vision under unfavourable visibility conditions. The visibility conditions play an important role on the survival of juveniles and to maintain a healthy balance of fish production. The level of clarity could be an important factor, being advantageous or disadvantageous for either type of fishes. Neritic epipelagic regions are very productive and abundant in fish. Hence, it is important to have an understanding of the clarity of this coastal water for the studies related to fish habitat and production. The transparency of water is defined in terms of the optical properties of light in water and depends primarily on the diffuse and beam attenuation coefficients. The transparencies of the Indian coastal waters derived using an in-house developed algorithm from the satellite data of SeaWiFS for the years 1998-2010 showed variations in transparencies of coastal



water over the years. The coastal waters on the west at the south off Kerala, Goa and Karnataka and off Gujarat have shown noticeable decrease in the transparencies of water. The transparencies of waters of the northern Lakshadweep Sea off Palk Strait are also found to have declined over the years. Most of the coastal waters off the east coasts have shown an increase in transparencies of water, as compared to the waters of west coast. The changes in transparencies of water are mostly observed at the mouth of rivers draining into the sea. The probable factors for changes in transparencies of coastal waters are attributed to rainfall, pollution, river-run off, coastal currents and anthropogenic activities and developments of the coastal regions.

EH-O 18

Diversity of bacterial population associated with aquatic and terrestrial weeds

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Weeds account for 37% of the total annual loss in crop productivity in India. Aquatic weeds such as water hyacinth, Azolla and Chara and terrestrial weeds such as *Parthenium*, *Chenopodium album*, *Solanum*, *Physalis subglabrata*, *Vetiveria zizanioides*, *Echinochloa colona*, *Acorus calamus* and *Arundo donax* are the major constraints to crop production. *Echinochloa colona* is a common weed of rice. It resembles rice plant morphologically. Traditional mechanical and manual methods are labour consuming. The weed management requires the use of herbicides. The use of such chemical measures in the effort to control weed, considering their cost, broad-spectrum, persistence and environmental impact indicates the need of biological methods for weed control. In the present study, three aquatic and eight terrestrial weeds were selected. Bacteria

associated with aquatic and terrestrial weeds were isolated and characterized using biochemical tests and 16S rRNA gene approach. BLAST similarity search analysis has been used for all the sequences. Gene sequences determined in this study have been deposited in the GenBank database. The accession numbers for the gene sequences are from JN638742 through JN638750. Phylogenetic trees have been constructed from the sequences. Adoption of molecular techniques led to the realization that bacteria associated with weeds are much more diverse. The present paper discusses the aquatic and terrestrial weeds and their associated bacterial population for prospective environmentally and economically viable bioaugmentation application in aquaculture and agriculture.

EH-O 19

Influence of UV-A, UV-B and UV-C radiation on aquatic life – a case study with zebrafish, *Danio (Brachydanio) rerio*, embryo development

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The fitness of aquatic ecosystems is critical to life on Earth. The impact of ultra violet radiation (UVR) is one potential stress factor that can have a negative impact on the health of certain species within these ecosystems. Although, there is a paucity of data and information regarding the effect of UVR on total ecosystem structure and function, several recent studies have addressed the effects on various species within each tropic level. Climate change, acid deposition, and changes in other anthropogenic stressors such as pollutants alter UV exposure levels in inland and coastal marine waters. These factors potentially have important consequences for a variety of aquatic



organisms. The present study focused the effect of UVA, UVB & UVC exposure on zebrafish, *Danio (Brachydanio) rerio* embryo, which is a small, cheap, whole-animal model which may replace higher animal models in some areas of bio medical and aquaculture research. It included various stages of development of the embryo of the zebra fish, under varying wavelength of UVR exposure and defined broad periods of embryogenesis—the zygote, cleavage, blastula, gastrula, segmentation, pharyngula, and hatching periods.

EH-O 20

Phytoremediation of aquaculture waste waters

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Phytoremediation technology using aquatic plants is increasingly applied to remediate eutrophic waters. Phytoremediation has been used to clean up contaminated soil and water systems because of its lower costs and fewer negative effects than physical or chemical engineering approaches. The principles of phytoremediation systems for cleaning up eutrophic water include: (a) identification and implementation of efficient aquatic plant systems; (b) uptake of dissolved nutrients including N, P, and metals by the growing plant; and (c) harvest and beneficial use of the plant biomass produced from the remediation system. Aquaculture wastewaters exert adverse environmental impacts when the effluent from these systems is discharged to receiving waters as organic matter loading reduces dissolved oxygen levels and contributes to the buildup of bottom sediments and high nutrient loading impairs water quality by stimulating excessive phytoplankton production.

Lemna minor commonly called as duckweed is a small free-floating aquatic macrophyte

belonging to the family Lemnaceae, was selected as an aquatic plant for nutrient recovery of aquaculture wastewaters as it has a high rate of nutrient uptake and preferentially takes up ammonium ions which is critically important for the treatment of wastewater; being the primary form of nitrogen in wastewater and responsible to accelerate eutrophication in lakes, ponds and streams. A number of studies on duckweed growth in relation to nutrient uptake and utilization in polluted waters have been reported. The objectives of this present work were to study the uptake of biologically important nutrients viz., nitrogen and phosphorus for water quality improvement from aquaculture wastewaters and to determine harvest time of *Lemna minor* for efficient nutrient uptake.

EH-O 21

Restoration of Lake ecosystem through biomanipulation and aeration

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The present study aimed at restoration of ecosystem of the Lake Nainital, an eutrophicated lake, through biological manipulation. It incorporated removal of unwanted biomass especially fishes, resorting to ozonation and aeration followed by stocking of fish species like mahseer and silver carp to keep the ecosystem stable. The application of biomanipulation as above was started in 2007, is operational till date and has helped to restore and stabilize the ecosystem of the eutrophicated lake Nainital. Diversion of sewage discharge from lake, its aeration and ozonation also constituted the part of strategy for restoration of lake ecosystem. Due to enhanced



anthropogenic activities, once the abundant population of golden mahseer in the lake Nainital had almost vanished. The lake was dominated by blooms of planktonic algae (*Melosira*, *Microcystis* etc.) and unwanted fishes like *Puntius* spp., *Gambusia* spp. and *Aristichthys nobilis*. After preparing eco-data base of lake Nainital for one year (2006) using standard methods, above techniques were applied. To control the population of unwanted fishes and blooms of algae, a large population of existing unwanted fishes (*Puntius* spp., *Gambusia* spp., and *Aristichthys nobilis*) was removed. Overall catch amounted to about 9212 kg *Gambusia* spp. & *Puntius* spp. and 6517 kg *Aristichthys nobilis*. Large number of advanced fingerlings of selected fish species i.e. *Tor putitora* and *Hypophthalmichthys molitrix* consisting of about 55000 and 105000 numbers, respectively were stocked. During initial harvesting in 2007, the catch composition of *Puntius* spp. and *Gambusia* spp. was 88%, while in 2011, it decreased to 17%. The composition of other fishes including bighead, silver carp and mahseer has increased from 12% to 83%. Initially, the physico-chemical condition of the lake was not satisfactory as there were wide fluctuations in the physico-chemical parameters. Now, these parameters were in the acceptable range viz., Secchi disc transparency (80.0-190.0 cm), TDS (220.0-300.0 mg/L), DO (4.6-7.9 mg/L), pH (7.2-7.8), total alkalinity (168.0-240.0 mg/L), nitrate (0.04-0.57 mg/L), phosphate (0.04-0.15 mg/L) and have become almost stable. The myxophyceae species *Microcystis* and Bacillariophyceae species *Melosira* were dominant, 22.58×10^5 cells/l and 26.74×10^5 cells/l, respectively, in earlier observations and now their quantity has decreased upto 20.10×10^5 cells/l and 22.50×10^5 cells/l, respectively. Useful zooplankton viz., *Daphnia*, rotifers etc., which were scarce at start, now are showing their presence with good numbers. The stocked fishes viz., silver carp and golden mahseer showed an annual average weight gain of 460 g and 370 g, respectively. These observations indicated that by the removal of unwanted fishes, stocking of

useful fishes and applying aeration technique, the ecosystem of the lake Nainital is well progressing towards restoration.

EH-O 22

Bacterial flora of Indian backwater edible oyster *Crassostrea madrasensis*, in Ennore and Muttukadu, Tamil Nadu

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Oysters are scientifically the best known marine animals in the world. *Crassostrea madrasensis* are the common edible oysters that are found along the south Indian coast. Oysters are rich in Zinc, Iron, Calcium and Vitamin - A, which are of good demand in Tamilnadu coast. The filter feeding nature predispose oysters to accumulate pathogenic bacteria and heavy metal from their immediate environment which are polluted with industrial and sewage wastes rendering the oysters unfit for consumption. The animals are vulnerable to toxic effect resulting from absorption or oral intake of contaminants from the water in which they live. The consumption of these oysters can result in various types of disorder in human beings. In the present study, a total of 100 samples were collected from Ennore and Muttukadu region, Tamil Nadu, dissected and tested for the presence of pathogenic bacterial population in adductor muscles, gills, stomach, intestine and gonads. The bacteria were isolated using non – selective and selective media and further confirmed by biochemical test. The predominant bacterial strains identified in *Crassostrea madrasensis* from Ennore and Muttukadu were *Salmonella typhi*, *Escherchia coli*, *Bacillus subtilus*, *Aeromonas salmonicida* and *Vibrio harveyi*.



EH-O 23**In situ accumulation of heavy metals in *Tenualosa ilisha* from the Hooghly River, West Bengal, India**ASHIM KUMAR NATH¹* AND BIDITA BANERJEE²¹Aquatic Ecology and Fisheries Laboratory, Postgraduate Department of Zoology, Serampore College, Serampore-712 201, West Bengal, India.²a-9/123, Kalyani, Nadia – 741 235, West Bengal, India

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Tenualosa ilisha constitutes 15-20% of the total fish yield in Hooghly- Matlah estuary. The fish has world wide demand due to its delicious taste and good medicinal values. Heavy metal accumulation was studied in *T. ilisha* in the downstream of the Hooghly River. Study revealed that cadmium and lead concentration were found more than permissible levels in gills, gonads and body muscles of the fish species but well below the permissible levels suggested by WHO. Heavy metal concentration and physico- chemical parameters in the water were also studied. Cadmium and lead levels in *T. ilisha* reported in this paper will be helpful for fish traders as well as general health of the people.

EH-O 24**Artificial intelligence networks based modeling, a tool for eco-health assessment in Sabarmati estuarine system**

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Integrated natural resource management (INRM) entails defining the management strategies followed by their religious implementation and ultimately critically analyzing the impact of defined management strategies. Artificial intelligence networks viz., neural networks and belief networks have been comprehensively tried to take up multidimensional tasks. Use of Bayesian Belief

Networks (BBNs) for environmental modeling to portray the integration of a score of variables working in resource management is of recent origin. Under the ambit of this study, an effort has been made to develop BBNs based modeling and explore its efficacy as an intelligent tool for the requisites of INRM from fisheries development perspective in Sabarmati estuarine system.

The system recorded anoxic to low content of dissolved oxygen at certain sites and this varied from nil to 6.66 mg l⁻¹. Prevalence of anoxic to hypoxic conditions indicated that the system is highly environmentally stressed owing to the receipt of brown/black colored composite effluents. High level of free CO₂ up to 58.2 mg/l corroborated the above inference. Transparency regime (6.2 to 86.0 cm) exhibited regional demarcation since upper estuarine region recorded higher transparency levels as compared to lower region. Total alkalinity (88.0 to 743.0 mg/l) and specific conductance (242.0 to 4620.0 μ S / cm) was observed to be significantly high at expanse from Rasikpura to Anandpura. Major nutrients viz., phosphate (0.055 to 1.543 mg/l), nitrate (0.125 to 6.176 mg/l) and silicate (8.217 to 36.10 mg/l) showed the richness of the system. Total standing crop of plankton (145 to 7329 nos/l) experienced wider variation among the sites and phytoplankton (64.15% to 97.29%) excelled as the main stay of this plankton abundance. The occurrence of bacterium *Zoogloea ramigera* (0.02 to 7.77 %), a bio-indicator of water contaminated with sewage and industrial wastes also indicated the environment being imperiled. The primary production studies revealed high respiration rate up to 162.50 mg C/m³/h and P/R ratio (nil to 0.83) further corroborated Sabarmati estuarine system is stressed and highly heterotrophic at certain sites. Bayesian belief networks (BBNs) based model was developed considering composite effluents discharge coupled with denial of environmental flows as the main cause of environmental degradation and computed the environmental



degradation being true to the tune of 87.58% this year as compared to 88.54% last year. As such, the efficacy of BBNs, being an innovative tool has been proved and can be used effectively to assess the eco-health status of water bodies.

EH-O 25

Interrelations between *Brachionus* species and environmental characteristics in Cochin backwaters, Kerala, India

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Rotifers and water samples were collected simultaneously from nine different habitats along Cochin backwaters during the period from August 2000 to July 2002. Thirteen species of *Brachionus* viz., *Brachionus plicatilis*, *B. rotundiformis*, *B. angularis*, *B. urceolaris*, *B. rubens*, *B. forficula*, *B. caudatus*, *B. calyciflorus*, *B. bidentata*, *B. quadridentatus*, *B. patulus*, *B. falcatus* and *B. mirabilis* were enumerated and quantified from rotifer samples. Water samples were analysed for different parameters like water temperature, pH, dissolved oxygen, salinity, hydrogen sulphide, biochemical oxygen demand, alkalinity, phosphate, nitrite, chlorophyll α , total suspended solids and ammonia. The correlation coefficients were worked out between different species of *Brachionus* and the environmental characteristics with respect to each station separately; as well as in the study area as a whole. In the study area, *B. rotundiformis* dominated and contributed 85.76% among the thirteen species of *Brachionus* and showed significant positive correlations with nitrite, biochemical oxygen demand, chlorophyll α and total suspended solids. *B. plicatilis* was found to show significant positive relation with phosphate. *B. plicatilis*, *B. angularis*, *B. rubens* and *B. patulus* exhibited significant negative relation with salinity while they showed

significant positive correlations with rainfall. Salinity showed significant negative correlation with *B. urceolaris* and *B. falcatus* which exhibited significant positive relation with rainfall. Stationwise results on correlation with the levels of significance are also presented and discussed in this communication.

EH-O 26

Effect of *Azotobacter* sp. immobilization in oyster based biofilter in a recirculatory system

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Azotobacter sp. is the most common free-living nitrogen-fixing bacteria found in different types of aquatic medium. Many workers reported that inoculation of *Azotobacter* sp. could optimize the productivity of freshwater fish ecosystems, but the effect of such inoculation on nitrification, phosphate reduction etc. has not been investigated so far. Study was carried out for 15 days in the up-flow aerated biofilter with oyster shell as the supporting medium to investigate the efficiency of the system. Biofilter was attached to a 40 liter recirculatory mode aquaria stocked with 20 fingerlings of *Cirrihinus mrigala* (average body weight of 3.9 ± 0.29 g); and inoculated with *Azotobacter* sp. (10 ml/40 l which corresponds to 10^5 CFU/ml) in the oyster shell medium.

The reduction of ammonical nitrogen was significantly higher ($p < 0.05$) from day 1 to day 15 of the post *Azotobacter* inoculation ($> 70\%$) in the oyster shell medium compared to the control. Comparison of inlet and outlet water in all the treatments showed that ammonia content was significantly ($p < 0.05$) reduced in the outlet treatments during the experiment. The reduction of nitrite in oyster shell was observed to be 39% compared to control. After day 7, the outlet water of treatment systems showed a lower concentration of phosphate than inlet



water. Whereas, phosphates concentration was insignificant ($p < 0.05$) at day 15 with respect to both inlet and outlet water. There was a significant ($p > 0.05$) reduction of DOM (65%) during the entire period in the outlet water as compared to the inlets. The total microbial population of the biofilter was also evaluated using plate count technique. Maximum mean population was observed in inlet water oyster shell ($197.5 \pm 17.7 \times 10^4$ CFU/ml) followed by control ($17.5 \pm 0.3 \times 10^4$ CFU/ml). Significant ($p < 0.05$) reduction was reported in the outlet water as compared to respective inlets. Similarly, the highest growth of *Azotobacter* sp. was reported in the inlet water of oyster shell treatment i.e., $86.5 \pm 2.1 \times 10^3$ CFU/ml, but no colony was recorded in the control. *Azotobacter* sp. has the potential to increase the nitrification rate and to reduce the DOM, ammonical nitrogen and nitrite-nitrogen when immobilized in biofilters containing oyster shells as substrate.

EH-O 27

Observations on variations in physico-chemical water parameters of marine cage culture farm of Karwar

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An investigation has been undertaken to study the fluctuations in the water quality parameters in a cage culture site off Karwar during the period 2009-2011. Two stations i.e., one from cage site (Station 1) and the other one away from cage site (Station 2) were selected. Seawater samples were collected from both the stations at weekly intervals during the period 2009 -10 and 2010 to 11. Water temperature varied from $28.5^\circ\text{C} \pm 0.89^\circ\text{C}$ to $32.5^\circ\text{C} \pm 1.04^\circ\text{C}$ at Station 1 during 2009-10 and it ranged between $26.7 \pm 0.83^\circ\text{C}$ and

$32.5^\circ\text{C} \pm 0.79^\circ\text{C}$ during 2010-11. The salinity was found to be minimum during July 2010 and maximum in May 2010. There was no significant difference observed in the water quality parameters of the two stations ($p > 0.05$). However, difference in salinity was significant between the two culture periods in Station 1 ($p < 0.05$). No significant difference was observed in the nutrient levels of the cage and reference sites and also in the entire period of study. It was also observed that there was no significant difference between the mean weight and temperature of both the sites and periods. But the reduction in the growth during the period 2010 – 2011 could be due to the sudden fluctuations in salinity during the culture period.

EH-O 28

Studies on the seasonal abundance of *Donax incarnatus* around Digga coast

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Donax incarnatus belonging to Class Pelecypoda under the Phylum Mollusca is important for pollution bio-monitoring as the species is found to accumulate heavy metals significantly. Thus the species may act both as pollution indicator as well as detoxifying bio-agent. Preliminary studies relating to the abundance of *D. incarnatus* with the related chemical and physical parameters was conducted along the marine water of Digga coast in West Bengal during October 2003 to September 2008. The results indicated the co-relationship between salinity, temperature and seasonal abundance of available *D. incarnatus*. It was also noticed that the species abundance pattern is proportionate to the salinity and also affected by the surface temperature, which is because of its horizontal locomotive behavior dependence upon other various determinants.



EH-P 01**Study on hydro-chemical parameters and their influence on ichthyofaunal diversity in a lentic water body, a model in Warangal district of Andhra Pradesh**

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Freshwater habitats have unique physico-chemical and biological characteristics which are subjected to modify by local conditions and physiographic features. Now a days, the ecology of reservoirs are under tremendous stress due to fast pace of industrialization, deforestation, cultural and agricultural practices. These activities certainly trigger the rate of sedimentation of the reservoir bed characterized by deposition of silt and organic suspended matter, which initiates the process of eutrophication at a very fast pace, which leads to deterioration of the quality of these habitats. The water quality parameters have a great influence on the growth and other allied factors of aquatic organisms, especially the lentic system.

Dharmasagar reservoir, a historical, rural, lentic fresh water body, which was constructed during the great Kakatiya period (1160-1323 AD), lies between 18°00' - 13° N latitude and 79°43' - 26° E longitude and it is 16 Kms away from the district head quarters of Warangal, Andhra Pradesh. The present investigation deals with the estimation of limnological and physico-chemical parameters and their influence on ichthyofauna abundance and diversity in a lentic water body. This study was carried out for a period of one year i.e., from October, 2008 to September, 2009. The investigation was focused on the determination of hydro-chemical parameters such as water temperature (25.4-33.0°C), pH (7.4-8.4), EC (0.28-0.33 millimhos), TDS (140.2-425.5mg/L), DO (7.1-10.0 mg/L), Free CO₂ (5.0-11.7mg/L), Total Alkalinity (94.0-240.5mg/L),

chlorides (27.0-70.7mg/L), Total Hardness (98.5-142.0mg/L) and BOD (3.6-11.1mg/L). The values of these parameters were higher during summer months. The study was also aimed to record fish fauna available in this reservoir. It is observed that there are 18 species of fishes identified in this reservoir, in which the major group consists of common carps and cat fishes. The data obtained in the present investigation has been discussed in the light of recent literature and it is concluded that limnological and physico-chemical parameters of this reservoir are most comply with suitability of human consumption and favorable for fishery.

EH-P 02**Community structure and succession of foulers on cages in open sea cage farming of lobsters at Chinnamuttam, Kanyakumari**B. SANTHOSH^{1*}, M. K. ANIL¹, K. VINOD², A. P. LIPTON¹, RANI MARY GEORGE¹, S. JASMINE¹, H. JOSE KINGSLEY¹, C. UNNIKRISHNAN¹ AND A. UDAYAKUMAR²¹Vizhinjam Research Centre of CMFRI, Vizhinjam, Thiruvananthapuram- 695 521, Kerala, India²Mandapam Regional Centre of CMFRI, Marine Fisheries P.O., Mandapam Camp- 623 520, Tamil Nadu, India

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Growth of foulers on suspended cages is one of the biggest problems in the sea cage farming. It is essential to know the succession development of fouling communities for controlling the biofouling effectively. Wooden framed panels of 1mx1m size were covered with nylon netting material which is commonly used for cage culture. These were suspended from open ocean floating cages for lobsters in monthly basis at Chinnamuttam area, Kanyakumari from July to December 2010. The experiment revealed a sequence in fouling with dominant species basically depended on the time of inception of the panel/ net. In July, the dominant species attached was mussel spat; in August, it was dominated by miscellaneous species; from September onwards algae started



appearing and during November and December algae had completely dominated. It was also observed that the season of installation of the cage has significant impact on the ultimate dominance of the fouling species. The succession of foulers started with oysters followed by barnacles, mussels and algae. Mussel patches were cleared by lobster themselves and algae patches were cleaned by algae eating fishes available in the area.

Overall dominance of foulers in the nets was in the order of barnacles (19.0%), oysters (18.1%), mussels (15.6%), algae (*Ulva*, *Gracilaria*, *Corelline* algae & *Sargassum*) (13.3%), amphipods (4.2%), limpets (3.7%), isopods (3.1%), serpulids (3.1%), polychete worms (2.5%), small crabs (2.1%), sponges (1%) and miscellaneous species (14.7%). Findings revealed that Sponges and ascidians which are the common foulers in Vizhinjam coast were rather rare compared to the fouling communities in Kanyakumari.

EH-P 03

Effect of exposure to sublethal concentrations of sodium cyanide on the carbohydrate metabolism of the Indian major carp, *Labeo rohita* (Hamilton)

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Experiments were designed to study *in-vivo* effects of sodium cyanide on biochemical endpoints in the freshwater fish *Labeo rohita*. Fishes were exposed to two sublethal concentrations (0.106 and 0.064 mg/L) for a period of 15 days. Levels of glycogen, pyruvate, lactate and the enzymatic activities of lactate dehydrogenase (LDH), succinate dehydrogenase (SDH), glucose-6-phosphate dehydrogenase (G6PDH), phosphorylase, alkaline phosphatase (ALP), acid phosphatase (AcP) were assessed in the various tissues. Result

indicated a steady decrease in glycogen, pyruvate, SDH, ALP and ACP activity with a concomitant increase in the lactate, phosphorylase, LDH and G6PD activity in all selected tissues. The alterations in all the above biochemical parameters were significantly ($p < 0.05$) time and dose dependent. In all the above parameters, liver pointing out the intensity of cyanide intoxication compared to muscle and gill. These results demonstrate switch over to anaerobic metabolism due to increased demand for metabolic energy, thereby altered metabolic profile. Further, these observations indicated that even sublethal concentrations of sodium cyanide might not be fully devoid of deleterious influence on metabolism in *L. rohita*.

EH-P 04

Bioremediation of fipronil in aquatic environment

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The experiment was conducted to characterize the fipronil resistant bacteria from aquatic environment and to evaluate their fipronil remediation capacity. Tank water enriched with fipronil was collected and significant number of culturable fipronil resistant bacteria was isolated. A total of ten fipronil resistant bacteria were isolated from the water sample. Molecular characterization based on 16SrDNA analysis was used to characterize the isolated fipronil resistant bacteria and four representative isolates were selected for further evaluation. 16SrDNA sequence analysis of the selected bacteria isolates showed similar identities to *Bacillus* sp., *Bacillus cereus*, *Staphylococcus epidermidis* and *Comamonas aquatica*. The above isolated bacteria were capable of tolerating high level of fipronil in the range of 35 to 50 mg/l. The percentage of fipronil remediation by the four representative isolated after 4, 8 and 12



days with the initial concentration of 10 and 20 mg/l fipronil in mineral salt medium were in the range of 9.90 ± 1.9 to $94.66 \pm 0.46\%$. The removal was highest at the concentration of 10 mg l⁻¹ for all the isolated bacterial isolates. At a concentration of 10 mg l⁻¹ of fipronil remediation within four bacterial isolates, *Bacillus cereus* showed the higher remediation to the tune of $51.17 \pm 4.39\%$, $83.21 \pm 2.17\%$, $94.66 \pm 0.46\%$ at an interval of 4, 8 and 12 days respectively. At a concentration of 20 mg l⁻¹ of fipronil, *Bacillus cereus* showed higher remediation of $41.42 \pm 1.18\%$, $45.63 \pm 1.42\%$, $73.15 \pm 2.30\%$ at the interval of 4, 8 and 12 days respectively.

EH-P 05

Heavy metal content of fish meal and squid meal samples from Gujarat region

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Gujarat state has longest coastal line of 1600km with variety of aquatic fauna. About 29% of the catch was used for reduction purposes in India, apart from curing and drying, meal production is one of the most effective ways of processing waste utilization. In and around Veraval about 300-400 tons of fishmeal and squid meal is produced and marketed every year. Since fishmeal and squid meal are dried directly under sun on the floor, there are chances of contamination with sand silica, heavy metals from soil. Toxicity does not depend on total accumulated metal concentration but is related to a threshold concentration of internal metabolically available metal. Heavy metals are an important group of chemical contaminants and food is the major vehicle for entry into the system.

Commercially produced fishmeal and squid meal was collected from different processing plants and analyzed for biochemical composition and trace metal analysis. The moisture and protein content fishmeal and squid meal were varied from 8.2-

11%, 40-61%, 9-10% and 37-52% respectively. By-Catch (trash fish) and processing waste of cephalopods were used for the preparation of squid meal and fish meal. The fish meal contained lead in the range of 4.6-18.2 ppm and cadmium in the range of 0.2-4.3ppm and whereas, cadmium was in the range of 2.54-14.11 ppm and lead was in the range of 0.46-1.77ppm in commercially available squid meal samples along Gujarat coast. The results indicated that the heavy metals, dominated by lead followed by copper and nickel were recorded in fish meal; whereas in squid meal, copper followed by cadmium formed the major heavy metals. In the fish meal, lead and nickel were significantly higher ($P < 0.05$) compared to squid meal. The cadmium and copper were significantly higher ($P < 0.05$) in squid meals compared to fish meal samples.

EH-P 06

Lysosomal membrane stability of haemocytes in green mussel, *Perna viridis* as a biomarker of environmental quality in shellfish waters of Karnataka

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Mussels provide a time-integrated measure of contamination reflecting the environmental concentrations present in the ambient environment over a period of time. In bivalves, chemical contaminants exert inhibitory effects on several physiological processes as well as the functions of cellular constituents, including lysosomes. The lysosomal membrane stability has successfully been used as an important cytological biomarker of pollution in environmental monitoring programmes. Membrane destabilisation or increased permeability results in the release of hydrolytic enzymes from the lysosomal compartment into the cytosol. In the present study, Neutral Red Retention Assay (NRRRA) was used to evaluate lysosomal membrane integrity in mussel



haemocytes from shellfish harvesting areas of Karnataka. Mussel samples collected from Someshwara and Surathkal mussel fishing areas were assayed during February-March, June-July and September-October. The granular haemocytes were examined to evaluate the efflux of dye from the lysosomes into the cytosol. The retention time of the neutral red by the lysosomes was recorded by estimating the proportion of destabilized cells. Organochlorine pesticides and trace metal levels were also analyzed in mussel tissue and seawater samples.

The lysosomes of the green mussel population in Someshwara were found to retain the dye for an average retention period of 122 ± 11 minutes. Mussels from the Surathkal had an average retention time of 127 ± 8 minutes. Analysis of variance in the retention time revealed no significant differences between the mussel beds. Reduced retention time is indicative of a high degree of stress due to pollution and retention times < 60 minutes indicate severely impaired health. Results of neutral red retention assay indicated that the haemocyte of mussels from Someshwara and Surathkal had the capacity to retain the dye for more than 120 minutes. The higher retention time observed indicates that the mussels are not exposed to any considerable contaminant stress induced by the inorganic or organic pollutants. The levels of OCPs and trace metals were very low in the mussel beds with concentrations below detectable limit in many of the tissue samples. The biomarker response described corresponded with the tissue burden of contaminants from the mussel beds of the area.

EH-P 07

Studies on phytoplankton in relation to tidal rhythm and hydrography of Gurpur estuary, Dakshina Kannada

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An investigation was carried out from May 2006 to April 2007 to understand the

spatial, temporal and tidal distribution of phytoplankton in relation to hydrography in Gurpur estuary, Dakshina Kannada. Sampling was carried out at five designated stations in the estuary during every spring and neap tidal phases of every lunar cycle for a period of one year. The study area experienced a total annual rainfall of 3779.5mm with maximum rainfall of 66% was recorded in the south west monsoon season. Air temperature exhibited a trimodal seasonal oscillation during both the phases of spring and neap tides and the maximum was recorded during neap tide which could be due to the shallower depth of the respective station. The surface water pH could not exhibit any clear seasonal variation; spring tide recorded the maximum pH values. Dissolved oxygen did not exhibit any distinct seasonal variation. The seasonal distribution of salinity in the estuary revealed the presence of three different salinity regimes at both the tidal phase of spring and neap tide i.e. a higher saline regime during pre-monsoon season, extremely low saline regime during monsoon season and a gradually building up regime during post-monsoon season. ammonical-nitrogen, nitrite-nitrogen and nitrate-nitrogen exhibited a trimodal seasonal oscillation during both the tidal phases of spring and neap tides and nitrite-nitrogen exhibited a decreasing trend from upper stretch towards the confluence during neap tide, while during spring tide there was not much difference between the stations. The present study revealed that not only monsoon season and the distance from the confluence but also different tidal phases have distinct influence on these nutrients. Both phosphate-phosphorous and silicate-silicon concentrations showed a distinct triple seasonal oscillation during spring tide, whereas in neap tide they showed a pulsating trend. Neap tide recorded the higher values of phosphate-phosphorous and silicate-silicon and the stations located away from the confluence also recorded higher values.

The composition of phytoplankton revealed the presence of four groups such as Cyanophyceae, Chlorophyceae Bacillariophyceae and



Dinophyceae. Cyanophyceae consisted of seven genera among them *Merismopedia*, *Lyngbya* and *Oscillatoria* were occurred more frequently with greater numbers and the greater abundance was observed only when the salinity was high. Bacillariophyceae consisted of 27 genera among them *Chaetoceros*, *Cosinodiscus*, *Nitzschia*, *Pluerosigma*, *Biddulphia* and *Mellosira* were dominant and spring tide recorded maximum numbers. Chlorophyceae consisted 19 genera among them *Pediastrum*, *Spirogyra*, *Ulothrix* and *Zygnema* were most common. Neap tide recorded higher numbers of green algae than that of spring tide. In Dinophyceae, four genera were recorded among them *Ceratium* and *Peridinium* were most abundant. The spatial distribution of dinoflagellates revealed the reduction in the population density with the increase in the distance from the confluence and no clear seasonal distribution was observed but the population abundance of Dinoflagellates coincided with higher salinity regime of the year.

EH-P 08

Physiological disturbances in common carp, *Cyprinus carpio* as an indicator of pollution stress

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The use of insecticides is increasing in the recent years to control the pest in which only 1% of the pesticide applied hits the target pest while, the remaining 99% of the pesticide drifts into the environment contaminating soil, water and biota. This poses a constant threat to the non-target organisms especially to fishes, because pesticides are known to alter their behavioral pattern, growth and physiology. One of the early symptoms of acute pesticide poisoning is failure of respiratory metabolism, reduction in the food consumption, alteration in absorption efficiency, scope for growth and

oxygen: nitrogen ratios of fishes. A static renewal bioassay was conducted to determine the acute toxicity (LC_{50}) of commercial grade organophosphate insecticide, quinalphos (25% emulsified concentration) to common carp (*Cyprinus carpio*). The acute toxicity of quinalphos to carp fingerlings exposed for 96 h was found to be 2.75ppm. For sublethal toxicity study, the fishes were exposed to two sublethal concentrations ($1/10^{th}$ of LC_{50} i.e. 0.275 ppm and $1/5^{th}$ of LC_{50} i.e. 0.55 ppm) with lethal concentration (2.75 ppm) for up to 48 hours. The carps were found to be under stress but mortality was insignificant in both sublethal and lethal concentrations. Considerable variation in respiratory rate was observed in both sublethal and lethal concentrations. The effects of this pesticide on the physiological condition were remarkable. Food consumption rate, absorption efficiency, scope for growth and oxygen: nitrogen ratio of the fishes was affected when it was exposed to increasing concentrations of quinalphos. The observed alteration in physiological condition may be a consequence of impaired oxidative metabolism and elevated physiological stress by the fish against quinalphos stress.

EH-P 09

Microbial diversity assessment and their possible impact in selected open water ecosystems in West Bengal

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Open water aquatic ecosystem is rich in microbes, most of which have still remained unexplored. Diversity of microbial communities in these natural aquatic systems and their metabolic functions has remained largely unexplored. Besides being involved in eco-management, these may also be a potential source of human and animal diseases. Studies of microbial communities in wetland aquatic



ecosystems provides important insights into relations between various aspects of ecosystem functioning and changes in biodiversity. In the present study, ecological studies on microbiological load and water quality parameters variations in selected beels of West Bengal at different time interval were carried out. Microbiological load in terms of total cultivable bacterial count, *E.coli*, total coliforms, total *Vibrios*, *Aeromonas* and *Pseudomonas* from selected sites were estimated. Microbiological analysis of soil, water and fish samples from Pachida Beel, Kole Beel, Kulti Beel, and Kulia Beel indicated variable degree of microbial pollution. Bacterial belonging to different species like *Aeromonas* spp., *Pseudomonas* spp., *Bacillus* sp, *Enterobacter*, *E.coli*, *Salmonella*, *Vibrios*, *Micrococcus* etc. were isolated. Seasonal fluctuation and abundance of microbes at different time intervals was also studied. The data indicated high microbial load in Kulia Beel compared to other beels.

EH-P 10

Ecological assessment of an ox-bow lake, Kulia beel through macrophytic and benthic study

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The present investigation was conducted to assess the ecological condition of an ox-bow lake, Kulia beel through macrophytic and benthic macro-invertebrate study. There were seven groups of macrophytes present in the beel, out of which *Eichhornia crassipes* was the dominant followed by *Hydrilla verticillata*, *Ludwigia ascendens*, *Polygonum barbatum*, *Lemna perpusilla*, *Ipomea aquatica* and *Nymphaea nouchali*. The wet-weight of the macrophytes varied between 1.01 and 5.18 kg/m² and dry weight between 55.26 and 498.40 gm/m². The species composition of infested macrophytes indicated that the floating types

were more in quantity (48%), followed by marginal (32%) and submerged (20%). During investigation the benthic population was represented by six species of molluscs viz; *Bellamya bengalensis*, *Lymnaea acuminata*, *Lymnaea Luteola*, *Gyraulus convexiusculus*, *Indoplanorbis exustus* and *Pila globosa*, two species of leeches viz, *Hirudo* sp. and *Helobdella* sp. and insects represented by *Tabanas* sp. Water beetle, mosquito larvae, crabs and prawns were also found. Among this *Bellamya bengalensis*, *Indoplanorbis exustus*, *Lymnaea luteola* were dominant followed by *Pila globosa*, *Gyraulus convexiusculus*; two species of leeches *Hirudo* sp. and *Helobdella* sp. and insects. The average benthic macro-invertebrates population varied from 123.0 to 191.6 no. /m² and the sequential comparison index (SCI) was found to vary between 0.39 and 0.53. From the results, it can be concluded that the Kulia beel water body is under stress and moderately polluted. The runoff and wastes from surroundings either directly or indirectly is increasing the organic load which is leading to profound macrophytic growth.

EH-P 11

Impact of successive harvest on *Gracilaria corticata* var. *corticata* beds along the Thikkodi coast, Kerala

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Marine macro algae popularly known as seaweeds are exploited commercially for their cell wall polysaccharides such as agar, algin, carrageenan etc and for manure, fodder and bioactive metabolites. India is endowed with 6000km coastline and bestowed with more than 0.2 mt/year wet harvestable biomass of seaweeds belonging to 700 species. Of these nearly 60 species to the tune of 30% are economically important for their polysaccharides. These seaweed resources grow best in the tidal and inter-tidal waters along our peninsular



coastline and the Andaman-Nicobar and Laccadive archipelagoes.

Though seaweeds are renewable resources, indiscriminate exploitation may affect their resilience and standing stock. To test this, red seaweed *Gracilaria corticata* var. *corticata* was harvested monthly from permanent quadrats made on *Gracilaria* beds along the Thokkodi (Calicut) coast. 100% regeneration of seaweed stocks after successive harvests was obtained from quadrants where the fronds were harvested monthly with scissors leaving the base. Whereas, the regeneration rate was only 50-60% in quadrants where seaweeds were harvested by hand, the normal method of harvesting by the local people which resulted in the destruction of the base. This result indicates large scale exploitation of seaweeds warrants immediate augmentation of these resources through mariculture.

EH-P 12

Defining the ecological status of reservoirs in Tamil Nadu using macrobenthos

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Hierarchical cluster analysis of macrobenthic abundance data on seasonal basis against sediment organic carbon gradient for 19 reservoirs in Tamil Nadu yielded a major distinct group in premonsoon and monsoon with few subgroups at 50% Bray-Curtis similarity. During premonsoon, the major group comprised of western ghat reservoirs and rain shadow reservoirs, whereas during monsoon, it was rain shadow with plain reservoirs apparently influenced by south-west monsoon and north-east monsoon respectively due to influx of allochthonous organic matter. Dipterans are dominant in all the seasons except monsoon, when oligochaetes outnumber concurrent to the shifting of many reservoirs to eutrophic state. During winter and summer the reservoirs formed

several groups owing to site specific disturbances to the lentic habitat. Molluscs were found absent in Western Ghat perennial reservoirs in seasons probably due to unfavorable bottom trophic conditions and non availability of suitable substratum.

EH-P 13

Climate change, environmental impact and aquatic health

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Climate change is a cause of increasing concern to scientists and it has dramatic effects on marine life. It is hard to predict how climate change affects the ocean, since there are so many factors that affect ocean ecosystems. Ocean acidity rises as sea water absorbs more carbon dioxide released into the atmosphere from power plants and automobiles and causes an increase in carbon dioxide concentrations and a decrease its overall pH, making it more acidic. The higher acidity threatens marine life, including corals and shellfish, which may become extinct later this century from the chemical effects of carbon dioxide. Glyphosate can contaminate surface water either directly as a result of aquatic weed control or indirectly when glyphosate bound to soil particles is washed into rivers or streams. Glyphosate and commercially formulated products containing POEA surfactant are toxic to fish and to some aquatic invertebrates. POEA is about 30 times more toxic to fish than glyphosate. Studies have shown that the acute toxicity of glyphosate varies according to species and age of fish and under different environmental conditions, such as water hardness, pH and temperature. Studies demonstrated that fish and other wildlife from various ecosystems commonly attain mercury levels of toxicological concern which is mainly from mercury-containing emissions from human related activities.



EH-P 14**An integrated approach of impact assessment from ionizing contaminants to marine species**M.FEROZ KHAN¹*, S. R. SUNITH SHINE² AND S. GODWIN WESLEY²¹Department of Advanced Zoology and Biotechnology, Sadakathullah Appa College (Autonomous), Rahmathnagar, Tirunelveli – 627 011, Tamil Nadu, India²Department of Zoology and Research Centre, Scott Christian College (Autonomous), Nagercoil – 629 003, Tamil Nadu, India.

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Protection of non-human biota from ionizing radiation, especially in the vicinity of nuclear installations is a very important aspect for nuclear engineers and ecologists. In order to ensure that certain limits of contamination are not exceeded, the absolute protection of biota and humans is mandatory for nuclear agencies. Based on the above scenario, the exposure of marine biota to naturally occurring radio elements like ²³⁸U, ²³²Th, ²²⁸Ra, ²²⁶Ra and ²¹⁰Po were worked out using a tiered approach using ERICA tool. The biota species were sampled from Kudankulam coastal region. The ecological sensitivity of the species to the radiation exposure and the safeness of the environment was analysed by calculating the external and internal dose rate. The total weighted internal dose rate was higher than the external dose rate. The calculated hazard quotient for all the species was lesser than the global bench mark dose rate of 10 μ Gy h⁻¹.

EH-P 15**Monitoring of trace metals accumulation and biochemical composition in squilla, *Oratosquilla nepa* off Saurashtra coast**

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Gujarat with about 20% of the country's coastline, 33% of the continental shelf area (1, 64,000 sq. km) and over 2, 00,000 sq. km of EEZ ranks second among the maritime states in

marine fish production. In recent years, with the expansion of fishing to the deeper waters, gradual increase in the landings of this squilla is observed along the northwest coast of India, especially in Gujarat region. The stomatopod, *Oratosquilla nepa* (Squilla) forms an important component of the by-catch of the shrimp trawlers. It is also widely distributed in the Indo-Pacific region, extending from Pakistan to Australia. Though squilla is landed in large quantities, no concerted attempt has been made to study the utilization of this resource as a good source of protein for human consumption. The proximate composition includes moisture has highest around 81%, crude protein 10.15%, total lipid 0.6% and total ash 5.1%. The minerals potassium, sodium were 86.09 and 76.45 mg respectively. Currently the major catch is discarded at sea and those that are landed are converted into fishmeal or manure. Comparisons of four heavy metal residues were made for the squilla species with size of below 8 grams and more than 8 grams in weight. One way analysis was carried out to find whether there was significant difference in the heavy metal concentration between the different size groups and organs. This will form a baseline data for comparison with other areas that are impacted with heavy metal residues. Data were subjected to Kruskal- Wallis non-parametric ANOVA and that indicated no significant difference ($P > 0.05$) in the mean concentration of cadmium in meat, shell and gut, between the two size groups of *O. nepa*. Similar trend was observed for the presence of copper between meat and gut for the two weight classes, however, the copper concentration detected in the shell was significantly higher in the > 10 gm class. In the mean concentrations of Fe, Ni and Zn, no significant difference was observed between the three tissues used for the comparison.

EH-P 16**Bioaccumulation of heavy metals in flying fishes, *Hirundichthys coromandelensis* (Hornell, 1923) and *Cypselurus spilopterus* (Valenciennes, 1847)**

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Metals are non-biodegradable and also major environmental pollutants causing cytotoxic and carcinogenic effects in animals. The accumulation of heavy metals in aquatic environments has direct consequences to man and ecosystem. Bioaccumulations of heavy metals (Fe, Zn, Cu, Pb and Cd) were determined from flying fishes *Hirundichthys coromandelensis* and *Cypselurus spilopterus*. The analysis of heavy metals indicated that among the five heavy metals tested Fe was accumulated at maximum level. Concentrations of heavy metals ($\mu\text{g/g}$) in *Hirundichthys coromandelensis* were for Fe, 3.559 to 8.726; Zn, 1.445 to 7.667; Cu, 0.213 to 0.370; Pb, 0.192 to 0.262; Cd, 0.019 to 0.028 and in *Cypselurus spilopterus* were Fe, 3.119 to 8.909; Zn, 1.337 to 6.158; Cu, 0.196 to 0.378; Pb, 0.108 to 0.361; Cd, 0.074 to 0.018. Results showed that heavy metal concentrations in muscles of investigated fish species were in the permissible safety levels for human uses.

EH-P 17

Invasive alien species in east Kolkata wetlands, West Bengal – a case study

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The exotic armoured cat fish has been treated in our country as an alien species of invasive nature, because there were only very sporadic or isolated cases of appearance of this species in our natural water bodies and were obviously reckoned as aquarium escapees, either by accidental or intentional. The present study was carried out to establish the status of the fish species by collating the information gathered through eco-observation on this species in the East Kolkata wetlands ecosystem.

Ubiquitous presence of this alien species in the East Kolkata wetland system not in frugal

numbers, but in myriads, forming viable naturalized populations competing with indigenous faunal-community populations for space and food within the habitat system certainly creates an invasive menace, which could be well-equated with similar kinds of negative impact caused by any other known invasive species. Mass-proliferation of this species to a seemingly, population explosion phase is already underway in East Kolkata wetlands. Unbridled proliferation of this alien species, a bottom dweller, is fast becoming a strong benthic guild in the lake waters; occupying considerable swathe of the habitat niches of the ecosystem, at the expense of the survival and the sustainability of the inhabiting indigenous species, especially the bottom dwellers, in the ecosystem. An easily understandable corollary to this notion is that the carrying capacity of the lake that is to be normally supported and shared by the indigenous biodiversity components are thwarted by the mass proliferation and the dominance of population of this alien species.

EH-P 18

Anthropogenic activities and habitat loss: a preliminary assessment in clam beds of Gurpur estuary, Karnataka

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Dredging of shoreline and river bed has resulted in destruction of several important habitats including mangroves and bivalve beds in estuarine areas. Estuaries are among the most threatened ecosystems, largely because of poor land use policies and indiscriminate use of natural resources. The Gurpur estuary formed by the confluence of two (mangrove-lined) rivers, River Gurpur and River Nethravati with the Arabian Sea; along the southern part of



Karnataka is an important bivalve fishing centre. Five productive zones with larger populations of clams were demarcated in the estuary. Clam production in Gurpur estuary was dominated by *Meretrix casta* and *Paphia malabarica*. Limited harvesting of *Villorita cyprinoides* occurs in the low-saline upper stretches of the estuary. Since 2007-2008, dredging activities in the estuary has resulted in the destruction of bivalve beds and mangroves. The dredging results in short/long-term physical disturbance and degradation of the bottom fauna and flora including the microbial communities thus reducing the nutrient recycling capacity. Suspended sediments in water column, block light there by reducing benthic productivity.

A preliminary assessment was carried out during November 2010 - March 2011 for estimating the loss in the extent of clam bed area due to dredging activities. The results were compared with the historic extent of clam bed in 2006, which was estimated as 2, 03, 266 m². The present study in 2010-11, revealed total destruction of bivalve habitat in the dredging area. The average biomass of clams in the control site adjacent to the dredging area was 2,109 g/ m², whereas it was only 0.08 g/ m² in the dredging area. The loss in average standing stock of live clams in the dredging area was estimated to be 4,28,774 kg. The mangrove patch in the study area was also estimated as 53,250 m² in 2006. The existing mangrove coverage is about 13,479 m² (25.3%) area, which shows that 39,770 m² of mangrove habitat or 74.7% of coverage found in 2006 has been destroyed. This estuarine habitat loss is mainly due to the continuous dredging and developmental activities in the area. The dredging and control areas were studied with respect to the ecological aspects of bivalve distribution. Sediment and bivalve samples were collected from the existing clam beds and the dredging area for comparison. Temperature, pH, salinity and dissolved oxygen levels were also monitored. Detailed site-specific ecological basis is a pre-requisite for successful restoration plans in any habitat. Clam restoration efforts by relaying clams in this study area, which is continuously under physical disturbances, may

not be successful, unless dredging activities are completely stopped.

EH-P 19

Comparative study on water quality parameters and microbial load from two selected locations in south Andaman

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A comparative study was conducted to analyse the water quality parameters and microbial load from two different water bodies viz., North Wandoor (NW) and Phoenix Jetty (PJ) in south Andaman. Samples were collected for four consecutive months from February to May 2011, and temperature (°C), pH, salinity, alkalinity, dissolved oxygen (DO), turbidity, nitrite, nitrate, phosphate, COD and CO₂ were estimated. It was found that nitrite, nitrate and phosphate levels were less in NW area compared to PJ. DO level was more in NW compared to PJ. The pH of water from both areas was more or less same, fluctuating between 8-8.9. When comparing the microbial load in water, soil and oyster (*Crassostrea rivularis*), the total number was higher in PJ compared to NW. Inferior water quality parameters in PJ area could be attributed to the discharge of high load of organic wastes from the open drainage which releases the city (Port Blair) effluents. For determining spatial pattern of water quality parameters, PJ was subdivided into five sub-sites starting from the opening of drainage towards the sea. It was found that DO level progressively increased from the discharge point towards the sea and nitrite, nitrate, phosphate, COD and BOD levels were found to decrease towards the sea. This might be due to constant dilution of effluent waters by seawater. North Wandoor is located far from the Port Blair city and remains undisturbed maintaining good water quality parameters.





Harvest and Post-harvest Technology

HP- O : Oral presentation
HP- P : Poster presentation

HP-O 01**Preparation and characterization of an edible film based on chitosan and virgin coconut oil**

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Edible film was prepared from an emulsion system based on chitosan and virgin coconut oil (VCO). The effect of incorporation of VCO was evaluated at various concentrations and the optimum concentration was chosen based on resultant changes in the properties of the film. Addition of VCO in film-forming solution resulted nearly 1.6 fold increase in film thickness. Chitosan films without VCO (control) exhibited excellent gas barrier properties but inferior water barrier properties. In contrast, chitosan-VCO film revealed better water sorption properties in terms of solubility, swelling rate and water vapour transmission rate. Improvement in water sorption characteristics was evident, especially when VCO was added at concentrations above 1 ml/g of chitosan. However, phase separation was evident at higher level of oil incorporation and the optimal oil/chitosan ratio was determined to be at 0.5. At optimal level of oil concentration, the solubility and swelling rate values of chitosan film in distilled water were reduced by nearly 48% and by 37%, respectively compared to control. The mechanical properties of the resultant film were also significantly affected by the addition of VCO to the film forming solution. Chitosan-VCO films showed a reduction in tensile strength values, but registered slight increase in elasticity of the films. However, film made from chitosan-VCO emulsion was less transparent than film prepared from chitosan alone.

HP-O 02**Collagen film and sponges from the fish skin for pharmacological applications**

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Collagen was extracted from the skin of the fish trevally (*Caranx* sp.), purified and characterized for their physico-chemical properties. The skin of trevally had protein content of 18.20% and collagen content of 11.02%. The collagen was extracted using 0.5M acetic acid and 0.1% pepsin to obtain acid soluble (ASC) and pepsin soluble (PSC) collagen. The yield of collagen varied from 77.43 to 83.34%, with PSC showing higher yield. The purified collagen was used for formation of collagen films and sponges. The collagen film formation was standardized using different collagen concentrations (0.75 to 2%) using glutaraldehyde (GTA) as the cross linking agents at 0.03 to 0.1%. Film formation occurred between 0.75% and 2.0% collagen concentration with 0.05% GTA. Collagen sponge formation was standardized at different collagen concentrations (2-6%) using 0.75% GTA as intermolecular cross linking agent. The collagen sponge formation occurred between 3 and 4% collagen concentration with 0.75% GTA. The water binding capacity and shrinkage factor of the collagen sponge were 95.5% and 12.85%, respectively. The collagen films and sponges developed from the fish skin collagen shall therefore find suitable application in the pharmaceutical industry as an alternative to mammalian collagen.

HP-O 03**Quality characteristics of smoke cured freshwater shellfish sold in major markets of western Odisha**M. M. PRASAD¹* AND T. V. SANKAR²¹*Research Centre of Central Institute of Fisheries Technology, Ocean View Layout, Pandurangapuram, Andhra University P.O., Visakhapatnam-530 003, Andhra Pradesh, India*²*Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri, Cochin- 628 029, Kerala, India***e-mail : prasadmothadaka@yahoo.com*

Bacteriological, chemical, heavy metal and physical contaminants, and sensory quality



characteristics of smoke cured freshwater shellfish sold in major markets of western Odisha viz., Kurumkel, Burla, Sambalpur, Rampaluga are reported. The samples showed the occurrence of mesophilic aerobes (2-6 log CFU/g), faecal coliforms (<1-4 log CFU/g), faecal streptococci (<1-5 log CFU/g), group D faecal streptococci (<1-5 log CFU/g) and staphylococci (2-6 log CFU/g). Except in Sambalpur, in all other markets, the occurrence of staphylococci in higher range exceeded the permitted levels of 6 log CFU/g of the sample. In all the markets, the moisture content (%), peroxide value (meq per kg fat), αNH_2 (mg%), TVN (mg%) and Fat (% DWB) of the smoke cured shellfish samples ranged from 5.46 to 21.69, 21.55 to 107.75, 193.03 to 555.13, 73.60 to 153.60 and 5.62 to 10.75, respectively. All the samples contained trash that included weeds, snails, sticks etc in the range of 0.29 to 4.19%. Likewise the presence of charred and broken pieces ranged from 0.56 to 10.77%. The heavy metal analyses of the samples indicate shellfish samples of all the markets were free from mercury. Similarly all the samples were free from lead except in one crustacean sample from Burla (0.5 ppm) which is below hazardous level of FDA in crustaceans and at the permissible level of FAO. All the samples contained copper (41.00 to 81.50 ppm) and zinc (56.20 to 124.75 ppm) more than permissible levels stipulated by FAO. The occurrence of Co, Ni and Mn ranged from 0.25 to 4.20 ppm, 1.00 to 3.25 ppm and 22.5 to 149.11 ppm, respectively. The sensory evaluation studies on 10 point hedonic scale showed that overall mean scores ranged from 6.25 to 6.98. This study suggests screening of samples at regular intervals and also to trace out the source of contamination in order to minimize the contaminants below the hazardous levels.

HP-O 04

Effect of PUFA from fish oil on lipid metabolism of heart in streptozotocin-induced diabetes in male albino rats

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India tops the list of countries with the highest number of diabetics. It represents a spectrum of conditions characterized by hyperglycaemia, with derangements in carbohydrate, lipid and protein metabolism. Cardiovascular disease, resulting from damage to large blood vessels, causes death of 50% or more of people with diabetes. Polyunsaturated fatty acids (PUFA) from marine fatty fish are known to be heart healthy constituents. PUFA are fatty acids with two or more double bonds and are generally 18-22 carbons in length. The PUFA of marine origin are usually rich in oleic, linolenic, arachidonic, eicosapentaenoic, docosahexaenoic acids. Several studies have described the beneficial effects of PUFA. In the present study we investigated the hypolipidemic effect of PUFA concentrate prepared from fish oil, in streptozotocin-induced diabetic albino rats. Adult male albino rats were divided into three groups: group I: non-diabetic control; group II: diabetic control; group III: diabetic rats treated with PUFA concentrate, administered via an intragastric tube (0.6 ml/rat), at a dose of 100 mg/kg for 27 consecutive days after the induction of diabetes mellitus. Diabetes was induced by an i.p. injection with streptozotocin for groups II and III. Lipid parameters like total lipid, total cholesterol, triglyceride and free fatty acids and lipoprotein lipase (LPL) activity in heart and plasma; and lipoproteins (VLDL, LDL and HDL) and creatine kinase in plasma were measured. In diabetes-induced rats, heart and plasma content of lipid fractions were increased; plasma LPL activity and HDL-C were decreased; and heart LPL activity and plasma creatine kinase activity were increased. The oral administration of PUFA concentrate reduced the levels of total lipid, cholesterol and triglyceride in heart and plasma; increased HDL-C and LPL activity and reduced VLDL and LDL levels and creatine kinase in plasma; and decreased LPL activity in heart of rats as compared with the diabetic control rats. These results suggest that the PUFA extract protected the group III rats from the



diabetes-induced alterations in the lipid metabolism. The high levels of total cholesterol, LDL cholesterol and triglyceride-rich VLDL seen in plasma of diabetic rats may be attributed to the low activity of LPL in plasma which may be responsible for the lowered rate of lipoprotein metabolism and clearance from blood. High glucose promotes intracellular lipid accumulation in vascular smooth muscle cells that goes on to develop into atherosclerotic plaques. In the present study, supplementation of PUFA did not alter the state of glycaemia but significantly reduced the levels of circulating lipids and lipoproteins, viz., total cholesterol, VLDL and LDL-C, triglycerides and free fatty acids in diabetic rats. Also PUFA supplemented rats have shown a significant increase in the activity of plasma LPL activity which may be responsible for the lowering of various lipid fractions in plasma as well as heart tissue, which implies that systemic increases in LPL could have beneficial effects on whole body tissue lipid metabolism. PUFA supplementation might have helped in lowering the circulating levels of LDL, VLDL and triglycerides by one or more of the following mechanisms, viz., a reduction in the absorption of dietary fatty acids, thereby reducing VLDL formation in the gut, enhanced plasma lipoprotein lipase activity and a reduction in the hepatic VLDL synthesis and secretion.

HP-O 05

Quality changes of chitosan edible coated unicorn leatherjacket, *Aluterus monoceros* steaks stored in iced condition

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The effect of chitosan edible coating (0.25 w/v in 1% acetic acid) on the quality of unicorn leatherjacket (*Aluterus monoceros*) steaks was compared with control and acetic

acid (1%) treated samples under iced conditions. The chitosan used in the study had higher degree of deacetylation (81%) and moisture content less than 10%. Treatment with chitosan and acetic acid resulted in a reduced pH whereas it showed a linear increase in control samples with the storage period. Chitosan treated samples maintained eating quality up to 19 d compared to only 11 d for both control and acetic acid treated samples. Chitosan treatment inhibited the growth of total bacterial count throughout the storage period reaching a count of 3.7 log CFU/g, from an initial count of 4.7 log CFU/g, on the day of sensory rejection (21st d). The total bacterial counts in control and acetic acid treated samples showed an increasing trend from an initial count of 4.7 log CFU/g to 6.2 and 5.48 log CFU/g, respectively on the day of sensory rejection (16th d). Treatment with chitosan inhibited the formation of total volatile bases and trimethylamine nitrogen. No significant differences ($p < 0.05$) was observed for the development of peroxides and free fatty acids between the samples.

HP-O 06

Multiplex PCR assay for the simultaneous detection of *Salmonella*, *Vibrio cholerae* and *Escherichia coli* from seafood

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A Multiplex (MPCR) assay was developed for the simultaneous detection of *Salmonella*, *Vibrio cholerae* and *Escherichia coli* using the specific genes *invA*, *RtxA* and *phoA* using Gradient Master Cycler. The products sizes of the selected genes were 275bp, 407bp and 903bp, respectively. This assay has been found to be specific, as no amplification occurred with the other related bacterial pathogens viz.,



Listeria monocytogenes, *Staphylococcus aureus*, *Vibrio parahaemolyticus*, *V. alginolyticus*, *V. harveyi*, and *Aeromonas hydrophila*. The sensitivity of the assay was tested by artificially spiking the shrimp homogenate with the control strains of *Salmonella* (ATCC 122235), *Vibrio cholerae* (Niced 16582) and *E. coli* (ATCC 9637) in different dilutions. The developed MPCR assay could detect 3, 4 and 7 cells of *Salmonella*, *Vibrio cholerae* and *E. coli* in 12 h pre-enrichment in trypticase soy broth. The assay was found to detect 1000 fg of genomic DNA. All the PCR products were easily detected by agarose gel (2%) electrophoresis, and the sequences of specific amplicon assessed and documented using the Gel Documentation System. The developed method is rapid, sensitive and specific for the simultaneous detection of the three pathogens in seafood and environmental samples.

HP-O 07

Reverse Transcriptase Multiplex PCR (RT-MPCR) assay for the detection of *Salmonella typhimurium* and *Salmonella enteritidis* in fish and fishery products

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The Reverse Transcriptase Multiplex PCR (RT-MPCR) assay was developed for the detection of live cells of *Salmonella enterica* serovars *S. typhimurium* and *S. enteritidis* in fish and fishery products. *Salmonella* genus and species specific genes viz. *hns*, *ent* and *rfbj* were selected to detect the target pathogens. The total RNA was extracted and confirmed by the RT-PCR assay. The products sizes of the selected genes were 157 bp, 401 bp and 625 bp, respectively, which aided in the identification of *Salmonella enterica* serovars *S. typhimurium* and *S. enteritidis* in a single reaction without any interference. The specificity of the selected genes

was analyzed with the other bacteria like *Listeria monocytogenes*, *Staphylococcus aureus*, *Vibrio cholerae* and *E. coli* and found that they are specific only for *Salmonella*. The sensitivity of the RT-MPCR assay for the detection of *S. typhimurium* (MTCC 98) and *S. enteritidis* (ATCC 13065) in artificially inoculated shrimp homogenate was investigated. The developed MPCR assay could detect 3 and 6 cells of *S. typhimurium* and *S. enteritidis* in 10 h pre-enrichment in trypticase soy broth, respectively. All the PCR products were easily detected by agarose gel (2%) electrophoresis, and the sequences of specific amplicon assessed and documented using the Gel Documentation System. The developed RT-MPCR method is rapid, sensitive and specific for the detection of *Salmonella enterica* serovars *S. typhimurium* and *S. enteritidis* in fish and fishery products.

HP-O 08

Functional properties of the bone and fin gelatin of grouper, *Epinephelus chlorostigma*

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Gelatin was extracted from fin and bone of grouper (*Epinephelus chlorostigma*) and their functional properties were compared for their suitability in food applications. The yield of gelatin from the bone was higher than fin with an average yield of 13.66 to 10.10%, respectively. The gelatin from bone had higher gel strength than the fin with 786.4 gf. The viscosity of bone gelatin was also higher with 18.5 cP as compared to fin gelatin (14.2 cP). On the other hand, foam forming ability (FA) and foam stability (FS) of the bone gelatin were slightly lower than the fin gelatin. But, the water holding capacity (WHC) and fat binding capacity (FBC) of the gelatin from bone were higher than the fin. The melting point of the bone gelatin was 2-3 °C higher than the fin gelatin while the



setting temperature was 1-2 °C lower. The nitrogen solubility index (NSI) of grouper gelatin was found to decrease with increasing pH. SDS PAGE pattern of bone and fin gelatin showed three distinct bands that correspond to α , β and γ chains of gelatin indicating partial denaturation of collagen. This study showed that the gelatin extraction method adopted was mild enough to retain the native structure of collagen by retaining the α , β and γ chains, substantiated further by their excellent functional properties. The gelatin from the fish bone had excellent functional properties than the fin, making them more suitable for food applications.

HP-O 09

Studies on biochemical composition and acceptability of pet food for dog, *Canis familiaris* from tuna processing waste

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Tuna and tuna based products are an internationally traded commodity. In the preparation of products in chilled, frozen and canned forms, large quantities of tuna waste is generated by the processing factories. Disposal of this waste causes many environmental problems. This solid waste in the form of head, skin, red meat and bones is rich in protein minerals, etc. and can be effectively utilized to make other products. The red meat generated from yellow fin tuna, during loin preparation and cutting waste during canning of skip jack tuna were used to develop pet food for dogs. The waste was incorporated at different proportions with cereal flour and extruded using a single screw extruder and cooked for 15 min. The cooked material was dried at 60 °C using an electrical drier till the moisture level reaches below 5%. The biochemical composition revealed that the pet food developed from tuna processing waste is highly nutritious and has good acceptability when fed to adult dog.

HP-O 10

Assessment of levels of bacterial contamination and safety of finfishes from retail markets of Kolkata, India

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The bacterial contamination and safety of finfishes of commercial importance and the frequency of antibiotic resistance in *Escherichia coli* isolated from fish collected from Kolkata retail markets were evaluated. The retail finfishes recorded high levels of total viable counts (log 4.30-7.93/g), coliforms (log MPN 1.60-4.38/g), faecal coliforms (log MPN d" 4.38/g) and *E. coli* (log MPN d" 4.04/g). Majority of the *E. coli* were resistant to oxytetracycline (73%) and exhibited multiple antibiotic resistance (52%). Mutation frequencies to oxytetracycline were quite higher (1.3×10^{-9} – 7.3×10^{-4}) compared to chloramphenicol (4.6×10^{-8} – 6.8×10^{-8}). Seven serotypes were recorded, of which O-type 95 was the most common. None was of O157 serotype, but shiga-like toxin-producing *E. coli* serotypes such as O2, O22 and O114 were recorded. The results revealed that most of the fishes, which were of great demand, did not meet the national and international quality standards and contaminated with antibiotic resistant and shiga-like toxin-producing *E. coli*. The prevalence of antibiotic resistant and shiga-like toxin producing *E. coli* in Kolkata retail fish may represent a health risk to the consumers.

HP-O 11

Studies on the quality parameters of Protein hydrolysate from the shell waste of Indian white prawn, *Fenneropenaeus indicus*

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Protein hydrolysate was prepared from the shell waste of Indian white prawn,



Fenneropenaeus indicus using bromelain enzyme under different treatment conditions. The samples were freeze dried and packed in airtight containers and analysed for the quality parameters. The yield, colour and biochemical quality parameters were assessed. The yield of hydrolysate varied between 3.8 to 5.1% depending on the concentration of the enzyme and the duration of hydrolysis. But the colour of the samples was almost similar. The protein content of the hydrolysate was found to be highest in samples hydrolysed for 90 minutes with 0.5% enzyme concentration (79.1%) which was not significantly different from the sample which was hydrolysed for 90 minutes with 0.25% enzyme concentration. The production of hydrolysate from prawn shell waste is a viable option for waste utilisation in seafood processing.

HP-O 12

Functional and antioxidative properties of Fish Protein Hydrolysate (FPH) produced from the frame meat of striped catfish, *Pangasius sutchi* using the alkaline protease alcalase

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Pangasius sutchi or striped catfish has gained importance as a very potential candidate for aquaculture in India. It is an abundant and underutilized resource that can be used as a unique protein source to make Fish Protein Hydrolysates (FPH). The objective of the present study was to prepare FPH from the frame meat of *Pangasius sutchi* using the alkaline protease alcalase at different enzyme-substrate concentrations of 0.5 % (v/w), 1.5% (v/w) and 2.5% (v/w) of the protein content of the substrate and to compare the yield, functional and antioxidative properties. Among the functional properties, foaming capacity, emulsification capacity, oil binding capacity and peptide solubility were studied. DPPH, reducing and

metal chelating ability study were carried out to assess the antioxidative property. Although the yield increased from 7.03% to 9.85%, the rate of increase in yield decreased with increase in enzyme concentration. With the increase in concentration of enzyme, there was increase in degree of hydrolysis from 7.64% at 0.5 % (v/w) to 20.03% at 2.5% (v/w) which correlated with increase in yield. The emulsification capacity, fat binding capacity and foaming capacity of the hydrolysates decreased with increase in degree of hydrolysis. Antioxidative property decreased with increase in degree of hydrolysis. The study proved that the protein hydrolysate produced from *Pangasius sutchi* is having excellent functional and antioxidative properties, and has potential uses as functional food ingredients.

HP-O 13

Freshness indicator for horse mackerel, *Megalaspis cordyla* stored under chilled conditions

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The present study aimed to develop a visible freshness indicator for horse mackerel stored under chilled conditions. Three indicators, bromocresol purple, bromocresol green and bromothymol blue impregnated on a sterile filter paper strips were placed on the interior side of the packaging tray containing fish steaks, without any physical contact between fish and indicator strip. The changes in the colour of the indicator strips at regular interval as well as changes in the quality attributes like biochemical, microbiological and sensory quality were monitored. Sensorily, the horse mackerel steaks retained its eating quality up to 8th day which is correlated well with the formation of total volatile base nitrogen (TVB-N) and trimethylamine nitrogen (TMA-N). Thiobarbituric acid value increased from an initial



value of 0.39 to 13.2 mg malonaldehyde kg⁻¹ whereas free fatty acid value increased from an initial value of 4.56 to 9.45% oleic acid, on 8th day of storage. pH value did not show any significant changes ($p < 0.05$) till 8th day which increased from an initial value of 6.51 to 6.75 on the day of sensory rejection. Histamine content did not exceed the rejection level of 5 mg 100 g⁻¹ specified by European Union, throughout the storage period. Total mesophilic bacterial counts showed an increasing trend with the storage period reaching 5.6×10^6 CFU/g on the day of sensory rejection from an initial value of 6.1×10^4 CFU/g. The counts of total psychrotrophic counts, *Pseudomonas* spp. and *Brochothrix thermospacta* also showed an increasing trend with the storage days. The indicator strips with bromothymol blue did not show any color changes with the storage days whereas strips with bromocresol purple and bromocresol green exhibited a change in the colour with the storage days indicating their possible applications as freshness indicators.

HP-O 14

Fish harvesting systems of Assam

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Based on an investigation carried on the fish harvesting systems operated in the water bodies of Assam, 113 types of fishing ways were identified. The frequency in the operation of gears varies in different seasons in relation to level of water, movement of fish and their migration. A number of age old traditional methods in the form of traps, fish aggregating devices, spears and stupefying devices like explosives, poisoning and electric fishing are also found seasonally in the rivers of Assam contributing to the total fish production and the economy of the local community. Catching methods in the Brahmaputra valley, on the whole, are dominated by labour intensive gears used on an individual basis, or by small groups; high efficiency

commercial gears are used by selected categories of fishers.

Seine nets form the major gear followed by gill nets, dragged gears, lift nets and traps in the river Brahmaputra. The floodplain (*bheel*) fishery in contrast was completely dependent on the natural stocking from the river Brahmaputra and its tributaries through a connecting channel. Fishing practices followed in the *bheel* depends on the species, size and season. Brush park (*katal*) fishing was observed as the major fishing practice in the *bheels* during October-January. During pre-monsoon and monsoon seasons, hook and lines, dip nets, gill nets and traps were important. The barrier fishing (*banas*) was predominant from August-October in the channels along with '*dheki jal*' in certain regions. In many instances, the same types of gear, with certain modifications, are used in different localities. Gill net, drag net and traps are some of the examples. Due to lack of uniformity and precision in construction of gears in different parts of the state, no two gears of the same type used at different places are exactly alike. Moreover, one type of fishing gear may have different names in different regions, and some of the gears are named after the names of the target fish species such as '*puthi langi jal*', '*ari phasi jal*', '*goroi langi jal*' '*bagar jal*' etc. The livelihoods systems of fishers associated with the river Brahmaputra and *bheels* are complex, diverse and intricately allied with many issues outside fisheries management systems.

HP-O 15

Standardization of processing and packaging technology and future prospects of Bombayduck

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Bombay duck (*Harpodon nehereus*) is a very important marine pelagic fish of north-west coast of India. The potential yield is estimated at 116,000 t and the landings during 2009 and



2010 were recorded at 112,000 and 110,000 t, respectively. About 90% of the catches of Bombay duck are from the states of Gujarat and Maharashtra and remaining is caught along the coasts of West Bengal, Orissa and Andhra Pradesh. The Important landing centers are Navabandar, Rajpara and Jaffrabad in Gujarat and sizeable quantity is caught along Mumbai waters. The major fishing gear used for harvesting the resource is Dolnet, which is a rectangular shaped bagnet, the mouth of which is fixed to the sea bottom using steel/GI pipes and the natural tidal flow of water is used for capture of Bombay duck. The Total length of a Dolnet varies from 50-80 m and the mesh size at the mouth ranges from 140-160 mm and the commonly used mesh size in the cod end ranges from 10-40 mm. Fresh Bombay duck contains about 90% moisture and 8% total protein with less than 1% of fat and minerals. Dried Bombay duck contains about 66% total protein with moderate amount of fats and minerals. Due to the high moisture content there are problems of storing the fish and hence fresh fish consumption is limited to the coastal areas. Sun drying on bamboo scaffolds is the traditional method of preservation along Gujarat and the dried fish is packed in gunny bags and sold to the traders. Red discoloration, contamination with soil and un-hygienic packing are some of the problems perceived which reduces the demand and hence the price of the product in the domestic market. Suitable interventions in drying, packing and value addition will make the product a big success both in the domestic and the international market.

HP-O 16

Scaling up of quality of dried anchovies, *Stolephorus indicus* with a eugenol based product

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Clove oil obtained by steam distillation of *Syzygium aromaticum* (Clove) has eugenol

as the major component. Eugenol has a broad spectrum of antibacterial activity against many gram positive and gram negative bacteria. In the present study the effect of treatment of clove oil on the quality parameters of dried anchovies was assessed. Dried anchovies were treated with 0.01%, 0.1% and 0.2% clove oil in ethanol (1:1 ratio) for 1 minute. Bacteriological quality parameters such as Total plate count (TPC), presence of *Streptococci* and *Enterobacteria* and biochemical quality parameter such as TVB-N and PV was studied for the untreated, control and treated samples. Dried anchovies treated with 0.1% ethanol were used as control to understand whether ethanol, the solvent of clove oil is having an impact on the bacterial load and biochemical qualities of the experimental sample. Marginal difference in TPC was noticed between the untreated (6.26×10^5 CFU/g), control (5.17×10^5 CFU/g) and the treated samples (5.57×10^5 CFU/g, 1.61×10^5 CFU/g and 1.6×10^5 CFU/g at 0.01%, 0.1% and 0.2% clove oil respectively). The *Streptococci* count also decreased only marginally in the treated samples (2.49×10^2 , 1.975×10^2 and 1.925×10^2 CFU/g respectively for 0.01%, 0.1% and 0.2% clove oil respectively) from the untreated (5.96×10^2 CFU/g) and control (3.099×10^2 CFU/g) samples. *Enterobacteriaceae* was not detected in untreated, control and treated samples. Further studies are envisaged to test the efficacy of clove oil at different and higher concentrations.

HP-O 17

Quality of salt cured ribbon fish, *Lepturacanthus savala* with special reference to control of staphylococcal load with chitosan

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Chitosan and its derivatives are known to exhibit antibacterial and antifungal



activities and because of this reason they are used as commercial disinfectants. In the present study bacteriological and biochemical quality of commercially available salt cured ribbon fish (*Lepturacanthus savaia*) was assessed prior to treatment with chitosan. The total volatile basic nitrogen (TVB-N) and peroxide value (PV) of salt cured ribbon fish was 93.09 mg/100 g and 4.54 meqO₂/kg, respectively. This indicates the biochemical quality of the product is within the acceptable limits. The sample contained a total bacterial load of 5.1×10^2 CFU/g.

In the second stage of experiments the chitosan powder was dissolved in acetic acid (1% chitosan in 2% acetic acid) and was incorporated at 1%, 2% and 3% concentrations to Baird Parker agar and plate count agar before plating to study the effect of chitosan on the growth of *Staphylococci*. The results showed that 64% of the staphylococcal isolates (n=17) showed sensitivity to chitosan at 2% and 3% concentration both by number and size of the colonies. The study shows that chitosan at 2% and 3% is effective in decreasing the staphylococcal load.

HP-O 18

Composite and nanocomposite fish gelatin films as packages for foods

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Fish gelatin prepared from the bones of red snapper (*Lutjanus campechanus*) and grouper (*Epinephelus chlorostigma*) was used for the formation of composite and nanocomposite films. Gelatin film (G) formation occurred well at 3% gelatin concentration using the cross linkers, sorbitol or glycerol added at 30% of the protein concentration. Composite films (GC) were prepared with the incorporation of 3% chitosan and nanocomposite films (GM) with the addition of 0.5% clay, montmorillonite (MMT) alone and with the combination of

chitosan (GMC). The thickness of the film ranged from 30-50 μ m and it increased with the addition of composites. Mechanical properties of the films examined showed that the tensile strength was higher in GMC films than GM and GC with the maximum of 49 MPa, as compared to simple gelatin films (G) having 6-8 MPa. The elongation at break (EAB) of the fish gelatin films were very high compared to animal gelatin with grouper fish gelatin films having the maximum of 170%. The water solubility reduced considerably in GMC and GC films to a maximum of 50%. The water vapour transmission rates (WVTR) of the gelatin films formed with MMT were lower with the minimum rate being 907 g/m²/24h/37 °C/90% RH. Micro structural observation by scanning electron microscopy showed that G and GM films had a smooth surface while the GC and GMC films had a rough surface due to the incorporation of the polysaccharide. The results thus showed that the GMC and GC films had good properties and shall be made as films for packaging fruits and vegetables.

HP-O 19

Role of gear selectivity in conservation of fishery resources with special reference to size selectivity of square mesh cod ends for *Saurida tumbil* (Bloch, 1795) and *Nebea maculata* (Bloch & Schneider, 1801) in Bay of Bengal

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Fishing Gear selectivity plays a vital role in the development of a sustainable and economically viable fishery. The results of selectivity experiments allow gear technologists to isolate the elements of gear or the harvesting procedures that permit the escapement of unwanted by-catch. Due to the use of conventional diamond mesh codends in the trawl nets, large quantities of juveniles of these



species are landed along the east coast of India. Selectivity studies i.e., the shape of the mesh affects the selectivity of codend. Studies were conducted on the exclusion and retention from 30 mm, 40 mm, and 50 mm square mesh codends. The paper also discusses the size selectivity of square mesh for *Saurida tumbil* and *Nebea maculata* along the east coast. The L25, L50 and L75 values for *Saurida tumbil* with 40 mm square mesh codend were 16.27, 19.3, and 22.5 while α and β values were 6.7 and 0.34, respectively. The selection range and selection factor for *Saurida tumbil* were 6.2 and 4.8 while the selection ratio was 1.56. Similarly L25, L50 and L75 values for *Nibea maculata* with 40 mm square mesh codend were in the order of 9.3, 10.9, and 12.5 while α and β values were 7.6 and 0.69, respectively. Selection range and selection factor for *Nibea maculata* were 3.16 and 2.74 and 2.7 however the selection ratio was found to be 0.79.

HP-O 20

An assessment of seafood processing waste from Gujarat

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Due to the aggressive expansion of fish processing sector in the recent years, the production of seafood products has increased. Seafood processing generates a lot of waste and its disposal is a serious environmental concern. In India, with its tropical and subtropical climate, the problem of decomposition process becomes more severe due to its high temperature and moisture content. The management of waste is an important issue. Gujarat is one of the leading seafood processing states with a capacity to process 14,877 t of seafood daily. A study was conducted to assess the solid waste generated from fish processing plants in Gujarat. Through stratified random sampling, 32 fish processing plants from Veraval and Mangrol were selected with plants stratified based on their installed

capacity. The monthwise production of seafood products was collected from these plants. Also, the stages at which waste gets generated were identified. Using structured schedules, the waste generated at each stage was recorded. Annually more than 1 lakh tonne of waste gets generated from Gujarat seafood processing sector. This paper presents the results of the analysis done and gives an annual estimate of waste generated for commercially important fish products.

HP-O 21

Shelf life of chill stored *Pangasianodon hypophthalmus* fish fillets: effect of vacuum and polyphosphate

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Pangasianodon hypophthalmus, commonly known as pangasius is internationally marketed in the form of frozen fillets. The annual production of *P. hypophthalmus* in Andhra Pradesh increased phenomenally and reached 5, 40,000 t in 2010 but most of the fish is marketed as whole fish in the internal markets. At present, the major crisis plaguing pangasius farming is the decrease of market price. Value addition for domestic markets in the form of fillets, fingers, cutlets and fish balls may be an alternative but the lack of proper cold chain facility (-18°C) in the domestic market is an impediment to market these products. The present study was taken up to determine the shelf life of pangasius fillets in chilled condition (<4 °C) in ice. The proximate composition showed that pangasius fillets are a good source of easily digestible protein (17.24%). Four batches of pangasius fish fillets were prepared. First batch (CC, chilled control) of pangasius fillets were packed individually in polythene pouches; second batch (VC, vacuum control) of pangasius fillets were vacuum packed in polythene pouches; third batch (CT, chilled treated) of pangasius fillets were soaked in chill



water solution (1% salt, 2% STPP) for 30 minutes and were packed in polythene pouches; fourth batch (VT, vacuum treated) of pangasius fillets were soaked in chill water solution containing 1% NaCl, 2% STPP for 30 minutes and vacuum packed in polythene pouches. All the pouches were stored under chilled condition (4 °C) in ice. The fillets were analyzed for chemical and microbiological parameters at regular intervals viz., 1, 3, 6, 9 and 12 days of storage. The phosphate content of CT (4410 ppm) and VT (4120 ppm) fillets at the end of 12 days of chilled storage was lower than the permissible limit of 5000 ppm. At the end of 12 days of chilled storage, the peroxide value was relatively higher in CC (4.8 meq/kg fat) than in CT (2.1 meq/kg fat), VC (1.5 meq/kg fat) and VT (1.5 meq/kg fat) fillets. TVBN was lower than 30 mg% in CC, CT, VC and VT fillets till 9 days of chilled storage and thereafter showed relatively rapid increase. The texture of treated fillets (CT and VT) was firm. The colour of vacuum packed fillets (VC and VT) was relatively darker. The total plate count of treated fillets (CT and VT) was lower than the corresponding control fillets (CC and VC) but the difference was always lower than 1 log value. The results indicate that pangasius fillets can be stored in chilled condition for a period of 9 days in chilled condition (<4°C) and soaking the fillets in 1% NaCl and 2% STPP chilled water would improve texture.

HP-O 22

Effect of processing treatments on the survival of white spot syndrome virus in farmed shrimps and bio-inoculation studies on WSSV

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The effect of processing treatments on the destruction of white spot syndrome virus (WSSV) in WSSV-infected farmed shrimps (*Penaeus monodon*) was investigated. The

presence of WSSV was tested by single step and nested PCR. The primers 1s5 & 1a16 and IK1 & IK2 were used in the single step PCR and primers IK1 & IK2 – IK3 & IK4 were used in the nested PCR. Various processing treatments such as icing, freezing, cooking, followed by slow freezing, cooking followed by quick freezing, canning, and cold storage were employed. The results indicated that icing, slow freezing, quick freezing, and cooking processes had no effect on the destruction of WSSV DNA. Canning and cooking followed by slow freezing process had some destructive effect on the WSSV DNA, as WSSV in such processed shrimp products was detected only by nested PCR. A gradual increase in the destruction of WSSV DNA was observed as the cold storage period increased. Cooking followed by quick freezing process could destruct the WSSV DNA. The frozen, frozen & cooked shrimps, that gave positive results for WSSV by PCR, was further confirmed for the viability of WSSV by the bio-inoculation studies. Mortality (100%) was observed within the 45 h and 123 h of intra-muscular post injection (PI) into the healthy live WSSV-free shrimps (*Penaeus monodon*), respectively. These results show that the WSSV survive the frozen and cooked processes; and infected cooked shrimp products may even pose a transmission risk for WSSV to the native shrimp farming systems. However, WSSV could be destroyed by the process of cooking followed by quick freezing and such combined process reduces the disease transmission risks from commodity shrimps to native shrimps.

HP-O 23

Effect of proteolytic enzymes on the textural quality of fresh and cook-chill stored green mussel meat

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Different techniques were used for tenderization of green mussel meat such



as papain, raw papaya latex, kokum salt extract, puncturing, kokum solution, vinegar solution and heat treatment. Raw and steam-shucked green mussel meat treated with different concentrations and durations of papain and raw papaya latex showed that there was no improvement in the textural quality of green mussel meat. The appearance scores of treated green mussel meat were lower due to disintegration of meat. There was no effect of puncturing and kokum salt extract on the texture of the meat. It was noticed that the punctured (Adductor Muscle (AM), Anterior Byssal Retractor Muscle (ABRM) and Posterior Byssal Retractor Muscle (PBRM) raw or steam – shucked green mussel meat treated in 10 DK (10 pieces of Dried Kokum – 9 g) kokum solution for 10 h followed by boiling in the dip kokum solution (10 minutes) had higher scores for all the attributes as compared to the other treatments. Green mussel meat treated with vinegar solution B (50:50) had other treatments. Green mussel meat treated with vinegar solution B (50:50) had better scores for all the attributes as compared to other concentrations of vinegar and control. Raw and steam – shucked green mussel meat was given a standardized kokum solution treatment i.e., 9 g dried kokum (10 pieces) per 100 ml water for as above and green mussel in curry was prepared and its shelf life was assessed. Raw and steam-shucked green mussel in curry product packed in trend pouches had a shelf life of 16 days at chilled temperature (0°C to 2°C).

HP-O 24

Role of fishing technology on sustainable fisheries development and conservation of resources

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Dynamic developments in harvest technologies and fish detection methods

along with uncontrolled expansion in fleet size have resulted in over fishing and negative impacts on the ecosystem. This highlighted the need for scientific management of the resources in order to ensure their long term sustainability and availability for future generations. Adoption of responsible fishing practices would ensure the long term sustainability of resources, minimise negative impact and protect biodiversity. Fishing technology plays a very important role in responsible fishing. The paper discusses diversifications in fishing practices, selective fishing gear practices, size selectivity and mesh size selectivity. Results of study highlight the need for developing and promoting selective fishing gears, by-catch reduction devices (BRD's), turtle excluder devices, square mesh codend, square mesh window, fish-eye and environmentally friendly fishing gears.

HP-O 25

A comparative study on the physico-chemical properties of gelatin extracted from the skin of rohu, *Labeo rohita* and yellowfin tuna, *Thunnus albacares*

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Gelatin, a commercially important polypeptide derived from collagen has wide applications in food and pharmaceutical industry. Gelatin extracted from the tropical fish species has an advantage over cold water species, the former having better rheological properties. In this study, the physico chemical properties of gelatin extracted from the skin of rohu (*L. rohita*) and yellow fin tuna (*T. albacares*) was studied. The results indicated that tuna skin gelatin was superior in terms of yield (15.86%) gel strength (310 B), viscosity (7.77 cP) and fat binding capacity (496%). However rohu skin gelatin was having better colour, higher melting temperature (28.13 °C), better foam formation



ability and foam stability. The amino acid composition showed a significantly higher content of glycine (34.2%) in tuna skin gelatin. The imino acid content of both gelatins were comparable. Although tuna gelatin had better gel strength, rohu skin gelatin is more suitable for food applications as it had better colour and sensory properties.

HP-O 26

Traditional fishing gears and methods of Uttarakhand Himalayas

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Uttarakhand in north-western Himalayas of India possess diverse fishing gears and methods including many common as well as traditional gears like cast nets, traps and hooks & long lines besides few destructive ones such as nets with small mesh size and use of bleaching powder, dynamiting, blasting, plant-based anesthetics or stupefiers and poisons. Though fishing in the region is small-scale and marginal in nature, both individual as well as group fishing like fishing festivals and fishing during nights are common. Fishing activity is more during off season of labour and agriculture activities or during the times of food scarcity. The prevailing fishing gears, their constructional details and catch composition are not adequately reported. Handheld, small shooting nets, traps with wide mouth (locally known as *godha* and *baadd*) and fishing during periods of intensive rainfall and floods are described for the first time. The fishing gears are made out of locally available materials such as wooden frame, bamboo splints, cane, nylon twine and indigenous craftsmanship. Almost all gears and methods have no species or size-selectivity but has season and location-specificity, catching majority of the fish species in rivers including various non-targeted small fish and endangered species like *Tor* sp. The main catches of most prevalent gears and

methods *per se* are not recommended in scientific principles. Low fishing cost and easy fish catch continue to tempt local people for frequent fishing and fish consumption in the region. Cost of illegal fishing gears and methods are often within reach of the people and socialized widely. As a result of easy availability of fish, its farming is not valued by local people and farmed fish had the least demand in the region. Since illegal and unscientific fishing are common and widespread, renewed corrective and regulative measures are essential to improve fisheries of the region.

HP-O 27

Optimization of process parameters for the production of chitin from prawn shell (*Metapenaeus dobsoni*)

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The present study was carried out with the objective to optimize the process parameters for the production of chitin from prawn (*Metapenaeus dobsoni*) shell by deproteinization and demineralization using simple linear regression. Four process variables each with three levels viz., alkali concentration (NaOH 2%, 3% and 4%), alkali treatment time (20, 30 and 40 min), acid concentration (HCl 1, 1.25 and 1.5N) and acid treatment time (75, 90 and 105 min) were considered for the study. Experimental data on two response variables viz., yield and ash were obtained from a total of 35 out of 81 experimental units and modeled as a function of process variables. The first order regression model fitted well to the experimental data with a significant R^2 value for both response variables. The regression coefficient (0.0265) of acid treatment time was found significant for chitin yield at 1% level of significance and other regression coefficients showed a non-significant increasing trend. The regression coefficients for ash content showed an increasing trend except for acid concentration which showed a non-significant decreasing



regression coefficient ($r=3.046$). The response variables were optimized using steepest ascent technique. The alkali concentration at 2% and treatment time at 30 min, acid concentration at 1N and treatment time at 90 min was found to be the optimum combination of process variables to maximize the chitin yield and to minimize the ash content.

HP-O 28

Studies on artisanal fishing (block net) in Kattumavadi coast at Palk Bay, southeast coast of Tamil Nadu

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Artisanal fishing methods contribute significantly to the economic growth of our country and provide protein source to rural community. In the present study artisanal fishing (block net) data was collected from the Kattumavadi coastal area of Palk Bay to check the profitability of the fishery to the local fishermen community. This method of fishing is highly suitable in Palk Bay region as this region is free from sea wind turbulence, wave and wind action. Moreover bottom soil is characterized by high silt, organic content and low depth. The catch data from block net fishery i.e., artisanal fishing was made in Kattumavadi coastal area of Pudukottai district, southeast coast of Tamil Nadu. In total, 60 days catch data were collected from randomly selected 4 to 6 block net out of 125 nets present in Kattumavadi coastal area. This method of fishing is alternative and fetches an additional income to the fisherfolk community by working 2 to 4 h more in the early morning. Every fisherman owns an average of 2 to 4 block nets, which reflect their socio-economic status. The average catch per net per day is approximately 6 - 15 kg of mixed catch. The major fish caught in the block net are *Loligo* sp., *Scylla serrata*, *Lagocephalus lagocephalus*, *Sepia*, *Hemiraphus far* etc. apart from the commercially important fishes, shrimps, *Hemiramphus* sp, *Lates calcarifer* etc.

HP-O 29

Nutritional composition and bio-chemical characteristics of Pacu, *Colossoma brachypomum*, an emerging freshwater fish species cultured in Andhra Pradesh

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Out of the total inland fish production of over 3.6 million metric tons, more than 60% is contributed by fish culture in ponds and reservoirs. The average productivity from ponds on the national level is around 2,500 kg/ha/year, though in Andhra Pradesh and Haryana it is more than 5,000 kg/ha/year. The Indian major carps are the widely cultured freshwater fish species in Andhra Pradesh. Pacu (*Colossoma brachypomum*), a native fish of South America has been recently introduced as an alien species into India via Bangladesh. Pacu were probably introduced in India in 2003 or 2004, and leading hatchery owners soon started culture in captivity to raise bloodstock for commercial breeding programmes. Pacu was introduced into the farming sector of Andhra Pradesh no more than five years ago. Pacu attains maturity at 3+ years in age with a stocking density of 2,000-2,500 individuals/ha. They are normally stocked at the ratio of 1 Pacu: 3 Indian major carps when polyculture is undertaken. At the fingerling stage, the fish possesses an alluring shining colour with a tint of blood red around the ventro-anterior region of the trunk. At maturity, the colour becomes more subdued with some round spots appearing throughout the body. The overall color is dark in nature with a shape similar to that of the marine fish, pomfret (*Pampus* spp). The characteristic pomfret-like shape is considered an attractive quality amongst fish consumers. Pacu have already established a place in the farming sector of West Bengal and a good number of freshwater hatcheries are likely to be converted into Pacu hatcheries in the near future. Cultured Pacu was collected from fish market in



Andhra Pradesh and subjected for various nutritional and biochemical analysis. The proximate composition constituents like moisture, protein, fat and ash were 75.17%, 18.56%, 4.95% and 1.29%, respectively. The mineral compositions were 1,177 mg% (K), 163.5mg% (Na), 66.18 mg% (Ca), 104 ppm (Fe), 1046.4 mg% (P). The lipid quality parameters such as free fatty acids and peroxide value account for 1.22% of oleic acid and 1.88 meq/kg of fat respectively. The freshness indicator parameter, TVBN was estimated as 14 mg%, the protein hydrolysis as indicated by α amino nitrogen was 64.19 mg%. The total plate count of fresh Pacu was 4.38×10^3 CFU/g. The sensory and organoleptic evaluations revealed that Pacu satisfies the outside attributes of 9 point hedonic scale methods. The results of nutritional composition show that Pacu is an excellent food fish.

HP-O 30

Analysis of the nutritive composition of wild and farmed tiger shrimp *Penaeus monodon* (Fabricius, 1798)

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The firm translucent flesh of raw shrimp is low in calories and saturated fat, and is a nutritious alternative to meat protein. People have been enjoying shrimp as a food since times immemorial. Shrimp is found throughout almost the entire world. Majority of the world's shrimp supply comes from India, United States, South and Central America, Japan, Thailand and Taiwan. The overall quality of the prawn is determined by its freshness which affects the chemical composition viz., the relative concentrations of essential compounds such as proteins, lipids and carbohydrates. The present study was undertaken to estimate and compare the nutritive value (moisture, protein, fat, carbohydrate, calcium, phosphorous, iron) of

peeled tails of wild and farmed shrimp, *Penaeus monodon* as there is a misnomer that farmed shrimp has high fat/cholesterol content compared to wild shrimp and also it is highly nutritious than farmed shrimp.

HP-O 31

Development of a new value added product "fish bakarvadi" using pink perch, *Nemipterus japonicus* meat

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Traditional bakarvadi is a vegetarian product that is very popular in the state of Rajasthan, Gujarat and Maharashtra. An attempt has been made in the present study to develop a new value added product i.e. 'fish bakarvadi using pink perch meat by both traditional and microwave cooking method. The shelf-life studies of both the products were also conducted at refrigerator temperature (0 to 2 °C) and at room temperature. The recipe for the preparation of fish bakarvadi was standardized and it was observed that fish bakarvadi prepared with 35% of bakarvadi masala, 16.66% of oil, and 30% moisture level had better scores with regard to texture, taste, appearance and overall acceptability. Before microwave cooking, moisture, crude protein, crude fat and ash content of fish bakarvadi were 78.08%, 11.6%, 18.69% and 1.9%, respectively and after microwave cooking, the proximate parameters were 69.77%, 12.6%, 18.75% and 1.9% respectively. On the contrary, the moisture, crude protein, crude fat and ash content of traditionally cooked fish bakarvadi before frying were 36.15%, 9.5%, 14.54% and 1.95% after frying were 28.6%, 10.1%, 27.18% and 1.95%, respectively. From the results, it was observed that fish bakarvadi prepared by microwave cooking method has better nutritive value and higher sensory scores as compared with traditionally prepared bakarvadi. From the



results of shelf life studies, it was observed that both traditionally prepared and microwave cooked bakervadi has shelf life up to 14 days at refrigerator temperature (0 to 2 °C) and 7 days at room temperature.

HP-O 32

Quality characteristics of cured fish of commerce in fish markets of Thoothukudi, Tamil Nadu

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A study was carried out to evaluate the quality characteristics of cured fish sold at the fish markets and curing yards in and around Thoothukudi. Totally, 35 samples consisting of seer fish, sardine, and anchovy were collected. Quality assessments like proximate composition, biochemical indices and microbiological parameters were estimated. Moisture and salt contents are the main factors contributing to the water activity that indicates the quality and shelf stability of cured fishes and they were higher in cured seer fish (49.83 ± 1.83 , $12.46 \pm 2.02\%$, respectively) followed by sardines (44.86 ± 5.83 , $7.86 \pm 2.44\%$, respectively) and anchovies (15.66 ± 4.38 , 2.26 ± 1.36 , respectively). TVBN and FFA are the indicators of protein and fat lysis. TVBN levels were higher in cured sardine and seer fish compared to cured anchovies while the FFA level was almost comparable in all the samples. The aerobic plate counts of seer fish (4.72 ± 1.32 log CFU/g), sardine (5.18 ± 2.34 log CFU/g) and anchovy (5.28 ± 1.01 log CFU/g) were found to be higher. The presumptive Staphylococci and presumptive *S. aureus* counts were found to be higher. Other human pathogenic bacteria such as *Salmonella* and *Vibrio* spp. were not detected but for one of the samples of cured sardine collected from a curing yard which contained *Salmonella*. No significant counts of fungi were apparent in the samples. The results showed that the market samples were of poor quality and are being handled,

stored and sold under unhygienic conditions. High moisture content in the samples could be a significant factor contributing to higher bacterial load.

HP-O 33

Comparative evaluation of *Lethrinus lentjan* fillets stored in flake ice and gel ice under chilled storage

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Effect of different icing viz., gel ice and flake ice in extending the shelf life of fish fillets (*Lethrinus lentjan*) was evaluated. Samples were taken at two days intervals for organoleptic, biochemical and microbiological analysis up to 16 days of storage. Based on t-test, the biochemical variables viz., pH, TMA, TVBN, TBA, FFA and PV showed a significant difference between two methods of icing at 5% level of significance during the storage period. Organoleptic scores for appearance, colour, odour, texture and overall acceptability were analyzed using nonparametric Mann-Whitney U-Test. The results revealed that there was no significant difference between two methods of icing at 5% level of significance during storage, but ($p=0.1$) significant difference noticed at 10% level of significance. Based on the biochemical and organoleptic analysis, it is inferred that gel icing was better than flake ice storage till 8 days. Simple linear regression model was fitted well (significant R^2 value) to the experimental data of both type of icing to quantify the rate of change which indicated a significant increase in the quality indices as the storage days increased. On the other hand, the rate of increase of biochemical quality indices was minimum for samples stored in flake ice. Exponential function model was fitted to the experimental data of total viable count (TVC) to estimate the change in bacterial load, which indicated that the bacterial growth rate was more for samples stored in gel ice compared to that in flake ice.



HP-O 34**Catching efficiency of Estuarine Winter Migratory Bag Net (EWMBN) operated along Hooghly–Matlah estuary, West Bengal**

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Hooghly–Matlah estuarine system in the state of West Bengal sustains world's important multi-species commercial fisheries. Winter migratory bag net is one of the most important artisanal fishing gears used for exploitation of the resources in stretches of the estuary. A study was carried out during 2009–10 to find out the current catching efficiency of this artisanal net. A total of 22 fishing trials were carried out in day time along the lower stretches of the estuary. Soaking period was fixed to 6 h for every experiment excluding the time of setting and hauling. After 6 h of hauling, the catch obtained was sorted out into finfish, shellfish and other by catch. Catching efficiency of the net was judged after testing the significant difference between the total catches by weight obtained in the net. Results revealed that the catch rate of existing estuarine winter migratory bag net had an average of 96.09 kg/haul. The average rate of by-catch was 27.13kg/haul. The percentage contribution of commercial groups of finfishes, shellfishes and by-catch were 56.06%, 17.93% and 26.01%, respectively. There was no significant difference found between the average catches obtained from the existing winter migratory bag net during the period of study at 5% level.

HP-O 35**Length frequency analysis of penaeid shrimps caught in newly designed demersal trawl (NDDT)**

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Penaeid shrimp resources worldwide were subjected to high intensity of fishing pressure and were being over exploited due to catching the undersized and juveniles by use of small meshes at cod end. A study was undertaken to determine the average sizes of penaeid shrimps at capture in newly designed demersal trawl (NDDT) with the large diamond meshes (150 mm) in forepart and square meshes (32 mm) at cod end. Fishing cruises were carried out randomly at depths between 24 - 34 m isobaths in the inshore waters of Mangalore coast. A total of twelve fishing experiments were made throughout the study and similarity in towing direction, towing duration, speed and depth of operation were maintained to minimize possible errors between the trawling operations. The penaeid shrimps were sorted out species wise from the catches obtained. The average catch per haul for each species as well as lengths of each species were estimated and compared with their size of maturity. The results revealed that newly designed NDDT with large diamond meshes (150 mm) in forepart and square meshes (32 mm) at codend caught larger size groups with less quantity of juveniles of *Metapenaens* sp. and *Parapenaeopsis* sp. The adoption of square meshes (32 mm) at cod end would be helpful for minimizing the juveniles of penaeid shrimps.

HP-O 36**Chemical composition and nutritive value of freshwater fish species, murels and catfishes: a comparative study**

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Airbreathing fishes and catfishes are considered as the most preferred and diversified species in aquaculture practices. Delicious taste, good odour and recuperative



properties of both types of fishes make them popular and unique among the consumers. Recent research mostly focus towards the fish consumption and its health benefits as fish is a good source of protein and polyunsaturated fatty acids (PUFA), which gives it a special place as compared to other food products. The health benefits of fish origin HUFAs, Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) are well documented. Three different cat fishes, *Ompok pabda*, *Wallago attu* and *Clarias gariepinus* and two different airbreathing fishes, *Channa striatus* and *Channa punctatus* were collected in a period of three months from May to July in five different samplings and pooled to five groups. The fillets were dissected from the fish, and analyzed for proximate composition following AOAC, 1998. Total lipids were extracted as per Folch's method (1957). Fatty acid methyl esters were prepared following Christie (1982) and analysed in Gas chromatograph. Moisture percentage of *C. gariepinus* fillet was found significantly lower and lipid percentage was significantly higher ($p < 0.05$) among the fish species. The fillet protein percentage of *C. striatus* was significantly higher among the different species. Between *C. punctatus* and *W. attu*, no significant difference was observed in the fillet protein content. Higher ash percentage was found in *C. punctatus* and lower in the case of *C. gariepinus*. It was observed that the fillet lipid percentage as well as energy content of airbreathing fishes was significantly lower than that of the catfishes studied. Saturated fatty acid (SFA) content of *C. punctatus* was significantly higher among the fishes and lower SFA was recorded in *C. gariepinus*. MUFA and n-6 PUFA were significantly higher in the fillet of *C. gariepinus* and no significant difference was observed in other four species. n-3 PUFA, EPA and DHA percentage of airbreathing fishes were found similar with that of *W. attu*. In lipid quality indices, Thrombogenicity Index (TI) and Atherogenicity Index (AI) were calculated. TI was found to be lower in *C. striatus* and AI was found lower in the case of *C. gariepinus*.

HP-O 37

Biochemical composition of the freshwater bivalve, *Parreysia corrugata* from Malthi River, tributary of River Tunga, in the Western Ghats of Karnataka

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The proximate composition (total glycogen, protein, total fat and ash) of *Parreysia corrugata* has been determined. The glycogen content was maximum (16.3 mg g^{-1}) during April-May. The average protein content was 7.37 mg g^{-1} . The fat content varied from 5.8 mg g^{-1} (January) to 7.8 mg g^{-1} (February). The ash content varied between 11.45 (May) and 24.5 mg g^{-1} (January). The fatty acid profile (percentage of total fatty acids) varied from 37.9 (May 2009) to 97.8% (February 2010). The minimum (January, May) and maximum (February) concentrations of total fatty acids in *P. corrugata* were 2% and 14% respectively. The PUFA content ranged from $1.759 \text{ (January 2009)}$ to 14.243% (February 2010) of total fatty acids. The maximum PUFA concentration (14.24% of total fatty acids) was recorded during February 2010 followed by January 2010 (8.41%) and March 2009 (7.27%). Omega fatty acids were analysed using GC and the micronutrients using AAS, and the results are discussed in the paper.

HP-O 38

Marine algal resources of India - their role in biotechnology, medicine and industry

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India with a vast coast line of about 8000 km supports a rich standing crop of marine algae wherever rocky or coral formations occur along the coast. The annual standing crop of marine algae of India is estimated at 2, 60,876 t. The algae are rich sources of minerals, trace elements (iodine and bromine), vitamins, proteins, carbohydrates, lipids, laminarin etc. The marine algae are also good source of organic constituents such as bioactive substances and polysaccharides and also they serve as raw material for biofuel production and liquid fertilizer.

The red algae such as *Gelidium*, *Gelidiella*, *Pterocladia*, and *Gracilaria* yield agar agar which is used as a culture medium for various microorganisms, as a thickener in food industry, in cosmetics, for clarifying beverages and in paper manufacture. Agarose, obtained by purification of agar is the most important medium in electrophoresis for estimation of the size of DNA molecules and in PCR product analysis. Red algae viz., *Hypnea*, *Kappaphycus*, *Acanthophora*, *Laurencia* etc. are rich sources of carrageenan. This is mainly used in frozen poultry industry, coffee industry, prawn feed, in tooth pastes, shampoo industry, air freshener gels and as a plant tissue culture medium. Algin extracted from brown algae like *Sargassum*, *Turbinaria*, *Hormophysa*, *Cystoseira* etc., is best used in the manufacture of antibiotics and insecticides owing to its property of being in suspension. Certain marine algae are rich source of mannitol, a sugar alcohol which is used as a diuretic and helps in excretion of some toxins. Many of the green, brown and red algae form part of the diet taken by people of South East Asia. In India, the red alga, *Gracilaria edulis* is eaten in certain coastal areas in Tamil Nadu as porridge. Some of the marine algae exhibit antimicrobial, antifungal, antiviral, diuretic, spasmolytic, hypertensive and antifertility properties. They are used in the treatment of goitre and as ichthyotoxic compounds. The other medicinal properties of marine algae are in combating tuberculosis,

cancer, influenza and in ulcer therapy and also as a laxative.

HP-O 39

Detection and quantification of shikimic acid from marine plants by biochemical method

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Shikimic acid is the principle precursor for the synthesis of aromatic amino acids, phenylalanine, tryptophan and tyrosine and other compounds such as alkaloids, phenolics and phenyl propanoids and used extensively as a chiral building block for the synthesis of a number of compounds in both pharmaceutical and cosmetic industries. In the recent past, the focus on shikimic acid has increased since it is the key precursor for the synthesis of Tamiflu, the only drug against avian flu caused by the H5N1 virus. In the present study, presence of shikimic acid in marine plants collected from Gulf of Mannar and Palk Bay was determined biochemically. Seaweeds such as *Grateloupia lithophila* (red algae), *Sargassum muticum* (brown alga), *Gracilaria edulis* (red alga), *Ulva reticulata* (green alga), *Sargassum tenerrimum* (brown alga), *Sargassum ilicifolium* (brown alga), *Sargassum turbinaria* (brown alga), *Gracilaria corticata* (red alga), *Padina gymnospora* (brown alga), *Ulva fasciata* (green alga), *Ulva lactuca* (green alga), *Ulva rigida* (green alga), *Turbinaria ornata* (brown alga); halophytes such as *Suaeda monoica* and *Salicornia virginica*; the seagrass, *Halodule wrightii* and the mangrove plant, *Avicennia marina* were screened for the presence of shikimic acid. Shikimic acid was detected in seaweeds, *G. lithophila* and *S. muticum* as well as in the halophyte *S. monoica*. Farming of these marine plants as an alternative livelihood for the fisher folk is discussed.



HP-O 40**Nutritional quality of golden mahseer, *Tor putitora* from coldwater Himalayan region with respect to size, season and geographic location**

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The present study aimed at evaluating the nutrient composition of the Himalayan mahseer (*Tor putitora*). Specimens were collected from the wild and also from production systems with respect to different seasons, geographical locations and size groups. Samples were subjected to analysis of proximate composition including minerals (Fe, Mn, Zn, Se, Na, K and Ca) and amino acid analysis. Higher protein level (17.29 g/100 g) was observed during breeding season. Mahseer of Kosi River had highest concentration of iron (1.28 mg/100 g) and moderate levels of manganese and zinc (0.16 and 1.19 mg/100 g). The fishes under the agro-climatic conditions of Kameng River had highest concentration of Selenium (1.56 mg/100 g). The major amino acids present were aspartic acid (7.61%), glutamic acid (9.63%), proline (6.68%), glycine (7.46%), leucine (7.59%) and lysine (9.41%). The findings revealed that the size, season and geographical location are prominent factors affecting the nutritional quality of the species.

HP-O 41**Effect of duration before de-skinning and lipid oxidation on yellow discoloration of Indian squid**

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The effects of lipid oxidation and duration before deskinning on yellow discolouration of squid were compared. Since chromatophores

present in the squid skin are responsible for natural yellow colour of the squids, an experiment was set up to study whether early deskinning can reduce yellow discoloration. Six lots of squids were held in ice and one lot each was deskinning on alternate days. One lot with skin served as control. The yellowness of the squids was measured using colour analyser in Hunter scale. It was observed that the yellowness significantly increased, when deskinning was delayed by 2 days. Measurement of fat oxidation product also indicated fat content has a strong correlation with the yellow discoloration. However, the rate of yellow discolouration of squid due to duration before deskinning was much higher compared to that due to lipid oxidation. Deskinning squid samples were treated with pro-oxidant and kept in iced storage for 10 days to understand the role of lipid oxidation in yellow discolouration. Sample treated with pro-oxidants showed higher TBARS and yellowness. But the yellowness was found to be less than the yellowness of samples held with skin. This indicated that in normal scenario, squids with skin on; have more chance of getting yellow discolouration.

HP-O 42**Evaluation of brown seaweed, *Sargassum tenerrimum* in fresh and powdered form for preparation of seaweed soup**RAKESH P. YADAV¹*, AMOD A. SALGAONKAR² AND TRIVESH S. MAYEKAR²¹College of Fisheries, Ratnagiri, Maharashtra, India²Central Institute of Fisheries Education, Versova, Mumbai – 400 061, Maharashtra, India

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The present study evaluated the brown seaweed *Sargassum tenerrimum* in fresh and powdered form for preparation of seaweed soup. Both types of soups prepared had corn flour (14%) as well as garlic and ginger (6%). For preparing fresh seaweed soup, different parts of the seaweed viz., whole *Sargassum* and leaf were used. Organoleptic evaluation of the soups indicated that soup prepared from *Sargassum* leaf was more acceptable. A storage study was also conducted for *Sargassum* powder used for preparation of the soup, and the results are discussed in the paper.



HP-P 01**Effect of pulsed light treatment on shelf-life of pearlspot, *Etroplus suratensis* stored at 2 ± 1°C**

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Pulsed light is a method of food preservation that involves the use of intense and short duration pulses of broad spectrum white light to inactivate microbial growth. In this study, an attempt was made to evaluate the effectiveness of pulses on pearl spot (skin-on-fillet). Pearl spot fillets were packed in 12 μ polyester and 300 gauge low-density polyethylene laminated pouches of size 14 x 18 cm. Pulsed light treatment was done for 12 sec using Xenon pulse light equipment with a total energy of 25 J/cm². The fish was then stored in chilled condition at 2±1 °C. Control and treated samples were analyzed at periodic intervals for biochemical (TBA, TMA, TVB-N, FFA, PV), microbial (Total plate count) and sensory parameters. The initial bacterial load of 5 x 10⁴ cfu/ml of the raw fillets got reduced to 2.2 x 10⁴ cfu/ml after pulsed light treatment. Microbiological and sensory parameters indicated that the treated samples were acceptable upto 18 days of storage whereas the control samples were rejected after 12 days. The chemical parameters indicated that the pulsed treated sample were superior to control samples. The storage study indicated a shelf life extension of 6 days for pulsed fillets when compared to control.

HP-P 02**Selectivity estimates of *Otolithes cuvieri* (Trewavas, 1974) in diamond and square mesh trawl cod ends**V. R. MADHU¹*, M. P. REMESAN¹, PUTHRA PRAVIN¹ AND B. MEENAKUMARI²¹Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri, Cochin- 628 029 Kerala, India² Division of Fisheries, Krishi Anusandhan Bhawan-II, NewDelhi – 12

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The knowledge of selectivity of fishing gears is vital for effective management and sustainable exploitation of fishery resources. Use of square mesh, which maintain its opening in codends, during towing are found to be very effective for improving selectivity. Although the Gujarat government has made 40 mm size square-mesh mandatory in the codends, the data on its selectivity estimates along the coast is limited. *Otolithes cuvieri* is one of the dominant species caught by trawlers along the northwest coast of India and this study attempts to derive the selectivity profile of diamond and square mesh trawl codends by experimental trawling using a 34 m High Opening Bottom Trawl (HOBT) for the species. Two codends of the same nominal size (40 mm) but with different mesh-shape configurations (viz., diamond and square shapes) were used for comparisons, using covered codend method. To account for the between-haul variation in parameters, the "stacked haul method", which accounts for the between-haul variation implicitly, by estimating replication estimate of dispersion (REP), was applied and the parameters were modified accordingly.

Escapement data from 8 hauls each, using diamond and square mesh codends were used for the analysis. The size selection curve for the diamond and the square mesh codends and the population retained and escaped from the codends were derived. The length at 50% retention (L_{50}) of *O. cuvieri* in diamond mesh codend was 13.19 (0.42) cm. The selection factor and the selection ratio for the diamond mesh codend were 3.48 and 0.43 respectively. In case of square mesh codend, the length at 50% retention (L_{50}) was 15.03 (0.32) cm and selection factor and the selection ratio were worked out as 3.76 and 0.34 respectively. Considering the length at first sexual maturity (LFM) of 256 mm for the species along the Gujarat waters and the selection factor, the optimum mesh size should be 73.6 mm and



68.1 mm respectively for the diamond and square mesh codends. This shows that the 40 mm square mesh, that is stipulated by the Gujarat government as mandatory is insufficient for conservation of *O. cuvieri* resource along Gujarat coast.

HP-P 03

Oral to digital – creating databases in indigenous technical knowledge in fish processing in Tripura

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Shidal (fermented *Puntius* sp.), Ghodak (fermented fish curry in bamboo), preparation of stinging cat fish in bamboo, *Paturi* (traditional fish preparation in banana leaf), *Lona Hilisha* (salted fermented *Hilisha* sp.) are some of hallmark indigenous technical knowledge in fish processing (ITKFP) in Tripura. The documentation of such unique, low cost knowledge systems was done with a view to, not only bring to attention the home-grown indigenous technical knowledge systems in fish processing of Tripura but also to digitally document these ITK's for future generations in the form of Internet accessible databases. ITKFP in Tripura has developed, over generations of communities, living in a particular geographical area. ITKFP like ITK's in other areas like agriculture provides evolved knowledge for problem solving strategies in fish preservation and processing for local communities. Against this background, this study was undertaken to document the ITKFPs in Tripura. Fish and fisheries is an integral part of the people of Tripura. Documentation of ITKFP was organised by interviewing the fishers of Tripura. Each ITKFP was documented in a specially developed manual record supplemented with appropriate diagrams. Subsequently these records have been digitised and will form the part of the digital repository of ITKFP and similar databases on the CIFE web site which will enable access to the information across the world. Preliminary evaluations of ex-ante gains arising from

knowledge preservation and knowledge use management are very encouraging. Most of the ITKs were found to be very much appropriate for further studies and validation. Such accessibility will enable the adoption of similar practices in other similar agro-ecological parts of the world.

HP-P 04

Jelly fish: An aquatic food product

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Jelly fish is abundant all along the Indian coast but the landings confining to specific seasons. In general jelly fishes are trapped in trawl fishing gears as by-catch and it is considered as a menace to the fishermen because it is difficult to remove from the net and it hardly fetches any price. However, jellyfish has been exploited commercially by Indians as an aquatic food for more than a hundred years and semi-dried jellyfish represent a multi-million dollar seafood business in Asia. Traditional processing methods involve a multiphase processing procedure using a mixture of salt (NaCl) and alum $[\text{AlK}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}]$ to reduce the water content, decrease the pH, and firm the texture. Processed jellyfish has a special crunchy and crispy texture. They are then desalted in water before preparing for consumption. Interest in utilizing *Stomolophus meleagris* (L. Agassiz), the cannon-ball jellyfish, from the U. S. as food has increased recently because of high consumer demand in Asia. The protein content of fresh and processed jellyfish observed in the present study is 0.24% and 11% respectively. The moisture content of fresh jellyfish was 96.21% and processed jellyfish was reduced to 66%; fat content of processed jellyfish increased marginally from 0.04% to 0.54%. Extensive variation was found in the sodium levels which ranged from 123 mg/100 g to 8760 mg/100 g whereas phosphorous values varied from not detectable level to 708 mg/100g in processed jellyfish. This study summarizes the efforts to process dehydrated chilled jelly fish



for the production of value-added products and also tremendous environmental and economic benefits.

HP-P 05

Studies on nutritional and biochemical quality evaluation of scampi *Macrobrachium rosenbergii*, a freshwater prawn of Visakhapatnam riverine systems

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The nutritional composition, biochemical and microbiological quality assessment of scampi prawn (*Macrobrachium rosenbergii*) was studied. Male and female shrimps were collected from the reservoir systems of Visakhapatnam. The results showed both protein and fat content were higher in the females (18.69% protein; 6.17% fat) when compared to males (17.8% protein; 2.70 % fat). The mineral contents viz., Na, K, Ca were 398.528 mg%, 1318.209 mg% and 173.82 mg%, in male shrimp respectively. In female it was (588.6 mg% of Na; 1208 mg% of K, 173.8 mg% of Ca. The freshness indicator parameter, TVBN for the male was 15.48 mg% whereas for the female it was 14.64 mg% which was in acceptable limit. The lipid quality parameters such as peroxide value (PV) and free fatty acids (FFA) were 12.077 meq/kg of fat, 37.35% of oleic acid in male prawn and in female prawn the PV and FFA were 9.375 meq/kg of fat and 28.005% of oleic acid, respectively. Both the male and female prawn had sulphite value of less than 10 ppm. The protein hydrolysis indicator such as α -amino nitrogen was 139.21 mg% for male and for female it was 135.97 mg%. The total plate counts were found within the acceptable limits in both males (4.3×10^2 CFU/g) and females (5.3×10^2 CFU/g). H_2S producing bacterial counts were marginally higher in males (1.2×10^3 CFU/g) than females (1.3×10^2 CFU/g). Fecal streptococci

enumerated 8×10^3 CFU/g and 9.7×10^3 CFU/g in males and females, respectively.

HP-P 06

Studies on preparation of fish sausage and its storage characteristics

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The fish sausages prepared from fish are generally less acceptable than pork, mutton and beef sausage due to its soft texture. The present work attempted to prepare fish sausage with improved texture and study its storage characteristics. Trials were carried out with different concentration of various ingredients to improve the texture. Twenty milli litre of water and 15 ml of oil per 100 g of minced meat was found to give acceptable flavour and coarse texture to the sausage. It was also found that incorporation of tapioca starch and guar gum at the rate of 7.5% and 0.2% respectively improved the texture of fish sausage. Vegetable oil substituted by animal fat (goat fat) at 50% level improved both texture and flavour considerably. The sausage was subjected to biochemical, bacteriological and organoleptic evaluation. It was found that the sausage was acceptable at ambient temperature (33 ± 2 °C) only for one day. At temperature of 12 ± 2 °C, the sausage was in prime condition for 10 days and acceptable for 14 days.

HP-P 07

Effects of twine material on the catch efficiency of drifting gillnets in river Brahmaputra

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Polyamide (PA) multifilament drift gillnets of 210/1/3, 210/2/3 and 210/3/3 and



polyamide monofilament with twine thickness 0.23 mm diameter was fabricated in order to study the effect of twine characteristics on fish catch efficiency in river Brahmaputra. All other technical parameters were kept constant. The catch per unit effort (kg/h) indicates that the PA monofilament net is significantly effective ($p < 0.05$) than multifilament nets which yielded 42.72 % of the total catch by weight. Further, it could be observed that twine size of PA (210/2/3) webbed for the drift gill nets have a considerable effect on the fishing efficiency among the three types of PA multifilament gill nets (210/1/3, 210/2/3 and 210/3/3) used in the study, contributing 26% of the total catch. Overall, PA monofilament gill nets were found to be 2.38 times, 1.63 times and 3.10 times more efficient when compared with the catching efficiency of PA multifilament. Fish groups categorized as catfish, major carps and minor carps expressed significant differences ($p < 0.05$) in their catch irrespective of the trial nets used during the experiment. Month wise, the value recorded for PA monofilament gill net had significantly ($p < 0.05$) higher catches by weight compared to PA multifilament gill nets (210/1/3, 210/2/3 and 210/3/3). Therefore the values recorded in the study clearly indicates that the characteristic of a netting twine can definitely affect the fishing efficiency and selectivity of gill nets operated in the Brahmaputra valley.

HP-P 08

Study on the traditional and indigenous fishing gears used by Kuramans, a tribal community in Wayanad district, North Kerala, India

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Plants and animals, from the natural environment was the basic food for humans from his past. Tribes residing in the various part of the world still use the traditional knowledge gained by them from their ancestors for the collection of wild and natural food. These techniques were usually simple and effective. It

is essential to make a database on the Traditional Knowledge (TK) of the tribes before these techniques are completely lost, by proper scientific study. Wayanad district, in the north-east of Kerala, India, (11. 27' to 15. 58' N and 75. 47' to 70. 27' E) has the largest population of aborigine people in Kerala and there are many indigenous tribes in this area. Fishes were found to be easily available major animal food source for them. *Paniyas*, *Kurumas*, *Adiyars*, *Kurichyas*, *Ooralis* and *Kattunaikkans* are the main tribal groups in Wayanad district. Among them, *Kurumans* shows more relation with fishing activities. The present study is an attempt to make out the various traditional fishing gears and its operation by the *Kuruman* tribes of Wayanad district. Scientific survey using questioners was conducted in the selected *Kuruma* colonies of Wayanad district. Traps and nets are found to be the common gears among them and there is no craft based fishery. Study also reveals that fishing has significant role in their tradition and important ceremony like marriage, death etc. This tribal group is aware about the conservation of fisheries resources and ecosystem.

HP-P 09

Size selectivity of diamond and square mesh cod-ends for large head cutlass fish, *Trichiurus lepturus* (Linnaeus, 1758) off Visakhapatnam coast

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Trawling is an efficient and popular fishing method to exploit fish and shrimp in large quantities, but trawling accounts for a high rate of by catch. Significant numbers of non-target organisms are captured and discarded in trawl fishery. FAO Code of Conduct for Responsible Fisheries (CCRF) has stressed to take appropriate measures to reduce discards to promote sustainability and conservation of fishery



resources. The method used to reduce the under sized fishes in this study is by using square mesh cod-ends to the regular demersal trawls. The size selection of otter trawl fitted with 40 mm diamond and square mesh codends for *Trichiurus lepturus* was studied along Visakhapatnam coast. Covered codend method was used to obtain the selectivity data. The L_{25} , L_{50} and L_{75} values for 40 mm square mesh cod-end were 30.75 cm, 36.2 cm and 41.65 cm respectively. The selection range, selection factor and selection ratio were 10.9 and 9.05 and 0.30 respectively. The L_{25} , L_{50} , L_{75} values for 40 mm diamond mesh codend were 25.96 cm, 33.4 cm and 40.95 cm respectively. The selection range, selection factor and selection ratio were 14.9, 8.39 & 0.44 respectively. The retention mean length in square mesh is greater than diamond mesh. The square mesh show efficient in eliminating juveniles than conventional diamond mesh codend. The size at first maturity of *T. lepturus* has been reported as 42.5 cm. It attains maximum size of 120 cm. The optimum mesh size for eliminating juvenile to sustain the *T. lepturus* fishery for 40 mm square mesh is 4.69 cm and for 40 mm diamond mesh is 5.06 cm.

HP-P 10

Evaluation of nutritive value of bivalve molluscs and crustaceans

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Bivalves such as *Anadara granosa* (Blood clam), *Perna viridis* (Brown mussel), *Perna indica* (Green mussel), crustaceans like *Oratosquilla nepa* (Matis shrimp), crabs namely *Portunus pelagicus*, (Reticulate crab), *Charybdis cruciata* (Cross crab), *Scylla serrata* (Green mud crab), *Portunus sanguinolentus* (Spotted crab) lobsters like *Panulirus homarus* (Green spiny lobster), *Panulirus polyphagus* (Banded spiny lobster) and almost all penaeid and non-penaeid prawns were reported from east-coast of India.

Blood clam, *Anadara granosa* collected from the Kakinada coast of Andhra Pradesh was screened for proximate composition. The moisture, protein and total lipid contents were 77.54%, 17.63% and 1.96%, respectively. The sample contained minerals phosphorus and iron at 413 mg% and 61 ppm levels. Green mussel (*Perna viridis*) of different sizes collected from the Bay of Bengal at Kakinada, Andhra Pradesh were analysed for microbiological and chemical parameters. The moisture, protein, fat and ash content of big sized *P. indica* were 78.5%, 17.1%, 3.06% and 7.93%, respectively. The sodium, potassium, and phosphorus content were higher in small sized *P. indica* (Na-2824 mg%, K-787 mg% and P-1019 mg%) than in large sized *P. indica* (Na-1594 mg%, K- 435 mg% and P- 910 mg%) whereas calcium and iron content were relatively higher in large sized *P. indica* (Ca-123 mg%, Fe- 232 mg%) than in small sized *P. indica* (Ca-79 mg% and Fe – 165 ppm). Histamine was not detected neither in small sized nor in large sized *P. indica*. The TVBN and PV values of large sized *P. indica* were 28.32 mg% and 2.46 meq/kg of fat, respectively. Freshwater snail (*Pila gracilis*) which is used for human consumption was collected from the paddy fields of East Godavari district, Andhra Pradesh. The moisture, protein, fat and ash content were 78.5%, 17.1%, 3.06% and 7.93%, respectively. Histamine was not detected. The TVBN and PV values were 35.52 mg% and 9.2 meq/kg of fat, respectively. Sodium, potassium, phosphorus and iron content were 506 mg%, 987 mg%, 865 mg% and 497 ppm respectively.

HP-P 11

Nutritional composition and quality evaluation of male and female black tiger shrimp, *Penaeus monodon*

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This study reveals the nutritional composition, biochemical and microbiological quality



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assessment of male and female black tiger shrimp (*Penaeus monodon*). The shrimp were collected from the commercial shrimp processing plant in Visakhapatnam. The protein content was relatively higher in male shrimp (21.56%) compared to the female shrimp (20.92%) whereas the lipid content was higher in the female shrimp (0.95%) than in the male shrimp (0.6%). The mineral contents like Na, K, and Ca were 436.2 mg%, 1255.78 mg% and 141.28 mg% respectively, in the male shrimp and mineral contents like Na, K, and Ca were 420.71 mg%, 1165.04 mg% and 172.94 mg% respectively in female shrimp. The freshness indicator parameter, TVBN was 16.34 mg% in the male shrimp and 11.96% in the female shrimp. The lipid quality parameters like peroxide value (PV) and free fatty acids (FFA) were 8.33 mili.eq/kg of fat, 11.75% of oleic acid were relatively higher in the male shrimp when compared to the female shrimp (PV 6.41 meq/kg of fat; FFA 11.30% of oleic acid). Sulphite was detected in both male and female shrimp but the level was 10 ppm, which was within the acceptable limit according to European norms. The protein hydrolysis indicator, alpha-amino nitrogen was higher in female shrimp (176.73 mg%) than in the male shrimp (147.76 mg%). Indole content of the shrimp was determined to assess the decomposition of shrimp. Shell-on, peeled shrimp of both the sexes were kept at room temperature and analyzed for indole at 2 h time intervals at the temperature range of 28 °C – 30 °C. The indole content of shell-on male shrimp increased from 0.29 µg% (0 h) and it increased to 3.2 µg% (24 h) whereas in female shell-on shrimp the indole content drastically increased from 0.3 µg% (0 h) to 12.84 µg% (24 h) which shows faster decomposition of female shrimp at room temperature. Interestingly, the indole formation was slower in peeled shrimps of both the sexes. The microbiological observations revealed that male had total plate count of 5.5×10^4 CFU/g where as female had 1.1×10^5 CFU/g which were in acceptable limit.

Study on quality upgradation of salt cured lesser sardines, *Sardinella gibbosa* with chitosan- a by product of prawn shell waste

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Chitosan and its derivatives have natural antibacterial or antifungal properties because of which it is commercially used as disinfectant. In the present study, the effect of treatment of chitosan on the quality parameters of dried sardine was assessed. Dried sardine was treated with 0.5%, 1% and 2% chitosan in 2% acetic acid for 5 minutes. Bacteriological quality parameters such as total plate count (TPC), presence of *Staphylococci*, *Streptococci* and *Enterobacteria* and biochemical quality parameters viz., TVB-N and PV were assessed for the untreated, control and treated samples. Dried sardine treated with 2% acetic acid was used as control to study the effect of acetic acid, the solvent of chitosan on the biochemical and bacteriological quality of the product. There was only marginal difference in TPC between the untreated (2.59×10^5 CFU/g), control (1.75×10^5 CFU/g) and the treated samples (1.75×10^5 CFU/g, 1.5×10^5 CFU/g and 1.5×10^5 CFU/g at 0.5%, 1% and 2% chitosan, respectively). Chitosan treatment showed an effect on *Streptococci* and *Staphylococci* growth as 5.7×10^2 CFU/g and 5×10^2 CFU/g respectively was found in untreated samples while none was detected in control and the treated samples. *Enterobacteria* were not detected in untreated, control and treated samples. The study showed that although the treatment with chitosan is marginal in reducing the total bacterial load in general, it had a positive effect in inhibiting the growth of *Streptococci* and *Staphylococci*.



HP-P 13**Development and comparison of extruded breadding with conventional bread crumbs coated on fish balls**

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Extrusion is a promising technology for the production of expanded snacks, pasta and other cereal based products. The use of this technology for production of crumbs as coating on fish balls were attempted in this study. Extruded breadding was prepared using two different flour combinations. The first one consisted of wheat flour (maida), rice flour and black gram powder and the second one with maida, corn flour and black gram powder. The flour mixture was extruded at 15% moisture level using a twin screw food extruder. The heater temperatures were maintained at 140, 90 and 45 °C in the three different compartments of the extruder. The feed rate was maintained at 200 g/min, screw speed at 350 rpm and the cutter speed at 670 rpm. The extrudate was powdered and sieved for uniform particle size. Both the extruded and conventional bread crumbs were coated on fish balls and packed separately in high impact polypropylene (HIPP) trays and top sealed with cast polypropylene (CPP) film under vacuum. The trays containing the fish balls were frozen in a blast freezer and maintained at -22 ± 2 °C for shelf life determination. Samples were drawn periodically and analysed for physical, sensory and biochemical parameters. Evaluation of the product for six months indicated that the extruded bread crumbs were comparable to conventional bread.

HP-P 14**Antibiotic resistance typing of *Escherichia coli* isolates from fisheries and clinical sources**A. SURENDRARAJ¹*, K. H. SABEENA FARVIN² AND NIRMALA THAMPURAN³¹Institute of Food and Dairy Technology, TANUVAS, Almathi P.O., Red Hills (Via), Chennai – 600 052, Tamil Nadu, India²National Institute of Food (DTU-Food), Technical University of Denmark, Lyngby, Denmark.³Retired Principal Scientist and Head, MFB Division, Central Institute of Fisheries Technology, Matsyapuri (PO), Cochin- 682 029, India

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Indiscriminate use of antibiotics in fish farming leads to the spread of antibiotic resistance among the bacteria of public health significance. A total of 64 nos. of *Escherichia coli* isolates from different sample sources which represents four broad groups viz., environmental non-pathogenic (27), environmental pathogenic (13), clinical non-pathogenic (18) and clinical pathogenic (6) were selected for the study. They were subjected to antibiotic resistance test against the 12 most commonly used antibiotics pertaining to aquaculture and clinical use. More than 85% of the isolates of environmental non-pathogenic *E. coli* were susceptible to 10 out of 12 antibiotics tested. All the isolates were resistant to Bacitracin and 50% of the isolates were intermediately sensitive for polymyxin B. The environmental non-pathogenic isolates were sensitive to only Nalidixic acid, Chlortetracyclin, Ampicillin, Nitrofurantoin and Trimethoprim. The antibiotic sensitivity pattern of *E. coli* isolates results revealed a source specific distinct pattern of resistance. Except isolates from prawn, feed; other environment isolates rarely showed resistance to more than one antibiotic tested and the MAR index was low. Except isolates from cow, all other clinical and veterinary source isolates showed higher level of resistance to eight antibiotics. Results indicated that source tracking of *E. coli* isolates based on multiple antibiotic resistances can be done.

HP-P 15**Biochemical and sensory qualities of iced rohu, *Labeo rohita* brought from outside Tripura vs un-iced local rohu of Tripura**

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The biochemical and sensory quality of *Labeo rohita* brought from other states and sold in local market (ROS) was compared with that of *L. rohita* locally produced in Tripura (RTR) over 6 month period (September to March, 2010). Results of biochemical analysis showed that total moisture content was significantly higher ($p<0.05$) in ROS than RTR. Total ash, protein and fat content were significantly higher

($p<0.05$) in RTR than ROS. pH was significantly higher ($p<0.05$) in ROS than RTR. TVBN concentration was significantly higher ($p<0.05$) in ROS than RTR, however, it was within the acceptable limit in both the cases. Peroxide value (PV) and free fatty acid (FFA) were not significantly different ($p>0.05$) in ROS and RTR. The results of sensory analysis showed that scores obtained by RTR was significantly higher ($p<0.05$) than ROS. However, it was within the acceptable limit in both the cases. The probable effect of icing on biochemical and sensory quality of fish is discussed.





Socio-economics, Marketing and Livelihood

SE- O : Oral presentation
SE- P : Poster presentation

SE-O 01**Economic valuation tools for conservation of fishery resources: an example of contingent valuation method application in economic valuation of mangroves**

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Economic valuation of natural resources acting as fishery base uses the principles of environmental economics for correcting market failures of free goods in nature. The present study focuses on the economic valuation of a mangrove ecosystem in Pichavaram, which is an important fishery resource for the 17 fishing hamlets neighbouring the Pichavaram mangroves. The objectives of the study were to analyse the fisherfolk's perceived role of mangroves on their livelihood, estimate the economic value of mangroves as a case study, and suggest policy measures needed for the conservation, management and development of mangroves. The Pichavaram mangroves have been in the lime light because of several scientific studies being carried out there and more so owing to the 2004 tsunami, where the mangroves have played an important role in protecting several villages. The required data were collected randomly from 41 experts and 120 villagers, making a total sample of 161. Information on the fisherfolk's perceived role of mangroves on their livelihood, and their views about the conservation, protection, management and development of mangroves were collected. The most important concern for protecting the mangroves was found to be strengthening of coastline against tsunami through mangrove plantation. The most important use of the Pichavaram mangroves as cited by both the experts and the villagers was services of mangrove through their ecological functions like protection against natural disasters; followed by contribution to fishery; and firewood collection.

The economic valuation of the Pichavaram mangroves was carried out based on the Willingness To Pay (WTP) of the respondents for the existence, development and sustainable utilization of the Pichavaram mangroves. About 59% of the expert respondents were willing to pay Rs. 913.42 per person per year, and 73% of the village respondents agreed to pay Rs. 564.46 per family per year. The overall value of the Pichavaram mangroves estimated through contingent valuation method was Rs. 1, 05,185. The respondents who were not willing to pay cited measures like it is only the Government's duty to pay; it is the job of NGOs and users, and some villagers could not afford to pay. This study showcased the fact that the Pichavaram mangroves play a great role which provides invisible economic investments in the form of reduction of life loss from natural disasters; an incredible base for fishery resources; and an important support for livelihood of fisherfolk. This indicative value is important for consideration in the country's economic planning for investing in protecting natural fishery resources on the part of the Government and other stakeholders in the wake of global agendas for protecting environmental resources, and also for mitigating climate change impacts.

SE-O 02**An assessment of literacy, income and health status of fishers in floodplain wetlands of Assam**

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Fisheries sector is one of the unorganized sectors of the country. The information on the socio-economic condition of fishermen/fish farmers is practically not available and wherever available, their reliability is questioned. Planners and policy makers can make plans and policies for the weaker section only if the estimates are



available on regular basis and in reliable manner. The present study was conducted in 2010 to have rapid estimates of socio-economic indicators for literacy, health and income for the floodplain wetlands (locally known as beel) fishers. A sample of fifty households from three districts of Assam was surveyed for assessing the literacy and income status of fishers of floodplain wetlands. The data was collected on a well structured questionnaire using personal interview method. The results indicated that, out of the total population of the 263 respondent households selected, 58 percent are male members and 42 percent female members. The average male: female ratio of respondent household at the state level is 0.86 with average family size of 5.26 members. Age composition analysis revealed that 67 percent of them are adults and 33 percent of children. Adult-children ratio in Nagaon, Barpeta and Morigaon districts were 52:48, 82:18 and 65:35 respectively. About 25 percent members of the selected household are illiterate. 21.57, 50.20 and 2.90 percent of the fisher household members have passed primary, secondary and collegiate level respectively. The literacy rate of the sampled beel fishers stood at 75 percent, which is better than the literacy rate of Assam (73.18) and India (74.04) as per the new census of 2011.

According to the field data collected, all the children of the beel fishers household have been covered against six preventable diseases, namely, diphtheria, pertusis, childhood tuberculosis, poliomyelitis, measles and neonatal tetanus. The vaccination schedule of the primary health centres has been perfectly followed by the villagers and no report of discontinuation was reported. Primary health centre is 4.16, 3 and 4 km away from the household to the primary health centre of Nagaon, Barpeta and Morigaon districts. The weekly income profile of the beel fishers shows that the 74 percent of the income was derived from fishery profession. The income from fisheries is the highest from the beel of Morigaon, at Rs. 2322 (89 percent) followed by Barpeta with Rs. 1070 (58.23) and Nagon

with Rs. 945.83 (66.76). The weekly expenditure of the fisher family of Nagon, Morigaon and Barpeta were Rs. 1000, 1184 and 1911 respectively. Food expenditure was the highest for the beel fisher family and at the state level the average for the same was Rs.1031.59 i.e., 73.58 percent of the total expenditure. The average savings per household of Nagaon, Barpeta and Morigaon was Rs. 416,652 and 700 respectively. The problems of the fish farmers are diverse, which should be addressed through a holistic approach to have a sustainable development of this poor rural community.

SE-O 03

Coastal Regulation Zone and fishing community in Mumbai

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The Coastal Regulation Zone (CRZ) Notification of 1991 was made under the provisions of the Environment Protection Act, 1986 with the purpose of preserving the coastal environment, and in particular, the ecologically fragile areas, by regulating use all along the coastal areas. Among one of the nine coastal states in India, Maharashtra has 720 km of coastal area in "Konkan region". During 1997 - 2009, fish production of Maharashtra was 3,60,000 tonnes, which was 13.49 percent of the national output. However, due to the rapid expansion of commercial (trawler) fishing over the last two decades, catch for smaller fishers is rapidly declining. Being an important source of livelihood for millions of fisherfolk in the state, the implications of urbanization, infrastructure projects, and environmental regulations need urgent research. To focus the above issues, the study was undertaken in Mumbai Metropolitan Region (MMR) which is the largest coastal city in India. The areas covered include: (i) Cuffe Parade, and Kulaba (ii) Mahulgaon and (iii) Mahim and Bandra. The high population



density and uneven growth rate in the region has resulted in environmental as well as socio-economic problems due to unplanned and non-integrated coastal developmental activities over the years. The aboriginal Koli (fishing community) in this region which is facing huge problems in the small-scale fishing sector, due to the rampant commercial fishing by big trawlers and large scale dumping of waste material by private firms into the sea, which has severely hampered fishing activity. On the other hand, some coastal areas have become restricted areas for fishing because of CRZ rules.

The present study reveals the impacts of CRZ regulations on small scale and artisanal fishing in the Mumbai coastal region on the basis of primary field research. The paper covered the issues like the changes in fishing livelihood due to the new CRZ rules of 2011 and ways in which environmental regulations affect small scale fishing. The information like aspects of fishing (jetties, parking of boats, access to sea, weaving and drying of nets, landing grounds, drying and cleaning of fish) got affected the most was also collected. The paper attempts to understand the social and livelihood security of fishing community in the context of CRZ rules and changes in the rules. In the process, the study critically reviews the 1991 Notification as well as the implications of 29 amendments to the rules and regulations. The stand of the National Fisher Forum against the 2010 and 2011 Notification is also evaluated.

SE-O 04

Innovative ICT advisory service for farmers for accelerating fisheries development

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Fisheries is the mainstay for many fishers and coastal small farmers, and fisheries produce form an important component of our

country's exports. However, farmers face persistent problems of low yield/production and income fluctuations due to devastating disease outbreaks. The enormous demand for knowledge and information to better farm management practices can never be met through traditional methods, which are propagated slowly and limited in coverage. Extension surveys conducted by Central Institute of Brackishwater Aquaculture (CIBA) have revealed that farmers have a very limited access to technical information from public funded research institutions. Number of extension personnels engaged in the field of fisheries is inadequate to meet the clientele's information needs. Further, even the available extension personnel may not be able to reach backward/remote areas due to lack of proper transport connectivity or due to budgetary constraints which may restrict the staff movement. Low frequency of fisher/farmer and extension meetings may also be due to multiplicity of administrative works that the staff of fisheries department are entrusted with. In this context, the latest developments in the Information and Communication Technology (ICT) can play a major role in fast and effective information exchange in Indian fisheries sector.

In addition to helping and educating small farmers, ICT will bring about an overall qualitative improvement in their life by providing timely and quality information inputs for decision making which will help to improve the efficiency and productivity of fisheries and their allied activities. Among these initiatives of ICT in the fisheries sector, the mobile phone ranks first in the application of disseminating information and knowledge to farmers. Three mobile technology based models such as Fisher Friend Mobile Application (MSSRF), MobiAqua (AA.Biotech), Krishi Vigyan Kendra, Kattupakkam mobile model were evaluated for their strengths and weaknesses. Based on the understanding gained from these models, CIBA proposed a pilot project, to disseminate information related to coastal aquaculture through text messages/VMS to aqua/fish farmers. The focus area was



identified as Tamil Nadu state, wherein about 300 farmers will be covered under this service. It is proposed to deliver at least two messages per week. This exercise will be continued and concurrently evaluated for a year and based on the feed back, the area coverage and information coverage will be expanded. CIBA provides voice mail services in the form of recorded messages. This service is provided to all farmers irrespective of telecom network. This service is highly recommended and accepted since it removes the language barrier and also adds a personal touch to the communication. Presently this service will be available only to respondents' of pilot study. This service can be availed at free of cost. There are several new voice based services and short message services which will be made available to the extension officers/farmers/farm women in the near future. Weather advisory, technologies/news, training programmes and market information are provided through this platform. The challenges of low literacy, poor infrastructure, climate changes, and disease outbreaks may drive needs for more information in the form of short messages/voice messages. A comprehensive model is needed to address the limitations of the existing methods by offering a holistic one stop-shop information service on a single fisheries platform and to include the feedback from farmers.

SE-O 05

Fishers of estuarine ecosystem of India: An assessment of socio-economic status

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The estuarine waters in India with an expanse of about 2.6 million ha contribute immensely

to the livelihood of local fisher community and fish production in the region. The fisher community in different estuaries of the country is characterized by poor family income, low level of literacy and unhygienic living conditions. The investigations on their socio-economic status of this community are very rare and critical for formulation of appropriate plan and policy for their development. With this backdrop, the present communication is devoted to assess their literacy, health income and expenditure profile. The primary data was collected from estuarine fisher households from the states of Gujarat, Kerala, Orissa, Tamil Nadu and West Bengal. The study period was July 2010 to March 2011. The average size of family was 4.56 with majority of them (52.55%) with 2 – 4 members. The male – female ratio (1.14) was less than the national average. The general literacy rate of the community was 81.76% with most of them left studies after primary education level (54.97%). This was due to their very poor economic condition. The average distance to educational institutions from their villages was 1.65 km for primary school, 3.66 km for high school, 9.38 km for college and 16.19 km for professional college. The average mortality for pregnant mothers and infants during delivery was 1.5% and 4%, respectively. The most frequent disease among adults was body ache among males (2.12 times/year) and fever among females (1.58 times/year). The average monthly income was estimated at Rs. 4834 with the minimum for Orissa (Rs. 2485), although, the percentage contribution of fisheries was maximum in the state. It is far below the Indian average per capita income. Hence, there is immense need to provide alternate income sources to ensure better income and standard of living. The average monthly expenditure was worked out to be Rs. 3893 per month. Food was the major component of expenditure (54.19%).

Mass awareness campaigns on importance of sanitation, hygiene and education may be conducted to improve their living conditions. They should be assured of basic amenities of



drinking water, toilets, drainage, health care system, etc. to have healthy environment for existence. Training on homestead/alternate income enterprises should be provided to them in general and women in particular to uplift their employment and income level. Further, training on self-help group formation, popularization of government developmental schemes are some of the steps to uplift this one of the poorest community of the society.

SE-O 06

Socio-economic and gender analysis in aquaculture - 'SEAGA' an analytical approach

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Women in coastal areas play an indispensable role in fishery sector by taking part in various activities both in capture and culture fisheries. Although women have proved to be competent in adopting new aquaculture technologies, their role is very much restricted and often ignored. One of the major reasons is the location of aquaculture sites and several socio-cultural taboos against women who strive to have a viable livelihood to support their family's subsistence in rural areas. There has been a recent interest on the role of women in aquaculture, and several studies have examined the ways in which women are involved in aquaculture. However, the question of how aquaculture influences the status of women and gender relations in the households and community, and how in turn these relationships affect the effectiveness of aquaculture in improving livelihood and elimination of poverty have not been properly addressed. In aquaculture, Socio-Economic and Gender Analysis (SEAGA) can be used as a tool to understand community dynamics, including the

linkages among social, economic and environmental variables.

A sample of all sections of the community members (both men and women, young and old), women self help group beneficiaries with a mix of socio-economic groups from the selected coastal villages of Tiruvallur and Kancheepuram districts of Tamil Nadu were selected for this analysis. Three different tool kits, namely development context, livelihood analysis and stakeholders' priorities for development under SEAGA were used. This has helped in understanding the farming systems, alternative livelihoods, income levels, various religion, community types, social events, environmental issues, institutional linkages and in identification of priority problems for both men and women. The salient findings of the study are: migration of men to cities has led to a greater shouldering of responsibilities by women to meet the family expenditure; brackishwater aquaculture technologies transferred to the coastal population has enhanced their earning capacities; formation of WSHGs was encouraged by men in view of the benefits available through government welfare schemes; women members belonging to the SHGs had a greater share in decision regarding generations and spending of money; and NGOs played a major role in creating linkages between WSHG with research institutions, bankers and state government departments and also facilitated community development activities. The use of SEAGA model helped to identify the priority problem of women as lack of sustainable livelihoods and one potential solution that emerged from the analysis is diversification of livelihoods through the adoption of brackishwater aquaculture technologies with adequate linkages to government and private institutions, NGOs, banks, research organization support and community support. The SEAGA model used in the present study could be applied for analysis and identification of a development model for rural coastal populations in other parts of the country.



SE-O 07**Discriminant function analysis of boat builders of Pulicat estuary and the cognitive and socio-economic predictors of their livelihood status**

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The present study deals with the cognitive and socio-economic predictors, influencing the livelihood status of the traditional boat building fisherfolk of Jamilabad fishing village of Pazhaverkaadu (Pulicat) in Tamil Nadu. Out of the 52 fishing villages in Pazhaverkaadu, 17 fishing villages are marine. Over centuries, fisherfolk have evolved various alternative livelihood strategies and ancillary income earning avenues in addition to fishing in order to enhance their socio-economic status. The fishing village of Jamilabad in Pulicat is one such village wherein, fishermen, apart from earning their livelihood through capture fisheries, have also taken up boat building as their ancillary occupation. A discriminant function model was applied on 39 boat building marine fishermen from the predominantly lake fishing village of Jamilabad, in order to analyse the relative importance of the 14 profile characteristics in discriminating between high and low groups of livelihood status of the boat builders. An ex-post- facto research design was used for the study. The results of the study revealed that variables such as annual income, scientific orientation, annual expenditure incurred, annual savings and annual debt incurred were the principal factors which showed a significant positive influence in differentiating the high level of livelihood status from the low level of livelihood status of these boat building fishermen. Individual respondents who have scored high on these variables have differentiated more significantly between high and low level of livelihood status, whereas variables such as education, age, risk orientation

and credit orientation had a significant and negative influence in differentiating high and low groups of livelihood status. The respondents who scored high in these variables have differentiated less between high and low livelihood status. The canonical correlation of 0.85 indicated that the function discriminated adequately. The overall predictive accuracy of the discriminant function or "hit ratio" was 92.3%.

SE-O 08**Socio-economic condition of families involved in dryfish trade in coastal districts of Odisha**

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Odisha is one of the nine coastal states of India that has a coastline of about 480 km, spread across six coastal districts, constituting approximately 8% of Indian coastline. It has a continental shelf area of 24,000 km that is open for fishing. Out of 1.3 lakh metric tonnes of marine catch produced annually, about 20% are processed for drying and curing. Women play a vital role in post-harvest activities like drying and curing. The study was conducted in five coastal districts of Odisha viz., Puri, Baleswar, Kendrapara Jagatsinghpur and Ganjam. According to the survey, the fisherwomen in the area not only work for fish trade but also work as daily wage labourers whenever work is available. Lean fishing periods are extending in the region to nearly six months in a year. During lean season, men go for fishing occasionally. Women, on the other hand, work in the agriculture sector during transplanting and harvesting of paddy, peeling of shrimps in various export companies and in construction work. However work is not available round the year. Non-fishing activities were generally less than 3 months in all the villages. In all the villages, women were involved in shrimp seed collection in the absence of any



other alternative income generation activity, to ensure the survival of their families. Unhygienic living environment, extreme poverty, lack of safe drinking water and over-work put the fisherwomen at disadvantageous position.

During the fishery season, the woman, on an average spent about 7.43 hours in fishery activities like purchasing, grading, washing, drying and packaging. On an average, the woman contributes about 27% of the family income. However, there are families where the share of woman's income is as high as 90-100%. About 29% fisherwomen respondents contribute in the range of 30-40% and about 25% women contribute more than 50% of the their family income. Primary data socio-economic problems of fisherwomen have been collected from 611 fisherwomen of 18 marine fishing villages of the region. The average family size of the marine fisherwomen respondents was 5. The fisherwomen were Oriya, Bengoli and mostly Telugu speaking with almost no education, and most of them had practiced child-marriage. They live in very unhygienic condition, mostly on government land. The infrastructural facilities available in the villages were very poor. The fishing capital of the households comprises of boats and nets, which was their own and also on others share basis. The fishing technology, which was traditional, is changing fast with the modernised efforts of the aliens in their land and sea. Several problems of hardships of the fisherwomen were identified which need considerable intervention from government and NGOs and other organisations for their sustainable livelihood.

SE-O 09

Upscaling of livelihood in flood prone areas of north Bihar by Makhana - Fish - Water chestnut based integrated aquaculture farming system

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North Bihar has the global monopoly for cultivation, processing and export of Makhana (*Euryale ferox*, Salisb), a monotypic genus belonging to the family Nymphaeaceae. It is an emergent floating macrophyte commercially grown in the littoral parts of the floodplain wetlands of north Bihar. It is naturally and organically grown nutritious dry food and contains 76.9% carbohydrate, 9.7% protein, 0.1% fat, 12.8% moisture, 20 mg/100 g calcium, 90 mg/100 g phosphorus and 1400 mg/100 g iron. The water chestnut (*Trapa natans* L. var. *bispinosa* Roxb.) is equally popular among the fishermen and also grown abundantly in the eutrophic, stagnant freshwater bodies. Its fruit mainly contains carbohydrate 65-75 %, protein 13.4 %, fat 0.8%, minerals 3.1 %, phosphorus 0.44 % and iron 0.0024 % on dry weight basis. These aquaphytes are cultivated as a cash crop and provides nutritional and livelihood security to a sizeable section of the populace involved in aquaculture operations.

ICAR-Research Complex for Eastern Region, Research Centre for Makhana, Darbhanga has developed the technologies of integrated farming system of Makhana with fish and water chestnut can be carried out round the year to ensure higher income per unit area. During 2010-11, under the NAIP Scheme in Darbhanga Sadar Block, integration of fish with aquatic commercial crops i.e., Makhana as a primary crop and water chestnut was undertaken. The average net profit recorded with makhana seed was Rs. 22,660/ha with a benefit cost ratio of 1.62 and per kilogram profitability of Rs. 14.75, respectively. The fish as a secondary crop integrated in Makhana ponds showed total fish production of 49.56 q in an area of 18.52 ha with average productivity of 2.67q/ha. The total income with fish was recorded at Rs. 5,39,975 and the total cost of fish production was found to be of Rs. 2,51,785 and per hectare cost of fish production was recorded at Rs. 13,597/ha. Whereas, the water chestnut tried in an area of 4.1 ha taken as a tertiary crop gave total water chestnut production



of 120.55 q with an average water chestnut productivity of 29.75 q/ha. The total income with water chestnut was found to be of Rs. 1, 23,350. The total cost of water chestnut production was recorded at Rs. 40,170. The average cost of water chestnut production was recorded as Rs. 9,916/ha. The per kilogram cost of water chestnut production was found to be of Rs. 3.33/kg and generated an additional net income of Rs. 83,180 with an employment generation of 330 man days/year and 80 man days/ha/year. The technology of Makhana-Fish-Water chestnut based integrated aquaculture farming system has been scaled up for the benefit of large population of fisherman community growing Makhana in flood prone ecosystem of north Bihar.

SE-O 10

Assessment of socio-economic status of reservoir fisher community in India

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Fisheries is one of the important sectors of our economy, which contributes significantly to livelihood and food security of economically poor, under-privileged rural populace in general and fisher community in particular. During past few plans, fisheries registered one of the highest growth rate among agriculture and allied activities. It also noticed one of the highest growth rates for exports. However, this sector is highly unorganized and information on social, economic, and institutional issues of fishing community is scarce. This impedes the policy makers and planners to formulate appropriate policy and programmes for the development

of this poorest community of society. Considering these facts, the present investigation was undertaken to document their demographic pattern, literacy rate and health and economic standards. The reservoirs are recognised as the most potential waters for fisheries development and much emphasis has been given during last few plans to develop their fisheries. Therefore, fisher community operating in reservoirs was selected for the study. Information was collected from 363 fishers of seven Indian states having reservoir fisheries resources. The result indicated average family size as 4.25 with 1.07 males per female and 1.69 adults per child. The literacy rate was 63.32% compared to 74.52% at national level. The dropouts were more at secondary level of education (57.75%). The vaccination regime of infants was followed in most of the states as per the recommendations of ICMR. Although, the major occupation of most of the fishers was fishing, 46% of them were also engaged in non fishing activities like labour, business, agriculture and other services. The average monthly income for the fishers was estimated at Rs. 1908, while the monthly expenditure was estimated at Rs. 1473. The major share of which was for food. These estimates are very low to sustain life of the fisher household. Further complexities in fishers' life are diverse. Therefore, it is emergent to prepare a holistic approach and fisheries development programmes to uplift this downtrodden community.

SE-O 11

Technology intervention at grassroot level for improved livelihood through value addition of low value fishes

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The study deals with the fisheries technology intervention models carried out by TIFAC for improving the livelihoods at grassroot levels. Under its Agro-Food Processing Programme of



Technology Vision 2020 for India, TIFAC has been playing a significant role in promoting and supporting adoption, diffusion and dissemination of technologies in fisheries sector. Women in fishing communities have low levels of education, lack of access to and control over productive assets as well as lack of investment and working capital. Value-addition is one unique technique by which profitability in fish processing could be enhanced and optimal utilization of valuable natural resources could also be ensured. Hence, TIFAC provided different innovative technology packages on production of value-added fish products from low value fishes to women cooperative societies and self-help groups; comprising of capacity building, partial financial assistance for development of micro-enterprise and to generate sustainable livelihoods.

TIFAC demonstrated three intervention models involving technology transfer for production of value-added fish products by fisherwomen. In the first model, fisherwomen were organized to form a cooperative society and further supported to establish a cottage level fish processing industry through technology partner. In the second model, existing women cooperatives were empowered and assisted in adoption of fish processing technology for income generation. In the third model, a NGO was supported, which in turn acted as an umbrella organization and assisted women self-help groups to adopt technologies for income generation and livelihood. Regular training on hygienic fish handling and fish processing were provided to women in addition to awareness creation on importance of sanitary and phyto-sanitary measures in fish processing. The demonstrations were regularly monitored and reviewed by an expert group. Such interventions resulted in technology diffusion in the traditional fish processing sector, product diversification with quality value-added products, income generation, resource optimization by utilization of low value fishes and empowerment of women.

SE-O 12

Socio - economics of catamaran fisheries of fisherfolk along south-east coast of India

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Among the Asian countries, India ranks second in culture and third in capture fisheries in spite of the fact that 16% of the world population is sustained on 2.4% of the global land available in the country. However, marine fisheries in India is in a rapid state of transition from a cottage industry into a major industry. The traditional methods of fish capture, fishing craft and tackle are gradually giving place to the modern mechanized fishing boats and fishing gears. The traditional and the most primitive types of fishing craft in India is the catamaran of the east coast which is still employed for fishing. Catamaran is just a few logs of light wood lashed together by ropes. With the introduction of modern fishing crafts and gears in recent years, the performance of catamaran has been falling behind. Consequently the income of a significantly large component of the fisherfolk engaged in catamaran fishing is reported to be very low. Hence, it was felt that an assessment may throw light for the better understanding of this trend. An integrated survey programme was undertaken to study the fishing methods employed in a typical fishing village, the resources exploited, the resources available, the fish handling methods, processing and marketing methods and the socio-economic conditions of the fisherfolk. A survey was made over a period of one year along the coasts of Killae and Parangipettai and the relevant data such as the number of catamarans operated, magnitude of fishes handed and the



socio-economic conditions of the fisherfolk were studied and the data have been processed and the details are presented in this paper.

SE-O 13

Partners in development: cases of fisherwomen self-help groups in enhancing the efficiency of domestic fish marketing in India

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Fisher women play an important role in domestic fish marketing. The per capita domestic consumption of fish is rising due to the increasing awareness among the public about fish as a safe and wholesome food. Nevertheless, hygienic handling and value addition of fish would enhance its marketability and consumption. Fisherwomen Self-Help Groups (FWSHG) organised for empowering and enhancing the economic status of women folk, has also been attempting innovative approaches in value addition and domestic marketing of fish. The present investigation documented three such innovative and successful domestic fish marketing models demonstrated by FWSHGs in three maritime states of India viz. Tamil Nadu, Kerala and West Bengal.

The model cases documented exhibited various kinds of marketing mechanisms. The 'Thenkumari FWSHG' in Tamil Nadu built a partnership with corporate firm by adhering to the standards prescribed. The institutional credit support is a critical factor and the women repayment discipline is lesson to be learned and emulated by others. In Kerala, the state owned co-operative federation for fisheries development. (MATSYAFED) experimented with FWSHGs in three modes viz., Fresh fish express, Fresh fish point' and 'Fish booths', all of them were established for special reasons but with

the exclusive objective of enhancing the income status of fisherwomen and their livelihood improvement. Similarly in West Bengal, the focal point is the women fish vendors in 'Benfish kiosks'. All these investigations have amply proved that given the opportunity, the women excel in their avocation. While the womenfolk accounted for the major labour force and performed major work hours, their ownership of the assets remains negligible. Nevertheless, their fiscal discipline, perseverance and group cohesiveness have proved that they are second to none. However, lack of awareness on technical and business management aspects, inadequate capacity building and ignorance of available opportunities on entrepreneurship development were identified as gaps. Hence, it is high time that awareness and capacity building programmes need to be conducted to enhance their skills not only in fish handling and value addition but too in food safety, business development and linkage management which would contribute for their socio-economic development and bring them to the mainstream visibility.

SE-O 14

Evaluation of consumer preferences for myctophids using conjoint analysis

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Karnataka produces around 3 lakh tonnes of fish annually contributing 4.8% of India's total fish production. The income elasticity of demand is very high for high value food products like meat, milk and quality protein items and animal protein costs much more than plant based nutrients. Dwindling catches from the inshore waters of the world oceans and a decline in the traditional marine fisheries has made the myctophids a potential resource for exploitation. In coastal Karnataka, consumers are more aware and giving importance to the



price and quality of fish. Fish marketers face the problem of responding to these developments by offering products which are consistent with changing consumer preferences. It is therefore increasingly important for marketers to understand the nature of consumer preferences. Conjoint measurement is a versatile marketing technique which focuses on the evaluation of alternative product concept or types which are defined in terms of specific levels of attributes. This study focuses on the preferences of low value fish purchasers and uses conjoint analysis to identify consumer preference segments in the market. The analysis reveals that the preferences of consumers are very heterogeneous, but it is possible to identify segments with distinct preferences for particular fish attributes. The price of the fish was found to be the most important attribute that explained consumers preference followed by fat content, texture and length of the fish.

Table. Relative importance factor for important attributes for consumer preferences

Attribute/ Factor	Length	Taste	Texture	Nutrition	Fat content	Price
Relative importance (%)	16.17	15.76	16.79	10.47	19.18	21.64

SE-O 15

Status and economics of shrimp farming in the coastal districts of West Bengal

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West Bengal has been the pioneer in traditional farming practices for shrimp production. Nearly 4.05 lakh ha of coastal area as backwaters, estuaries, *bherries*, ponds, low marshy lands in West Bengal provide potential sites for brackishwater shrimp farming. Presently around 1.09 lakh ha of coastal saline lands

are in use for shrimp farming in India, of which 47,488 ha are in West Bengal. About 80% of the farms following traditional farming are mostly concentrated in North 24 Parganas district. Most of the semi-intensive shrimp farms are located in East Midnapore and some are in South 24 Parganas district. *Penaeus monodon* farming has been dominating the brackishwater sector since two decades compared with other brackishwater fish and shrimp species. In early nineties shrimp farming was low-risk and high profit venture, however the present form of shrimp farming has become low-profit and high-risk venture. During 2009-10, shrimp aquaculture production has been 33,685 metric tonnes in West Bengal and the state contributes nearly 36% of the total farmed shrimp and prawn in the country. Substantial impacts have come from the technology of Low Cost Low input shrimp farming which was initiated at KRC of CIBA and some of the marginal farmers are practising the same either with commercial feed or with farm made feed. Zero water exchange based shrimp farming has been very popular and share from this farming system has increased from 0.5% in 2003 to 3.4% in 2010. The productivity level has increased from 0.5 to 0.7 tonne/ha/crop in traditional farming system whereas the semi intensive farming yielding a productivity of 6 tonnes/ha/crop.

The economics of the shrimp farming has been varying in all the districts in respect to farming practices. The farmer from South 24 Parganas gets a gross profit of 84.61% compared to 62.5% in North 24 Parganas in traditional practices per ha per crop over the operational cost. The scientific farming has yielded a gross profit of 33.09% in South 24 Parganas and 34.37% in East Midnapore district over the operational cost. In addition, shrimp has been a part of polyfarming in West Bengal and a marginal amount of shrimp is produced from polyfarming. Even though the white shrimp, *Litopenaeus vannamei* culture has been initiated in other coastal states, farming of this species is yet to find a place in West Bengal and government agencies are putting effort to



introduce it in West Bengal. This presentation aims to bring out various issues that affect shrimp farming and economics of different shrimp farming practices in the coastal districts of West Bengal.

SE-O 16

Socio-economic profile of FRP craft fishermen in Nagapattinam, Tamil Nadu: A special focus on poverty and income inequality

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Socio-Economic Status (SES) is the major factor determining the standard of living of the people in which poverty and income inequality play a crucial role. Even the adoption levels of new technologies are mainly linked to the socio-economic condition of the fishermen. In this background, a study to assess the socio-economic profile of fishermen operating motorised FRP crafts at Nagapattinam District in Tamil Nadu has been carried out.

The FRP craft with 29 – 30 feet size have been selected for the study. The poverty level of FRP craft owners (FRP_O) and FRP craft labourers (FRP_L) in terms of their per-capita income and also the inequality in income of the FRP_O has been assessed. The daily per-capita income for the FRP_O ranged between Rs. 975.00 to Rs.1537.50 and for the FRP_L the same was between Rs. 81.25 to Rs. 128.13 during fishing days. The per capita income level of FRP_L was less than \$2 per day which is below the level prescribed by the World Bank during the minimum income period. The expenditure pattern of FRP_O showed their highest spending on food (44%) as highlighted in the Engel's law of expenditure. As the prime aim of majority of the social development programmes in India is concentrated on improving the standard of living of a person through socio-economic development, the possibility of improving their SES has also been suggested.

SE-O 17

Efficiency of different techniques in dissemination of Potential Fishing Zone (PFZ) forecasts: a case study from the Andaman Sea

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Potential Fishing Zone (PFZ) forecasts based on Indian Remote Sensing satellite P4 Ocean Colour Monitor (IRS P4 OCM) derived chlorophyll data and National Oceanographic Aerospace Administration Advanced Very High Resolution Radiometer (NOAA AVHRR) derived Sea Surface Temperature (SST) valid for 2-3 days were disseminated to active fishermen across various islands of the Andaman and Nicobar. Out of 59 received forecasts during 2010-2011, 25 forecasts for Andaman sector and 10 forecasts for Nicobar sector were disseminated employing different communication modes viz., Digital Display Board, e-mail, telephoning/text messaging, radio, community networking and distribution of print-outs of forecasts in person. The efficiency of different dissemination modes was tested. Profound reach of technology dissemination was observed in mobile text messaging with an average of 72 users per PFZ forecast. Printouts of PFZ maps were distributed to an average of 35 fishermen/boat-masters in person and it is estimated that Digital Display Board was viewed by 30 fishermen per forecast. E-mail messages containing PFZ forecasts were sent to regional Fisheries sub-stations of remote islands of Andaman and Nicobar for further dissemination and it was inferred that an average of 15 fishermen per forecasts were benefitted. Further, PFZ messages were transmitted through All India Radio and Agromet Field Unit of Port Blair for extensive reach all along the inhabited islands. Since the validity period of PFZ forecasts are limited to 3 days, near real-time dissemination of PFZ through telephoning/text messaging was found to be the



optimal tool for efficient utilization of PFZ forecasts. Field level constraints in different dissemination modes are illustrated in the paper.

SE-O 18

Motorization and its impact on fishing communities in Andhra Pradesh

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The Government of India has introduced the Motorization of traditional crafts under Centrally Sponsored Scheme (CSS) with the main objective of technological up gradation of traditional sector, to help the fishermen to reduce their physical strain and to extend their area of fishing operations mainly to increase the fish catch, income and thereby to raise their socio-economic status. This field based study examines the impact of motorization scheme on fishing households of Andhra Pradesh. The paper classifies into three sections (i) system, procedures and constraints in motorization scheme; (ii) analyzed the motorization scheme and its impact on catch and income; and (iii) examined the socio-economic conditions of the beneficiary households.

The results of the analysis show that most of the bankers have not shown interest in financing to the fishing community due bad experience of previous repayment record. Huge difference in value of catch was observed particularly between the beneficiary and control group households. Most of the beneficiary households expressed that motorization has improved in their fish catch, incomes and socio-economic conditions. The study discovered that the beneficiary households have spent less money on alcohol, toddy etc due to reduction of physical strain in their fishing operations and spent more money for children education. To sum up, the beneficiary households have been able to improve their living conditions with the help of motors fitted to their traditional crafts.

So there is a need to extend credit facilities to other poor and real needy persons in the marine villages. This would long way to improve the economic status and then automatically their social status, awareness, perception and attitudes of the next generation.

SE-O 19

Ornamental fish farming - An innovative approach for livelihood development of the tribal women in Keonjhar, Odisha

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Women in India have proved themselves equal to men in adopting diverse innovative technologies in the field of aquaculture. They have involved themselves in enhancing their livelihood by means of various aquaculture practices. One of them is the ornamental fish farming through which they have explored the opportunities for enhancing their socio economic condition. To improve the sustainable livelihood and to enhance the socio-economic condition in the tribal dominated district of Keonjhar, a study has been undertaken since 2009. The aim of the study was mainly to improvise the living conditions through increasing the sustainable livelihood of the tribal inhabitants of the region. The geographical area of the district is 8303 km². Out of the total population of 1561990, the percentage of scheduled caste is about 11.6 while the scheduled tribe population comprises of about 44.5%.

Central Institute of Freshwater Aquaculture has initiated the work with financial support from NAIP to develop awareness in the breeding and culture techniques of ornamental fishes. As such, two blocks namely Patna and Kendujhargarh were adopted for demonstration and provide the know-how. Trainings were conducted and people were motivated for adopting the



technology. The tribal women are engaged seasonally as agricultural labours. The recess period from the agricultural activities in the on-season and off-season was studied to identify the time accessible for ornamental fish culture. About 7 women SHGs and two male SHGs, however, showed interest and these were then targeted to carry out the skill. After selecting the areas, water samples of those areas were analysed to find out the physico-chemical parameters before implementation. With their own interest, the groups constructed concrete platforms and 6 to 10 numbers of cement tanks. Each of the groups was provided with rectangular FRP tanks and circular breeding tanks were provided from CIFA. Besides brood fishes of some livebearers like guppies, Mollies, Platys and Swordtails were initially stocked in the tanks for breeding as well as for culture for commercial purpose. The farmers were directly linked with the traders for selling their production. With such interests, the groups have started selling their produce in standard rate to the trader. The institution through the researchers provided them general techniques and helped the women folk in taking care of the other activities. These efforts have slightly strengthened their economic condition. The collected revenue is deposited in the group's account which will be the basis of credit for the infrastructure obligatory for the future. By linking the women with credit, technologies, infrastructure, trainings and trade, such effort by CIFA can become a model in enhancing and improving the sustainable livelihood, economical and financial security of women in tribal community.

SE-O 20

A socio-economic assessment of seaweed farmers in Tamil Nadu: a case study in Ramanathapuram district, Tamil Nadu

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Seaweed mariculture is a potential income earning activity and an economically viable livelihood option for the coastal fishing community especially for the fisherwomen. In Tamil Nadu, the organised seaweed farming on an industrial scale was initiated by the Pepsi Holdings India Private Limited (Pepsi Co) in 2000 in Ramanathapuram district (Gulf of Mannar), which spread gradually to the neighbouring coastal districts. After proving the economic viability of seaweed farming, Pepsi Co modified its business model in 2003 by motivating the fishers to take up seaweed farming in contract farming mode through formation of Self Help Groups (SHGs). An attempt has been made in this paper to assess the socio-economic status of seaweed farmers in Ramanathapuram district of Tamil Nadu, which is the pioneering district in India in seaweed farming. Fishing and seaweed farming are the most important occupations in this district. Seaweed farming has become the primary livelihood activity of a few fishers in Rameswaram, which has contributed to reduce pressure on the fish stocks of the area. A considerable number of seaweed farming practitioners reported relatively high annual income up to Rs.100,000. In Ramanathapuram, seaweed farming is estimated to provide employment to the tune of 765,000 man days in the country. Significant structural changes in the socio-economic status of many fishermen who have taken up seaweed farming have taken place over the last 10 years, which also included the transformation of fishers from labourers in seaweed farms to seaweed farmers. Thus the gains realized through the SHG model of seaweed farming should be consolidated with consistent institutional and financial support to the seaweed farmers.

Table. Occupational profile of respondents

Occupation	Mandapam		Rameswaram	
	Number	%	Number	%
Fishing	108	48	24	13
Seaweed farming	118	52	187	87
Total	226	100	211	100



SE-O 21**Socio-economic impact of farming of the seaweed, *Kappaphycus alvarezii* on marine fisherfolk of Tamil Nadu coast, India**

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Commercial cultivation of *Kappaphycus alvarezii* was started in 2003 along the Tamil Nadu coast. At present, *K. alvarezii* production is carried out in five coastal districts of Tamil Nadu namely Ramanathapuram, Pudukottai, Thoothukudi, Thanjavur, and Kanyakumari. During 2003 - 2009, *K. alvarezii* production has shown a steady increase with the maximum (865 tonnes) in 2009. At present, around 1000 to 1200 families are dependent on *K. alvarezii* farming for their livelihood in Tamil Nadu coast. Around 180 and 70 families in Sambai and Mangadu village respectively in Ramanathapuram district, depend entirely on *K. alvarezii* farming for their livelihood. In these villages, there are around 8000 seaweed culture rafts floated in the Palk Bay. The farming is taken up for nine months (i.e., February to October) in a year. The crop is ready for harvest after 45 days from seeding. On an average, three to four crops are harvested in a year. Average yield per raft (12 x 12 feet) is 240 kg. They retain 60 kg as seed material for the next crop. The current price is Rs. 2.50/kg on wet weight basis and Rs. 18 to 20/kg on dry weight basis. A fisherman family earns around Rs. 9000 to Rs.12000 per month. The acceptance of this farming practice is indicative of the fact that a low cost simple technology, which can provide substantial returns, can find a better adoption among the coastal fisherfolk. It is well understood that due to declining catch and catch rates of marine capture fisheries in future, it will become mandatory to adopt management regulatory measures for sustaining the fisheries. In this context, the present example of *K. alvarezii* farming is a

trend, worth promoting, which can lead to the development of small-scale mariculture as an alternate livelihood option to supplement the income from capture fisheries.

SE-O 22**Profitable marketing potentiality of *Bellamya bengalensis* in western zone of West Bengal - a survey**DEBAJIT CHAKRABORTY^{1*}, JOYDEV MAITY² AND MADHUMITA MUKHERJEE¹

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Freshwater mollusc, *Bellamya bengalensis* has latent potential in western part of West Bengal, especially in a socio-economic point of view. Around this freshwater molluscs several industrial and market sectors can be extended and a socio economic development can be created mainly for poor people, as it has good edible value and act as a cheap and steady source of protein. It has also good medicinal value for the cure of vitamin A deficiencies, controlling diarrhea and several gastric disorders. It can be served either in boiled or canned form, which increases its export potential. Its shells are important for lime production and also for lucrative models which create a debonair status in the drawing room. In east and west Midnapore, Purulia, Bankura and some parts of Howrah districts, 70% to 85% poor people are engaged in marketing of edible molluscs, mainly *Bellamya bengalensis*. They collect this species mainly from ponds, swamps and other wetland areas of east Midnapore, Howrah and some parts of Kolkata etc., and sell @ Rs. 3 to 4 per kg to the wholesalers earning Rs. 200 to 250 per day. The wholesalers market it directly to the consumers or sell to the retailer @ Rs. 6 to 7 per kg and those retailers sell it @ Rs. 8 to 9 (whole body) per kg and meat alone @ Rs. 100 to 150 per kg. Both wholesalers and retailers get a profit of Rs. 200 to 300 per day.



SE-O 23**The impacts of fisher migration on the fishery sector of Kerala: A study of migrant fishing fleet in Ernakulam, Kerala**

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Marine fishery resources, being mobile and dynamic, pose difficult management problems. In traditional societies, fisher migration was tuned according to the seasonality and mobility of various species. Those mobile pathways were limited to the boundaries of neighboring communities and legitimized locally by various communitarian institutions. Intra-state and inter-state migration of fishers and fleet as experienced today in the fishing economy of India has been a product of blue revolution that increased especially since the early seventies. Complexity of push and pull factors that fastened fisher migration and lack of a proper administrative mechanism to regulate access to distant fishing grounds resulted in the ruin of marine commons. The objective of the paper is to explore the administrative and informal institutions which provisioned access to migrant fleet at various fishing grounds within the Exclusive Economic Zone of India. This paper also examines the change in fisher population in the Ernakulam district of Kerala.

SE-O 24**Utilization of non-conventional seasonal water bodies for improving livelihood of rural farmers through fish rearing: A case study**

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Karnataka with its rich inland aquatic resources, amounting nearly to 9.3% of the

country, has great potential for aquaculture. In addition to these water bodies, a variety of non-conventional water bodies have been created under various developmental programmes. Farm ponds, check dams, canal bunds and govu katte (village tanks) are rain fed and retain water ranging from 5 to 8 months. Fish culture demonstrations were taken up in selected water bodies of Kunigal taluk, Tumkur district, Karnataka. Size of the water bodies ranged from 100 to 2000 m². These demonstrations aiming to exploit their potential for fish rearing as it would help not only in supplementing protein rich food but also improve the livelihood of rural community. Indian major carps (*Catla catla* and *Labeo rohita*) and common carp (*Cyprinus carpio*) seeds were reared at a stocking density of 5000/ha over a period of 6 months or until the water bodies retained water. Fish production in farm pond, canal bund, check dam and govu katte were 1500 kg/ha, 1250 kg/ha, 1300 kg/ha and 1250 kg/ha respectively. The villagers are benefited by getting proteinaceous food as well as good revenue from fish sales. These demonstrations proved the potential of small water bodies for aquaculture in improving the economic status of the fish farmers.

SE-O 25**Polyculture of prawn with carps: an assessment to enhance production in Khurda district of Odisha**

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An assessment of polyculture of freshwater prawn (*Macrobrachium rosenbergii*) with carps (catla and rohu) was conducted during 2010-11 by Krishi Vigyan Kendra, CIFA, Orissa. Attempt was made to assess and enhance the productivity and profitability of the technology at farmer's field, taking into account the farmers' practice as control and the scientific practices as different trials. Three ponds with area 0.13, 0.14 and 0.09 hectares were



selected in two blocks of the Khurda District, Odisha. Owner of the ponds were contacted and motivated to adopt scientific practices of polyculture. Carp fingerlings (catla and rohu) were stocked @3,500/ha and juveniles of *M. rosenbergii* were stocked @10,000/ha. Pond fertilization and liming were carried out after testing the key water quality parameters. Supplementary feeding was done with groundnut oil cake and rice bran. During the culture period, all the scientific packages of practices were demonstrated through training and regular visit to farmer's field for their capacity building and knowledge up-gradation.

An average production of 1.92 tonnes/ha of carp and 0.294 tonnes/ha of prawn were achieved by scientific practice in comparison with 1.09 tonnes/ha of carp and 0.062 tonnes/ha of prawn in farmers' practice. The increase in yield of carp and prawn were 76.14% and 374.19% respectively. The average increase in 231.46% of net return and an increase in B-C ratio from 2.16 to 3.18 strongly indicated the productivity and profitability of the technology. The result of the trial with respect to productivity, income generation and farmers' reaction are highly accepted. It is observed that more farmers are coming forward to adopt the technology in Khurda District of Odisha.

SE-O 26

Fish seed stocking in Indian reservoirs: An appraisal

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Inland fisheries sector has the mainstay in fish production in our country. The increase in fish production from inland capture/open-water ecosystems is also expected in a big way. Reservoirs are recognized as the sleeping giant for inland fisheries development. Further, their importance also derives from environmental and social perspective. Keeping these facts in

mind, National Fisheries Development Board (NFDB) has taken welcome step to stock the reservoirs (2000 fingerlings/ha for small and 500 fingerlings for medium and large reservoirs) through assistance of State Departments of Fisheries (DoFs) and State Federations/Corporations. CIFRI has been assigned the job of monitoring this stocking programme. The paper describes the major findings of this study in terms of i) criteria adopted in selecting the reservoirs ii) collection of fish seed stocked and landing data, iii) assessment of impact of stocking on the fish yield and iv) suggestions for improvement.

The results indicated that the programme had 20 beneficiaries from 18 states. The fish seed stocking was proposed in 2311 reservoirs. Out of these, the states of Andhra Pradesh, Karnataka and Orissa had adopted more than 100 reservoirs. The overall percentage of disbursement of funds was 73%. The maximum reported criteria for selection of reservoirs was good market potential, proper approach road and large number of fishers operating in the reservoir. Most of the states followed NFDB procedure for preparation and submission of proposal. Only few states monitored size of fingerling, species composition and survival rate properly towards the fish seed stocked. Overall, only 48% of the targeted fish seed was stocked with states of Arunachal Pradesh, Punjab and Kerala meeting the target. The protocols for fish catch statistics and impact assessment were probably the weakest link of the scheme. Significant increase in fish yield was observed in many states (from 11% to about 9 folds in the states/Federations of Punjab and DVC, respectively). It indicated the success of the scheme. Most important problems reported were *in* and *ex-situ* availability of fish seed followed by co-ordination among the reservoir stake holders, non-availability of quality fisheries requisites and shortage of manpower in DoFs. The paper recommended number of measures for improving implementation of the programme and enhancing fish productivity of reservoirs in the country.



SE-O 27**Impact of social security interventions on marine fisheries sector**

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Social security is achieved when vulnerability is reduced as a result of social means, in the process making lives and livelihood more secure. Marine fisherfolk are socially, economically, politically and ecologically vulnerable. Apart from the high population density of coastal villages which makes the unemployment problem very severe, other key areas of vulnerability found by this diagnostic study conducted in different maritime states were sea-safety, housing, water, education, sanitation and public health. Social security initiatives for the empowerment of women were also found to be less or absent. Despite a number of social security means implemented by various agencies, coastal poverty still remains a formidable developmental challenge for the maritime states of the country. Moreover, the top-down approach, poor delivery systems and the lack of people's participation become major weaknesses of many social security schemes. It also results in poorer implementation and greater asymmetry, resulting in skewed or elite capture of distribution of benefits. The study fulfills the need to find out the impact of location specific, developmental and social security /welfare interventions through the state and civil society organisations on the enhancement of the standard of living among the marine fisherfolk.

SE-O 28**A review on the socio-economic status of the adopters of major fish farming practices in central Brahmaputra valley zone, Assam**

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Primary data were collected in the fish farming pockets of central Brahmaputra valley using 150 randomly selected progressive farmers through structured questioner during the period October 2010 to March 2011. The analysis of socio-economic status of fish farmers proclaim different factors i. e., age, family size, religion, caste, educational qualification, experience, social participation, land holding, type of house. Results for overall fish farmers indicate that farmers with fish farming as primary income source, age ranged 21-40 years; religion Muslim, educational level higher-secondary standards, family size having 6-10 members, low experience (<9 years), kutcha house, primary income less than Rs. 50000 per annum, membership in one society were the most important adopters of major farming systems. It was also found that newly developed techniques such as multiple stocking multiple harvesting (MSMH) farming system have variation in terms of some socio-economic factors. MSMH adopters have more than one society membership and more primary income Rs.50000-100000 per annum compared to single stocking single harvesting and single stocking multiple harvesting.

SE-O 29**Successful demonstration of inland fish farming as a livelihood activity through KVK in Navsari district of Gujarat**

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Krishi vigyan kendra, Navsari agriculture university, Navsari is engaged in Transfer of Technology (TOT) activities in the district since 2006. KVK has implemented under the Rastriya Krishi Vikas Yojana (RKVY), a project on "Holistic development of 20 adopted villages of south



Gujarat" during 2007-08 to 2010-11, which had inland aquaculture as a sub component and operated at Pathari Ta village, Gandevi, Navsari District by forming a Self Help Group (SHG) as - Samarpan Fish Grower Group. This SHG has taken the village pond on lease from village panchayat for fish culture. In south Gujarat, every village possess pond which is primarily used for irrigation purpose. The ponds are not used for fish culture operations due to lack of proper scientific knowledge. Keeping this in view and the possibilities of fish culture thereon, under the RKVY scheme, the pond was renovated by dividing it into nine blocks covering 3.43 ha areas. Initial training on carp nursery, rearing and grow out technologies were imparted to this SHG. Technical support including inputs were given by KVK as and when required and the farmers were also sent to CIFA, Bhubaneswar and CIFRI, Barrackpore for training and exposure visit regarding inland aquaculture under RKVY scheme. On the embankments of the renovated ponds, plantations were carried out to serve as an integrated farming model. Three species of Indian major carps such as catla, rohu and mrigal and one exotic carp, grass carp were stocked. The nursery, rearing and grow out ponds were stocked with recommended stocking densities of fry, fingerlings and yearlings respectively. Also, one pond was stocked with 18 kg of scampi seeds. With a total expenditure of Rs. 3.5 lakh, now the farmers are in a position to earn 8-10 lakh of returns from this activity. Further, the formation of SHG has facilitated to remove social partition among the groups which was existing earlier and they have come together for the well being and development of the village.

SE-O 30

Profitability assessment of banned catfish, *Clarius gariepinus* farming in Palakkad district of Kerala

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This paper presents a study undertaken to analyze the feasibility and financial sustainability of fish farming operations of banned catfish (*Clarius gariepinus*) in the eastern part of Palakkad. The analysis formulated assumptions based on secondary data on catfish production and market. The data was collected by reviewing both printed and electronic articles from research publications. Other information was derived from the personal experience of the authors in catfish farming and research. A budgetary unit of a 1 ha (10 ponds) catfish farm was used. To evaluate the profitability of the venture, indicators of investment returns were determined such as net present value (NPV) and internal rate of return (IRR), payback period and debt service coverage ratio. A sensitivity analysis on stocking density, survival rates, cost of feed, cost of fingerlings and sales price was also conducted. The findings of the analysis indicated that catfish farming is financially feasible. The results obtained indicated a positive NPV and an acceptable IRR. A debt service coverage ratio of more than 1.8 was obtained thus indicating that the cash flow is adequate. Sensitivity analysis on price, sales and investment obtained indicate that the enterprise is highly sensitive to stocking density, survival rates and sales price but less sensitive to costs of fingerlings and costs of feed used in the production. It is also more economical to operate small ponds than one large pond due to the easiness in operation.

SE-O 31

Disappearance of fishing community due to shrinkage and degradation of Pallikaranai marshland

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Natural Resources are the wealth of the country. Local community generates lot of employment benefits from common property resources which on its own, take cares of their livelihood. Many natural resources are in the



verge of extinction. This aggravates the multifaceted problems to the people who are dependent on such resources. One live and standing example is the shrinkage and degradation of Pallikarandai Marshland, as a result of which many fishermen community have lost their livelihood who were all dependent on interconnecting water bodies for their occupation. Inclusive growth means each and every individual in the society has one's share of income which will contribute to the nation's income. When natural resources are converted for developmental purposes, this affects the stakeholders' benefits. Pallikarandai Marshland (PML) is located at the south eastern sub-urban areas of Chennai city. PML is considered significant by the Tamil Nadu scientific community and is included in the All India Bird Survey as a water fowl habitat, home to variety of birds, reptiles and amphibians due to dumping of solid wastes and letting out of raw sewage directly into the marshland which was home to a large number of fishes earlier.

PML offers many direct and indirect values by supplying wetland goods and ecological services. Fishing was one of the important activity though it is not included in inland fishing but yet served as an important economic input by PML for the households depending on it for their livelihoods. The paper examines not only the loss of income, but also the number of beneficiaries, caused by shrinkage and degradation of PML and its interconnecting water bodies.

SE-O 32

Carp seed production in FRP hatchery for livelihood development of some selected SC/ST communities in Nayagarh District, Odisha

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In Odisha, fish production has always occupied the second place to agriculture. To meet the

demand for freshwater carps, there exists dependency on the neighboring state, Andhra Pradesh. The main constraint to augment fish production in farmer's field is the availability of quantity and quality of pure seed at right time and right place. Many farmers are unaware of scientific fish culture practices. Since 2009, one project funded by Department of Biotechnology (DBT) has been operating at CIFA to develop the livelihood of some selected SC/ST communities through implementation of freshwater aquaculture technologies e.g., carp seed production and rearing, carp brood raising, etc. in Nayagarh District, Odisha.

20.77 hectare water area has been covered for project implementation in the district. FRP carp hatcheries are used for seed production. The hatcheries are installed in Nuagaon and Khanguri Villages of Nuagaon Block; Madhyakhanda Village of Daspalla Block; and Bhetabar and Randa Villages of Raj Ranpur Block. More than 85 farmers were trained for hatchery operation, fish breeding and seed production; seed rearing and grow out culture of carps. In 2011, the installation year of four hatcheries, in Nayagarh District, 36.5 lakh pure carp spawn were harvested for further rearing in the ponds of beneficiaries.

In 2010, in one trial in FRP carp hatchery at Nuagaon, 4.5 lakh spawn was produced. These were stocked in nursery ponds and 1.8 lakh fry were harvested with 40% survival. Fry were again reared and 72,000 fingerlings were harvested after three months of rearing. These were further kept for yearling production and during May 2011, advanced fingerlings of 56,000 (77.7%) were harvested and stocked for grow out production of carps in beneficiaries' ponds. As a result, the farmers at Nuagaon are getting carp seed locally, thus the misery of getting carp seed from far off placed has been reduced substantially for them. In seed rearing, the production from the pre-adoption level has increased to 0.25 - 2.2 fold in Nayagarh District. The fish seed production has also increased maximum up to 146.06% in beneficiaries' ponds than the previous year. The beneficiaries



have adopted the scientific fish rearing practices and in grow out culture, the production from the pre-adoption level has increased to 0.19 - 8.5 fold in the District.

SE-O 33

Role of aquaculture in the sustainable rural livelihoods of Tripura

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Aquaculture plays an important role in enhancing household income through production and employment generation and providing nutritional security. But the sector received very less attention towards its promotion and popularisation. The present study tried to evaluate the impact of aquaculture on the rural livelihoods of Tripura, a hilly state in the north eastern region of India. The study was carried out using the Sustainable Livelihood Framework developed by the Department for International Development (DFID), UK. Aquaculture, in general, was found to have significant impact on rural livelihoods in Tripura. The greatest effect of aquaculture on farming households were observed in income and consumption. Qualitative investigation suggested that aquaculture not only increased income through greater production volume, but also improved farmers' asset holding. The other important outcomes of aquaculture were the enhancement of social safety nets through increased sharing of inputs and labour among farmers.

The impacts of aquaculture spread beyond the farming households to the broader rural livelihoods. Wage labourers and fishers, two of the poorest groups of people directly involved in aquaculture, were benefited most. Intensification of aquaculture increased the demand for hired labour. A large section of agricultural labourers were found part-time employed in aquaculture activities. Promotion of aquaculture in the state increased food

availability providing nutritional security to the people. The micro level findings of the study regarding impacts of aquaculture indicated that aquaculture practices in the state have significant impacts on enhancing rural livelihoods in Tripura.

SE-O 34

A study on the impact of microfinance on coastal indebtedness in the marine fisheries sector of Kerala

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The microfinance organisations/ Self Help Groups mobilised in the marine fisheries sector play vital role in reducing the indebtedness among marine fisherfolk. The paper makes an attempt on the assessment of the extent of indebtedness among marine fisherfolk in mechanised, motorised and traditional sectors and the perceived impact assessment of Microfinance Institutions (MFI) on coastal rural indebtedness. The study was carried out in northern, central and southern coastal belts of Kerala state. Situational analysis was done through PLA in the selected locations in the above mentioned zones of Kerala and the sample respondents were selected from mechanised, motorised and traditional sectors. Data was collected through personal interview from members of 12 selected MFIs and non members in these sectors comprising a total of 300 respondents. The level of indebtedness of members of MFIs is less compared to the non members. Even if indebtedness is more in certain cases, the repayment capacity is found to be significantly improved in MFIs. There is an extreme necessity of strengthening the MFI ventures in the traditional sector and secondary and tertiary sectors in the state. It was also found that the MFIs ranked better in most of the major attributes in the perception of stakeholders. A comparative assessment of the sources of credit, the purposes of credit and the utilisation



pattern of loans in the state also was undertaken to draw valid conclusions. Success cases of MFIs on entrepreneurial capacity building, those significantly played the role in the debt redemption and poverty alleviation were documented which can be used as a practical manual for mobilizing MFIs in any key areas on a sustainable basis.

SE-O 35

Research-Extension-Farmers linkages in India

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Linkage mechanism refers to the mutual and reciprocal connection between research, extension and farmers. Efficient use of resources available to the farmers is achieved through encouraging and facilitating feedback from farmers to researchers through extension personnel who visit and advice farmers on a regular fixed schedule, thus helping researcher to solve actual production constraints faced by farmers. The ultimate aim of all fisheries research is to increase production and improve the standard of living of farmers. For these to occur, the technologies generated must reach to its clients and be adopted by the intended users. In order to have an improved quality of life and agricultural development, functional linkages between research and extension are of paramount importance. Linkage among research- extension-farmer can be considered as a precursor for undertaking and implementing any participatory programmes at the field level. The effectiveness of linkage can be measured in terms of frequency of flow of technological information, level of linkage existing among the existing three actors, fidelity with which the linkage enhances two-way flow of information. To make the technology triangle work efficiently, India has a vast network under Indian Council of Agricultural Research, which includes Institutes, Bureaus, National Research

Centres and Project Directorates, State Agricultural Universities, Agricultural Technology Information Centres (ATIC) and Krishi Vigyan Kendras (KVK) throughout the country. Apart from these, the State Department of Agriculture of various states also works for the research and extension activities of the respective states. The state agricultural universities are expected to pay attention on extension besides teaching and research. It also provides feedback from farmers to the scientists, which in turn helps in strengthening the research and extension activities. Hence, extension function is also considered a very important in these universities.

SE-O 36

Decision making behavior of fisherwomen of Dakshina Kannada district of Karnataka

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Among the different sectors of Indian economy, wherein women contribute significantly, fisheries sector occupies a prime place. Fisherwomen play a pivotal role in the development of the fisheries sector in addition to their role as household managers, in majority of the fisher families. In spite of their immense contribution on the domestic and occupational fronts such as education of their children and meeting the nutritional, and health requirements, their significant roles have not been given adequate recognition.

The present study was undertaken in three selected villages in Dakshina Kannada district of Karnataka state using multi-stage random sampling method. From the findings, it was observed that, 84.16% of women fresh fish vendors were involved in medium level of decision making. Fisherwomen were observed to be the sole and independent decision makers with respect to all aspects of fish marketing. The results of the multiple regression analysis revealed that, among the profile characteristics



studied, the variable, namely self-confidence, showed a high and positively significant contribution towards the decision making behavior of the women fish vendors.

SE-O 37

Consumer preference and willingness-to-pay for value added fish products in Kerala

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The technological changes in production, processing and distribution dictate the happenings in food market. Moreover, changing life style, rising income and increasing awareness about diet and health has set a new trend in the demand for food among the consumers. Therefore, the necessity to bring in strict quality control, value addition and consumer appeal in food products has become important. An ongoing NAIP project at CIFT, Cochin has attempted to create a value chain for bulk landed low value species through development of innovative fish value added products and promote them through fisherwomen self-help groups. A study was conducted in Kerala to evaluate the consumer preference and willingness-to-pay for these value added fish products. Ingredient, price, cooking method and perceived quality were the attributes studied at various levels. Applying an orthogonal design, nine hypothetical product concepts were generated and 120 selected respondents were asked to rank the product concepts according to their preference. A conjoint analysis of the data revealed that quality is the most important attribute influencing consumer behaviour. A positive willingness-to-pay was also observed for quality. The results show that to improve market opportunities for value an added fish product, a certified quality is important. It was seen that the consumers in the young and earning age group were ready to pay 10-15% more for a quality ensured fish product.

SE-O 38

Domestic fish marketing – A case of seer fishes in India

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The marine capture fisheries sector of India is faced with issues of sustainability with production from the sector reaching a plateau in recent years. Hence a paradigm shift from increasing marine fish production to increasing profitability and sustaining the marine fishery resources through management interventions is needed. Having an efficient domestic marketing system is one of the approaches for increasing profitability in this sector. A study was undertaken to analyse the marketing cost, margin, efficiency and price spread of one of the prominent marine fish group, viz. seer fishes and also its price integration between various states of the country using monthly price data for a ten-year period from January 1998 to December 2007 of retail fish markets of Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu and West Bengal. The results revealed that fishermen's share of consumer's price varies with the margins charged by the market intermediaries. It was highest (86.40%) in Thoothukudi market channel, where the wholesaler charged the lowest margin (5.20%), while it was lowest (68.75%) in Cochin market where the retailer charged the highest margin (21.14%).

Table. Coefficient of price transmission (%) between various domestic market pairs for Seerfishes

States	WB	GJ	TN	AP	OR	MH	KL
KA	0.79*	0.32	NI	0.33*	0.54	NI	NI
WB		0.60*	NI	0.40*	0.71*	NI	NI
GJ			NI	0.42*	0.61*	NI	NI
TN				NI	NI	0.04	1.20*
AP							(-4.39*)



SE-O 39**Entrepreneurship development of women through aquaculture activities in Tripura: scope and impediments**

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Aquaculture plays a multi-dimensional role providing nutritional security, generating employment; alleviating poverty and finally uplifting the socio-economic status of those who are directly or indirectly connected with exploitation, production and processing of fish. Besides, aquaculture can play a significant role towards empowerment of women through entrepreneurship development. The present study tries to trace the scope and impediments of women entrepreneurship development through aquaculture activities in Tripura. It was found that though women involvement in aquaculture has significant positive impact on productivity, their intensity of involvement is very less and insignificant. Different social, economic and cultural factors are found to be responsible for such reluctance of their getting involved in the activities. In view of those determining factors, appropriate measures may be taken to enhance the involvement and thereby developing entrepreneurship among women in Tripura.

SE-O 40**Social networking and navigation for fishermen**

PRIYANKA KABRA*, PANKAJ DOKE AND SANJAY KIMBAHUNE

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Fishing industry plays an essential role in fulfilling food and non-food needs, like medicines, fish leather products, fish skin gelatin etc, and promoting trade for most nations across the world. Along with agriculture, fishing plays

a vital role for the economic growth of a country. Like agriculture, fishing is a traditional occupation and mostly carried out by the population staying in the coastal areas. Research has been done in the field of fishing for equipping the fishermen with better techniques, better catches and increases their turnover. However, the research work is restricted to the fishing equipment, nets, navigation details providing devices, construction of the fishing boats or ships or the like. This research facilitates the fishermen to gain access to latest equipment and techniques but appropriate information dissemination seem to be lacking. Without appropriate mechanisms and tools for information dissemination and guidance, the research conducted for fishermen stays in the lab and its full potential cannot be exploited by lay fishermen. The true value of research is realized only when ordinary people can apply it to enrich their lives.

Apart from lack of reliable and valuable information at fingertips, fishermen deal with various problems in their day to day lives for example, appropriate prices for their produce, micro region weather forecast, immediate storm warnings, collaboration et cetera. For solving some of these problems, fishermen are dependent on their peers and various data sources. All required information is present in some form either on internet or with some expert but the fishermen do not have ready and easy access to this information in local language. The reason for this can be either low level of literacy or lack of communication technology or IT infrastructure or discomfort in using new technologies. There is therefore felt a need for a system using which fishermen can collaborate for faster dissemination of reliable information and get advice using a single system, which will enable the fishermen to get navigation details, emergency assistance and other important fishing domain related information in their local language and pertaining to their geographical location. We have conceptualized and developed a system to aid fishermen in their quest for making ends meet using low cost mobile phones. This system which has been developed in local language can be used for



providing guidance to the fishermen, assisting in navigating to potential fishing zones and for information dissemination.

SE-O 41

An assessment of marketing efficiency of fish markets in Bangalore City

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The impact of improved infrastructure and accessibility of fish on fish production and consumption has been well documented. In this study, an attempt was made to assess the marketing efficiency of freshwater fishes in Bangalore retail market by using some of the standard concepts such as price spread, producer share in consumer rupee, and cost of marketing services across identified marketing channels. The results revealed that although there is no significant difference between the selected retail markets, the efficiency varies with reference to channels. Hence, policy intervention for supporting the improvement of distribution channels is suggested. Further, the results of the consumer preferences suggest that carps with more than one kilogram weight is most preferred. Hence, the producers need to be educated to modify their harvesting strategies to supply preferred size and get maximum price.

Table: Marketing efficiency indicators of selected fish markets in Bangalore city

Marketing efficiency	Russell market	City market	Y.pur market	Overall indicators
Producer share in consumer rupee (%)	45.22	50.56	50.22	48.67
Cost of marketing services (Rs/kg)	3.14	3.27	3.32	3.24
Price spread (Rs/kg)	58.78	59.44	60.67	59.63
Marketing efficiency	1.0008	1.0003	1.0062	1.0024

SE-O 42

Marketing of ornamental fishes in the National Capital Region, India

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This study was undertaken in the National Capital Region, India with the objective of assessing the marketing of ornamental fishes in the region. Marketing channel, disposal pattern, marketing costs, marketing efficiency, price spread and constraints in ornamental fishes market were studied. They were analyzed using primary data. Data was interpreted using percentage analysis, Rank Based Quotient and Shepherd's Index. The latter two methods were used for ranking and estimating market efficiency. The marketing channels were indirect, starting from wholesaler to customer, (channel I); wholesaler to customer via retailer (channel II); wholesaler to wholesaler cum retailer to retailer to customer (channel III). Disposal pattern of fish follows tessellation pattern. Ornamental fishes had higher sale during summer season whereas, price and quantity procured were higher during winter season. Price skimming and price discrimination were the pricing strategies used. The cost enhancing elements were primarily cost for aquarium (Chinese and traditional), transportation, labor, electricity charge and rentals. The wholesaler has highest marketing cost and margin in NCR due to near monopoly in marketing system. Study revealed that the price spread was lower in channel II (Rs.17.67) as compared to channel III (Rs.21.00). Channel II was more efficient (1.336) than channels III (1.286) owing to less number of intermediaries reflecting less marketing cost. The major constraints in ornamental fish market were high price of fish, mortality, demand for specific fish, diseases, maintenance of water quality and bargaining. Whereas, poor demand of good quality fish, production facility, access to market, handling, availability of fish and competition with alternative pets were also ranked in decreasing



sequential order in the constraints in marketing of ornamental fishes.

SE-O 43

Information dissemination and collaboration platform for fishermen

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Fisheries sector plays an essential role in fulfilling food and non-food needs, like medicines, fish leather products, fish skin gelatin etc, and promoting trade for most nations across the world. Along with agriculture, fisheries plays a vital role for the economic growth of a country. Like agriculture, fishing is a traditional occupation and mostly carried out by the population staying in the coastal areas. Research is been done in the field of fisheries for equipping the fishermen with better techniques, better catches and increase their turnover. However, the research work is restricted to the fishing equipment, nets, navigation devices, construction of the fishing boats etc., this research facilitates the fishermen to gain access to latest equipment and techniques but appropriate information dissemination seem to be lacking. Without appropriate mechanisms and tools for information dissemination and guidance, the research conducted for fisher stays in the lab and its full potential can not be exploited by lay fisher.

The true value of research apart from lack of reliable and valuable information at fingertips, fisher deal with various problems in their day to day life for example, appropriate prices for their produce, micro region weather forecast, immediate storm warnings, collaboration et cetera. For solving some of these problems, fisher are dependent on their peers and various data sources. All required information is present in some form either on Internet or with some

expert but the fishermen do not have ready and easy access to this information in local language. The reason for this can be either low level of literacy or lack of communication technology or IT infrastructure or discomfort in using new technologies. There is therefore felt a need for a system using which fishermen can collaborate for faster dissemination of reliable information and get advice using a single system, which will enable the fisher to get navigation details, emergency assistance and other important fishing domain related information in their local language and pertaining to their geographical location. We have conceptualized and developed a system to aid fishermen in their quest for making ends meet using mobile phones. This system which has been developed in local language can be used for providing guidance to the fisher, assisting in navigating to potential fishing zones and for accurate information dissemination.

SE-O 44

Critical factors associated with successful community based floodplain wetland management: A study on four selected floodplain wetlands (Beel) in Assam, India

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India has extensive wetland areas which are basically low-lying. Wetlands are mostly situated on floodplains of major rivers namely Ganga and Brahmaputra and are designated as floodplain wetlands. These are one of most important fishery resources of India that provide livelihood to surrounding poor fishers. Among the Indian states, Assam is endowed with vast areas of flood plain wetlands, locally called *Beel* (perennial), *Haor* (seasonal floodplain) and *Anua* (river-formed oxbow lake). They constitute an important fishery resource of the state and



SEO 45**Co-management of reservoir fisheries: Experiences from the Bergi Reservoir in central India**

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retain their vast potential for fish production as they cover about 100000 ha of the state water resources (World Bank, 2011). The average existing fish production of Assam Beel is only 173 kg/ha/year against its production potential of 1000-1500 kg/ ha/year.

A study was conducted in four selected floodplain wetland (*Beels*) of the state namely Talu Malu (22 ha), Amuguri Basapathar (50 ha), Kutuha Bar (16 ha) and Bhitorkuri (20 ha) wetlands to see the critical factors associated with knowledge level of *Beel* users on community-based *Beel* fisheries management. Mean comparison analysis indicated that *Beel* users with high knowledge scores on community-based fishery management were characterized by service holder, high school and above level of education and semi pucca house. They were the members of more than one organization with high scores on participation in development programme, decision making ability, women empowerment, community-based fisheries organization and involvement of NGOs. Correlation and regression analysis revealed that four variables viz., involvement of NGOs ($r=0.49$), women empowerment ($r=0.18$), community managed market ($r=0.49$) and community-based physical assets ($r=0.25$) have significant correlation ($p<0.01$) with the dependent variable, knowledge scores of *Beel* users on community-based fisheries management. They explained 43% of the variability in the dependent variable. Path analysis indicated that involvement of NGOs was the prominent predictor variable having the highest direct effect on Knowledge scores of *Beel* users on community-based fisheries management. Similarly, community-based physical assets, socio-political empowerment and *Beel* users' decision making ability had considerable indirect effect on Knowledge scores of *Beel* users on community-based fisheries management via involvement of NGOs. Hence these variables appear to be the critical factors for successful implementation of *Beel* fisheries management.

A case study of the management of fishery resource by fishing co-operative societies of the people displaced due to Bergi Reservoir on River Narmada - a major river system of Central India, is presented in this paper. The reservoir spread in 16648.50 ha submerged 162 villages in three districts of Madhya Pradesh Province. The state fisheries corporation started fisheries development in the reservoir in 1990. The displaced people organized themselves into 54 primary fishermen co-operative societies and a federation, and got the reservoir on lease for fishery management in 1994-'95 for five years. A system of co-management of the resource by local people was developed. However, this initiative was curtailed as the management of fishery resources was taken back from these co-operative institutions in 2000-'01, by the state agencies through legal interventions. The changing management pattern had negative impact upon the resource health and, the livelihood of local fisherfolks. The total fish production and per hectare productivity decreased by more than 50% after the management of reservoir was taken back by the state agencies from cooperative institutions and given to contractors. This not only resulted in loss of revenue to the state government, but, also impacted sustainability of the resources as the social force in the form of community monitoring of resource use as per the established conservation rules was severely weakened in the absence of management rights to the cooperative bodies of the dam displaced people. The study focuses on the role of various stakeholders during different management regimes and their impact on the resource



sustainability and livelihood security. The study also assesses how the changes in the management regime of the resource have impacted upon the orientation and actions of fisherfolks towards resource conservation and concludes by summarizing key implications emerging from the rise and fall of co-management of fishery resources in Bergi reservoir.

SE-O 46

Economics of trawler fishing and implication of fishing ban : a case study at Tuticorin Fishing Harbour

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Tuticorin Fishing Harbour in Gulf of Mannar is one of the very few places where the Marine Fisheries Regulation Act of Tamil Nadu is strictly implemented for more than 400 trawlers practising single day fishing. It is widely quoted that, the depletion in fish catch and its composition in recent years is due to the prevailing trawler fishing techniques which scrape the bottom of the sea and end up catching juvenile fish leading to overfishing as a negative externality to the fishing industry in the region. Here an attempt has been made to analyse the economics of trawl fishing in the landing centre, making use of primary and secondary data collected through a survey. Comparison of pre- and post-fishing ban period was made to ascertain the need for fishing ban during specific months of the year, and to evaluate the effectiveness of this method of resource conservation and suggestions were given for improving the livelihood security of those involved in fishing industry. An effort was also made to assess the technical and economic efficiency of input use in trawler fishing to ascertain optimisation of resource use. The estimated operating cost per trip was Rs. 53,515/- for single day trawling. While the net operating income per trip was Rs. 62,085/-

The capital productivity was high with low level of operating ratio of 0.23. As far as the labour productivity is concerned, it was Rs. 4,435/- per trip per head during 2010-'11 indicating labour efficiency and returns to investment.

SE-O 47

Valuation of goods and services provided by seasonally flooded areas in West Bengal

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The real values of the aquatic systems comprise values of both tangible and non-tangible goods and services. It is hard to assign monetary values to the non-tangible services and goods. But, with advances in the valuation methodologies, number of techniques which varied in degree of accuracy and reliability are available for this purpose. The methodologies vary according to the aquatic systems, as the goods and services provided by them vary significantly. The utilization of aquatic system or its interaction with community, largely depends upon existing institutional arrangements, governance and policy, which define the stakeholders and ultimately the value of its goods and services. The present paper addresses the issues of i) institutional arrangements, governance and policy, ii) the stakeholders, iii) livelihood and community interaction with resource, and iv) value of goods and services provided by Janki Chak beel in Moyna block of Purba Medunipur District of West Bengal.

Located in Damodar-Kangsabati basin, the beel has a water spread area of 33 ha with average depth of 1.3 m. During rainy season river water flows down in the beel. It can be utilised for fish based farming system following deepwater rice-fish (DWR) cultivation. The information on institutional and governance arrangements and policy issues indicated that farmers/fish farmers/



fishers organised themselves into a co-operative society, namely, Moyna Vivekanand Fishermen Co-operative society Ltd. Gram Samiti, an informal local governance institution annually leased out the water through open auction. The lease for fish culture was for one year during May-April at lease amount of Rs 15 lakhs. The owners of the land were compensated for not growing the paddy by higher lease amount. The institutional and governance environment were favourable for the fish based production system. The stakeholders using the *beel* included 79% farmers, 12% fishers and 9% others. The livelihoods of the community directly depended on fish culture. Only 29 families of the lessee co-operative members

conducted the fish culture activities. Due to intensive fish culture, domestic activities were ceased, primarily because of the poor water quality. The direct uses included fisheries; agriculture, habitat for aquatic biomass; domestic uses; dumping of domestic waste, fuel wood, fodder, etc. Indirect uses were for nutrient cycling, biological/ecosystem support, groundwater recharge, etc. The total value of goods and services provided by Janki Chak *beel* for both fish culture and paddy cum fish production systems were estimated at Rs 167.85 and 125.79 lakhs with highest share for fish followed by paddy and irrigation/ground water recharge. The present production activities favoured fish culture production system.

SE-P 01**Economic efficiency of mechanised fishing in Tamil Nadu – A case study in Chennai**R. GEETHA^{1*}, R. NARAYANAKUMAR², SHYAM S. SALIM² AND CHANDRASEKAR²¹Madras Research Centre of Central Marine Fisheries Research Institute, Chennai – 600 028, Tamil Nadu, India²Central Marine Fisheries Research Institute, P. B. No 1603, Kochi - 682 018, Kerala, India

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The craft and gear combinations over the years had shown dramatic changes on account of the huge cost of fishing, duration and depth of operations and maintenance. The mechanised gill netters have been one such, which had shown tremendous increase in the fishing fleet in Chennai, Tamil Nadu mainly due to their assured returns and consistent marketing margin. Targeted fishing, no damage to juveniles, less labour dexterity, high fuel efficiency and marginal engine depreciation by gillnetters lead to sustainable fishing when compared to trawlers. The present study compares the economic efficiency of mechanized gillnet units and trawlers. Average operating cost and net income per day for the multiday (MD) gillnetters were Rs. 17757 and Rs. 6613 whereas in the case of multiday trawlers, the operating cost and net income per day were Rs. 18095 and Rs. 3219 respectively. Targeted tuna fishing and better price realization in the value chain have contributed to better performance of gillnet units. Gillnet units are showing highest capital productivity with lowest operating ratio of 0.7 than that of MD trawlers (operating ratio of 0.8). An analysis of labour productivity showed that MD gillnetters are earning Rs. 3131 per labour man day while for MD trawlers, it was Rs. 2739 per labour man day. The average cost of fuel requirement for producing one kg of fish for MD trawlers and MD gillnetters were Rs. 21 and Rs. 13 respectively. The higher fuel requirement by MD trawlers was because of longer distance travelled and use of mechanical power for propulsion and fishing. The study found that efficiency measures in terms of labour, capital and fuel have established the supremacy of mechanised gillnetters.

Table. Key economic indicators of mechanised fishing units during 2010-11 at Chennai Fisheries Harbour

Particulars	MD Trawler (7-10 days)	MD Gillnetter (>7 days)
Average no of fishing days per year (days)	250	200
Quantity of fish production per man day (kg)	58.50	60.40
Average operating cost per fishing day (Rs)	18095.50	17757.10
Average total cost per fishing day (Rs)	18690.50	18432.10
Fuel required to produce one tonne of fish (lt)	512.80	295.40
Average gross revenue per day (Rs)	21910.00	25045.70
Annual net profit (Rs)	804875.00	1322712.00

SE-P 02**Frontline demonstration of composite fish culture in Khurda district of Odisha: an evaluation of the technology to enhance production**

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Community ponds having potential for scientific fish culture are under-exploited water resources in rural villages of Khurda district, Orissa. To demonstrate scientific composite fish culture technology, under Frontline Demonstration (FLD) Programme, the Krishi Vigyan Kendra of Central Institute of Freshwater Aquaculture, Bhubaneswar, selected two community ponds having a total water area of 0.8 ha in two adopted villages of the district. The main objectives of the programme were to demonstrate the productivity potential of the technology, to know the yield gap between improved package of practices and farmer practices, to identify the constraints, to test their adoption ability and obtain feedback from the farmers to improve their acceptability in real farm situation.

An increase in average production from 0.87t ha to 1.89 t/ha and increase in average net



income of 163.79% due to scientific method of culture proved the potentiality of the technology. The extension gap of 1.02 t/ha, emphasized the need to increase the capacity building of the farmers through training and demonstration to adopt the improved technology for getting better production. The technology gap of 0.61 t/ha indicated the status of the natural ponds, key water quality parameters and pond productivity, which can be minimized through regular water quality monitoring, timely pond fertilization and liming, better feed management, eradication of predatory and weed fishes and maintaining proper stocking density. The technology index value of 24.4% proved the feasibility of the technology at farmers' field. It could be concluded that by conducting frontline demonstration of composite fish culture, yield potential and net income can be enhanced with increase in the income level of the farmers; the technology is feasible at farmers' field and can be adopted by the farming community. The feedback and reactions obtained from the farmers were highly accepted. The major constraints being identified were high cost of groundnut oil cake, short leasing period of ponds and other social rivalry.

SE-P 03

A study on consumer behaviour for freshwater fishes in selected markets of Bangalore City

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The Indian food industry was estimated at over US \$182 billion, accounting for about two-thirds of the country's total retail sector. The dominance of multiple retail stores, the hypermarkets is increasing and so the purchasing behaviour of consumers. There are many factors such as price, availability, personal factors, advertisement, packaging, and family habits that shape fish consumption habits. The present study was conducted in three markets viz. Russell market, Yeshwanthpur market and the City market

in Bangalore. The study has covered a sample size of 270 consumers in all the three markets of city put together. The correlation analysis results indicated consumers with high income purchased more of high priced freshwater fishes such as murrel and singhi. Significant negative correlation between quantities of catfish purchased per week and income, indicating high income consumers purchase less quantity of catfish, whose price in almost half of that of murrel and singhi. The constraints faced by consumers were irregular supply of fish, poor quality, unhygienic condition of fish markets and foul odour in fish markets. The results suggested modernization of unorganized fish selling outlets, regulatory measures for checking weight, grade, freshness, hygiene, sanitation and hygiene maintenance of fish selling outlets.

Table. Correlation coefficient between income and quantity of fish purchased by respondent consumers

Fish Markets	Variables	Correlation
Russell market	Annual income (Rs) & quantity of murrel purchased (kg)	0.68**
	Annual income (Rs) & quantity of catfish purchased (kg)	-0.77**
City market	Annual income (Rs) & Quantity of mackerel purchased (kg)	0.53**
Yeshwanthpur market	Annual income (Rs) & Quantity of <i>Notopterus</i> purchased (kg)	0.52**
	Annual income (Rs) & Quantity of mackerel purchased (kg)	-0.72**

** Correlation is significant at 1% level. (2 tailed)

SE-P 04

Empowerment of fisherwomen in Kerala – An overview

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UNDP (2008) opined that investing in women capabilities and empowering them



to exercise their choice is not only valuable itself but also the surest way to contribute to the economic growth and development. The fisheries sector is an important source of livelihood for women. In India, about 25% of women labour force is involved in pre-harvest activities, 60% in export marketing and 40% in internal marketing. The fisherwomen in Kerala play important role in the fisheries sectors in terms of their involvement in fish related activities viz. fish vending; fish drying, prawn peeling, sorting, grading, fish packing, and net making. The study is focused on the empowerment status of fisherwomen in Kerala across the four occupational groups viz. fish retailer, fish vendor, dry fish makers, and value added fish producers. The specific objectives were to estimate the social, political and economic empowerment of fisherwomen involved in processing and marketing of fish and fishery products in Kerala. The study was based on the data collected from primary and secondary sources from selected coastal districts across the state. The different empowerment parameters like social, economic, legal and political were analyzed with the help of scoring indices. The study revealed that the highest level of gender discrimination faced by all the respondents across the four different occupational groups have been in handling, transporting and storing of bulk quantities of fishery resources. Self help groups and co-operatives were the major networking institutions found among the fisherwomen irrespective of their four different occupational groups. It revealed that income sharing pattern exists mostly with dry fish makers and value added fish producers since the involvement of their husband or other family members in the business was found to be very high.

Table. Networking among respondent fisherwomen community

Occupation	Networking Institutions			
	SHG	Mahila Mandal	Co-operatives	Others
Fish Retailer	74	0	26	0
Fish Vendor	55	2	43	0
Dry fish maker	68	0	25	8
Value added fish producer	86	0	14	0
Total	71	1	26	2

SE-P 05

Saline soil aquaculture in western Maharashtra: An impact study

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India has 9.2 million hectares of saline land in the semi-arid and arid zones of northern and southern states. Maharashtra also has its share of saline soils. It has currently 0.1 million ha of such lands. Due to intensification of irrigation, agricultural lands have become water logged and large areas of agricultural lands have become saline since 1960s. The salinisation of these soils is increasing every year at an increasing rate. Sugarcane is the major agricultural crop in Satara district of western Maharashtra and 66% of the respondents now understood that their soil have become degraded and infertile because of faulty water management practices. Therefore, in order to put these lands to best use, aquaculture was propagated in this area as an alternative livelihood from 2008 onwards under the CIFE-NAIP project.

An impact study on the saline soil aquaculture in western Maharashtra was conducted in Satara district. Prior to 2008, 98% of respondents of the project area did not have awareness and knowledge about fish culture. But at present, 87% of the respondents were aware of fish culture as a profitable venture for putting their barren saline lands to best use. In this context, 92% of the respondents were willing to lay sub surface drainage system (SSD) and undertake fish culture collectively with other neighbouring farmers. Most of the respondents were very much interested in laying sub surface drainage systems in their barren lands with some support from either the state Government or the ongoing NAIP project. Despite the fact there was resistance among the farmers to aquaculture prior to 2008 to the



extent that 98% of them were opposed to use of their lands for any other purpose other than agriculture, has now come down to 89%. The farmers' attitude to aquaculture has improved since the returns generated from aquaculture that has been made in these lands is increasing their income manifold. The performance of SSD system has brought a ray of hope to the farmer as after the introduction of SSD system, the sugarcane production has increased up to 40 tonnes from 16 tonnes, ground nut and soybean production has increased three fold. Therefore the impact study concluded that 90% of the respondents in the target villages felt that the project is useful to farmers but only 73.3% in non beneficiaries in the neighbouring villages were of the opinion that the project was useful.

The project has benefited not only large farmers but also small farmers as per the views of 91.4% of the respondents. Therefore, there was a general consensus among all the farmers including non-beneficiaries from Kobi and Karve villages that the project may be extended so that they could practise agriculture as well as aquaculture in a cluster farming system.

SE-P 06

Transformational technology - Ornamental fisheries as growth engine for fisheries development in north east India

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Ornamental fisheries sector in India is emerging as a potential non-food fishery opportunity for small and marginal farmers. The value of ornamental fish exports from the country has increased from Rs. 3.2 crore in 2001-02 to Rs. 5.6 crore in 2005-06. Further, the country's potential share in the global ornamental fish market is estimated to be US\$ 282 million. Realizing its potentiality, the Marine Products Export Development Authority, Kochi, has come up with many schemes to expand the country's ornamental fish trade

aiming to boost exports by US\$ 50 million in 2012. The north-eastern states play a vital role in India's ornamental fish trade as it contributes more than 85% of total exports of the country (Nair, 2004). The north-eastern region comprises of eight land-locked states, and has vast water resources in the form of lakes, rivers and streams, reservoirs, beels, wetlands etc. which sheltered a rich and unique ichthyofaunal diversity. The region has plenty of small fishes having negligible commercial value but can fetch fair price as ornamental fish in both export and domestic market. However, the potentiality for generating local employment and income from of such small fishes as ornamental fishes has not been much realised by the local people.

There is a major gap between potentiality and utilization, which needs to be bridged. Advanced institutional support and reorganisation is the need of the hour. The need is reinforced by the fact that, out of 250 native species of ornamental fishes in the north eastern states, the conservation status of 144 species has been reported as 10 critically endangered, 28 endangered, 50 vulnerable, 45 lower risk – near threatened, 8 lower risk – least concerned, 3 data deficient and 106 species remain unevaluated (Mandal *et al.*, 2007). In a preliminary investigation to assess the ground realities, the response of stakeholders in ornamental fish trade in select locations in north-east India to the existing production systems and institutional arrangements indicated that 70% of the local populations involved in this trade were ignorant of their role in the supply chain. About 25% were vaguely aware but had hardly any influence on price and quantity traded. Preliminary results indicate that 5% of the stakeholders in various positions in the supply chain controlled the ornamental fish trade in north east India. Under such circumstances, there is a need to organise both production systems as well as institutional arrangements for the development of the sector. As India's ornamental fish trade is mainly sourced from the wild collection, there is an urgent need to ensure the sustainability of the resources. In order to achieve the sustained development of ornamental fish trade there is need to shift from



the present practice of wild collection to culture systems. This requires the development of appropriate and standardised breeding techniques for the native species. Furthermore, the dissemination of technical knowhow, scientific strategies at different production level and capacity building among the different stakeholders involved in the sector is equally important. Information stations, both physical as well as virtual, the role of the DoF, the synchronised functioning of central departments like MPEDA, NFDB, NABARD and North Eastern Development Finance Corporation Ltd (NEDFi) will go a long way to strengthen the ornamental fish trade in north-east India.

SE-P 07

Marketing efficiency of dry fish – a study of Jagiroad dry fish market, Morigaon, Assam, India

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Jagiroad Dry Fish Market, Morigaon, Assam is Asia's largest dry fish market that supplies dry fish products to the entire north-eastern part of India. The market receives dry fish products from the western, southern and northern parts of the country. A study was conducted to identify marketing channels and estimate cost and margins in each channel. An attempt was also made to analyse marketing efficiency of dry fish sold at Jagiroad Dry Fish Market. Five channels for the marketing of dry fish at Jagiroad market have been identified and a channel consist of dry fish producer – assembler – commission agent (CA) – wholesaler – retailer – consumer is found to be the most dominant channel as it contributed about 56% to the total dry fish sold at the market. In this channel, total marketing costs of dry fish producer, assembler, CA, wholesaler, retailer have been found to be Rs. 10.18, Rs. 5.81, Rs. 10.71, Rs. 10.24 and Rs 8.29, respectively. The marketing margins of these intermediaries have been estimated at Rs. 15.46 for dry fish producer,

Rs. 6.26 for assembler, Rs. 11.63 for CA, Rs. 17.67 for wholesaler and Rs. 26.23 for retailer. Similarly, marketing costs and margins for other channels have also been estimated. Dry fish producer's share in consumer's rupee has shown variations across the marketing channels and found to be relatively more in channels having lesser number of intermediaries. The Shepherd index of marketing efficiency of these identified channels have been found to be vary from 1.36 to 1.55 and as per Acharya's method, efficiency ranging between 0.49 to 0.83. The marketing efficiency has been found to be more in case of channels having lesser number of intermediaries. One of the channels comprising of dry fish producer – wholesaler – consumer found to be the most efficient marketing channel. Despite having better marketing efficiency in this channel, its market share to the quantity of dry fish sold was smallest as it is always not possible for the consumers of north-eastern states to buy dry fish products directly from the wholesalers.

SE-P 08

WOMEN - The invisible workers

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A livelihood comprises people, their capabilities and their means of living, including food, income and assets. Chambers and Conway (1991) defined a sustainable livelihood as, "a livelihood is environmentally sustainable when it maintains or enhances the local and global assets in which livelihoods depend, and has net beneficial effects on other livelihoods". The fisheries sector is an important source of life and livelihood for millions of people around the world. Fishing and aquaculture are usually portrayed as occupations or recreations of men hauling nets and lines in dangerous seas, piloting fishing boats and negotiating with fish traders and fisheries officials. What these pictures miss are the contributions and roles of women. Though women are engaged in a variety of works related to fishing and fish farming, the



work done is still invisible. Women in fisheries only means, a woman with a basket of fish on her head for marketing or in processing industries wearing a mask and apron. Why their work is invisible? Is it because of lack of recognition or gender bias? Why women are invisible workers? FAO (1987) has documented women fish from canoes in coastal lagoons in Philippines, whereas Madhu (1989) identifies the diversity of women's role as fish retailers, auctioneers, marketing agents, net repairers, seed collectors, fish processors and labourers. Nandeesh (1994) found that in Cambodia, ponds in which women carried out 50% or more of the tasks associated with the culture of fish showed higher yields than other ponds. The success is visible from the women SHG working on seaweed farming and processing in Ramanthapuram district of Tamil Nadu (Krishnan and Narayankumar, 2010, 2011). Though we have enough literature showing women's role in fisheries, fisheries is considered to be a man's work and not as work performed by men and women. Only women empowerment and awareness will not serve the purpose of bringing "Equality" in the society, but both men and women must be aware of the roles and responsibilities of both the genders in each and every task to have a better environment and sustainable development.

SE-P 09

A comparative assessment on the literacy, health and income status of marine capture fishers in Kerala and Tamil Nadu

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Literacy, income and health are interlinked for the overall development of the personality of an individual and development of the society. There are about two lakh active fishers involved in fishery and fishery related activities like pre-processing, processing, and marketing related activities at different level. This paper makes an attempt to assess the status of literacy, health

and income of marine capture fishers in Kerala and Tamil Nadu. A total of 280 respondent households from nine coastal districts were covered from Kerala and Tamil Nadu. The literacy status of the respondent households was analyzed by assessing their educational status – continuing and dropouts and access to educational facilities. The health status was studied based on the parameters like administration of vaccines, incidence of their discontinuation, birth weight of infants, incidence of maternal and child mortality at the time of birth, incidence of common diseases and special ailments among adults and children. The income profile of the respondent households is analyzed using income patterns, respondent's involvement in non-fisheries activities and expenditure pattern. In addition, the indebtedness and savings were analyzed using details on savings, indebtedness, sources of lending organization, purpose of availing loan and suggestions for enhancing the income and employment generation. The fishery sector contributes to the prime income of the fishers across the states and contributing to 75 and 90% in Kerala and Tamil Nadu. The analysis clearly indicates that the improved or increased access to educational facilities has helped to increase the literacy level of the fishers.

Table. Access to health care (distance in km)

States	Primary Health Centre	Hospital
Kerala	1.18	5.78
Tamil Nadu	0.84	5.08

SE-P 10

Production and marketing of the black clam, *Villorita cyprinoides* in Perumbalam Island, Alappuzha District, Kerala

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Black clam, *Villorita cyprinoides* is abundant in the Vembanad estuarine system. Perumbalam Island in Alappuzha district is also



part of the estuarine system and black clam fishing has been an important livelihood activity in this region. The resource has long been exploited for its shell, but now the meat also has a growing domestic market. This paper presents the existing production to marketing chain of black clam in the island. Clam fishing, processing and marketing have been family centric activities in the region. The operational cost of harvesting and processing clam was Rs. 24,500. The gross and net returns were Rs. 82,720 and Rs. 58,220 respectively per family per year. The marketing efficiency was highest for the direct marketing channel, i.e., producer to consumer.

The harvest of small sized clams had been in vogue earlier, but now the fishers resort to relaying and culturing of the clams to bigger sizes before harvesting it. Since the clam fishing activity is having a degree of concentration in the island with a number of households being engaged in it, the possibility of clustering and organising the activity for sustainable harvesting and better processing and marketing can be explored.

SE-P 11

Promoting composite carp culture in seasonal ponds in Boudh: an empirical investigation

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There are geographical diversifications in the country. Based on its existence, the freshwater resources (large, medium and small; seasonal and perennial) varied. These water resources have immense potential for fish production. The tribal regions of the country also endowed with such water bodies but fish production is reported to be low due to various socio-economic and bio-physical constraints. The fish production from the existing ponds in

tribal areas can be accelerated through the implementation of scientific management for providing self employment, income generation and improving nutritional security of the tribals.

In view of this, an investigation was carried out with the objective of disseminating technology of composite carp culture among SC/ST women through demonstrations. The demonstration work was carried out in Boudh, a tribal dominated, socio-economically backward district of Orissa. The project was sponsored by Science for Equity and Empowerment Division (SEED), Department of Science and Technology (DST), Government of India. Resource inventory was made in the region using Participatory Rural Appraisal (PRA). Limiting factors for low fish production were analyzed and intervention points were identified. To mitigate limiting factors for low fish production the composite fish culture technologies were demonstrated in 4 ponds covering 7.5 ha water area through participatory approach. Different aspects of scientific carp culture viz., pond preparation, aquatic weed removal, manuring, stocking, liming etc. were demonstrated to tribal women. Capacity building skill training was conducted with the help of charts, banners, and provided leaflets in local language- Oriya to improve the knowledge about composite carp culture. Total 114 SC/ST women beneficiaries belonging to 9 women Self Help Groups (SHGs) of Kantamal block were trained. Quality fingerlings of rohu, catla, mrigal, common carp and grass carp were stocked in the prepared ponds @ 6500 fingerlings/ ha which were procured from State Government hatchery. The women took active interest in practising scientific fish farming. The mean fish yield of adopted ponds rose to 1123 kg/ha/year in 2010-11 from pre-adoption production level of 576 kg/ha/year despite several constraints like low water retention, adverse climatic condition, social restriction for use of manures and fertilizer and above all the short-term culture for 6-8 months. Fish were harvested 2-3 times and was distributed among the members for household consumption. At the end of the culture period, surplus fish were sold in the market and the money generated was kept in the SHG's bank account for meeting



future expenditure. Involvement of SC/ST women in composite carp culture has proven to be economically beneficial and it is hoped that this would go a long way in strengthening their livelihood.

SE-P 12

An assessment of the status of empowerment of fisherwomen in coastal Karnataka

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Fisherwomen contribute substantially to the Indian fisheries economy in general and to the marine economy of Karnataka state, in particular. Fisherwomen form an invisible work force but they are dominant in shore-based activities such as processing, vending and trading of fish. Studies have revealed that, the fisherwomen's contribution to the family income was found to be vital and indispensable for the fisher families' livelihood. The present study was conducted in three selected villages of Dakshina Kannada district of Karnataka. The findings of the study revealed that majority (76.66%) of women fresh fish vendors had medium level of empowerment. The results of the correlation analysis revealed that, the socio- personal and socio-psychological variables such as education, mass media participation, contact with extension agency and social participation showed a high and positive significant relationship with the empowerment status of the women fish vendors.

SE-P 13

***Eurale ferox*, Salisbury integration into fish ponds in Manipur, India**

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Aquaculture is one of the promising food producing sectors in terms of highest growth

rate. In India, the system of integrated farming using various components has gained momentum due to its higher production. In Manipur, integration of fish culture with *Eurale ferox* with fish as a major component is practised in marginal level. A survey was conducted to visualise the present level of such farming techniques adopted by the farmers in the state. The innovations adopted by the farmers were acceptable but few modifications are required. The practices were socially, ecologically and economically viable. The indigenous technical knowledge of such an innovative farming technique can be promoted to a higher level through adoption of scientific farming technique to improve the present level of production in the state where fish remains a major commodity for local consumption.

SE-P 14

Extension strategies towards market development of traditional smoked freshwater low-value fishes for Jabalpur Division of Madhya Pradesh

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Indian market is the final destination of any commercially valued products produced by the producers in earning livelihood for their family such as either ready to eat or ready to cook. The Madhya Pradesh has been among the pioneering states in the country. The participation of fisherwomen in fisheries is well established and highlighted by several workers and providing them with greater opportunities and demand for smoked fish in fisheries sector in the Satpudha region in Madhya Pradesh. The Jabalpur Division in M. P. is the largest smoked fish market, specially freshwater fishes, which are small in size or have low consumer preference or have either little or no value, are considered as low value / trash fish, where smoke fish from almost all nearby districts is



brought, traded and taken to the other districts in the region. Fisherwomen have involved various technologies in fisheries over a period of time by trial and error, continuous observations and evaluation to use the indigenous technical knowledge by traditional practices in this field.

The present study on the quality of smoked fishes Jabalpur division of Madhya Pradesh reveals that the quality of smoked fish in general is very good and also offered for sale is superior in quality. Consumers of smoked fish in this region are poor tribal labourers, working and weaker sections in the society. Their socio-economic and educational backgrounds compel them to go for low cost stuffs rather than quality products and economic loss due to quality degradation is quite significant. The findings of the present study indicated that majority of the fisherwomen were high adopters of recommended traditional smoked technology. On Survey, it was found that the fisherwomen have more active participation and practical knowledge along with their spouses. Efforts are needed to organize co-operative marketing and processing of smoked fish under Self Help Groups (SHG). Awareness programme to improve the quality of smoked fish is the need of the hour which will ensure quality improvement and thereby good health of the consumers as well as contribute better returns to the producers and dealers. Therefore, keeping in view certain unique factors of the state like associate to them and also if fisherwomen were given proper education and training in the field, they can be of much help to improve their socio-economic status. The need of the hour is to utilize various developmental schemes for fisherwomen under co-operative marketing and processing of smoked fish by Self Help Groups and utilize various development marketing approaches with adequate schemes for evolving profitable packaging, processing, and transportation facilities to traditional smoked freshwater low value fishes for over the country, which can generate self-employment for women.

SE-P 15

Economics of shrimp farming in Gujarat – A case study

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Shrimp farming in Gujarat started during 1991-92 with an average production of 377.80 kg/ha. It was during 1994-95, that shrimp farming started in Dandi (Olphad) village of Surat district. However, owing to disease problems, there was a lull in the progress of shrimp farming in Gujarat. In 2000, shrimp farming recorded a production of 8 tonnes from six ponds i. recording a productivity of more than 1 tonne/ha despite the fact that there were initial setbacks in achieving successful crops. It was under M/s. Mayank Aquaculture Private Limited, that the scientific shrimp farming started in April 2005. A remarkable transformation was achieved by this in shrimp farming in Gujarat. Fifty five ponds at different locations, MAPL-1, MAPL-2, MAPL-3, and MAPL-4 in Surat district were under shrimp farming. The production strategies were organized in such a way that the Kapasi farm (MAPL-4) had eight stocking ponds and two nursery ponds with a total water spread area of 9 ha. This farm was taken up as a case study to work out the economics of shrimp farming. The major items of fixed cost included equipment and implements. This amounted to Rs. 1, 42,540. Operational expenses included seed, feed, complementary inputs and others, the total of which amounted to Rs. 30, 31,911. Therefore the total cost amounted to Rs. 31, 74, 451, at the beginning of the culture operations for 9 ha area. With the output price @ Rs. 300/kg (30 cts.) and the output /ha @ 2 tonnes / ha, on the basis of market price of the primary product farmed i.e. *P. monodon*, and additional income secured in the form of sale of mud



skippers in the crop culture period, gross return/crop in 9 ha amounted to Rs. 55, 00,00. After deducting the operational costs, the net return was Rs. 2,48,545 or Rs. 2, 76,172/ha. The returns indicated normal average performance rates i.e. available from similar shrimp culture locations in other parts of country. Therefore, it may be safely concluded that MAPL farms on an average conformed to the prescribed practices of shrimp culture advocated by the Coastal Aquaculture Authority. Another interesting feature practised in MAPL-4 Kapasi farm is that they were under zero exchange water system and successful cropping system based on appropriate use of complementing inputs.

SE-P 16

A comparative study of traditional and modern marine fish supply chain in Mumbai District, Maharashtra

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The present study was undertaken to have a comparative study of major modern and traditional marine fish supply chains operating in Mumbai district. A survey was conducted using personal interview method with the help of pre-tested schedule. A total of 7 traditional and 2 modern supply chains were found operating in the area. The dominant traditional fish supply chain in Mumbai was "Fishers–wholesaler–retailer–consumer" disposing of about 45.4% of the total marine fish production followed by "Fishers–retailer–consumer" (11.4%); and others. Among the modern supply chains, "Fishers – agent of modern retail outlet –modern retail outlet- consumers" was the dominant one disposing of about 11.2% of total marine fish production in the area. The overall marketing cost of wholesaler, retailer, vendor, commission agent for retail outlet of

modern marine fish supply chain was Rs. 6.52/kg, Rs.13.11/kg, Rs.13.11/kg, and Rs.18.0 kg, respectively. Among the traditional marine fish supply chain, the "Fishers–retailer–consumer"; was found to be the most efficient as price spread for the chain was minimum 19.07% of fisher's price and marketing efficiency was highest at 62.86%. In case of modern supply chain, the price spread was found to be lowest (Rs.109.21/kg) and marketing efficiency was highest (78.83%) in supply chain "Fishers– agent of modern retail outlet (vendor) – modern retail outlet- consumer" as compare to the other one and hence the supply chain was better than the other. Majority of fishers face problem of declining fish catch (93%), auctioneers face problem of inadequate space for auction (87%), retailers experienced constraints of inadequate storage facility (70%) and consumers found improper cleanliness and hygiene (75%). About 80% of the agents of modern retail outlet expressed irregular demand of fish from retail outlet as major problems. In modern fish supply chain, both the consumer and producer are happy because fishers getting better price and consumer are happy to get better quality of fish even though at higher prices. Intermediaries are also getting benefitted with higher margin and hence it can be concluded that the modern marine fish supply chain is better than traditional one.

SE-P 17

An economic analysis of mud crab fattening

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Water crabs were procured from local fishermen and stocked in two different places in Karla and Bhatye of Ratnagiri. The stocking density maintained at the rate of 100 numbers of different weights viz. 0.505 kg/m²



and 0.510 kg/m² in two different sized ponds. The water quality parameters were monitored on weekly basis. The mud crabs were fed with brown mussel meat and clam meat at the rate of 10% of the body weight and proximate composition of both the meats were analyzed, which were found to be more or less similar. Final harvest of fattened crabs was on 35th day and the average weight gain was 12% and about 85% survival rate was recorded in both ponds. Production economics of mud crab fattening for 30-35 days was calculated and estimated net profit was Rs 16,996 for 500 m² pond.

Table. Production economics of mud crab fattening

Expenditure/Income details	Amount (Rs.)
Capital Investments	
Pond excavation + Bund building	1100
Bamboo fencing @ Rs 200/labour (Total four labour for two days)	800
Birds scare net (1.5 kg)	400
Total capital investment	2300
Operational costs	
Water crab @ Rs 50/crab (Total crabs is 100 numbers)	5000
Feed purchased @ Rs . 24/kg (Total 107 kg brown mussel meat and clam meat)	2568
Total operational expenditure	7568
Gross income (Total 92 kg yield @ 87% survival and sold at Rs 310/kg)	24840
Operational costs	7568
Depreciation amount is 12% of total capital investment	276
Net profit (Gross income - Total deductions)	16996

SE-P 18

Reclamation of wetlands for community development in Assam - a case study

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Assam is rich in wetlands in various forms which play a vital role in the fish basket of the state. Department of Fisheries, Government of Assam has been giving stress on developing these wetlands through different development schemes on community basis. Kasubeel, a wetland (beel) covering about 12 ha area, completely covered with aquatic weeds (*Eichornia* sp.) was taken for development under Chief Minister's Special Employment Generation Plan in the year 2007-08 in the district of Sonitpur, Assam. Earlier, this wetland was unmanaged and fish harvesting was done by the local community and had no fish culture activities. Prior to the implementation of the scheme, PRA was conducted and a committee, Kasu Beel Agrabami Samiti was constituted with local members. With dedicated effort by the committee and Department of Fisheries, an area of 6.5 ha was selected and construction of dykes, complete de-weeding, construction of separate nursery tank etc was undertaken. Further, all inputs for fish culture and fishing nets were provided for one year. At the end of the project, the fish production showed a paradigm shift from the negligible quantity to 1000 kg/ha/year. Profit was shared among the community.



Fisheries Trade, Policies and Governance

FT- O : Oral presentation

FT-O 01**Export competitiveness of Indian marine products during post-WTO period**

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Fisheries sector in India has witnessed spectacular growth after independence both in terms of production and export. Fish production increased from 0.75 tonnes during 1951 to 7.8 tonnes during 2009-10 and export earnings from mere US \$ 10 million in 1960-61 to US \$ 2.84 billion in 2010-11. There was a great concern about the impact of trade liberalization measures and progressively stricter food safety requirements in developed countries on export performance and competitiveness of Indian marine products during the post - WTO era. In this paper, an attempt has been made to examine the temporal changes in the composition and direction of Indian marine exports and comparative advantage of Indian marine products in the international markets. For the study, time-series data on export of seafood for India vis-à-vis world were obtained from FAO trade year book, export statistics of MPEDA and commodity trade statistics of UNO by visiting their respective websites. To study the temporal changes in composition of exports of marine products, percent share were worked out on triennium basis. The Export Performance Ratio (EPR)/ Revealed Comparative Advantage (RCA) was estimated to examine the comparative advantage of India in export of marine products. It was found that export of marine products from India during 1995 was dominated by crustaceans and molluscs (live, fresh or chilled) accounting for about 54.3% of the total export in quantitative terms and 83.17% in value terms followed by fish (fresh, chilled or frozen). A total of about 98% of total exports of marine products were mainly in non-processed form (non-prepared/non-preserved). The contribution of processed products in total export of marine

products was more than 15% during 2008 from about 2% during 1995, and that of non-processed decreased from 98% during 1995 to about 85% during 2008. This is one of the positive developments for marine products exports sector of India because value addition create more income and employment. During 1995, Japan was the major destination of Indian marine products exports, accounting for about 47% of total marine products exports from India followed by European Union (25%), South East Asia (14%) and USA (10%) in value terms. During 2008, European Union emerged as the major export destination accounting for about 30% of total marine products export from India followed by China and Hong Kong (18%), South East Asia (15%), Japan (13%), USA (10%) and others (9%). Owing to non - tariff barriers to seafood trade in developed countries, such as allegations of contaminated consignments, the market for Indian seafood diversified into more open/transparent exports markets such as China, Hong Kong, countries in the middle east and south east Asia. Analysis of export competitiveness of Indian seafood indicates that India should give more emphasis on value addition rather than exporting unprocessed products that will increase export competitiveness of marine products which in turn will create more income and employment in the country. Diversification of export to more transparent markets will ensure sustainable growth of marine products export from India.

FT-O 02**Status of potential exploitation of marine fishes in Andaman and Nicobar Islands**

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Fish is one of the most important marine food resources of the Andaman and Nicobar Islands. The fish fauna of Andaman and Nicobar Islands is nearly about 1200 species and out of these, 240 species are commercially



important. To understand its exploitation status, the present study was carried out based on the existing database (2009-2011) available from the Department of Fisheries, Andaman and Nicobar Administration. As per 2009-10 records, catch of the pelagic fishes exploited was of 17785 tonnes; 15028 tonnes for demersal fishes and the oceanic resources was 187 tonnes totaling to 33000 tonnes. For the year 2010-11, it was 17995 tonnes, 15039 tonnes and 701 tonnes for pelagic, demersal and oceanic resources respectively.

The fishing boats in operation during the year 2009 were 63, 1431 and 1620, respectively for mechanised, motorised and non-mechanised categories. However, during 2010-11, the number got decreased to the tune of 8 (55), 138 (1293) and 155 (1465) for mechanized boats, motorized boats and non-mechanized crafts respectively. Based on the rate of exploitation available from the Kerala state, only 7.5% are exploited in Andaman and Nicobar Islands. Further, the catch per unit also exhibit around 12 tonnes/ year in Andaman and Nicobar Islands instead of 13.23 tonnes/ year in Kerala. About 1.48 lakh tonnes of estimated fishery resources is being under-utilised in Andaman and Nicobar Islands till date. In this circumstance, the reduction of vessels and other infrastructural facilities are of major concern for the minimal development of fishery exploitation. Consequently, the immediate necessary action needs to be taken for further development of fishery sector and for the utilisation of resources as well as fisher folk economy concern.

FT-O 03

Factor productivity and sustainability of marine fisheries in Kerala

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Total factor productivity (TFP), which is a measure of the increase in total output, not

accounted by increase in total inputs, is an excellent indicator of the performance of any production system and sustainability of the growth process. The TFP growth of marine fisheries in Kerala was estimated using Divisia - Tornqvist index and the maximum economic yield was estimated using Gompertz - Fox growth model. The different types of fishing vessels in the state were categorized in to five groups consisting of mechanised trawlers, mechanized gill netters, mechanized seiners, motorised units and non motorized units. The total marine fish production in the state increased from 3.25 lakh tonnes in 1985 to 6.70 lakh tonnes in 2008. A comparative analysis of the compound annual growth rate during the periods 1985-96 and 1997-2008 indicated that most of the marine fish species had positive growth during 1985-96 period and negative growth during 1997-2008 period. There were very high fluctuations in landings during 1985-96 as compared to 1997-2008. The study concluded that there exists excess fishing capacity above the economically optimal levels resulting in wastage of money, manpower and fuel in the fishing industry. This necessitates the need for optimal use of the resources in the sector.

FT-O 04

Management regimes and institutional arrangements in wetland fisheries: an evaluation of two eastern Indian states

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India is bestowed with a wealth of wetlands due to wide variation of climatic and topographical features. Wetlands are amongst the most productive life support systems in the world and are of immense socio-economic importance by providing food, fodder, fuel and water for domestic, irrigation and industrial purposes. Two eastern states viz. Assam and Bihar are endowed with copious aquatic wealth in the form of wetlands, swamps, ponds and rivers. The floodplain wetlands (beels) extending over one



lakh hectare, constitute the most important fishery resource of the Assam and more than 50000 ha in Bihar. Livelihood of fishers' family from time immemorial is dependent upon fishing in floodplain wetlands. The floodplain wetlands are used for multiple uses and as multiple user system. Multiple institutions play its role through ownership and control over the fisheries of wetlands. A large number of stakeholders are associated directly and indirectly with the wetlands, which include fishers, lessees, various state government departments, fisheries development corporations, financial institutions, research institutes, NGO's etc. These wetlands are common property resources and under various management regimes, such as private management (individuals and groups), fishermen cooperative management, community-based fisheries management (decentralized management, wherein the Government works as facilitator) and open access. The leasing period for cooperative as well as individual fishers was seven years in Assam; and ten years in Bihar under Maun Chaur Vikash Yojana.

An attempt has been made through this communication to describe management regimes and institutional arrangement in the frame work of stakeholders' mechanism of access to utilize the floodplain wetland resources for outcomes (positive or negative). Two wetlands viz., Haribhanga in Assam and Amuwa in Bihar were taken for case study for institutional arrangement and management regime. This communication also discusses about the sharing arrangement in the private managed wetlands.

FT-O 05

Fisheries policies, their effectiveness - Is there a need for anticipatory laws?

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Distress signals coming from coastal/marine ecosystems suggest that they are strained

to the limit in spite of forging international treaties, organizing global-level summits, passing green laws and forming green parties. U.N. Reports regarding the scientific findings on analysis of global ecosystems, such as coastal/marine systems, have accounted the stunning scale and character of human impact on them. Many species are disappearing without discovery and all the coastal ecosystems are under severe stress. Home to over two billion people, coastal areas play a vital economic role and also bear the brunt of human impact. Two-thirds of all fish harvested depend at some point in their lives on coastal wetlands, sea grasses or coral reefs, all of which are fast disappearing.

Overfishing, especially overexploiting and unregulated fisheries, is ever-increasing; fishing fleets are 40% larger than oceans can sustain. Trawling disturbs/destroys vast areas of sea floor with varieties of plant/animal life. The catch is declining for about one-third of major commercial fish. The collapsing fisheries will directly hurt over one billion people, particularly in southeast Asia. Sharks, for example, are keystone species in our oceans. The global conservation status of 64 species of open ocean sharks and rays reveals that 32% are threatened with extinction, primarily due to overfishing. Once considered only incidental "by catch", now these species are increasingly targeted due to new markets for shark meat and valuable fins. Despite mounting awareness for their conservation, many elasmobranchs remain virtually unprotected not only in the high seas but also in the coastal areas. Serious over-fishing of shark species and many other commercially important fish species in national and international waters demonstrates a clear need for immediate action on a global scale. The vulnerability and lengthy migrations of most open ocean species like sharks mean that coordinated, national/international conservation plans are needed for their restoration. It urges governments to fully protect threatened species of sharks and rays, or large predatory species with a view to improve the monitoring of fisheries. There is imperative necessity to invest



in research and population assessment, minimise incidental by-catch, and employ wildlife treaties to complement fisheries management. The volume of wastage of potentially valued species in the very recent past due to the least rated shore-seine fishing, which is considered a bygone art of fishing by many present day fish conservationists and the weird canny means coastal populations employ to counter the effectively framed fish protection laws and policies, create an urge to formulate anticipatory laws. The conservation laws in vogue in different coastal states and their level of effectiveness are discussed critically in this paper.

FT-O 06

Finfish export from India and impacts on domestic trade

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Finfish export from India is growing rapidly since 90s and the frozen fish export increased from mere 93,219 tonnes in 1993 to 3, 09,172 tonnes during 2010-11. With an overall quantity of 1, 18, 972 tonnes of fish worth Rs. 692 crores. China ranks first in finfish export from India in both volume and value terms followed by Thailand, Tunisia and Malaysia. There was diversification of exports from high value fishes like ribbon fishes, pomfrets and seer fishes to low value fishes like tunnies, mackerels, croakers and sardines over the years. In order to evaluate the impact of finfish exports on domestic production and prices, the trend in the production and exports of selected varieties of finfish and the domestic and export prices of finfishes was compared for the period 1997-98 to 2007-08. The price increase for seer fishes and ribbon fishes in the domestic sector during 1997-2008 was very high when compared to their export market prices. The decline in the exports of high value

fishes like pomfrets and seer fishes even with increase in landings may be attributed to the growing demand and prices in the domestic market.

FT-O 07

Institutionalise or perish - shrimp farming revisited

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Introduction of Pacific white shrimp *Litopenaeus vannamei* (Boone, 1931) has created a serious concern over the very basic concept of sustainability in India. The Coastal Aquaculture Authority (CAA) has recommended a stocking density of 60 pieces of *L. vannamei* per square metre, besides other stipulations in farming practices. But the lack of clear organizational framework and institutional governance has led to the conditions of free entry into the sector leading to unregulated growth. Input industry is also driving the market to a feverish pitch. Market imperfections have led to price crash and reports of disease occurrence is also frequent. Trends indicate a mirror image of the debacle of the late nineties happening in the offing. Post harvest market mechanisms, in terms of handling capacity, inadequate and low quality technical manpower, poor supply response to the export markets and market collusions at the farm gate level may prove to be major causes of a second debacle in the shrimp farming sector. The Coastal Aquaculture Authority in tandem with the Department of Fisheries of various states have developed number of regulations and safeguards for the controlled expansion of shrimp farming in the country. Farm level dynamics have been orchestrated in such a way to ensure sustainable farming of the white shrimp and black tiger shrimp. But implementation of regulations seems to be woefully lagging behind. All these are attributed



to the improper production planning and weak institutional governance. Adoption of BMPs has been proven to be a remedy to make any farming practice a sustainable one especially shrimp farming. To make *L. vannamei* farming more profitable and sustainable, number of strategies could be evolved. Strict enforcement of BMPs as practiced by the NaCSA demonstration farms, promotion of organic shrimp farming to command a captive exports market, regulated markets to control market inefficiencies, contract farming models to ensure fair price deals to the farmers etc need to be institutionalized in order to save the shrimp farming sector from a second disaster which perhaps has already been set in motion.

FT-O 08

Export performance and competitiveness of Indian ornamental fish trade

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Ornamental fish trade is a multibillion dollar industry today. While most of countries in the world have taken up the lead in ornamental fish trade, India is still a sleeping giant with a share of less than one percent. In the present study, an attempt has been made to study and examine the export performance, export pattern and competitiveness of Indian ornamental fish trade in international market based on the data pertaining from 1991-2009 from UNCTAD and WTO statistical database. The results indicated that share of India's ornamental fish exports to fisheries exports, agricultural exports, fisheries GDP, agricultural GDP and total GDP have been increased over the years. India's ornamental fish exports showed a positive CGR in terms of value, quantity and unit value when compared to world's total growth rate. India's ornamental fish trade has also been quiet competitive but intensity being very less, in recent years its competitiveness was also declining. This indicates that in order to sustain and enhance

competitiveness, India needs to have manifold increase in ornamental fish production, grow parallel with world's trend in ornamental fish trade and export more to those countries where it is highly competitive. To achieve this, India needs to adopt better technologies to culture vibrant ornamental fishes rather than just depending on wild collection, more professionals need to enter this sector, and there is need for a strong distribution channel and good infrastructure facilities. As India has shown immense growth rate over the years, taking care of all its constraints using suitable policy measures, it can emerge as a leading ornamental fish exporter of the world in years to come.

FT-O 09

Status of fishery resources export in Andaman and Nicobar Islands

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The economy of the Andaman group of islands depends on the exploitation of its marine resources. These marine resources of Andaman and Nicobar Islands may broadly be divided into two groups as fin and shellfish. It has been estimated that an area of 0.60 million km² of EEZ around these islands has potential for fishing. The estimated fishing potential of the Andaman and Nicobar Islands is 1.48 lakhs tonnes per annum. But it is reported that the present catch in these islands is only 130 tonnes. The total fishery export ranged between 25,000 - 1, 70,000 kg per year in the recent past in Andaman and Nicobar Islands. When comparing the export during 2009-10 and 2010-11, there was around 60,000 kg reduction in export. The average quantity of chilled fish exported was maintained more or less same during 2009-10 and 2010-11. The status of shark meat export showed an increment in the year 2010-11 as compared to 2010-11. The shark fin exhibited almost the



similar trend as shark meat which reflected the landings of shark. Dry fish export showed a decreasing trend with about 65% reduction in the year 2010-11 as compared to the previous year. The shellfish export market showed a moderate level of increase in the year 2010-11 than 2009-'10. The frozen lobster also showed an increasing trend in 2010-11 (12,423 kg) as compared to 2009-10 (4,771 kg), the quantum

of increment being around six fold in the year 2011. The live crab export showed an increasing trend between the years 2009-10 (34,000 kg) and 2010-11 (43,000 kg). The chilled prawn export was recorded mainly in the months of June to September in both the years but the year 2010-11 (190 kg) showed comparatively lesser export than 2009-10 (275 kg).





Fish and Fish related Biodiversity

BD- O : Oral presentation
BD- P : Poster presentation

BD-O 01**Challenges in conserving freshwater fish diversity in the Western Ghats**

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The Western Ghats, with only 5% of India's total land mass, are home to a rich array of life forms, many of which are endemic. Watered by both the South-Western and North-Eastern monsoons, the Ghats give rise to three major east flowing river systems-the Krishna, Cauvery and Godavary, that together with numerous other east and west flowing rivers, comprise a diverse freshwater ecosystem. Human impacts on these freshwater ecosystems have risen dramatically over the past century, leading to ever-growing threats to biodiversity.

Concerns about impacts on freshwater fish in the Western Ghats have focused on two main areas (a) Decline in the population of fish as a result of human activities, (b) Impacts of introduced predatory/nuisance species, and, attempts to protect or restore populations have focused on selected species via regulations on harvests, restoring habitats and captive propagation. While there is no doubt that human activities have greatly accelerated the rate at which native fish populations are reduced and that fish species have intentionally and accidentally been introduced in a number of drainages, there have been few attempts to contrast historical biogeography of native fishes with current distributions, taking into account the dispersal of non-native species and environmental change. Moreover, it is not exactly clear what functional effects these introductions or extinctions will have on freshwater ecosystems in the long term.

A better framework for conserving freshwater fish biodiversity in the Western Ghats might include the following:

- (i) Estimates of true ichthyofaunal diversity and habitat preference to correlate habitat loss with impacts on diversity

- (ii) Studies on life history, dispersal and tolerance limits to estimate likelihood of extinction
- (iii) Assessments and study of specific threats and consequences of species loss for ecosystem function
- (iv) Studies on metapopulation ecology
- (v) Studies on the synergistic effects of multiple stressors
- (vi) Studies on biotic homogenization and the creation of novel assemblages
- (vii) Assessment of weaknesses of current protective legislation

BD-O 02**Present status of Schedule-IV *Trochus niloticus* (Linnaeus, 1767) in the Andaman and Nicobar Archipelago**

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Trochus niloticus (Linnaeus, 1767) is a marine Prosobranchian gastropod found in tropical and temperate waters. This shell has been commercially exploited for several decades since the establishment of a regular *Trochus* fishery in October 1929 at Andaman Islands. Due to indiscriminate fishing, in the present day, the *Trochus* beds of Andaman waters are getting depleted rapidly. As a consequence, the Government of India, Ministry of Environment and Forests brought this species under Schedule IV of the Wildlife (Protection) Act, 1972. Present status survey on *T. niloticus* was carried out during August 2009 to March 2010 at 80 stations covering entire Andaman and Nicobar Islands to assess their distribution and standing stock on their natural beds. Extensive undersea and intertidal surveys revealed out the occurrence of *T. niloticus* throughout the sublittoral zone of continental shelf of Andaman and Nicobar Archipelago up to the depth of



20m. The mean numerical density of *T. niloticus* varied from 6 shells/10m² in the coastal waters of South Andaman to 15 shells/10m² in Nancowry Islands. Among the study area, the minimum mean size (basal diameter) i.e. 9.31 cm was recorded at North Andaman while maximum of 12.73cm found at Nancowry Islands. The epitome of the study indicated that the density and size of the *T. niloticus* is comparatively higher in Nicobar group of islands than Andaman group. The results on standing stock of *T. niloticus* in Andaman and Nicobar waters estimated in the present study was quite significant as their natural stock in this archipelago is marginally higher than their density in other reef areas of Indo-Pacific region. This indicates that the ban on fishing of *T. niloticus* in Andaman and Nicobar Islands since 2001 has made a greater impact on the recovery of their natural population in an optimal size over a period of ten years.

BD-O 03

Diversity, distribution and abundance of oceanic resources around Andaman and Nicobar Islands

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Waters around Andaman and Nicobar are bestowed with rich oceanic resources. An attempt has been made to understand the diversity, distribution and abundance of oceanic resources around Andaman and Nicobar Islands. Exploratory tuna long line survey data collected by M.V. Blue Marlin, survey vessel attached to the Fishery Survey of India, Port Blair during the period January 2006 to December 2008 was utilized for the study. A total of twenty seven species of fishes of which fifteen species were pelagic sharks were recorded during the study. Dominance of pelagic sharks over the target species ie. tuna shows the abundance of these resources in the area. Species composition of the fishes caught during the study were

compared with the results of earlier studies. Since 1989, a drastic reduction was seen in the composition of tuna and sharks. Latitude-wise and seasonal wise hooking rates recorded during the study are presented. Sharks were found to be dominant between Lat.08° N and 12°N, while no significant pattern was observed in the case of yellow fin tuna. This rules out the aggregation of these resources in any geographical location around Andaman & Nicobar Islands. Pelagic sting ray was abundant in lower latitude and it was found to be decreasing towards upper latitudes. Diminishing trend of hooking rates of tuna and sharks since nineties is an indication of the over exploitation of the oceanic resources. This warrants stringent management measures for the conservation of oceanic resources.

BD-O 04

Status and exploitation of seaturtles in Tuticorin district, Gulf of Mannar

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Sea turtles have been swimming the world's oceans for more than 100 million years, persisting through natural predators, climatic events and even the mass dinosaur extinction. Their shells are widely used for the production of various curios, and are being exported to earn foreign exchange. There are four species of sea turtles found in Gulf of Mannar the green turtle (*Chelonia mydas*, local name *Paer aamai*), Olive ridley (*Lepidochelys olivacea*, local name *Yeth aamai*), Leatherback (*Dermochelys coriacea* local name *Ezhuvari aamai*), Hawksbill (*Eretmochelys imbricate*, local name *Kilimooku aamai*). The Gulf of Mannar area is prone to severe anthropogenic pressures from the coastal fisher population. Marine turtles are caught worldwide for the food industry. In many parts of the world, marine turtles are considered as a fine dining for their flesh. In many coastal communities marine turtles are



considered as the best source of protein. The important turtle's habitats like coral reefs, seagrass beds, mangrove forests and nesting beaches had changed drastically due to which they are under serious threat. Accidental drowning of turtles in fishing gear, over-hunting of turtles are also considered as a major threat to the existence of the marine turtles. Green turtle, olive ridley and hawksbill were exploited at 62.0%, 34.8% and 3.2% respectively during June 2006 to July 2007 from the study area.

BD-O 05

Marine algal biodiversity in the inshore waters of Indian coast

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The west coast is a region of intense upwelling and is generally exposed with rocky shores and headlands, whereas the east coast experiences only weak upwelling is generally interrupted with beaches, lagoons, deltas and marshes. All islands along east coast are continental while those along west coast are oceanic atolls. The above features result in marked differences in hydrography, productivity, qualitative and quantitative composition of fauna and flora of the west and east coasts of India.

Marine algae from Indian coasts have been fairly well surveyed since several decades. The list of species is 844 and another 50 have been added in recent years. The most predominant number is for Rhodophyceae, followed by Chlorophyceae and Phaeophyceae and among these, the maximum number has been recorded from Tamil Nadu (455), followed by Gujarat (202), Maharashtra (152), Andaman-Nicobar Islands (133), Lakshadweep (89), Andhra Pradesh (79), Goa (75), Karnataka (43),

Kerala (35), Orissa coast including Chilka Lake (21) and West Bengal (14). The variation in number of species of algae is dependent on the type of substratum, absence of strong currents, availability of nutrients, tide, surf action, clarity of water etc. The littoral and sub-littoral rocky and coral rich areas support a good growth of different marine algae. There is luxuriant growth of marine algae along the south east coast of Tamil Nadu from Mandapam to Kanyakumari and rich marine algal beds are present in the vicinity of Pulicat & Chilka lakes and Visakhapatnam. Many *Gracilaria* species which has been reported from all around the coast of India, is found on surf exposed areas of the coral reefs and therefore restricted to the east coast and in Gujarat. *Gracilaria edulis* grows in lagoons and protected areas attached to pebbles and shells in muddy substratum. *G. crassa* grows in shallow near shore waters and *G. verrucosa* like species on sandy bottoms of salt water, buried in sand or attached to small stones. The algin yielding brown algae *Turbinaria conoides*, *T. decurrens*, and *T. ornata* need hard substratum and are found mainly on sheltered parts in the coral areas of Mandapam, Lakshadweep and Gujarat. *Gracilaria corticata* and species of *Sargassum*, *Ulva*, *Enteromorpha* and *Chaetomorpha*, which thrive in littoral habitats, have a more continuous distribution all along the intertidal rocky areas of the coast line. The economically important marine algae such as *Gelidiella acerosa*, *Gracilaria edulis*, *G. corticata*, *G. foliifera*, *G. verrucosa*, *G. crassa*, and species of *Sargassum* and *Turbinaria* are exploited along Tamil Nadu coast for supply to marine algae based industries. There are nearly 25 agar and algin industries in Tamil Nadu, Karnataka and Kerala and to cope up with the ever increasing demand of these industries, there is extensive and indiscriminate harvesting by algal collectors resulting in the depletion in the natural stock of algae. Therefore it is necessary to train the algal collectors in rational exploitation of natural beds and by adopting culture practices to augment the supplies needed by industries. A time table available, for commercial harvesting of marine



algae coinciding with peak periods must be implemented. Losses of marine biodiversity are also the result of urbanization of coastal habitats, pollution from industrial wastes etc. Destruction of biodiversity besides its ethical and aesthetic implications has severe economic affect, therefore it is very essential to protect the biodiversity and conserve the natural stocks of marine algae by all concerned agencies.

BD-O 06

Taxonomy and key for the identification of tunas and tuna like species exploited from the Indian EEZ

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Tunas and tuna like species have been collected from the commercial landings at Kochi, Tuticorin, Mangalore, Vishakhapatnam and Veraval at regular intervals during 2006-2010. After noting the colour and pigmentation in fresh condition, the specimens were injected with 5 % formalin and then stored in 5 % formalin. For most species, 30 specimens were examined for describing the species. However, for species, which are rare in the catch, the descriptions were based on fewer specimens. In taking meristic and morphometric data, the methodology of Hubbs and Lagler (1947) was followed. All the linear measurements were made in the median longitudinal axis. Detailed morphometric data, viz height of dorsal and anal fins, eye diameter, snout length, head height and height of body were taken. The relationship between certain body measurements and standard length and between certain dimensions in the head and head length were calculated after ascertaining the type of relationship through a scatter diagram, following the least squares method (Snedecor and Cochran, 1967). Taxonomic details of tunas and tuna like species have been generated from the present work and past

studies and all nine species were redescribed with color photographs. The species included are *Thunnus albacares* (Bonnaterre 1788), *T. obesus* (Lowe, 1839), *T. tonggol* (Bleeker 1851), *Sarda orientalis* (Temminck & Schlegel 1844), *Katsuwonus pelamis* (Linnaeus 1758), *Euthynnus affinis* (Cantor 1849), *Auxis thazard*. Key for the identification of the different species was provided for field usage. (Lacepède 1800) *A. rochei* (Risso 1810), and *Gymnosarda unicolor* (Rüppell 1836).

Table. Key characters for species identification of tuna speceis

Species	Gill rakers	Pectoral fin length	Finlets
<i>Thunnus albacares</i>	26-35	Extends beyond origin of second dorsal fin	lemon yellow with black margin
<i>T. obesus</i>	23-31	Reaches origin of second dorsal fin	yellow with black margin
<i>T. tonggol</i>	19-26	Reaches origin of second dorsal fin	yellow with gray margin
<i>Katsuwonus pelamis</i>	53-63	Very short and broad	dusky
<i>Euthynnus affinis</i>	37-43	Short and broad	dusky
<i>Sarda orientalis</i>	16-23	Very short	gray
<i>Auxis thazard</i>	39-42	Short and broad	grayish black
<i>A. rochei</i>	40-47	Short and broad	grayish black
<i>Gymnosarda unicolor</i>	18-51	Short curved	dusky bluish

BD-O 07

Some observations on the flatfish diversity of Indian waters

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Flatfishes are deep bodied, laterally compressed fishes, easily recognizable by the presence of both eyes on one side in juvenile



and post-metamorphic individuals. They are well known organisms as they occur in all of the world's oceans, are represented by large numbers of species and genera. In India, of the estimated 3.3 million tonnes of marine fish landed in 2010, flatfishes contributed 45644 tonnes ie. 1.2% of the total fishery resources and 6% to the total demersal resources of the country (CMFRI, 2010). Even though flatfishes make only minor economic contributions to tropical fishery landings, subsistence and artisanal fishers by their sheer numbers and intensity, harvest large numbers of flatfishes.

Results of a study undertaken to assess the diversity of flatfishes of South India are presented. 63 species of flatfishes belonging to 8 families and 26 genera were collected from different locations. The most speciose families were Family Soleidae with 9 genera and 19 species followed by Family Bothidae with 9 genera and 16 species. Extension of geographical distribution has been noticed in some species. Some of the flatfishes collected were ornamental in nature especially *Pardachirus* spp. and *Heteromycteris* spp. paving way for their use in the marine aquarium use. The present study thus offers an insight into the flatfish diversity of these waters.

BD-O 08

Clownfishes and their host sea anemones: Species diversity in India and world

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Anemonefishes are members of the Family Pomacentridae which includes 29 genera and 350 recognized species living mainly in coral reef environments. Pomacentrids are classified into four subfamilies: Amphiprioninae, Chrominae, Lepidozyginae and Pomacentrinae. Members of Pomacentridae family, commonly

known as damselfishes are distributed from tropical to subtropical latitudes. About 70% of damselfishes including anemonefishes are restricted to the Indo-West Pacific region. Twenty eight species of anemonefishes have been reported from the world oceans, of which 27 species belongs to genus *Amphiprion* and 1 species to genus *Premnas*. In India, 13 species under the genus *Amphiprion* viz., *A. akallopis* (Skunk Anemonefish), *A. bicinctus* (Two-band Anemonefish), *A. chrysogaster* (Mauritian Anemonefish), *A. clarkii* (Clark's Anemonefish), *A. ephippium* (Red saddleback Anemonefish), *A. frenatus* (Tomato Anemonefish), *A. melanopus* (Red and black Anemonefish), *A. ocellaris* (False clown Anemonefish), *A. percula* (Clown Anemonefish), *A. perideraion* (Pink Anemonefish), *A. polymnus* (Saddleback Anemonefish), *A. sandaracinos* (Orange Anemonefish), and *A. sebae* (Sebae Anemonefish), and one species under the genus *Premnas* viz. *P. biaculeatus* (Spine-cheek Anemonefish) has been recorded from the coral reef ecosystem of Andaman and Nicobar Islands during 2000-2005. Field observations revealed that the anemonefishes have proclivity to live in association with only 10 host sea anemones viz. *Cryptodendrum adhaesivum*, *Entacmaea quadricolor*, *Heteractis aurora*, *H. crispa*, *H. magnifica*, *H. malu*, *Stichodactyla gigantea*, *S. haddoni*, *S. mertensii* and *Macrodactyla doreensis* though there are nearly 1000 species of sea anemones. This host specific invertebrate and vertebrate relationship was observed at a depth of 0.5 to 10 m during low tide in the coral reef areas. The sea anemones such as *C. adhaesivum*, *H. aurora*, *H. malu*, *S. haddoni*, *M. doreensis* are often found buried in the sediment or sand and retracted completely when disturbed whereas, *H. magnifica*, *H. crispa*, *S. gigantea*, *S. mertensii* and *E. quadricolor* were usually found attached to hard substrata. Among the fish species, melanistic variation was also noticed in *A. ocellaris*. Surveys show that the numerical abundance of *Amphiprion* populations from these groups of islands has diminished due to rapid developmental activities in the islands, turbidity, discharge of waste, increase in water temperature, sand deposition by tsunami,



destruction of natural habitats, etc. The clownfishes *A. nigripes* (Maldives Anemonefish) and *A. clarkii* are also distributed in Lakshadweep group of islands whereas *A. sebae*, *A. clarkii* and *A. polymnus* were noticed at mainland India (Mandapam and Tuticorin).

Apart from the above, the other clown fish species reported from other part of world include *A. akindynos* (Barrier Reef Anemonefish), *A. allardi* (Allard's Anemonefish), *A. chagosensis* (Chagos Anemonefish), *A. chrysopterus* (Orange-fin Anemonefish), *A. fuscocadatus* (Seychelles Anemonefish), *A. latezonatus* (Wide-band Anemonefish), *A. latifasciatus* (Madagascar Anemonefish), *A. leucokranos* (White-Bonnet Anemonefish), *A. maclelochi* (McCulloch's Anemonefish), *A. omanensis* (Oman Anemonefish), *A. rubrocinctus* (Australian Anemonefish), *A. thiellei* (Thielle's Anemonefish), and *A. tricinctus* (Three-Band Anemonefish). As these clownfishes are very attractive due to their bright colours, they have very high demand in marine ornamental fish industry.

BD-O 09

Macrobenthic composition and diversity in mangroves along Nethravathi estuary, Karnataka, south-west coast of India

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Macrobenthos are benthic organisms (whose size is greater than 0.5 mm) that reside in mangrove sediments performing a variety of ecological functions. They occur in different body shapes, feeding styles, reproductive modes and form the critical link in the marine food web. Macrobenthos consume organic matter (bacteria, planktonic and benthic organisms, detritus, etc.) and in turn act as food for many fishes, birds and other marine invertebrates in aquatic the ecosystem. Studies on benthic animal communities have gained greater importance in the tropic cycles. Detailed knowledge of the bottom fauna is essential for

the determination of the fishery potential of an estuary especially the demersal fisheries. Macrobenthos constitute a major component in the estuarine as well as marine realm and play a main role in the ecology of many bottom feeding finfishes and shellfishes. The present study on macrobenthic composition and diversity was carried out in mangroves along Nethravathi estuary for period of one year from May 2009 to April 2010. Benthic fauna was mainly represented by polychaeta, crustacea, and mollusca. Total macrobenthos density varied from 1404 to 8352 no.m⁻². Higher macrobenthos density observed during pre monsoon months followed by post monsoon and monsoon months. Compared to all other stations, S5 showed very high density of macrobenthic population. In stations S1, S2, S3, and S4 polychaete were dominated followed by molluscs and crustacean, whereas in station S5 mollusca dominated followed by crustacean and polychaetes. Species diversity index varied from 1.560 to 2.501 and evenness varied between 0.6733 and 0.9829.

Multivariate statistic analysis such as Principal Component Analysis (PCA), Cluster Analysis (CA) and correlation matrix was carried out to see the relationship between water quality parameters and macrobenthic diversity indices and results discussed.

BD-O 10

Observations on the preliminary growth studies on hard corals carried out in Vizhinjam Bay, southern Kerala

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The transplantation of corals to an artificial habitat provides an unique opportunity for replenishment of their colonies by means of



enhanced survival and growth rates. Knowledge of growth and survival rate of hard corals would aid in the selection of species suitable for transplantation. Vizhinjam is bestowed with patchy coral growth and it was noticed that the available *Poecillopora* colonies are diminishing in their area due to sedimentation and bleaching. To replenish, a preliminary study was initiated in Vizhinjam Bay using the locally available coral *Poecillopora* species from a floating raft using different substrates through deliberate fragmentation. This study was carried out to gain insights on coral growth and survival strategies on different substrates to initiate coral transplantation. Results obtained on the observations on fragments of the coral *Poecillopora* spp. transplanted to different type of substratum suspended from a floating raft is discussed. The transplants were fixed to substrates using an adhesive epoxy glue. Growth was monitored using a caliper calibrated in millimeters to obtain the following dimensions: length as the longest dimension of the corallum through the center and width as the longest dimension perpendicular to the length. Average growth increment of poecilloporid colonies in the natural habitat is also discussed. An average increment of 7.5 mm length for three months was observed in the colonies grown in the raft. Other observations like survival and mortality in relation to hydrographic parameters and fouling in the relevance of this growth information is also addressed.

BD-O 11

The shallow water marine sponges (Porifera) in the coastal waters from Enayam to Kollam, southern India

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Underwater surveys were conducted in the shallow coastal waters extending from Enayam to Kollam, southern India. A total of 24 species of sponges were identified during the study which belonged to 20 genera, 13 families

and 6 orders. Maximum species diversity was recorded at Enayam (11 species), followed by an equal number of species at Vizhinjam and Adimalathura (10 species). Five species were recorded at Odayam, while three species were recorded at Varkala and only one at Paravur. A majority of sponge species at Enayam, Vizhinjam and Adimalathura were found to be associated with the mussel beds. At Enayam, the dominant species was *Callyspongia fibrosa* (30.77%), and at Vizhinjam, the dominant species was *Sigmadocia carnosa* (28.57%). The species *Myxilla arenaria* was dominant at Adimalathura (25.64%), while at Varkala, three species viz., *Aulospongos tubulatus*, *Endectyon fructosa* and *Axinella donnani* showed equal dominance. At Odayam, all the five species viz., *Aulospongos tubulatus*, *Trachyopsis halichondriodes*, *Epipolasis topsenti*, *Protylyssa foetida* and *Axinella donnani* had an equal dominance, while at Paravur only one species i.e. *Axinella donnani* was recorded.

Biodiversity indices such as Pielou's Evenness Index, Shannon Diversity Index and Simpson Diversity Index were also determined for each study site.

BD-O 12

The glory and gory of ichthyo-diversity of east coast of India

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The coastal marine fish faunal composition of the east coast of India on the western bank of the Bay of Bengal is mostly derived from the centre of evolution in the Malayan region which is supposed to be the centre of distribution. A long coastline of about 2550 km with a variety of coastal ecosystems encompassing estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, sandy stretches, mud flats and coral reefs, and its integral continental shelf harbour a rich fish fauna sustaining its vast coastal population. The total faunal diversity of east coast is higher than the west coast of India.



Information on fish faunal diversity of the east coast of India is collected and collated in this paper to provide an overview of their status. Over 1100 species of fishes belonging to 35 orders, 166 families and 536 genera are recorded from the East Coast of India till date (State Fauna Series, Zoological Survey of India). Of the 73 species known as endemic to coastal waters of India, 52 are from east coast. Three elasmobranchs, viz., *Glyphis gangeticus* is known by three museum specimens only; *Himantura fluviatilis* is known by the name only and *Rhinobatos variegatus* is restricted to Gulf of Mannar. The rest 49 species are teleosts and most of them are small and commercially unviable species including 13 gobioids. Only about 45 families which comprise less than 45% of the species known, contribute to fisheries. Our concern was more for these economically viable species, main target groups being Serranidae, Haemulidae, Sparidae, Lutjanidae, Nemipteridae and Lethrinidae. But more than 50% of fishes belonging to 120 families usually goes as trash and are thus neglected. Many species even become extinct before discovery. Our knowledge and interest are very much limited with the groups such as gobies, wrasses, damselfishes and cardinal fishes. Status evaluation of the fishes of east coast of India reveal that 6 species are critically endangered, 7 species Endangered, 25 species Vulnerable and 26 species are near threatened (IUCN Red List). Most of the threatened fishes are Elasmobranchs (total 54 species) owing to their low fecundity and rate of exploitation. This paper emphasises the present day need for inventorising less studied groups, their importance; loss of biodiversity as a result of bycatches and strategies suggested for protecting the threatened and endemic species.

BD-O 13

The biological diversity of freshwater bivalves from the rivers of the Western Ghats, India

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A total of 4 species of the genus *Lamellidens* (*L. marginalis*, *L. jenkinsianus*, *L. generous*, *L. phenchooganjensis*) and 6 species of the genus *Parreysia* (*P. naagpoorensis*, *P. khadakvaslaensis*, *P. cylindrica*, *P. sikkimensis*, *P. favidens*, *P. gowhattensis*) were recorded during the study period. Hitherto, *Parreysia cylindrica*, *P. kadakvasleinsis* and *Arcidopsis footei* have been reported only from Medha and Pune regions of Maharashtra and Ghataprabha Falls in Karnataka region of Upper Krishna river basin, respectively. During the present study, *P. cylindrica* has been recorded from Gangavalli, Aghanashini, Tungabhadra Rivers of Karnataka and Payaswini river of Kerala in very small numbers. *Parreysia kadakvasleinsis* was recorded from Tungabhadra River in large numbers. A few individuals of *Arcidopsis footei* have been recorded from the river Tungabhadra. Of the 5 genera (*Lamellidens*, *Parreysia*, *Pseudomulleria*, *Arcidopsis*, *Oxyaia*) recorded, two genera (*Pseudomulleria*, *Arcidopsis*) are endemic to the Western Ghats. A total of 3 species (*Arcidopsis footei*, *Parreysia cylindrica*, *Pseudomulleria dalyi*), are endemic to the Western Ghats. *Pseudomulleria dalyi*, the only northern hemisphere species of the family Etheriidae, is widely distributed in the upstream of river Tungabhadra.

BD-O 14

Nonconventional uses of some aquatic animals as covered in Wealth of India—raw materials series

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The "Wealth of India—Raw Material Series" is the richest and most authentic source material for full text information on Indian Raw Materials—Plants, Animals and Minerals,

recognized as a biodiversity and bioresources document contributed by the CSIR to the people of this country. It contains vital information on identification, distribution, cultivation, products and byproducts, yield, export and import statistics, utility, active principles, chemical constituents, pests and diseases etc., of at least 5000 plants species, 73 minerals and more than 50 animal titles including those found in aquatic habitats. The importance of marine ecosystem is obvious from the fact that out of the existing 34 phyla, 24 are aquatic, and 12 are exclusively marine. With its 8% hold on the world's biodiversity and a source of rich traditional knowledge, India has a potential role in the global trade of alternative medicine and products, including marine organisms. The 8000 km coastal line hosts about 15000 species in a variety of coastal ecosystems viz., coral reef (218 sp.) ecosystem, estuarine ecosystem and lagoon ecosystem including sea weed (850 sp.) and sea grass (16 sp.). The coral reefs are regarded as the food factory of the marine environment. Indian coral reefs, known for its rich biodiversity, have more than 3000 species linked to this ecosystem. Aquatic entries in the wealth of India include corals, crabs, crocodiles, molluscs, oysters, porpoises and dolphins, prawns, shrimps and lobsters, starfishes and other echinoderms, tortoises and turtles and whales. Apart from providing vast authentic information on all these, the WOI enlists non-conventional yet potential uses of various such animals. This study attempts to provide an overall view of all such information which are otherwise hidden to the eyes of researchers/readers.

BD-O 15

Fish diversity of Dolu Lake, Silchar, Assam

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Ichthyological survey conducted in Dolu Lake of Silchar in Assam revealed the occurrence of 24 species belonging to 8 different orders, 14 families and 20 genera. The most abundant fish species were *Notopterus notopterus* and *Gudusia chapra* followed by *Puntius ticto*, *Puntius muzaffarpurensis*, *Amblypharyngodon mola*, *Mystus tangara*, *Chanda nama*, *Channa punctatus*, *Colisa fasciatus* and *Xenentodon cancala* respectively. *Heteropneustes fossilis*, *Clarias batrachus*, *Channa orientalis* and *Channa striata* are found in large number only in hot seasons i.e., from March to August.

BD-O 16

New record of two reef fishes (Apogonidae and Platycephalidae) with a key to the genus *Apogon* from Lakshadweep, India

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The present study reports the occurrence of two species of reef inhabiting fishes based on specimen collected from the intertidal and lagoon area of Agatti Island, Lakshadweep at a depth of 1-5 m. Collected materials were identified by analyzing morphometric and meristic characters based on standard literature (FAO) and field guides. The following species were identified and recognized as new to the Lakshadweep waters (i) Cardinal fish *Apogon indicus* Greenfield (Apogonidae) and (ii) Fringelip flathead *Sunagocia otaitensis* Cuvier (Platycephalidae). Species taxonomy, distribution and habitat are discussed. These species are widely distributed throughout Indo-Pacific and known geographic range was also extended to the Lakshadweep waters. Key characters to the genera *Apogon* (Apogonidae) recorded from Lakshadweep are also provided.



BD-O 17**Recent spatial and temporal variation in ichthyofaunal diversity in the lower middle stretch of the River Ganga**RAJESH Kr. SINHA¹ AND R. K. SINHA^{2*}¹Environmental Biology Laboratory, Department of Zoology, Patna University, Patna- 800 005, Bihar, India²School of Earth, Environmental Science and Biological Science, Central University of Bihar, Patna - 800 014, Bihar, India

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The present study deals with fish diversity undertaken during the period December 2007 to May 2009. The study has been conducted to assess the spatial and temporal variation in ichthyofaunal diversity in the lower middle stretch of the river Ganga. The results of present investigation revealed the occurrence of 106 species belonging to 73 genera, 29 families and 10 orders. Presence of 106 species in this stretch in the current surveys indicate the rich diversity of fish fauna and highlight the conservation measures that should be taken to sustain the ichthyofaunal diversity. The objective of study is to provide the recent data of spatial and temporal variations in fish biodiversity

BD-O 18**Distribution and abundance of seaweeds at Veraval coast, Gujarat**

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Seaweeds are ecologically important as primary producers and are valued commercially for their phycocolloids. Distribution and abundance of seaweeds was studied for a period of one year in 2010 in and around Veraval Coast, Gujarat. Three sites such as Adri, Jaleswar and Somnath were selected at Veraval for the study. Biomass and diversity was maximum at Adri, followed by Jaleswar and Somnath in December. At Adri maximum biomass of 2034.5 g wet weight per

square metre recorded in December. *Ulva lactuca* biomass was maximum at Jaleswar (2233.5 g wet weight per metre square) in December. Veraval coast comprising Adri, Jaleswar and Somnath has extensive beds of *Ulva lactuca*, *Gracilaria corticata*, *Sargassum wightii*, *Caulerpa racemosa*, *Caulerpa peltata* and *Chaetomorpha antennina*. Plastic bags, nets, thermocol pieces and non biodegradable dumped from Veraval fishing harbor endangers seaweed abundance at Veraval Coast. Hydrographical variables such as water temperature, salinity, and nutrients were monitored.

BD-O 19**Observations on the systematics of Leptocephali from the Deep Scattering Layer (DSL) of the south-west coast of Indian EEZ**

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The DSL is an important ecosystem of the world oceans and supports a wide assemblage of zooplankton, micro and macro nekton. The existence of "deep scattering layer" in the Ocean was discovered in 1942 by Eyring, Christensen and Raitt of the University of California, Division of War Research. The wide spread occurrence of deep scattering layer in the world oceans and their rich bio-composition aroused scientific interest ever since their discovery (Duvall and Christensen, 1946; Eyring *et al.*, 1948 and Raitt, 1948). The studies on the bio-composition indicated the occurrence of a wide assemblage of young or adults of epipelagic, mesopelagic and to a lesser extent bathypelagic fishes. The pelagic, long-lived *Leptocephalus* larvae is common to the families of eels, but also shared by Elopiform, Saccopharyngiform and Notacanthiform fishes. They inhabit the upper few hundred meters of the water column throughout the world oceans, primarily in tropical and sub tropical areas.



Leptocephali in the DSL were mainly represented by the families of the order Anguilliformes viz., Congridae, Muraenidae, Muraenesocidae, Synphobranchidae, Nettastomatidae, Nemichthyidae, Ophichthyidae etc. Leptocephali are distinctive among larval fishes (Smith, 1989 a; Hulet and Robins, 1989). A small, thin, laterally compressed head gives the leptocephalus its name (leptocephalus = slender head). They are laterally compressed, largely shaped by a gelatinous material surrounded by a thin layer of myotomal muscle ('V' or 'W' shaped), have a simple gut and are nearly transparent. They possess well-developed eyes, olfactory organs and bear a series of slender, fang like, forwardly directed teeth. The leptocephalus stage lasts for months to years, and grows to a large size for larval fishes, typically 50-100 mm (Bohlke, 1989 b), but much more in some species (Smith, 1989 b-d), before metamorphosing into elvers.

In the present study an attempt has been made to study the systematics of leptocephali, from the DSL, belonging to five families viz. Congridae, Muraenidae, Nemichthyidae, Ophichthidae and Synphobranchidae of the order Anguilliformes and efforts have been made to identify them up to genus and species level. Leptocephali of the order Elopiformes were also represented in few instances. Since the work done on Indian leptocephali is scarce, some of the genus has been tentatively identified based on the number of vertebrae. The samples for the present study are from deep-sea, Lat. 6° – 14° N, Long. 67° – 77°E and bottom depth 180 – 4600m, from the southwest coast of India. The materials for study was collected during the cruises of FORV Sagar Sampada from 1998-2001 as part of the Department of Ocean Development (DOD) funded project "Studies on Deep Scattering Layer". The author is greatly obliged to the Department of Ocean Development, Govt. of India, New Delhi, for granting Senior Research Fellowship and also permission to use the samples for the research work without which the present study was not possible.

BD-O 20

Dominance of exotic fish species over local fish diversity of the Yamuna River

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Aquaculture has been a major cause for introduction of exotic fish. Over 40% of the national freshwater fish production is presently contributed by various exotic fish species. Recent increased occurrences of exotic fish species in rivers is a serious concern in view of conservation of the local fish biodiversity. We have studied the abundance index of exotic fish species over the 900 km stretch of the Yamuna River and found that some of the stretches were having major catch of only exotic fish species. Common carp and tilapia constituted the bulk of catch. Recent upsurge in the catch of African catfish *Clarias gariepinus* in the Yamuna river in the size range of 300 g to 11.6 kg was found to be another threat to the local fish biodiversity of the river. We have investigated the reproductive propagule pressure of exotic fish species at five river confluences and found higher propagule pressure at the confluences. The gut content analysis and reproductive staging of the wild caught exotic fish specimens was carried out. Our results demonstrated that some exotic fish species established in the river. Direct impacts have been found on riverine ecosystem and consequently upon local species which declined drastically after invasion of exotic species.

BD-O 21

Studies on ichthyofaunal diversity of the Gour River in Jabalpur, Madhya Pradesh

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The major rivers of India and their tributaries traverse through varied agroclimatic conditions, displaying high diversity in their biotic and abiotic characteristics throughout their 28,000 km. stretch. The diversity and conservation status of freshwater fishes have been studied and documented across the country (Jayaram, 2010; Molur *et al.*, 1998; Daniels, 2001). In Madhya Pradesh, several workers have studied fish diversity in rivers, dams, lakes and reservoir. Sharma (2007; 2008) studied fish fauna of Madhya Pradesh and Jabalpur District and recorded 172 and 93 fish species respectively.

The Gour River is one of the most important

rivers of Jabalpur and Mandla districts of Madhya Pradesh. The river flows from Niwas village (origin point) of Mandla district and meets river Narmada at Jabalpur. The river is the lifeline of the people residing nearby villages. The fish diversity of the river is still unexplored and not documented. Keeping this in view, the diversity of fish fauna of the Gour River in Jabalpur district, Madhya Pradesh was studied from the period April 2010 to March 2011 based on samplings from three stations. In Jabalpur, a total 33 fish species under 5 orders belonging to 12 families viz., 16 species of Cypriniformes, 7 species of Siluriformes, 3 species of Synbranchiformes, 7 species of Perciformes and 1 species of Belontiiformes were recorded. The Cyprinidae family was found to be the most dominant followed by Channidae and Bagridae. Overfishing and pollution are major threats to fish diversity of the Gour River.



BD-P 01**Fishermen perception on biodiversity conservation in Gulf of Mannar Biosphere Reserve**

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The Gulf of Mannar Biosphere Reserve is the first Marine Biosphere Reserve not only in India, but in all of South and South East Asia. The unique ecosystem has variety of environments and harbours a rich biodiversity and hence the reserve has been selected as an international priority site based on criteria such as bio-physical and ecological uniqueness, economic, social, cultural, scientific, national and global significance. It has about 3,600 species of marine flora and fauna and hence it is called as biologists' paradise. The Gulf of Mannar Biosphere Reserve was being degraded for a long period of time by severe anthropogenic pressures from the coastal fisherfolk population. The interaction of human dimensions in Gulf of Mannar Biosphere Reserve should be studied more precisely to design effective conservation programs. The aim of this study is the analysis of perception of fishermen on conservation of the biosphere reserve. A three point Likert scale was developed for the study. Twenty statements were identified and grouped under four categories namely status of fisheries resources, endangered animals, responsible fishing, community based management. Majority of the fishermen agreed overfishing as the reason for the declining of the fishery resources and the need to conserve the endangered animals. Majority of them were not fully convinced with the monsoon fishing ban and other responsible fishing methods. However fishermen welcomed the community based fishery management practices in the Gulf of Mannar Biosphere Reserve Trust such as Eco Development Committees and efforts made for alternative livelihood opportunities for fishermen. Therefore, a key to success will be to educate the fishermen more about the responsible fishing through formal and informal organisations and

involve them in conservation programs in an effective way to manage their own resources.

BD-P 02**A study on the diversity of groupers in India**

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The groupers belong to Family Serranidae are large-sized marine food fishes, many species reaching 25-100 cm in length and some species attaining more than 10 kg in weight. They are also the top-level predators in coral reef ecosystems worldwide. Most species of groupers inhabit coral reefs and rocky habitats but some prefer sea grass beds and muddy (or) sandy bottoms. An attempt was made to document the reef fishes of South India for a period of two years 2009-11. During the present study, about 40 species of groupers belonging to 7 genera (*Aetheloperca*, *Anyperodon*, *Cephalopholis*, *Epinephelus*, *Hyporthodus*, *Plectropomus*, *Variola*) were collected from traps, hook and lines, gill nets and trawlers of Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Andaman and Lakshadweep Islands. The diversity of fishes and species presence/absence data among all the landing centers is presented. Diversity indices were calculated only for three sites Kerala, Karnataka and Andhra Pradesh. The values of Shannon-Wiener diversity H' (\log_2), Margalef richness (d), Simpson species richness and Pielou's evenness (J') from the three areas were 2 to 2.2; 1.1 to 2.6; 0.85 to 0.88 and 0.6 to 0.8 respectively. Based on the species presence/absence data, maximum species diversity was recorded from Kerala and Andaman Islands. Among the 40 species recorded in the present study *Aetheloperca roga*, *Cephalopholis miniata*, *Cephalopholis sonnerati*, *Epinephelus areolatus*, *Epinephelus chlorostigma* are some of the common species which was found in all the sample sites. Diversity indices were calculated using PRIMER 6 package developed by the Plymouth Marine Laboratory, UK. Studies on the



species richness and diversity will help evolve suitable strategies for the protection and management of these species.

BD-P 03

Diversity and distribution of fishes in Andaman and Nicobar Islands

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This paper details on the diversity of fishes in different ecosystems such as coral reefs, seagrass, mangroves, offshore and freshwater ecosystems of Andaman and Nicobar Islands. A total of 1484 species under 603 genera belonging to 177 families are represented from these islands, of which 400 species having commercial significance as food fishes. Among the fishes, 73.4% of species are recorded as coral inhabitants (i.e. 1089 species). Besides, 277 species from mangroves, 152 species from seagrass meadow, 23 species from freshwater streams and 101 species from offshore environment, while 279 species were commonly observed as overlapped between mangrove, seagrass, coral reefs and offshore ecosystems. Significantly the number of reef fishes so far reported from Andaman and Nicobar Islands is the highest among Indian reefs. The distribution, abundance, conservation and management of these fishery resources at different ecosystems are given in the paper.

BD-P 04

Evaluation of multi-species fishery in West Bengal using diversity indices

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The effective management and conservation for the ecosystems rely greatly on the

understanding of spatial and temporal distributions of the fish community, ecological variables and fishing activity. The information on landings for all species by commercial fisheries can facilitate an analysis of species diversity and distribution patterns. This paper attempts to assess the marine fishery in West Bengal (Figure 1.), with an importance on the diversity with special emphasis on the variation in quantity of fish caught among different seasons. The total marine fish landings in West Bengal during 2007-2010 was constituted by pelagic (57%), demersal (29%), crustaceans (13%) and molluscs (1%). During this period, a total of 160 different species of fish and shellfishes were landed along the West Bengal coast among which demersal fishes had the largest species number (74), followed by pelagic (60); crustaceans accounted for 24 different species. Only two or three species were dominant in different seasons. During the fourth and first season, the dominant species were Bombayduck, croakers and prawns; while, in the third season, the dominant species were hilsa shad followed by Bombay duck and croakers. For assessing the diversity of fisheries in West Bengal, Simpsons' index was calculated from the season wise estimated marine fish landings along the coast for the period 2007-2010. The one way analysis of variance indicated that the index differs significantly among the seasons. The values of index varied from 0.06 to 0.37, the lowest in first season of 2009 and highest in third season of 2007. The highest value was mainly because of the landings of single species, hilsa shad.

BD-P 05

Biodiversity and distribution of fishes of the family Lutjanidae along the coast of Gujarat

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Fishes of the family Lutjanidae, commonly known as snappers, were collected from



different landing centres along Saurashtra and Kutch coasts of Gujarat for a period of one year. Morphometric and meristic characters of the different species were documented after identifying and photographing the specimens. Ten species (*Lutjanus argentimaculatus*, *L. johnii*, *L. lemniscatus*, *L. rivulatus*, *L. quinquelineatus*, *L. vitta*, *L. russelli*, *Pristipomoides filamentosus*, *Paracaesio sordidus* and *Pinjalo pinjalo*) were recorded from Gujarat during the study period. *L. rivulatus* and *L. johnii* formed the dominant snappers in marine catches, followed by *L. argentimaculatus* and *L. vitta*. All other snappers such as *Pristipomoides filamentosus* and *Lutjanus lineolatus* were observed occasionally. Distribution of *Paracaesio sordida*, dirty ordure snapper, was reported for the first time from the northwest coast of India. *Lutjanus quinquelineatus* and *Pinjalo pinjalo* were first reports from Gujarat coast. Taxonomic and distribution details collected from this study adds to the biodiversity information of this less known family from this part of India.

BD-P 06

Marine sponges of Pongibalu and Burmanallah, South Andaman

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Sponges are among the most ancestral metazoans and are often notoriously difficult to identify due to their complex morphological characters. However, as a group they are highly diverse, ecologically important and of significant importance to the pharmaceutical and biomaterials industry. Therefore, means of unambiguous identification is urgently needed. Phylum Porifera consists of more than 8000 described species, with an estimated species no of 15000 (Hooper and Van Soast, 2002). Many sponge species are difficult to identify even by taxonomic experts, because morphological characters for comparative morphology are

scarce and prone to homoplasies, highly variable or otherwise unsuitable for the unambiguous identification. In addition, many sponges discovered in large scale biodiversity surveys remain undescribed (Hooper and Ekins 2005), partly also due to the lack of skilled taxonomists.

The present study has revealed the richness of poriferans in the South Andaman. The sponges collected from Pongibalu and Burmanallah are totally different even though both are in same coast. A total of 16 sponges belonging to 15 families were identified upto genus and 2 sponges till family Boring sponges which are affecting the corals also were identified from the family Clionidae, Polymastidae. The genera *Clionaopsis* sp., *Stylissa* sp. were the most dominant sponges followed by *Acarnus* sp, *Microtylostylifer* sp. and *Sarcotragus* sp. in Burmanallah. While *Carteriospongia* sp. dominated in the Pongibalu followed by *Acanthotetilla* sp., *Desmacella* sp., *Tethyopsis* sp., *Plakinestrella* sp. and *Raspailia* sp.

BD-P 07

Temporal and spatial variation of meiofauna in Mulky estuary, south west coast of India

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The organisms which live in, or on, are occasionally associated with aquatic sediments, mode of life is referred to as "Benthos". Benthos constitute a major component in the estuarine as well as marine realm and play an important role in the ecology and food of many bottom feeding fin fishes and shellfishes. Among benthos, meiobenthos are known to be more sensitive than macrobenthos. Meiobenthic groups are used as biomonitoring tool to detect the pollution status of the aquatic system. Meiobenthos has a metabolic rate,



roughly five times that of macro fauna. It has been found that the meiofauna takes about 81% of its energy requirements from the sediment carbon and about 19% from water column. Meiofauna organisms are found abundantly in estuarine environments where their spatial distribution is associated with an aggregated behaviour. The communities of meiofauna from soft bottom habitats show notable patchiness in their temporal, spatial variation abundance with environmental factors.

The Mulky estuary is the most productive estuary. This estuary has been formed by the confluence of Mulky and Pavanje Rivers with Arabian Sea at Mulky (latitude 13° 04' N and longitude 74° 46' E) along Dakshina Kannada coast. Mulky or Shambavi River takes its birth in hill ranges of Padal gudda in Karkala taluk of Dakshina Kannada and after flowing for about 40 km it empties in to the Arabian Sea at Mulky. The abundance and occurrence of meiofauna in relation to water and sediment characteristics in Mulky estuary was studied from May 2008 to April 2009. Hydrographical parameters like water temperature, dissolved oxygen, pH and salinity fluctuated between 26.69 to 33.6 °C, 2.44 to 8.54 mg/L, 7.1 to 8.4 and 1.31 to 33.09 ppt respectively. Not much variation in hydrographical parameters was noticed between the stations. Seasonally, higher dissolved oxygen, pH and lower salinity were recorded during monsoon season. The sediment textures, mainly sand (sandy-clay), clay and silt percentage varied from 21.52 to 99.28, 0.46 to 86.35 and 0.03 to 2.62% respectively. Total nitrogen content in sediment ranged between 0.04 mg/g to 2.07 mg/g, whereas phosphorus varied from 6.38 µg/g to 178 µg/g of sediment. The total organic carbon in the soil varied from 0.08% to 2.41%. Seasonally, the stations near mangrove areas recorded higher nutrients in the sediment during pre-monsoon. 26 groups were recorded in the meiobenthos population, of which nematodes were the dominant group, followed by foraminifera, herpectoid copepoda, tubellaria, ostrococha, polychaeta and oligochaeta. The total population of meiobenthos varied from 165 no/10 cm² to

8650 no/10 cm² in Mulky estuary. The meiobenthic density and abundance decreased with depth, while horizontal distribution revealed higher density in sandy substrate than muddy substrate. Higher meiobenthos density was recorded during pre and post-monsoon, followed by monsoon season.

BD-P 08

Assessment of genetic diversity among *Sargassum* species

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The present study has been carried out to assess the species diversity of three different species of *Sargassum* viz. *S. swartzii*, *S. tenerrimum* and *S. plagiophyllum* collected from Okhaport, Malwan and Veraval respectively using Inter-simple Sequence Repeats (ISSR) primer. A total of five ISSR primers namely, ISSR-807, ISSR-811, ISSR-840, ISSR-855 and ISSR-859 were used for the genetic diversity studies. A total of thirty number of each species were taken for the analysis. Software POPGENE version 1.32 was used for estimating percentage of polymorphic loci (P), Nei's gene diversity (h) and Genetic identity and genetic distance (D).

The percentage of polymorphic Loci over all the primers was 12.5% in *S. swartzii*, 20% in *S. tenerrimum* and 40% in *S. plagiophyllum*. The genetic diversity was very less in *S. swartzii* (0.06) and *S. tenerrimum* (0.07) whereas, it was 0.21 in *S. plagiophyllum*. ISSR-807 and ISSR-859 gave two polymorphic bands each, 600 bp and 400 bp in *S. plagiophyllum*, only one polymorphic band in *S. tenerrimum*. No band appeared polymorphic in *S. swartzii* using this primer. ISSR-859 also showed two bands sized 600 bp and 430 bp bands showing highest polymorphism in *S. plagiophyllum*. In *S. tenerrimum* ISSR-855 and ISSR-840 gave two polymorphic bands each while other three primers gave only one band



separately. Several diagnostic band had appeared in ISSR-PCR amplification which could be use a specific to characterize the *Sargassum* species. Nei's genetic distance (D) was higher in all the species as they were expected among

species of same genus. Population studies among different species of *Sargassum* had drawn a prior attention using ISSR primer to fulfill the sequence data base, parental distribution along Indian water.



Climate Change and Natural Disaster Management

CC- O : Oral presentation
CC- P : Poster presentation

CC-O 01**Road map for mitigating threats of natural disasters and associated livelihood challenges in climatically vulnerable Raigad district of Maharashtra**

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Considering the significance of emerging challenges of climate change to livelihood security, in marine sector as well as in drought and flood prone areas of India a detailed road map has been prepared for the most vulnerable Raigad district of Maharashtra. Findings of a preliminary survey conducted in selected clusters of the district after developing synergy with stakeholders have revealed at least ten technological interventions for identified beneficiaries.

In the first phase, roadmap has been prepared for 15 villages of 5 selected clusters in the target district viz. Cluster 1-Alibag, Saswane, Bodani, Mandwa; Cluster 2-Ekdara, Murud, Rajapuri; Cluster 3-Mora, Ulwa, Vasheni; Cluster 4- Salav, Korlai, Nandgaon; Cluster 5- Karjat & Neral. The clusters were extensively covered by RRA (n=711) and clusterwise coverage was 35.02%, 7.88%, 16.32%, 15.33 and 25.46% respectively. Though there are number of technological interventions available for mitigating climate change induced threats, surveyed population and there peers were ignorant about most of these options. Awareness about PFZ and wind early warning advisories is also very low. There is no direct access to such data by fishers due to non-availability of TELEFAX or Digital Boards in villages. Frequent electricity shutdown in Raigad further impedes dissemination of such information. To overcome all these problems a unique technological interventions i.e. 'm-KRISHI® Fisheries Service' has been developed by joint collaboration of CMFRI with TCS to

disseminate Potential Fishing Zone and wind advisories on mobile handsets. In addition to the above, there are more than ten suitable technologies that are integral part of the roadmap to mitigate the impacts of present and future threats to the vulnerable area selected in the study. The present paper deals with these technologies and there propagation among stakeholders.

CC-O 02**Climate change and its perceived impacts on small scale shrimp aquaculture in Nagapattinam district of Tamil Nadu**

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Climate change as seasonal and temperature variations and extreme events is being experienced and expected to impact shrimp aquaculture due to its location and delicate farming species. Knowledge on climate changes, their consequences and impacts would aid in creating awareness among the primary stakeholders, development and dissemination of adaptive measures that would minimize the adverse impacts. A case study conducted among the small scale shrimp farmers in Nagapattinam district of Tamil Nadu adopting participatory methodologies revealed that seasonal irregularities, temperature variations, flooding due to heavy rain and cyclone were the climate change events being experienced by the shrimp farmers. Moreover, taking into account their likelihood and consequences, flooding was ranked as the major risk followed by seasonal variations and cyclone. Changes in water quality parameters, poor shrimp growth, infrastructure damage, 50-100 % shrimp escape, water pollution, disease outbreak and its rapid spread, non-availability of quality seed, mortality and low survival, poor feed intake, poor molting and stunted growth were experienced as the negative



consequences of climate change. The impacts due to the above consequences include high cost of production to the tune of 15-20%, 30-50% loss in production, delayed stocking (30-45 days), change in crop plan and prevented possibility of the second shrimp crop, premature harvesting and 50-100% economic loss. The study through a multi-stakeholder interaction suggested that the shrimp farmers need to modify the water exchange regimes, use of probiotics and minerals to improve the water quality, stock SPF shrimp seed, better aeration during night, increase the depth of water column, tree planting on bunds, postponing of seed stocking for a month and culture of alternative species to manage the problems due to seasonal and temperature variations. Further, changing the cropping season to advance the harvest before monsoon, netting around the bund and increase in the bund height were the adaptive measures suggested to deal with extreme events like heavy rain, flood and cyclone. The study suggested that the researchers need to strive for developing an alternative shrimp/fish species with reduced culture period, monitoring of sea water quality and brood stock during colder seasons, preparation of tidal charts, identification of an effective grass species for strengthening of bunds and monitoring of water quality at different temperature regimes to develop climate resilient practices to minimize the climate change impacts. Finally the study identified appropriate planned adaptive measures and implementing agencies with time line to enhance the resilience of shrimp aquaculture vis-à-vis climate change impacts.

CC-O 03

Changing climate-all set to impact reef ecosystem of Andaman and Nicobar Islands: Status and policy imperatives

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Andaman Sea witnessed massive bleaching during 2010 and the extent of bleaching in selected reefs in Andaman was studied through Line Intercept Transect (LIT) survey. It was found that percentage of fully bleached corals maximum at Havelock Island (69.49%) followed by South Button Island (67.28%), Nicolson Island (56.45%), Red Skin Island (43.39%), North Bay (41.65%) and Chidiyatapu (36.54%). Branching corals were the worst affected, while the massive corals were found to have withstood the elevated SST relatively. About 70% of the reefs that were affected are hitherto dead. The sea surface temperature (SST) during 2010 was higher than the average SST of each of the last three decades during January to October thus affecting the coral reefs and enhancing the potential risk of storm surges. The recent storm surge off Myanmar coast during March 2011 swept the reefs in some of the islands in Ritchi'e Archipelago, reducing them to rubbles.

The projected changes in mean temperature and precipitation for Nicobar region assessed based on the recent GCMs using the MAGICC/SCENGEN software indicate that the rainfall pattern is all set to change significantly ($P < 0.05$) during different seasons and the pattern of change in Nicobar would be different from that in Andaman. The Nicobar group of Islands are highly vulnerable to climatic variation due to their flat topography, limited physical size and geographical isolation. Among the Nicobar Islands, Trinket and Chowra have over 15% of the total land area with an elevation less than 10m above MSL. The digital elevation data taken together with the population density of different islands in the Nicobar district showed that Chowra is the most vulnerable island to climate-associated disasters. The variability in bleaching with the progression of SST with respect to different coral species are studied and the impact of climate change on Andaman and Nicobar Islands summarized, highlighting the need for an adaptation-centric, pro-development climate policy for the islands.



CC-O 04**Impact of extreme climatic event, Cyclone Laila on shrimp aquaculture in Prakasam district, Andhra Pradesh**

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Shrimp aquaculture is vulnerable to extreme climatic events such as flood, drought and cyclones whose frequency and intensity are expected to increase due to climate change. In order to assess the impacts on shrimp farming due to extreme climatic events as and when happened, Cyclone Laila impact was studied in Prakasam District, Andhra Pradesh (AP). Cyclone Laila struck Andhra Pradesh and Tamil Nadu coast during May 2010 and its damage was severe in Prakasam District, AP. Indian Meteorological Department (IMD) designation for this cyclone was severe cyclonic storm (BOB 01) and Joint Typhoon Warning Center (JTWC) designation was 01B. It is the first cyclonic storm to affect southeastern India in May since the 1990 AP cyclone and severe storm to hit AP over the last 14 years.

A total rainfall amount of 60 cm was received in a single day and 40 cm in less than 12 h in the district. Shrimp farming areas like Maddipadu, Ongole and Kothapatnam received the highest rainfall of 51, 32.3 and 25.8 cm respectively on a single day and Rivulets like Gundlakamma, Addavagu and Pothurajukaluva were flooded. The depth of source waters for shrimp farming increased from 12 to 20' in Buckingham canal and 3 to 10' in Mudigundi and Gundlakamma drains. Heavy gusty wind speed of 115 to 125 km/h damaged the infrastructure in the farms and ponds were inundated up to a height of 10-15' over the pond bunds in less than 12 hours. Shrimp farming area of 362 ha was affected severely and 100-120 DOC stock was lost. An increase in water turbidity and siltation to an

extent of 1-2 feet was observed on the pond bottom. A sudden decrease in salinity of source waters from 48-50 ppt to 18-20 ppt was registered and it was reported that the use of this water created stress to the shrimps in upland ponds that were not flooded. Fisheries Department estimated a loss of Rs. one lakh per hectare, which was not scientific. It is conclusive from the present and previous studies that heavy gusty winds and extremely heavy rainfall/tidal waves associated with cyclones and storm surges damaged the infrastructure in shrimp farms and the standing shrimp stock was lost due to inundation of ponds. This indicates the need of planned adaptation measures by the Government to mitigate the severity of impact and to provide the relief measures on par with agriculture.

CC-O 05**Climate change and its impacts on mountain fisheries in India**ROSHAN R. AKHADE¹*, TRIVESH S. MAYEKAR², SATISH V. VASAVE³ AND PRATIBHA VYAVAHARE¹¹College of Fisheries, Shirgaun, Ratnagiri - 415 629, Maharashtra, India²Central Institute of Fisheries Education, Versova, Mumbai - 400 081, Maharashtra, India³College of Fisheries, Pantnagar - 263 145, Uttarakhand, India**e-mail: roshanakhade723@gmail.com*

India is blessed with the huge mountain 'Himalaya' ranging from Kashmir at north to Arunachal at eastern side. Himalayas has around 7000 glaciers in the Indian part (ICIMOD). The peninsular part has mountain water resources, including those in the Western Ghats in the states Tamil Nadu, Kerala. The rise in global surface temperature of the earth started as early as the 20th century. The rise in temperature affects species distribution, growth, physiology, behaviour, habitats and population dynamics in the mountain region. These impacts in the mountain region can be analysed by changing the snow level of the glacier. The melting of glaciers directly impacts coldwater fish in ways like increased riverine flow, more debris load, destruction of breeding grounds, spawning, faunal composition etc.



Mountain fisheries of Indian subcontinent consist of mainly brown trout (*Salmo trutta fario*) and rainbow trout (*Oncorhynchus mykiss*) which is considered the beginning of coldwater aquaculture in India. The golden mahseer (*Tor putitora*) and common carp (*Cyprinus carpio*) are also used as candidate species in mountain region. The breeding and culture techniques for these species have been standardised and practiced successfully. Other than this, about 260 species of fishes have been recorded from the hills of our country. The mountain fishery is most susceptible to the climate change impacts as it sustains a very narrow range of temperature. An average 1 °C increase in temperature shifts the species distribution by 300m upwards. The anthropogenic factors add to the threats of climate change. Human beings alter the hydrological regimes in many ways and degrade water quality both directly and indirectly. Thus there is need to increase knowledge about climate change and to develop measures for mitigation from this big threat.

CC-O 06

Climatic variability and its effects on oilsardine fisheries of south west coast of India

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It is now known that the oil sardine *Sardinella longiceps* is influenced by climatic variabilities and climate change along the Indian coast, particularly along the southwest coast. The influence of climatic factors such as Sea Surface Temperature (SST), Zonal Wind (U), Meridional Wind (V), Scalar Wind (W), Coastal Upwelling Index (CUI), Sea level pressure (SLP), Sea level (SL), Multivariate El-Nino Southern Oscillation Index (MEI), and Rainfall on quarterly catch of the oil sardine during the years from 1970 to 2008 along the southwest coast of India was analysed. Over the 38 year period, an increasing of Sea Surface Temperature, Zonal Wind, Scalar Wind, Multivariate El-Nino

Southern Oscillation Index and sea level was observed in the annual trend values. Meridional Wind, Coastal Upwelling Index and Sea level pressure showed a decreasing trend. The annual rainfall fluctuated, but without a definite trend during the period. The annual oil sardine catch fluctuated widely during the 38 year period. The catch decreased from 225517 tonnes in 1970 to 3187 tonnes in 1994, but substantially increased thereafter in the last 14 years, reaching 361757 tonnes in 2008. The oil sardine landings along the southwest coast are positively correlated with Sea level ($r = 0.35$, $p < 0.01$) and Sea level pressure ($r = 0.36$, $p < 0.01$). A significant negative correlation was obtained between Rainfall ($r = -0.34$, $p < 0.01$), CUI ($r = -0.522$, $p < 0.01$), U ($r = -0.41$, $p < 0.01$), V ($r = -0.22$, $p < 0.01$), W ($r = -0.24$, $p < 0.01$), MEI ($r = -0.17$, $p < 0.05$), between the oil sardine landings. Sardine landings are negatively correlated at a time lag of 3 months, with the SST ($r = -0.28$, $p < 0.01$). In this present study, we find oceanic wind components and sea surface temperature effects on oil sardine landings along southwest coast of India.

Table . Correlation coefficient between the oil sardine catch and climatic variables off southwest coast of India.

	SL	SLP	SST	CUI	Rainfall	U	V	W	MEI
Oil sardine	0.35**	.356**	-0.28**	-.522**	-0.34**	-0.40**	-0.22**	-0.24**	-0.17*

** . Correlation is significant at the 0.01 level (2-tailed)

* . Correlation is significant at the 0.05 level (2-tailed)

CC-O 07

Relationship between *Noctiluca scintillans* bloom and zooplankton in the northern Arabian Sea using *in situ* and remotely sensed data

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Noctiluca scintillans is a non-photosynthetic dinoflagellate species. Well-mixed nutrient-



rich waters due to convection and favorable water temperature trigger *N. scintillans* bloom during winter season in the Northern Arabian Sea. We used *in situ* data collected on board SS-212 (Feb-March 2003), SS-253 (March 2007), Sk-256 (February 2009) and SS-263 (March 2009) to study the *N. scintillans* bloom. Phytoplankton analysis indicated that the bloom of *N. scintillans* dominated oceanic waters in winter season. In-house biophysical model was developed to estimate zooplankton biomass in Arabian Sea using data collected on board R/V Thomas G. Thompson ship in the Arabian Sea during January and March 1995 under US JGOFS 1995 programme. Remotely sensed chlorophyll-a (SeaWiFS) and SST (AVHRR) were used to estimate zooplankton biomass using in-house developed bio-physical model. *In-situ*

N. scintillans, chlorophyll-a and satellite derived zooplankton biomass were compared. As observed on cruise SK 256 in February 2009, the surface water samples measured 08-9600 cells/l of *N. scintillans*. Higher chlorophyll concentrations ($0.32-1.07 \text{ mg.m}^{-3}$) indicated a higher primary productivity which in turn also supported the higher concentration of the zooplankton ($3.47-21.19 \text{ mgC.m}^{-3}$). Similarly, the *in situ* data collected on cruise SS-212, SS-253 and SS-263 revealed high chlorophyll-a concentration during bloom period. Estimated zooplankton concentration also revealed high zooplankton biomass during bloom period. High chlorophyll-a concentration and zooplankton biomass production in oceanic waters during bloom in winter season indicate that there is no adverse effect of *N. scintillans* bloom.

CC-P 01**Indigenous Technical Knowledge (ITK) of fisherfolk on climate change: a case study in Chennai**

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Climate change will have strong impact on fisheries with far-reaching consequences on food and livelihood of a sizeable section of the population. The frequency and intensity of extreme climate events is likely to have a major impact on future marine fisheries production. Fishermen have excellent knowledge on the relationship between climatic, oceanographic factors and fish catch abundance. This knowledge enables them to switch their fishing activities with respect to species exploited, location of fishing grounds and gear used. Based on this backdrop, a survey was conducted to collect primary data on Indigenous Technical Knowledge (ITK) from 200 fishermen in and around Chennai with a structured questionnaire. Fishermen believed that reduction in fish catch in recent years is essentially due to overfishing (82% of fishermen interviewed) and juvenile exploitation (11%) rather than climate change (5%). Fishermen opined that current (62%) and wind direction/speed (28%) were the major climatic parameters affecting fisheries. Current from south to north direction which generally remains for nine months off Chennai leads to good fish catch, since it is favourable for larval distribution. They believe that combined wind blow from south and west leads to coastal upwelling, which occurs during May-June every year for 45 to 55 days. Current flow from south to north yields more rocky fishes due to turbid water condition and leads to heavy catch. However in recent years fishermen are not able to predict climatic events like in earlier years due to large unexpected seasonal variations. Fishermen believe that spawning activity of fish increases when temperature increases. Almost

all the fishermen agreed that ban period should be from April to May. They agreed that oil sardine, pufferfish, leatherjacket, tuna and red ring catches significantly increased in recent years. They also found that mackerel catch in the shallow waters is significantly reduced for the gillnetters since the fish have moved to deep sea. In the event of cyclones and sea erosion, fishermen of Chennai preferred temporary exit from their villages. About 90% of fishermen listen to and follow TV and newspaper for weather related information. Fishermen suggested that government should bring regulations on craft, gear, period, fish species etc., to maintain sustainable fishing.

Table Fishermen perceptions on the importance of climatic parameters to fisheries

Parameters	No of fishermen (%)
Current	124 (62)
Wind direction/speed	56 (28)
Coastal upwelling	10 (5)
Sea level rise	6 (3)
Temperature	2 (1)
Salinity	0 (0)
Rainfall	2 (1)
Total	200 (100)

CC-P 02**Statistical investigations on climate paired resource data-challenges and possibilities**

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Climate Change and its impact on natural resources of the country have reached the centre stage for quite some time now. Although the influence of the irrevocable changes is quite palpable, quantification and testing of postulations are proving to be quite a challenge. The primary reason for this is the intertwining of climatic and not-so climatic factors performing differently in face of jumps in



performances. Put down simply, unlinting of the time collated information is more complicated, but a necessary step towards progressing on regressing resource performance onto environmental upheavals. With a view to studying this particular angle, annual landing data of three pelagic resources viz. Oil Sardine, Indian Mackerel and Other Sardines of a particular region of the country was studied over a period of 42 years from 1967 along side certain highly influential climatic parameters like atmospheric pressure, sea surface temperature, relative humidity, cloudiness, wind speed components (zonal, meridional), salinity, coastal upwelling etc. The data series were analysed in two generic ways- first treating them as non-temporal entities and the second treating them as time series. While treating them as non-temporal entities, the resources and the environmental parameters were considered as multivariate manifestations and analysed simultaneously. Canonical correlation analysis were also performed between the resource group and the environment group. In the second attempt, time series were fit with resource and environmental anomalies and the auto and cross correlation functions were fitted for the resource time series and the climatic anomalies. Another attempt was also made to include the plausible epochs in fishing methods and infrastructure like introduction of outboard crafts, fishing regulations etc. which later went on to stay for years to come. The known factors were eased out and the time series analysis were carried out using the detrended- defactored data sets.

CC-P 03

Changes in sea surface temperature along Tamil Nadu coast – an indication of climate change?

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Increase in sea surface temperature (SST) over the years is the primary indicator of global warming. Temperature in turn affects other ocean parameters like salinity, pH, dissolved oxygen etc. All these factors have a synergistic effect on the biota, ranging from microscopic plankton to large fishes and marine mammals. As a prelude to understanding changes in biotic communities along the Tamil Nadu coast of India induced by alterations in climatic conditions, annual fish catch data of two major pelagic resources, the Indian oil sardine and the Indian mackerel, was correlated with SST. Data on SST were downloaded from the website of ICOADS (NOAA) following standard protocol. Three regions, Chennai, Nagapattinam and Kanyakumari were selected for retrieving the SST data over the last 105 years (1905-2011). The data was sorted for four seasons (post monsoon, summer, southeast and northeast monsoon) and mean value and anomaly for each season of every 20 years was calculated for all the three regions. Pooled data was used to arrive at a profile of the SST along Tamil Nadu coast. Available fish catch data (CMFRI) was tabulated along with the SSR and correlations were studied.

There is a rise in SST over a period of 105 years. The increase is more perceptible in all four seasons for the past 20 years in all the three regions selected. Rate of change in minimum and maximum SST at the 3 centers between the periods 1906-1925 and 1986-2010 was calculated. The trend shows an increase in minimum and maximum SST in all the seasons at Nagapattinam and Kanyakumari while at Chennai, minimum SST in SW monsoon season and maximum SST in summer season has decreased. The catches of oil sardine and mackerel show an increasing trend over the last 25 years. Seasonal analysis shows positive correlation of the catches with SST. The catch of oil sardine during the summer months in particular showed an increasing trend over the period.



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