# SUSTAINABLE FISHERIES IN AN ECOSYSTEM PERSPECTIVE

Dr. Antony P.J.
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# Sustainable Fisheries in an Ecosystem Perspective

Proceedings of the

***National Seminar on***

## Sustainable Fisheries in an Ecosystem Perspective

Held at

**St. Michael's College**

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# *Preface*

*Managing declining fishery resources and fulfilling the fish food requirements of exploding human population is a major issue the world confronting. As fishes constitute the major part of their habitat ecosystems, the management of fisheries require a broad ecosystem perspective. In multispecies fisheries management, ecosystem approach is an apt method. So the seminar is designed with the objectives to create a platform for scientists, academicians, research scholars and students to discuss the issue on management of declining inland and marine fishery resources; to exchange the views and ideas of scientific community working in this field; to generate recommendations for the proper management of available wild fishery resources and to improve fish production through aquaculture; to evolve ideas to fulfil the protein requirements of humankind along with managing fisheries in a sustainable manner.*

*In this backdrop the department of zoology, cherthala organised a National Seminar on 'Sustainable Fisheries in an ecosystem perspective' at St. Michael's College on 10th and 11th of December 2015. All aspects related to fisheries management were included in the seminar under six different sessions.*

*This book of proceedings of the National Seminar contain selected papers presented during this National Seminar. The papers are very much relevant and timely to discuss the various issues relating to fisheries and aquatic ecosystems and sugesting recommendations for management of fisheries in sustainable manner using ecosystem approach.*

*The editors are thankful to all the contributors of this book for having made sincere efforts to present their works and submit the papers in time. We thank the University Grants Commission who extended the financial support and and Principal and management of St. Michael's College for providing all the facilities for the conduct of the semnar and printing this proceedings.*

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# CONTENTS

# Present and Future Scenario of Indian Marine Fisheries

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**Abstract**

The Indian marine fisheries sector has high potential for rural development, domestic nutritional security, employment generation, gender mainstreaming as well as export earnings. The marine fisheries sector in India which existed as sustenance fishery for years, underwent a series of change through adequate support and care in the Five Year Plans and now evolved as a multi-million dollar industry. Through mechanization of indigenous crafts, introduction of mechanized vessels, improvement of fishing implements, establishment of infrastructure facilities for processing and storage, the marine fish production increased from 0.53 million t in 1950-51 to a maximum of 3.94 million t in 2012. The demand for fish in the next decade is expected to increase due to the awareness of the people on the nutritive value of fish. Sustainability of marine fish landings at the projected level is a major concern and there exists limited scope to increase the capture harvest in future. The marine fishing sector is facing serious challenges like unsustainable harvesting, socio-economic conflicts, low catch per unit from an open access to a regulated regime which in turn demands the establishment of a scientifically informed marine fisheries management system. Here, a brief on the present status of Indian marine fisheries sector, the issues plaguing the industry and suggestions to overcome the problems are given.

## INTRODUCTION

Indian marine fisheries which existed as a sustenance fishery for years, underwent a series of change with the advent of mechanisation in 1950s, evolving itself into a multi-billion dollar industry. The value of marine fish landings at the landing centres was estimated at 19,753 crores during 2009-10; whereas at the retail point the value was 28,511 crores. (Narayana Kumar, 2011). India has earned US$ 2.84 billion mark in the export of marine products from the country (MPEDA, 2011). India is one of major fish producing countries in the world contributing over 3% of both marine and freshwater fishes to the world production (Srinath and Pillai, 2006) with third position in capture fisheries and second in aquaculture. India has an Exclusive Economic Zone (EEZ) covering a total area of 2.02 million sq. km, i.e., 0.86 million sq. km on the west coast including the Lakshadweep Islands and 1.16 million sq. km on the east coast, including the Andaman and Nicobar Islands and a continental shelf of half a million sq. km (Vivekananadan *et al.*, 2003). The marine fisheries sector has high potential for rural development, domestic nutritional security, employment generation, gender mainstreaming as well as export earnings. The first formal step towards the development and management of marine fisheries was the enactment of the Indian Fisheries Act of 1897, delegating various erstwhile provinces with the responsibility of fisheries administration and management (BOBP, 1982; Bensam, 1999). To increase fish production from the seas, the different Five-Year Plans took adequate care by developing the marine fisheries by mechanization of indigenous craft, introduction of mechanized vessels, improvement of fishing implements, establishment of infrastructure facilities for processing and storage and to establish a strong R & D facility (James and Rao, 1992).

Indian fisheries sector has been witnessing a steady growth since the First Five Year Plan. The marine fish production increased from 0.53 million t in 1950-51 to a maximum of 3.3 million t in 2010.The growth of marine fisheries in India can be demarcated into three phases (Srinath and Pillai, 2006). The **I Phase** which extends from 1950s to late 1960s witnessed a slow, but steady growth in fisheries where non-mechanised craft and gears were operated. **Phase II** (late 1960s-mid 80s) was marked with use of improved gear materials, export trade expansion, increased mechanisation, initiation of motorisation of country craft and intensification of fishery activities. The **III Phase** which extends from mid 80s to the present is characterised by intensification of mechanised fishing, growth in motorisation and multiday fishing, extension of fishing grounds, seasonal fishery ban, introduction of molluscan aquaculture, open sea cage farming and breeding and hatchery development of marine finfishes for aquaculture. The developments in fish harvest technology has been in areas of craft technology and mechanization of propulsion, introduction of synthetic gear material, acoustic fish detection and satellite-based remote sensing techniques, advances in electronic navigation, provisions for on-board fish processing and preservation. Thus, the fishing industry in the last five decades has undergone significant developments leading to improvements in the working conditions and reducing the drudgery of fishermen.

**A. Present scenario of capture fisheries**

The period 1960 -70s saw a gradual increase in fisheries production from 0.63 million t in 1960 to 1 mt in 1970; a twenty year period (1950–1970) was required to raise production by double. Another 20 year period (1970 – 1989) was required to cross the 2 million t mark. During 1989 – 2010, fishery production did not have a smooth sail, but increased by leap and bounds. However, the period 2005 - 10 witnessed a meteoric increase in production by over 45 % i.e. 1.03 million tonnes (m.t) compared to that of 2005. Production reached all time high of 3.9 million t in 2102 after which it fell down and now stands at 3.59 m.t in 2014 (Fig. 1).

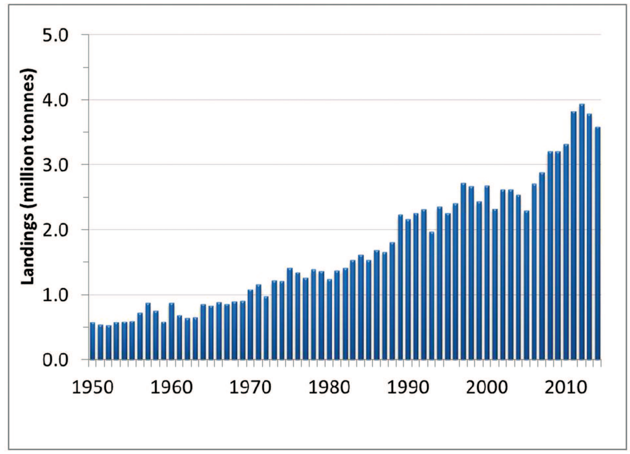



**Fig.1. Annual marine fish production in India for the period 1961-2014**

**State-wise production**

Among the coastal states, Gujarat, followed by Tamil Nadu, Kerala, Karnataka, together contribute a major share (64%) to the marine fish production of the country. However, considering the production per unit length of coast line, West Bengal has the maximum productivity of 2,259 t/km followed by 953 t/km by Karnataka, 878 t/km by Kerala, 682 t/km by Goa, 496 t/km by Tamil Nadu and 439 t/km by Maharashtra. While the east coast has 57.2% of the total coastline, it contributes only 28.8% of the total marine fish production, with rest 70.2% contributed by west coast.

On the east coast, Tamil Nadu was the major contributor followed by West Bengal and Orissa. Marine fish production has shown a steady increase in Tamil Nadu from 1.23 lakh t in 1960 to 6.5 lakh t in 2014. In West Bengal the production increased to 3.6 lakh tonnes in 2010, but, subsequently fell and now stands at 0.9 lakh tonnes in 2014. Marine fish production has been more or less steady in Andhra Pradesh during 1960-2010. In Orissa, the production has increased from 0.3 lakh t in 1976 to 1.4 lakh t in 2014; the production showed a tremendous increase of 1.1 lakh t during the last five years.

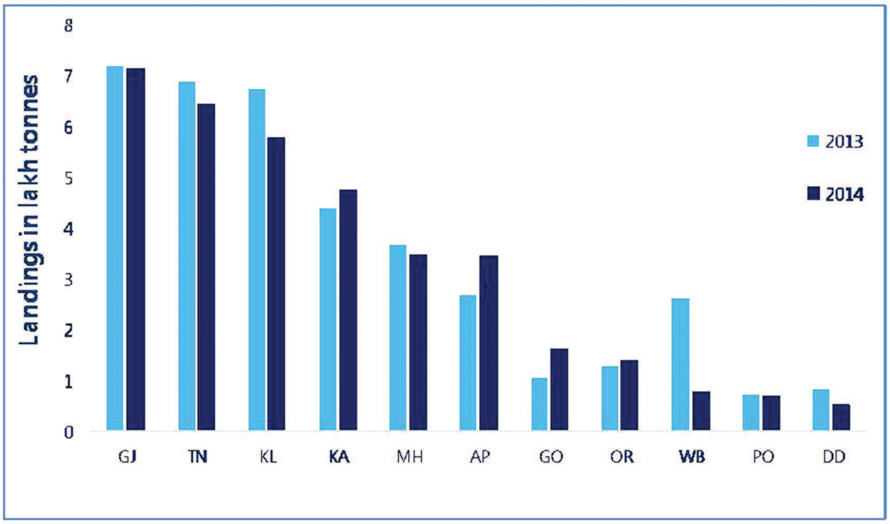



Fig.2 Stat-wise marine fish production of India in 2014

On the west coast, Gujarat was the major contributor which increased its production to 7 lakh t in 2014 from 0.95 lakh t in 1960, showing over a seven fold increase during the last 50 years; the increase has been very prominent during the last 14 years. Kerala which stood first in fish production till 2012 lost its place to Gujarat and now stands at third position. The production increased from 2.68 lakh tonnes in 1960 to 5.7 lakh t in 2014. Highest marine fish production of Kerala was in 1990-91 when it touched 6.62 lakh t. Maharashtra showed a steady increase in production from 1.2 lakh tonnes in 1960 to 3.5 lakh t up to 2014.

**Resource-wise production:**

The fishery resources of India is constituted by a large variety of species (nearly 1,570 species of finfishes and about 1,000 species of shellfishes) co-existing in the same grounds (Srinath and Pillai, 2009). Among these, only 200 species of finfishes and shellfishes are commercially important. Region-wise studies show that pelagics contribute to the major share of the landings in the southwest (SW) and southeast (SE) and northwest (NW) regions, while landings are poor in the northeast (NE) (fig.2 ). On the other hand, demersals are exploited more in the northwest NW and SE and to a lesser extent in SW; however, landings are poor in the northeast NE. Crustacean resources especially the non-penaeids dominate the landings in the NW and to a lesser amount in the SW; landings are less from the SE and NE waters.

Important groups of marine fisheries resources of the country and their composition are as follows: (i) Pelagic resources (oil sardine, mackerel, seer fish, tuna, lesser sardine, anchovies and ribbon fishes); (ii) demersal resources (perches, sciaenids, catfishes, polynemids, flat fishes, pomfrets, eels, sharks, skates, rays and fishes which are mainly caught by trawls); (iii) Mid-water resources (Bombay duck, silver-bellies and horse mackerel); (iv) Crustacean resources (prawns, shrimps, lobsters and crabs); (v) Molluscan resources (oysters, mussels, clams, chanks, squids and cuttlefishes); and (vi) Seaweed resources. Annual average landings of all major resources have shown considerable increase over the period; however very high change was noticed in oil sardine landings, non-penaeids, pomfrets and cephalopods during the last 5 years (Table 1). No significant increase was noticed for perches, mackerel and ribbonfish, croakers, carangids and penaeid prawns. Contrary to this, landings of apex predators like elasmobranchs, after registering an increase during 2000-04 has shown a decline during 2006-10. Landings of Bombay duck, lesser sardines, silverbellies however, did not show much variation.

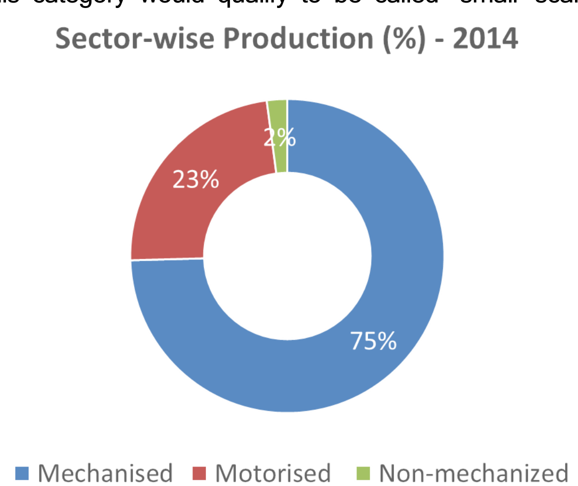
**Table 1. Annual average landings (in 1000 tonnes) for major exploited resources**

| | 1985-89 | 2000-2004 | 2006-2010 |
|---|---|---|---|
| Elasmobranchs | 53.5 | 60.3 | 48.0 |
| Cat fish | 50.6 | 53.9 | 80.7 |
| Oil sardine | 141.7 | 353 | 426.7 |
| Other sardines | 75.5 | 87.4 | 103.7 |
| Bombay duck | 93.2 | 109.8 | 106.9 |
| Perches | 89.1 | 197.1 | 215.2 |
| Croakers | 103.3 | 131.7 | 163.1 |
| Ribbon fish | 79.1 | 166.7 | 161.7 |
| Carangids | 105.1 | 122.2 | 152.3 |
| Silverbellies | 60.2 | 51.3 | 68.7 |
| Pomfrets | 37.1 | 38.9 | 144.5 |
| Mackeral | 123 | 114.1 | 179.5 |
| Seer fish | 34.8 | 47.9 | 53.1 |
| Tunnies | 28.6 | 42.3 | 66.6 |
| Flat fish | 29.7 | 43 | 41.1 |
| Penaeid prawns | 144.2 | 194.2 | 208.4 |
| Non-Penaeid prawns | 58.8 | 137.6 | 160.9 |
| Cephalopods | 40.3 | 109.4 | 137.1 |

(Source: CMFRI Annual Reports)

**Sector-wise landing**

Even though the size of the Indian fishing vessels, in general, range from 5 m OAL (overall length) to 30 m OAL, most of the fishing vessels are below 20 m OAL. Fishing vessels of this category would qualify to be called 'small-scale' and this would include all fishing methods that are employed by these vessels including trawling, purse-seining, gill-netting and long-lining. Thus, small-scale fisheries contribute almost the entire marine fish production of India (Mathew, 2003, Vivekanandan and Mohamed, 2009).




While mechanized fishing sector of the country produces 75% of the all India marine landings, motorized and artisanal sectors contribute 23% and 2% respectively (CMFRI, 2015).The pattern of marine fish landings in India during the past fifty years clearly reveals that the contribution by the artisanal sector to the total production was significant up to the sixties. As a result of the popularization and consequent expansion of mechanized fishing during the subsequent periods along with the motorization of artisanal crafts, the contribution by the artisanal sector declined considerably.

An examination of the gear-wise landing of Kerala reveal that percentage contribution of gears like trawl, purse seine, mechanised drift gillnet among and motorised boats seines has declined over the years and its place has taken over by motorised drift gillnets, ring seines. Contribution of non-motorised gears to total production has declined considerably from 11.8% to 1.9%. Ring seines have appeared in Kerala during 2000-04 period and now it contributes nearly 20% of marine fish production of the state.

**Major fisheries of India**

***Trawl Fisheries***

Trawling is the major gear used to exploit marine resources from all along India's 8,129 km coastline. While the number of trawlers increased twice, the estimated efficiency (engine horsepower) increased by nearly 4 times, from 951,200 hp (1980) to 3,448,570 hp (1998) (Vivekanandan and Mohamed, 2009). From 1999, the trawlers are also employed for deep sea fishing up to 400 m depth by modifying the winch drum and the trawl net. CMFRI census currently shows that 29,241 trawlers are registered and the states of Gujarat and Tamil Nadu have the maximum number of trawlers.

Penaeid shrimps are the mainstay of the trawl fishery and catches showed more than 5-fold increase between 1960 (32,000 tonnes) and 2005 and at present contributes nearly 7-8% of the all India marine fish production. The introduction of high opening bottom trawls has reduced the dependence of trawlers on shrimps as the chief revenue earner and cuttlefishes and squids have also emerged as principal income earners (Mohamed, 2006). The finfishes exploited by trawls belong to 21 major fish groups, out of which, sciaenids contributed maximum (18.4%) to the demersal landings along the Indian coast, followed by threadfin breams (17.3%). Each region is characterized by dominance of specific finfish groups. Whereas the NE coast is characterized by the dominance of sciaenids, catfish and pomfrets (together contributing 74.0% to the demersal landings), the SE coast is characterized by the dominance of silverbellies and pigface breams, the SW coast by the threadfin breams and other perches, and the NW coast by the sciaenids, catfish and threadfin breams (Vivekanandan and Mohamed, 2009).

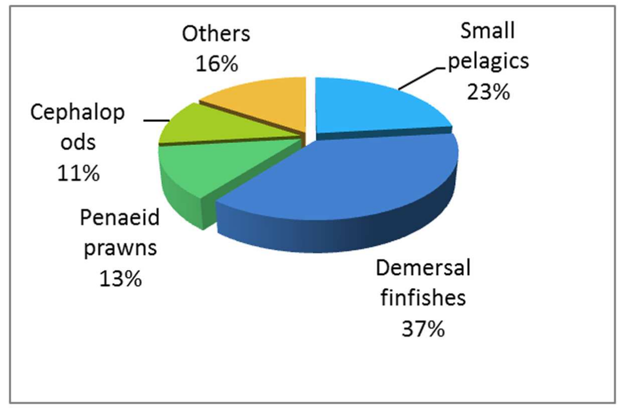



Fig. Composition of trawl landings in southwest coast of India

***Seine Fisheries***

With the advent of mechanization during the 1970s, the purse seines with larger nets and power blocks became the method of choice along the SW coast. A modification to the traditional boat seine vessels to make it more efficient was the mini purse seines or locally called as the Ring Seine which has become the most popular seining method for the pelagics along Kerala coast. Currently there are close to 1000 purse seiners mainly in the states of Karnataka (>50%), Goa and Maharashtra and more than 240 ring seiners mainly in the states of Kerala (>70%) and Tamil Nadu. Ring seines continue to be operated from traditional crafts fitted with outboard or inboard engines. The main species harvested by seines are the small pelagics such as oil sardine, lesser sardines, anchovies and mackerel. A fishery for this resource has recently emerged along the SE, NW and NE coast and this has been attributed to the phenomenon of climate change (Vivekanandan and Mohamed, 2009).

***Gillnet Fisheries***

Gillnets are traditional gears which are being used by fishermen to capture pelagic fishes both large and small. The gillnet catches which ranged from 100,000 to 135,000 t during the 1980s and 1990s, increased by more than 4-times in recent years. Gillnetting has become popular among fishers due to less capital intensive, could be selectively operated depending on availability and demand and can be operated at areas where bottom is not suitable for trawling (Vivekanandan and Mohamed, 2009). Trend in gillnet catch during the last 5 years in India show that the share of mechanized gillnetters (MGN) is increasing as compared to outboard gillnetters (OBGN). As compared to trawls, gillnets exploit only a few species and up to 60 species have been recorded from drift gillnets along the Indian coasts. Clupeids and croakers are mostly exploited by small meshed gillnets and large meshed gillnets exploit mostly sharks, seerfishes, mackerels, catfishes, pomfrets, tunas and carangids. Average productivity of this gear has been estimated as 13.7 kg/h and maximum was observed along the SW followed by NE coasts.

***Bag net Fisheries***

Bag nets are a major gear used by artisanal fishers along NW and NE coasts. In Gujarat and Maharashtra, the fixed variety of bag nets is called Dolnets. They are operated up to a depth of 40 m by employing mechanized crafts and also outboard engine crafts and currently there are about 8,862 dolnetters. Because the volumes are high (~300,000 t), it also contributes a substantial portion (11%) of the all India catch estimates. The average catch rates are about 72.5kg/h and the catches are principally comprised of non-penaeid shrimps (mainly the Kiddi shrimp *Acetes indicus*), the mid-water carnivore Bombay duck (*Harpadon nehereus*) and the golden anchovy *Coilia dussumeiri*. Other species include penaeid shrimps and ribbonfishes. Being a bag net, the dolnet exploits the resources indiscriminately. The non-penaeid shrimps, which are epipelagic and occurring in high abundance, such as *A. indicus* (length range 20-35 mm) and *Nematopalaemon tenuipes* (length range 40-60 mm) constitute the principal by-catch.

***Hooks and Line Fisheries***

H&L contribute just about 2% of the all India marine fish catch. This gear mainly targets the large pelagic fishes such as sharks, tunas and barracudas. The development of H&L fisheries has been mainly in the motorization of the traditional boats, and this class of vessels still contributes to the bulk of the estimated catches. Several development schemes of the government has targeted promotion of H&L fisheries particularly the modern version of longline fishing for tunas. As longline fishing for yellowfin tunas has been proven to be lucrative the world over, and since these resources are relatively untapped from Indian waters, many idle large shrimp trawlers (>17 m LOA) in the NE coast have been recently converted to longliners. Consequently, the yellow fin tuna catch has increased significantly from 9,086 t in 2007 to 13,206 t in 2008 and many tuna products including loin and sashimi grade are exported to the Far East.

***Artisanal Fisheries***

The artisanal fisheries sector has dwindled with the advent of mechanization. The contribution to the total catches decreased from an overwhelming 88% in 1960s to about 2% presently and continues to show a decreasing trend. However, the artisanal fishers were instrumental in bringing innovation in their fishing gears, and to withstand competition from the mechanized sector, motorized their crafts, initially with outboard engines and lately with inboard engines as well. The development of the Ring Seine fishery for small pelagics along the SW coast is a typical example of this innovative spirit.

**Bivalve fishery**

Fishery exists for clams and mussels mainly in inland waters and bays; collection is by handpicking and by use of hand dredge operated from a dug out canoe. The meat is also sold both in internal markets as well as to export processing plants. The shell is also sold to cement and carbide factories. The State of Kerala leads India in the production of clams with estimated annual landings of about 66,000 tons (t) in 2008-09 (Suja and Mohamed, 2010). The estimated fishery from bivalves is approximately 1 lakh t.

**Sea-weed production**

The total production of seaweeds in India in 2005 was approximately 1,00,000 tons (wet weight) (Dhargalkar and Pereira, 2005). India produces 110-132 t of dry agar annually utilizing about 880-1100 tons of dry agarophytes. Annual algin production is 360 to 540 t from 3,600 to 5,400 t dry alginophytes. The surveys carried out by Central Salt and Marine and Chemical Research Institute (CSMCRI), Central Marine Fisheries Research Institute (CMFRI) and other research organizations have revealed vast seaweed resources along the coastal belts of South India. On the west coast, especially in the state of Gujarat, abundant seaweed resources are present on the intertidal and subtidal regions. These resources have great potential for the development of seaweed-based industries in India.

**A. The present scenario of mariculture in India**

Concerted efforts have been taken recently to begin mariculture initiatives like sea farming of finfishes and lobsters in cages, culture technologies which are in use are bivalve farming and sea weed culture. Although scientific demonstrations have been carried out successfully in the case of open sea cage farming, commercial scale operations are yet to begin.

**Bivalve mariculture**

Bivalve mariculture is a relatively recent activity in India and growth in the sector has been remarkable with production touching more than 20,000 tonnes in 15 years, making India one of the top-ten countries in Asia. The main commodities being farmed are mussels (> 90%) and oysters, besides progress is also being made in pearl and clam farming. Mussel farming has been demonstrated in different coastal regions of southwest coast which has led to adoption of this simple farming technology particularly in Northern Kerala. The technology developed for oyster farming in 1970s was lying dormant for years and recently the concerted technology transfer efforts by scientists has led to a commercial practice in southern and central parts of Kerala. The technology developed for pearl culture in the nineteen seventies, is yet to become a full-fledged commercial practice in the country and efforts are being taken to transfer the technology through the help of women SHGs.

**Cage farming/ CBA of finfishes and lobsters**

CMFRI has been successful in demonstrating open sea cage farming of lobster and Asian sea bass at different parts of Indian coast with the support of NFDB and fishermen societies and CMFRI is targeting to harvest one lakh tonne of fish through open sea cage farming. Efforts are also on in development of cost effective cage structures to make cage farming more profitable. Under sized lobsters encountered in the "*ching valai*" and traps are used for stocking the cages. This ensured their survival and growth without affecting the natural stock. The hatchery production technology of Asian sea bass (*Lates calcarifer*) has been standardised. CMFRI has recently been able to raise brood stock of Cobia in cages, breed them in captive conditions and raise seeds to culturable size. The technology is being standardised for transfer to the end users. Efforts to breed pompano, red snapper and groupers are being vigorously pursed at different locations.

**Marine ornamental production**

The ornamental fish keeping is a million dollar industry and the entire trade is contributed by collections from coral reef habitats which can raise sustainability issues. Realising this CMFRI has developed technologies for broodstock development, breeding and larval rearing of marine ornamental fishes such as the clownfish (*Amphiprion chrysogaster*, *A. percula*, *A. frenatus*, *A. ocellaris* and the one-spot damselfish *Chrysiptera unimaculata*, *Dascyllus aruanus* and *D. trimaculatus*. Success has also been achieved in the breeding of the protected marine animals like sea horse and sea cucumber. Low cost marine ornamental fish feed has also been developed.

**Sea-weed farming**

Despite the great number of sheltered bays and lagoons suitable for mariculture, no large-scale attempts to grow seaweed have been made in India so far. Pepsi Food has introduced farming of *Eucheuma cottoni* and *Hypnea musciformis* in 100 ha through contract farming system. Later *Kappaphycus alwarezi* was introduced for farming along southern coastal waters of Tamil Nadu and the annual production is estimated as 6,000 tonnes (wet weight).

**Trade and export**

The contribution of fisheries sector, at an overall annual growth rate of 4.5% (6%, if aquaculture alone is considered) during the previous five year plans is estimated around 1.0% to the GDP and 5.4% to the agricultural GDP. Besides providing livelihood security to over 14 million people, the sector has been one of the major foreign exchange earners, with revenue reaching Rs. 10,048 crores in 2010 accounting for about 18% of the agricultural export. Producing 5.42% of the world's fish, India trades to the extent of 2.5% in the global fish market. Indian exports and its share in the global trade have shown a steadily increasing trend over the years. The total marine fisher folk population of 3.51million is in 3,202 marine fishing villages and spread across the coastal States and Union Territories (including islands). Of these, 0.90 million are active fisher people, and another 0.76 million fisher people are involved in other fisheries related activities (CMFRI, 2005). The fisheries sector has been providing employment to over nine lakh full time and 11 lakh part time fishermen through fishing operations. The number of people involved in marine fisheries related activities included nearly four lakh in fish marketing, three lakh in repairs of fisheries requisites, around 50,000 in fish processing and four lakh in other ancillary activities. In all, an estimated 31.5 lakh people are engaged in fishing and farming operations directly or indirectly (CMFRI, 2005).

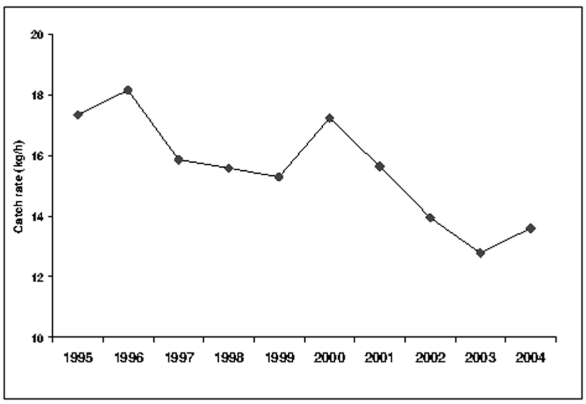
Demand for fish and fishery products is increasing considerably, both at domestic and export fronts. Between VIII and IX Five Year Plan, the quantity of fish exports increased by 62% in quantity and over 117% in value. It improved the share of exports in total output and enhanced the integration of the sector with global market. A trend towards export of shrimps, fishes like groupers, breams, seerfish and cephalopods and retention of other fish for domestic market was seen in the recent years. Export of marine products during 2014-15 has achieved the US$ 5.5 billion mark according to the export figures (MPEDA, 2015). This is the first time in the history of marine products industry that India is crossing the 5 billion mark.

**Issues in Marine fisheries**

***a. Declining catches and overfishing in coastal waters***

Being open access to a large extent, there is intense competition among the stakeholders with varied interests to share the limited resources in the coastal waters (Vivekanandan and Mohamed, 2009). Studies on the status of exploitation revealed that out of 24 species studied, 19 species were exploited above optimum level in 2009. An assessment of the status of marine fish stocks along Kerala revealed that out of the 18 stocks assessed, stock of catfish have collapsed, *Lactarius* and white pomfret have been depleted and nine other fish stocks including *Carcharhinus* and *Stolephorus* declined (Mohamed et al, 2010). Similarly, in Karnataka, out of 22 fish stocks examined, stocks of catfish and goatfish have collapsed, *Metapenaeus monoceros* declined and 12 other fish stocks including silver pomfret, Lactarius etc., have declined. Vivekanandan (2006) found that though not reflected in the catches, the catch per unit effort of several resources is declining. The catch rate of demersal finfishes decreased from 17.3 kg/h in 1994 to 13.6 kg/h in 2004 (fig 3A). Fishing down marine food web has been detected along the

Indian coast, especially along the southeast coast (fig. 3B) at the rate of 0.04 trophic level per decade during 1950-2004 (Vivekanandan et al, 2005). This shows that fishing is affecting not only fish stocks, but also the ecosystem structure and function. Even though there exits laws to regulate fisheries in territorial waters, the significant drawback is that there are no entry restrictions nor programmes to retire fishing fleet or take effective deterrent legal action against vessels that violate regulations (Mathew,, 1993).



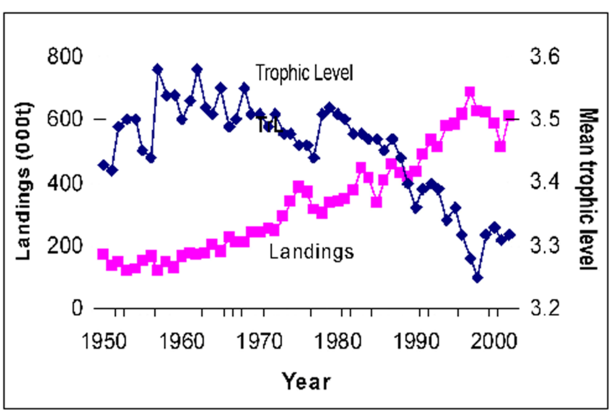




**Fig A:** Catch rate of demersal finfish in trawlers along the Indian coast, and **B**: Decline in mean trophic level of exploited stocks along southeast coast of India (**reproduced from Vivekanandan and Mohamed, 2009**)

### *b. Post-harvest losses*

In India, the large fleet of multi-day trawlers discards a substantial portion of the catch into the sea. Discarding results from a number of factors, *viz.*, biological (multispecies nature of the resources), technological (difficulty in developing species-selective gear, use of fine mesh size gear, scarcity of space in fish-hold), and economic (unprofitable holding of catches of low or no commercial value). Apart from discards, the extent of physical losses due to spoilage of landings and value loss of harvests due to reduced quality are major concerns (Vivekanandan and Mohamed, 2009). Besides, none of the fishing boats are equipped with processing facilities and their small size prevents them from ensuring a HACCP-compliant, on-deck processing facility in the future. High perishability of fish coupled with poor harvest handling has led to high losses, even to the extent of 15% in both marine and inland fisheries.

### *c. Habitat degradation*

One of the often-ignored factors that causes degradation of environment and depletion of fish stocks is the anthropogenic interference other than fishing (Vivekanandan and Mohamed, 2009). The man-induced alteration of physical, chemical and biological integrity of air, water, soil and other media is causing, in several cases, irreversible damage to the structure and function of ecosystems. Runoff from domestic, municipal and industrial wastewater discharges and agricultural fields, solid waste disposals, discharge from ships, oil spills from tankers and wells, are some of the major sources that cause deterioration of water quality, and cause damage to the aquatic organisms, from phytoplankton to mammals. It is estimated that the cities of Mumbai and Kolkata together release more than 800 million t of domestic sewage into the sea every year (Brown, 1997). Phosphate-phosphorus concentration in estuaries and coastal waters has doubled in 30 years; average DO has reduced by 50%. In India, 55,000 tonnes of pesticides are used annually, and about 25% of pesticides end up in the sea

### *d. Climate change*

Another major perceived threat is from climate change, which is causing rise in seawater temperature, increase in salinity, glaciations, sea level rise and acidification of water. It is feared that the oceans, which are the carbon dioxide sink, may get saturated and may lose carbon sequestration potential. Most fish species, being poikilotherms, even a difference of 1° C or 0.1 unit pH in seawater may affect their distribution and life processes. Depending on the species, the area it occupies may expand, shrink or be relocated. This will induce increases, decreases and shifts in the distribution of marine fish, with some areas benefiting while others lose. From the recent investigations carried out by ICAR, the following responses to climate change by different marine fish species are discernible in the Indian seas (Vivekanandan, 2009): (i) Changes in phytoplankton abundance and species composition; (ii) Extension of distributional boundary of small pelagics; (iii) Shift in latitudinal distribution; (iii) Shift/extension of depth of occurrence; and (iv) phenological changes. Coral reefs may experience regular bleaching and become remnant in another 50 years in the Indian seas (Vivekanandan, 2011). These changes are likely to alter the structure and function of marine ecosystems.

***e. Illegal, unreported and unregulated (IUU) landings***

The IUU catch is estimated at the tune of 1 million t/year from the Indian EEZ (Promod, 2010). Illegal fish catches were very high in island territories, with most violators being foreign trawlers targeting sea cucumbers, shark fins and reef fish in the Andaman Islands, while shark fins were the target of poachers in Lakshadweep archipelago. Species listed as Protected in the IUCN are being caught and exported to S.E Asian countries. Though there are deep sea vessels operating in the different maritime zones, the presence of them has not been recognised much. Unreported catch occur as the catch of these boats are not often going to the export market, and hence not noticed properly. The catch of the long liners –cum gillnetters of the south west coast of the country is often not landed in the main landing centre, but in private yards. The shark fins go to the export market through unauthorized channels, while the shark meat goes to the local market. The case of other units is almost the same though the landings occur at the landing sites itself. The major problem here is the absence of a suitable mechanism to identify whether a particular variety of fish is coming from deep sea or not.

***f. Poor implementation of regulations***

Though there is no dearth of fisheries related regulations in each state (MFRA), implementation of these acts is virtually absent, except for the state of Orissa where serious attempts have been made to implement laws in marine sanctuaries (Promod, 2010). Though mesh size regulations are in place enforcement of mesh size regulations is dismal in all States, with Fisheries Departments in all maritime States being ill equipped to carry out surveillance or implementation of regulatory measures. Experiment was conducted in Gujarat to compare the economic viability of trawl operations fitted with the regulatory 40 mm square mesh size to the existing trawling practice using small meshes showed that the loss of revenue due to compliance to the legal mesh size is very small (Mohamed et al). Since the loss in terms of value of escaped catch was determined as 1.3% on account of using 40 mm square codend mesh, it is not expected to make any significant impact on vessel economics and overall profitability of operations.

**Future Plans for marine fisheries development**

A road map for ensuring sustainability, equitability, ecosystem conservation, eliminating destructive gears, reducing by-catch and discards and juvenile destruction, diversification of fishing into new areas, ensuring conservation of endangered and threatened species groups, putting into practice the FAO Code of Conduct for Responsible Fisheries (CCRF), evolving working model for an informed participatory management of marine fisheries resources of the country is the need of the hour.

Fisheries sustainability needs to be addressed in an integrated way by considering the issues of all the anthropogenic interferences such as increasing fishing intensity, damage to the physical, chemical and biological integrity of the ecosystems, and climate change (Vivekanandan and Mohamed, 2009). As fisheries are impacted by the developmental needs of several other important primary sectors such as agriculture, industries, power generation etc., it is not possible to find solutions to the issues from fisheries sector alone. For instance, issues such as water contamination, enforcement of standards for water discharge, maintaining the quality of river runoff, and reducing greenhouse gas emissions, have to be addressed by non-fisheries sector.

***Management and conservation of the resources***

As managing marine fisheries is a highly complex task, it is important to concentrate the focus on sustaining the fish stocks supported by precautionary actions. The goal of management should be to promote sustainable fishing practices that do not decrease stock levels, but ensure livelihood security, resource sustainability economic efficiency and ecosystem integrity (Srinath and Pillai, 2009). Equitable distribution of resources between various players is an issue that needs attention in order to reduce social conflicts and economic inequity. Quota based systems should be strictly enforced in fishing. Ensuring sustainability is of prime concern in marine fisheries management. There is a need to develop appropriate indicators of sustainability. Stock size, exploitation rate and replenishment rate, potential yields of species/groups, species ratios, social development indices (SDI), trade and market indices etc. could serve as indicators. Unless these are developed and quantified, it would be incorrect to relate sustainability to issues in marine fisheries. Biodiversity conservation in the coastal waters must find immediate attention. Sea-ranching and artificial reefs are attempts in the direction of stock replenishment and conservation. Establishment of Marine Protected Areas (MPAs), restoration of critical habitats and stock enhancement through provision of Fish Aggregating Devices (FADs) to a limited extent could also be useful.

***Ecosystem-based fisheries management (EBFM)***

Ecosystem-based fisheries management has been advocated as a better management tool relative to single species resource management. India is a signatory for adoption of EBFM. Ecosystem evaluation and modelling are prime requisites for adopting EBFM and this approach will identify factors, which may cause ecosystems to destabilize, allowing predictions and management decisions to be taken. Trophic models have been made for Karnataka, NW coast and Gulf of Mannar. EBFM has to be integrated into future fishery management plans of the country.

***Bycatch reduction***

Bycatch can have substantial economic and biological consequences not only on the species caught incidentally, but on the predator and prey dynamics in the ecosystem. The reduction of bycatch needs to attract management priority. A bycatch reduction programme has to be initiated that would include: recommending new gear technologies and fishing practices that minimize bycatch; an extensive education and outreach activity to transfer these technologies and techniques; and developing comprehensive monitoring capabilities to evaluate the effects of bycatch reduction policies. CIFT scientists have demonstrated that there is definite reduction in bycatch coupled with improvement in the quality of catch when trawlnets are fitted with BRD developed by them. The adoption of BRD and semi-pelagic trawlnet developed by CIFT by fishermen need to be encouraged. Bycatch mitigation can be done by seasonal or permanent transition to semi-pelagic trawling, supported by incentive programmes to reduce overall benthic footprint.

***Capacity reduction***

Fishing capacity reduction is perceived as the cornerstone of fisheries management programme. Overcapacity (too many vessels and/or fishermen for the sustainable levels of fish stocks) results in economic and biological overfishing. The A roadmap for capacity reduction through implementation of transferable management systems that allocate rights to harvest shares and through buyback of overcapacity, vessels and/or fishing permits, in combination with other policy measures to control latent permits and limit entry. Buyback of overcapacity may use either appropriated funds or industry funds (supported by government loans) depending on the circumstances of the particular fishery.

***Understanding climate variability and fisheries***

Coastal and marine ecosystems are particularly vulnerable to the effects of climate variability, and such variability can lead to severe social and economic dislocations of the fishing industry and the communities. For understanding the impacts of climate variability and changes on marine ecosystems, improved information on climate effects on living marine resource health, and implementing these assessments into resource management policy are necessary. Steps may be initiated to develop a data product and climate information delivery system, linked to fisheries resources. This information will allow an optimal utilization management strategy to be developed that would interpret short and long term climate factors into assessment models.

***Implementation of CCRF***

The Code of Conduct for Responsible Fisheries is one of the most important international instruments devised for wholesome management of the living aquatic resources. The Code is an outcome of several contemporary global initiatives, which expresses concern about the overexploitation of important fish stocks, damage to the ecosystems, economic losses and issues affecting fish trade. Massive efforts would be needed to take the Code to the grassroots level quickly. The MSC standard is consistent with the 'Guidelines for ecolabeling of fish and fishery products from marine wild capture fisheries' adopted by the FAO in 2005. Efforts at certification of some of the important fisheries in the country have already begun as in the case of short neck clam fishery of Ashtamudi lake (Vivekanandan and Mohamed, 2009). This should be further strengthened and more and more resources should be included.

***Natural hazards -disaster management plans***

Cyclones, floods, landslides as well as the recent tsunami, which struck the coastal India for the first time created havoc and misery for the fishers with regard to their livelihood and infrastructure since the country lacks definite disaster management plans.

***Increase production through Mariculture***

With technologies developed in the recent years, is an option for supplementing the marine capture fisheries, also for gainful employment for the fisherwomen in the coastal areas. Mussels, oysters and seaweeds have been the main component of mariculture, with some possibilities of crab and lobster fattening. Though the pearl culture programme was initiated in the country in 1972 and there have been some commercial ventures, it needs to be enhanced to be competitive at the global level. Cage culture, capture based farming and Sea ranching can be used as side alternatives to fishery to augment production. This could provide supplementary income for fishers as also livelihoods during the closed seasons for capture fisheries. In order to take mariculture forward, it is necessary that potential mariculture sites along the Indian coast are mapped with due reference to prevalent tidal and wave conditions, water quality and aquatic pollution, availability of seed and feed, infrastructure and access to markets. Cage culture is to be done in a participatory mode. The prospect of developing commercial interest in lobster farming (*Panulirus* spp.) in India is bright due mainly to the substantial increase in price consequent to the heavy demand from export market. Ornamental fish farming can be taken up on a larger scale. The bottlenecks associated with mariculture technologies including location testing, ownership of water bodies, leasing policy, multiple sues of coastal areas and coastal zone regulations to be eradicated (James, 2009). National policy guidelines for farming have to be formulated which must include areas such as water body leasing, ownership of rights, protection from poaching, crop insurance etc.

***Development of Infrastructure***

High perishability of fish coupled with poor post-harvest handling has led to high losses, even to the extent of 15%, in both marine and inland fisheries. Public investments to expand access to rural infrastructure and services such as rural roads and transport services, primary and secondary fish markets, telecommunications, and electricity, will be critical to reducing transaction costs and physical losses and to enhancing transparency and competitiveness in traditional fish markets. Though communication facilities such as radiotelephone and Global Positioning System (GPS) are at present available in the fishing vessels, satellite-based Vessel Monitoring System (VMS) is still to become operational. Facilities at the fishing harbours and landing centres need to be upgraded, along with product diversification, value addition and domestic marketing, to realize the value of marine fish landings.

***Diversification of vessels and deep sea fishing***

Development of deep sea fishing is necessary in the future. It is estimated that 1.36 lakh tonnes comprising of oceanic tuna, sharks, bill fishes, squids, deep sea lobsters etc. can be safely harvested from deep waters (table 3). As a part of the national marine fishing policy, the Government of India has fixed the upper limits of the number of permitted deep-sea fishing vessels for effective exploitation of the resources. In order to exploit this component, the steps suggested are introduction of vessels comprising 500 tuna long liners/drift gill netters, 18 purse seiners and 15 squid jiggers, as also developing storage and harbour facilities incorporating total quality management (TQM) and HACCP concepts. To realize the full potential as well as ensure that the country benefits from deep sea fishing, it is necessary that measures such as deployment of IOTC-recognized observers on fishing vessels; Monitoring, Control and Surveillance (MCS) of vessels; and provision for certified graders at the landing sites are undertaken.

**Table 3**. State of exploitable fisheries resources in EEZ (in '000 tonnes) (Source: ICAR, 2010)

| Resource | Potential yield | Harvestable stock |
|---|---|---|
| Yellow fin tuna | 115.0 | 57.50 |
| Big eye tuna | 12.5 | 6.25 |
| Skipjack tuna | 85.2 | 42.60 |
| Billfishes | 5.1 | 2.55 |
| Sharks | 26.2 | 13.10 |
| Coastal pelagic | 6.8 | 3.40 |
| Oceanic squids | 19.9 | 9.90 |
| Deep sea lobsters | 2.3 | 1.10 |
| **Total** | **273.0** | **136.40** |

Measures are also to be designed for exploitation of hitherto unexploited resources ie, myctophids and oceanic squids, the quantity of which have been estimated as several million tonnes (GLOBEC, 1993) as well as underutilized resources which have not much market value at present but can be utilized after suitable conversion into value added products (eg., Black ruff, *Centrolophus* spp., Drift fish *Ariomma* spp., Green eye *Chloropthalmus* spp.), gempylids etc.

***Diversification of products***

Work on nutraceuticals has been initiated in the country with promising results (squalene, glucosamine hydorchloride, GME, GAE etc.). These need to be strengthened further in the coming years. Development of drugs from marine plants and animals have been initiated with promising initial results which requires further research. Development of innovative value added items like ready to serve fish products, extruded fish products, battered and breaded products etc., also needs further support and progress.

***Utilisation of fish waste by value addition***

A large quantity of fish waste is generated while processing marine products and disposal is a major problem associated with this. CIFT has developed an efficient and economical technology to produce Chitin and Chitosan from shell waste, which has extensive applications in medical and pharmaceutical fields. Collagen-chitosan membrane from shell waste and fish air bladder, etc are examples of products developed from fish waste. Tuna waste which is high in protein content was used as a fortified amino acid source for black tiger shrimp larvae feed. A formulated feed (Cadalmin-Silo feed) for farmed seabass from tuna waste has been successfully developed jointly by CMFRI and CIFT. Similarly, waste from canning and processing plants should be utilised for manufacture of fish or poultry feed.

***Marine Protected Areas (MPAs)***

Currently, there are 31 MPAs along India's coastline (including the islands) that have been officially declared for conserving and protecting coastal and marine biodiversity (SCBD, 2006).

Most of the MPAs were designated during the 1980s and early 1990s. They were notified as either 'national parks' or 'wildlife sanctuaries', under the Wild Life (Protection) Act 1972, where, in most cases, no extractive activity is allowed. The current area under MPAs is 6.16 per cent of the area in the coastal biogeographic, which is proposed to be expanded to 7.12 per cent (SCBD, 2006).

**Endangered, Threatened and protected species (ETP)**

One of the greatest challenges before modern fisheries is to minimize ecological and environmental impacts of fishing. A strategy has to be evolved for managing retained, bycatch, Endangered, Threatened and protected species (ETP) and benthic habitat. The TED developed by CIFT is useful for turtle exclusion. CIFT semi-pelagic trawl system, CIFT SPTS was developed by scientists of Fishing Technology Division of CIFT as an alternative to bottom trawling, which causes high impacts on the sea bottom and also are non-selective

India continues to play a leading role in various international conventions pertaining to conservation and protection of wildlife and natural resources. During recent years exploitation of Sharks, Rays, Groupers and Holothurians have increased due to its demand for its parts and derivatives including human consumption in the international market especially in South-Asian and for Eastern countries. This has resulted in sharp decline in the population of these species all along the Indian coasts. Sea cucumbers have been harvested due to their high commercial values. Similarly the corals have been exploited for their use in cement industries and decorative purposes. Since corals are a major component of marine eco-system, decline in the coral population adversely affects the other marine species. In view of this, the Environment and Forest Ministry has, in consultation with scientific institutions and experts working in this field, included the following marine species under the purview of the Wild Life (Protection) Act, 1972:

- Ten Species of Sharks & Rays Schedule I
- 9 Species of molluscs Schedule I
- All species of Sea horses- Schedule I
- Giant Groupers- Schedule I
- All Reef Building Corals, all Black Corals, all Fire Corals, all Sea fans and Organ pipe coral- Schedule I
- All Holothurians - Schedule I
- 15 Species of molluscs- Schedule IV.
- All Calcareans Sponges- Schedule III
- All five species of sea turtles - Schedule I
- All marine mammals- Schedule I and II

# Need for Sustainable Utilisation of Marine Fishery Resources-from Health Perspective Point of View

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**ABSTRACT**

Marine Fisheries is an important sector in India. . With a coastline of over 8,129 km, and an Exclusive Economic Zone (EEZ) of over 2 million sq km and with extensive estuaries, marine fisheries play a vital role. Also with a potential catch of 4.45 million tonnes and exploitation to the tune of 3.9 million tonnes it supports the livelihood of those engaged in fishing and dependent industries. For the 0.9 million active fishermen and 3.5 million fishermen population, this sector is the bread and butter. The average annual value output is Rs.31, 682.50 crores (during the Tenth Five Year Plan-2002-2007) and its contribution to the national Gross Domestic Product (GDP) is 1.07 per cent and to the agriculture and allied activities is 5.3 percent. This sector is also a foreign exchange earner with the marine capture fisheries constituting 65% of the more than 5 billion US $ being earned. All these call for sustainable management of this sector as it means so much to the fishers and the country. Another important perspective from which it should be managed on a sustainable basis is the nutritional security and health benefits to the vast Indian populace. With top notch protein having the all the essential amino acids in the proportion Man requires, it is helpful in doing away with the malnutrition that is ruling roost in our country. With the rich presence of unsaturated fatty acids in particular the Decosa Hexaenoic Acid (DHA) it is helpful in producing the knowledge capital of the country with very good brain power. The unsaturated fatty acids are helpful in preventing 80 % - of cardiac infarctions (breakdown), 90 % - of diabetes type 2 and 30 % of cancer occurrences. They are also useful in lowering the chance of developing dementia so also the Alzheimer's disease. The usefulness of seafood in preventing stroke, blood pressure, rheumatoid arthritis, and osteoporosis will all so be discussed besides its role in improving the functioning of kidney and gene expression. The higher level of microelements and vitamins present are very useful to the eyes, skin, teeth, hair and bones in addition to building better blood. These are all highly advantageous to the consumers. For many, food is not complete without fish. In the absence of sustainable management, the whole thing will collapse. This talk mainly focuses on sustainable management of marine fisheries from the perspective of human health.

## INTRODUCTION

Marine Fisheries is an important sector in India. With a coastline of over 8,129 km, and an Exclusive Economic Zone (EEZ) of over 2 million sq km and with extensive estuaries, marine fisheries play a vital role. Also with a potential catch of 4.45 million tonnes and exploitation to the tune of 3.78 million tonnes in 2013 and 3.59 million tonnes in 2014, it supports the livelihood of those engaged in fishing and dependent industries. For the 0.9 million active fishermen and 3.5 million fishermen population, this sector is the bread and butter. The average annual value output was Rs.31, 682.5 crores (during the Tenth Five Year Plan-2002-2007). The value of marine fish landings during 2014 based on the price at landing centre level was Rs. 31, 754 crores and at the retail level was estimated as Rs.52, 363 crores. Its contribution to the national Gross Domestic Product (GDP) is 1.07 per cent and to the agriculture and allied activities is 5.3 percent. This sector is also a foreign exchange earner with the marine capture fisheries constituting 65% of the more than 5 billion US $ being earned. All these call for sustainable management of this sector as it means so much to the fishers and the country. Another important perspective from which it should be managed on a sustainable basis is the nutritional security and health benefits to the vast Indian populace. This article explains the imperativeness of sustainable utilisation of marine fishery resources from the point of view of the health benefits.

**Importance of diet**

Obesity and other lifestyle-related diseases are increasing in the world. The World Health Organisation (WHO) has estimated that 80 per cent of cardiac infarctions, 90 per cent of diabetes type 2 and 30 per cent of cancer occurrences could be prevented with better diets, regular physical activity and not smoking. In Europe, more than 70 per cent of the most important risk factors associated with non-communicable diseases are related to our diet. These diseases are closely related to excess weight gain partly due to a high intake of e.g. sugar and energy dense foods, highlighting the importance of a healthy diet.

A varied and healthy diet is a prerequisite for good health. Fish and other seafood are an important part of a balanced diet and contribute to a good nutritional status. Therefore the Norwegian health authorities' general recommendation is to increase the consumption of fish. Children, young people, pregnant women in particular are advised to eat fish as a good nutritional status is especially important for these vulnerable groups. It is also advised for the active adults and the elderly.

**Nutrients present in seafood**

What you are is what you eat". Eating seafood will improve health as it is superior to all the other animal protein sources accessible to man. It is an important and a cheap source. Quality-wise the trash fish which one can buy for a throw-away price is no way inferior to the pompret or seer fish which commands a premium price in the market. Variety and quality are there as fishes belonging to various groups occur in trash.

**Protein**

Proteins are large molecules composed primarily of amino acids. Our body's digestive enzymes break down the protein we consume to release amino acids which are in turn used to make new proteins the body uses for growth and maintenance. There are 9 amino acids which the body cannot manufacture; we must get them from food. They are called essential amino acids. Seafood contains all nine essential amino acids in the proportion we require. Therefore, it is an excellent choice for meeting our daily protein needs. An added advantage of seafood is that its protein is highly digestible. The protein in seafood is more readily broken down and absorbed than the protein in red meats and poultry. This advantage makes seafood an excellent food choice for people of all ages. Fish contain 17 to 25% protein with an average content of 19 g/100 g. Helps build muscles and tissues.

**Omega-3 fatty acid**

The human body can only produce saturated and omega-9 fatty acids which means we have to get the omega-3 fatty acids we need through our daily foods. Fish has two types of fatty acids namely saturated fatty acid and unsaturated fatty acid. Saturated fatty acids are those which have all the hydrogen atoms. These are not that important. Some fatty acids are missing hydrogen atoms. So they are called unsaturated fatty acids. If they miss one pair of hydrogen they are monounsaturated. If they miss two or more pairs they are called poly- unsaturated. The fatty acid content of any food is denoted by the P:S ratio where the P expresses the amount of polyunsaturated fatty acids in a fat related to its content of saturated fatty acids (S). The site where a pair of hydrogen is missing is called a double bond. Fatty acids are often described in terms of how many double bands they have.

The unsaturated fatty acids which are present at higher levels than the saturated especially the omega-3 fatty acids have been proven to offer significant health benefits. Fish is thought to protect the heart because eating less saturated fat and more Omega-3 can help to lower the amount of cholesterol and triglycerides in the blood – two fats that, in excess, increase the risk of heart disease.

Fish is thought to protect the heart because eating less saturated fat and more Omega-3 can help to lower the amount of cholesterol and triglycerides in the blood – two fats that, in excess, increase the risk of heart disease. Cooking techniques such as broiling, barbecuing, poaching, microwaving, or steaming on a rack will help reduce the amount of fat in the total fish recipe

The most important omega-3 fatty acids found in seafood are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (It is important to understand that the omega-3s found in plant oils such as flax and olive oil is not the same as those found in fish).

**Good for health of heart**

Seafood is good in treating certain disease like heart ailments, stroke and blood pressure. About half of the people who die, do so due to atherosclerosis which is nothing but the collection of cholesterol and extra tissue like scar tissue which block the blood flow through the coronary arteries producing a heart attack, or block the flow through the cerebral arteries producing a stroke or block the flow of some other organ that will destroy the health of that individual. Blood flow is impeded due to blood clotting. The small cells present in blood namely platelets are responsible for blood clotting. They have the ability to stick together or clump that forms a clot at the site of a wound. Platelets can also stick to the lining of blood vessels that have been damaged or narrowed due to arterosclerosis. When the blood flow to the heart is restricted by lipid deposits and platelet clumps, a heart attack may occur. If the blood flow to the heart is completely blocked, the attack is fatal. If arteries do not narrow due to lipid deposits or clots, there won't be heart attacks.

Cholesterol is an essential part of all living animal tissue. But levels of cholesterol can be too high if we eat too much saturated fat. Seafood has very little cholesterol and what it does have is mostly unsaturated fat. Eating fish two or three times a week can reduce the risk of heart disease. Omega-3 fats also have natural built-in anti-oxidants, which stop the thickening and damaging of artery walls. The EPA and DHA make the veins more elastic and prevent blood clots. The clot promoting material in blood is Thromboxane A2 (blood platelet aggregator). Omega 3 fatty acids favour the production of prostayclins that discourage blood clotting. The Omega 3 fatty acid also brings down blood cholesterol level and then no deposition (atherosclerosis) of lipids is taking place in blood vessels. Omega 3 fatty acids also favour removal of very low density lipoprotein (VLDL) in blood and not high density lipoprotein (HDL) which is a good cholesterol.Regularly eating fish oils is also thought to reduce the risk of arrhythmia – irregular electrical activity in the heart which increases the risk of sudden heart attacks. Omega-3 fatty acids prevent sudden death. The polysaturated fish fats alter the composition of heart muscle cells. This change decreases the likelihood of the heart rhythm disturbances and hence decreases the incidence of the kind of heart attack from which the victim dies quickly.

Consumption of marine omega-3 fatty acids has been shown to prevent and aid in the treatment of many other clinical ailments.

**Omega-3 fatty acids and blood pressure**

The above acids reduce blood pressure, stabilise heart rhythm and generally reduce the risk of a heart attack. The pressure is due to constriction of blood vessels. Stroke as mentioned early refers to blockage of blood flow to a part of the brain. Stroke is more likely if a person has high blood pressure. Controlling the blood pressure will decrease the likelihood of stroke and omega-3 fatty acids are helpful in reducing hypertension, when heart has to work harder to pump blood through our tissue as there is greater resistance to the flow of blood through the vessels. Increased blood volume also demands greater pumping capacity.Omega-3 fatty acids may affect prostaglandins metabolism in such a way that hormone activity in the kidney is modified. By getting rid off excess sodium and by controlling the retention and removal of water, kidneys are active in the control of blood pressure. Prostaglandins can influence salt and water excretion and affect blood vessels. These prostaglandins enhance the effect of hormone epinephrine which constricts or narrows blood vessels. In the presence of omega – 3 fatty acids, the action of prostaglandins on epinephrine is diminished and thus construction or narrowing of blood vessels is prevented. Therefore intake of seafood rich in omega – 3 fatty acid is helpful in avoiding the chances for stroke and blood pressure.

**Omega-3 fatty acids and cancer**

Intake of seafood is helpful in avoiding cancer too. There is plenty of evidence that about 35% of all cancers is related to the way we eat. There is a correlation between the amount of fat we eat and cancer of breast colon, rectum, prostrate ovary and pancreas. Countries with highest levels of fat consumption have the highest rates of these cancers. Omega – 3 fatty acids present in seafood affect many system implicated directly in cancer development namely immune responses, cell division, membrane structure and function and prostaglandin's production, all of which contribute to the growth of malignant cells in some way. Tumours produces excessive amount of certain kind of prostaglandins which inhibit the response of certain white cells in the immune system, antibody production and cell destruction. Such effects enable cancer cells to escape the body's usual defence mechanisms. In creased thromboxane metabolism and prostaglandin production are associated with spread of cancer to another tissue in the case of breast cancer. Omega-3 fatty acids discourage such a development.

**Omega-3 fatty acids and diabetes**

The omega-3 fatty acids improve the action of insulin and therefore are considered as good for type 1 diabetes. These acids also do away with the insulin resistance syndrome and are that way good for type 2 diabetes. Therefore for diabetic patients who have high risk of CHD, fish oils are prescribed along with hypoglycemic (which reduce sugar level) drugs

**Omega-3 fatty acids and arthritis**

Including fish as a regular part of a balanced diet has been shown to help the symptoms of rheumatoid arthritis – a painful condition that causes joints to swell up, reducing strength and mobility. Studies also show that sufferers feel less stiff and sore in the morning if they keep their fish oil intake topped up. Recent research has also found a link between Omega-3 fats and a slowing down in the wearing of cartilage that leads to osteoarthritis, opening the door for more research into whether eating more fish could help prevent the disease as omega 3 fatty acids are helpful in pronouncing less inflammatory response of the above disease.

Dietary adjustments can set right these disorders. A few types of cells active in the immune responses can make a potent group of compounds called leukotrienes. Leukotriene is a class of twenty carbon compounds more powerful than prostaglandins in provoking an inflammatory response. These are made from arachidonic acid. When omega-3 fatty acids are present they produce a kind of prostaglandins and Leukotrienes that have less pronounced immunological effects. Thus dietary adjustments through way of intake of seafood rich in omega-3 fatty acids is helpful in pronouncing less inflammatory responses of the above disease.

**Omega-3 fatty acid and brain power**

About 10-12% of the human brain is composed of lipids including the Omega-3 fat DHA. Recent studies suggest that older people can boost their brain power (improving memory power) by eating more oily fish, what with regular consumers being able to remember better and think faster than those who don't consume at all. Other research has also suggested that adding more DHA to the diet of children with attention-deficit hyperactivity disorder can reduce their behavioural problems and improve their reading skills, while there have also been links suggested between DHA and better concentration. Separate studies have suggested that older people who eat fish at least once a week could also have a lower chance of developing dementia and Alzheimer's disease.

**Good for pregnant women and foetus**

Consumption of fish which has DHA and AA (Arachidonic acid) is essential during pregnancy and foetal development of infants including foetus growth and neurobiological development. It builds brain tissue. Pregnant women must take 250 mg/day of DHA for supply to foetal and to provide stores for breast feeding. Maternal PUFA (n-3 and n-6) status during pregnancy critical in determining AA and DHA status in newborn and AA & DHA levels in breast milk. It is associated with improved infant health outcomes such as visual and cognitive development. Low PUFA is responsible for post partum depression.

**Other roles of omega-3 fatty acid**

PUFA of both n-6 and n-3 are important for the structure and function of the cells. AA, EPA and DHA are important components of membrane phospholipids. Their levels as well as ratios affect a range of biochemical processes such as Membrane fluidity, Nutrient transport, Activity of membrane bound enzymes, Receptor function and Ion channel activation besides Intracellular signaling pathways either directly or via production of eicosanoids and cytokines.

The Omega-3 fatty acids, proteins, vitamins, minerals reduce the symptoms of asthma and bronchitis.

**What seafood is high in omega-3 fatty acids?**

Seafood varieties that are commonly consumed in the United States that are higher in healthy omega-3 fatty acids and lower in mercury include salmon (wild and farmed), anchovies, herring, sardines, oysters, cod, trout, and Atlantic and Pacific mackerel (*not* king mackerel, which maybe high in mercury). For more information, see the U.S. Department of Agriculture's Dietary Guidelines for Americans.

**Lower prevalence of depression**

Epidemiological studies have shown an association between seafood consumption and a lower prevalence of depression. This indicates that consuming seafood result in lower risk of depression.

**Seafood and calories**

What is a calorie? Many people count calories or "weight watch," but do they really understand what they are counting? The food calorie or kilogram calorie is a measure of energy, defined as the amount of heat required to raise the temperature of one kilogram (approximately 2.2 pound) of water one degree Celsius. The calories in food supply the energy the body needs to carry out all its many functions. The nutrients in food that supply energy are fat (nine calories per gram) and carbohydrates and proteins (four calories per gram each). Most varieties of finfish and shellfish are low in fat, less than 5%, and, in many cases, less than 1% fat. Therefore, most varieties of seafood provide 100 to 200 calories per 3-1/2 ounces. The Dietary Guidelines published by the USDA and the Department of Health and Human Services advice us to eat less total fat. More specifically, it advices to reduce overall fat consumption from approximately 40 to 30% of energy intake. This means that of all the calories we derive from the food we eat, only 30% of them should come from fat. The Dietary Guidelines go on to suggest the type of fat. "Reduce saturated fat consumption to account for about 10% of total energy intake, and balance that with polyunsaturated and monounsaturated fats, which should account for about 10% of energy intake each."Seafood has less calories. Seafood averages less than 2% fat. For slimmers, seafood is all good news. All seafood is low in kilojoules, with fewer kilojoules than other sources. And of course with seafood you don't need to trim any fat. Just grill, barbecue, bake, steam, poach or microwave seafood to keep a low kilo-joule count.

**Nutrients and minerals**

Research over the past few decades has shown that the nutrients and minerals in seafood can make improvements in brain development and reproduction and has highlighted the role for seafood in the functions of the human body. Fish is high in minerals such as phosphorus, potassium, iron, iodine, fluoride, zinc and cancer fighting selenium which keep the body running smoothly. Iodine is essential for the thyroid gland, which secrete hormones and controls the growth and metabolism. These hormones also regulate body temperature, metabolic rate and the functions of most tissues. Selenium helps to protect polyunsaturated fatty acids from being oxidized to from harmful products like peroxides. It has protective functions against cancer and harmful effects of mercury. The enzymes produced by selenium protect cell walls from cancer-causing free radicals, and helps prevent DNA damage caused by radiation and some chemicals.

**Osteoporosis**

Seafood can also take care of the requirement of major minerals like calcium, phosphorus, magnesium and potassium. Among these calcium is needed in greatest amount. It is in the limelight because of its association with a bone disease called osteoporosis, prevalent among elderly women in whom bones gradually lose calcium, there by becoming weak and prone to breaking. Seafood is a very good source of calcium.

**Other minerals**

Phosphorus is important for bone structure and for energy storage. Certain substances store energy by means of high energy phosphate bonds. Magnesium is also important for bone structure and has metabolic function like phosphorus. It assists in a vast number of enzyme reactions including energy transfers, fatty acid break down and protein synthesis. It is also necessary for the communication of nerve impulses in muscle. Potassium is crucial for maintaining normal heart beat and is important for maintaining water balance in cells. People with high blood pressure are advised to take plenty of potassium rich food like seafood.

**Vitamins**

The common denominator amongst those people with robust health, from what I can tell, seems to be the fat soluble vitamins – A, D, E & K. The vitamin complexes – especially vitamins A, B & D are vital for the healthy growth of eyes, skin, teeth and bones. These also reduce the symptoms of dry eye. Vitamin B niacin and pantothenic acidpresent in seafood assists in the functioning of the digestive system, skin and nerves and conversion of food to energy. B12 plays a critical role in building DNA and RNA, maintenance of the nervous system, fatty acid synthesis and energy production.

**Seafood for building better blood**

Sea food is helpful in building better blood. Blood has a variety of cells and substances. Among them red blood cells are vital to many of the blood's tasks. In order to have abundant healthy red blood cells we need sufficient supplies of several nutrients. These nutrients include iron, copper, zinc, vitamin B12, folic acid etc. The major task of the blood is to deliver oxygen to tissue and take away wastes and carbon-di-oxide. This is done by red blood cells. The transport capacity of red cells depends on having enough haemoglobin – an iron containing pigment that binds oxygen. When iron is in short supply less haemoglobin is made and fewer healthy red cells are produced. This leads eventually to anemia, which we can detect in the form of fatigue, listlessness and sometimes headaches. The muscles also need iron to make the protein myoglobin. Like haemoglobin, myoglobin binds oxygen and holds it in reserve for muscular activity. Too little iron relates to insufficient oxygen in muscles which reduces muscular activity and ability to perform. Iron also plays a critical role in pregnant women who have to support the foetus through supply of blood with enough haemoglobin. Copper is the second mineral important for the formation of haemoglobin and red blood cells. Its presence enhances iron metabolism. It is also required for proper collagen formation. Collagen is a part of connective tissue such as cartilage, tendon and skin. Its formation is a key to normal wound healing. Copper also affects the metabolism of fat and cholesterol and nervous tissue function. Next important mineral is zinc. Like iron, zinc is involved in some of the body's most important activities. It acts as a helper for many enzymes which drive the body's biochemistry. It is necessary for the normal processing of protein, carbohydrate, fat and alcohol. It is involved in making DNA which carries the genetic blueprint for reproduction. It is important in immune reaction, taste perception, wound healing and in making the pancreas's all important hormone insulin. It is also related to healthy red blood cells because it is part of enzymes needed for cell production in the bone marrow.

Vitamin B12 is the chief vitamin required for red cell production. Folic acid (folacin) is also very important. The cobalt containing vitamin B12 is needed for the production of folacin. Both vitamin B12 and folacin are needed for successful red blood cell production in bone marrow. In their absence the type of anemia with large pale red blood cells develops. Pregnant women need more of these vitamins in order to make the additional Vitamin B12 is found only in animal food. Seafood has all these nutrients, some in substantial amounts. Therefore eating seafood regularly is one of the easiest ways to build better blood.

Fish liver oil has vitamins A and D in proportions most suitable for human needs. Therefore fish liver oil has been in medicinal use for a very long time as a prophylactic and curative. So fish liver oil is good to cure or prevent vitamin deficiency diseases as rickets, xeropthalmia, impaired vision (night blindness) and other eye defects and abnormalities of skin, mucous membrane and vertebrae. Intake of fish liver oil also ensures good growth of bone and teeth helps to maintain normal skin and vision and will develop more resistance to counter bacterial attacks.

**Seafood and skin**

Seafood is one of the best sources of anti-oxidant that helps boost the condition of the skin. Seafood helps body to make better use of the skin-boosting nutrient vitamin C as well as helping maintain collagen. It is also thought to help boost blood circulation, increasing the supply of oxygen and nutrients to your skin. High in fibre it also detoxifies the body helping keep your skin clear of spots and irritation.

**Eating seafood is nutritional insurance**

Eating is one of the joys of life. Eating seafood is not only joy but is nutritional insurance too. Any wholesome food we consume must supply protein, vitamins, minerals, small amounts of fat, fibre and water. Seafood is an excellent food because it is nutrient rich. It has the best and top-notch protein which supplies essential amino acids, we cannot make ourselves. It is easily digestible as it has very little connective tissue. It gives many nutrients we need without worrisome amounts of fats. The small amount of fat present in seafood is of the most favorable kind as it promotes health. Therefore it is not surprising that it has captured headlines due to its unique nutritional merits. Seafood is nutrient rich and therefore it is not surprising that intake of seafood is the nutritional insurance.

**How much seafood should one eat?**

In January 2011, the U.S. Department of Agriculture (USDA) updated their Dietary Guidelines recommending that consumers double their seafood consumption to eat at least two servings (3 to 6 ounces each) of seafood each week and that women who are pregnant or breast feeding eat 8 to 12 ounces of seafood per week. According to USDA, evidence shows that consumption of about 8 ounces per week of a variety of seafood – which provide an average consumption of 250 mg per day of EPA and DHA –USDA therefore makes the quantitative recommendation of at least eight ounces of seafood per week.

**What seafood is high in omega-3 fatty acids?**

Seafood varieties that are commonly consumed are higher in healthy omega-3 fatty acids and include mackerel, salmon, anchovies, sardines besides many others.

**Can raw seafood be eaten?**

It's always best to cook seafood thoroughly to minimize the risk of food-borne illness. However, if you choose to eat raw fish anyway, one rule of thumb is to eat fish that has been previously frozen. Some species of fish can contain parasites, and freezing will kill parasites that may be present. However, be aware that freezing doesn't kill all harmful microorganisms. People with certain immune or liver disorders should never eat raw seafood.

**Conclusion**

All the above medicinal properties are highly advantageous to the consumers. For many, food is not complete without fish. In the absence of sustainable management, all the very important benefits will be lost. Therefore sustainable utilization and management of the marine fishery resources are highly imperative.

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# On the exploited fisheries of three major estuaries of Kerala

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**Abstract**

More than thirty interconnected back-waters and estuaries constitute more than 60% of inland water bodies in Kerala. They serve as most productive areas supporting a rich array of fin fish and shell fish fauna including true estuarine resident species, marine migrants and fishes of limnetic origin. Though prone to fluctuations in environmental factors, estuarine habitats provide most conducive conditions for sustaining their early life stages and therefore, are being regarded as "natures cradle"s. Fisheries in estuaries and backwaters have been contributing considerable share in fish production and the economy of the state. Exploited fishery resources in major estuarine habitats of Kerala such as Vembanadlake, Ashtamudi estuary and Azheekode estuary are reported. Among various estuaries, Vembanad lake, the largest estuarine ecosystem in south west coast of India supported the most lucrative fishery. There is also good amount of knowledge on large varieties of fishing methods and gears operated in these water bodies. However, status of fisheries exploitation in most of estuaries and backwaters is poorly understood.Moreover, unscrupulous human interventions have led to severe ecosystem alterations in these areas. Anthropogenic activities like extensive reclamation, urbanization, destruction of mangroves, sand mining, construction of bunds and barriers, pollution, over exploitation etc. have affected estuarine fish fauna adversely. Changes in estuarine ecology have greatly affected the faunal composition of these water bodies. Further, periodic evaluations on exploited fisheries are lacking which cause considerable paucity in planning proper fisheries management practices aimed at long term sustainable fishery production from these natural resources.

**Introduction**

Fisheries is one of the major economic avocations in the state of Kerala from time immemorial thanks to highly productive coastal waters and rich expanses of inland water bodies. Fisheries sector has been contributing nearly 1.58% of state GDP and the state has achieved an all time high fish production level of 0.73 million tonnes in 2014-15, of which 28% was contributed by inland waters. Having bountiful inland water resources, Kerala has been noted among various states in the country with respect to rich ichthyodiversity, diverse water bodies and increased fish production. The state is endowed with 85,000ha of rivers, 46,129ha of estuaries and backwaters, 61,805ha of freshwater bodies (Anon, 2015). The state supports 905 species of fishes belonging to 172 families and 41 orders (Bijukumar and Raghavan, 2015). Rivers in Kerala are natural abode to a large array of fish diversity. River Bharatapuzha provides habitat for 117 fish species (Bijukumar et al., 2013). However, only less than 20% of total ichthyodiversity in the state constitutes the mainstay of capture fisheries in both marine and freshwater bodies. In contrast to marine capture fisheries, inland capture fisheries in the state is poorly monitored, owing to lack of uniformity in landing patterns. Very few information of capture fisheries from various rivers of Kerala has so far been reported. A total of 394.22 tonnes of fishes has been reported to have landed annually in river Pampa, supported by 26 commercially important species (Renjithkumar et al., 2011). An annual average of 2.32 tonnes of fishes has been exploited from Periyar lake (Kurup et al., 2006).

**Estuarine capture fisheries**

Estuaries and backwaters constitute more than 60% of inland water bodies in the state and possess considerable status in its capture fisheries. Estuarine ichthyofauna comprise large diversity including resident, migrant and vagrant populations (Kurup and Samuel, 1985). These waters are considered as highly productive as they serve as constantly recharging natural habitats to both marine and freshwater migratory fauna which largely constitute capture fisheries production from these waters. Further, they also provide conducive environment to large number of fish fauna of commercially importance, though these waters are prone to frequent changes in environmental conditions. Ichthyodiversity from estuaries and backwaters of Kerala have been extensively studied. 150 species of fin fishes were reported from Vembanad lake (Kurup and Samuel, 1985), 67 species of fishes from Kadinamkulam backwater (Nair et al., 1983); 24 species from Paravur lake (Shibu, 1991), 112 species from Ponnani estuary (Bijukumar and Sushma, 2000), 38 species from Anchuthengu backwater (Rajukumar, 2005), 37 species from Thottappally backwater (Bhargavan et al., 2008).

The state is endowed with more than thirty backwaters and estuaries which contribute significantly to state economy in terms of fish production. Fisheries has been providing livelihood to people living close to estuaries and backwaters, for ages. However, considerable changes were brought about in these water bodies through anthropogenic activities which have adversely affected their capture fisheries. Therefore, periodic evaluations of capture fisheries in these waters need to be adopted for evolving befitting management strategies and foresighted implementation of governance policies. Unfortunately, very scanty information on capture fisheries of these estuaries is only available. It has become pertinent that considerable efforts are to be made in evaluating capture fish production in various inland water bodies.

**Capture fisheries of Vembanad lake**

Vembanad lake (Lat.9$^{0}$29' and 10$^{0}$ 10' N ; Long. 76$^{0}$ 13' and 76$^{0}$ 31' E) (Fig.1) extends from Alappuzha in south to Cochin Harbour mouth in north with an area of 21,050ha. Believed to have originated in 1341 AD (Menon, 1913), the lake is now part of Cochin backwater system and is connected permanently to the Arabian Sea. Five rivers viz., Pampa, Achencoil, Manimala and Meenachil and Muvattupuzha empty out into lake while former four rivers form a network of channels in Kuttanad before joining the lake. Depth of lake in northern part ranges from 8 to 12m while other parts of the lake are generally shallow ranging from 0.75 to 5m.

Environmental parameters like temperature, oxygen and salinity are reported to have influenced the occurrence and abundance of fish fauna of the lake, of which salinity was regarded as 'master ecological feature' (Kurup and Samuel, 1985). The lake experiences high fluctuations in salinity profile from almost freshwater conditions in monsoon to highly saline conditions during post and premonsoon seasons (Joseph and Kurup, 1990). Kurup and Samuel (1985) reported an ichthyodiversity of 150 fish species belonging to 100 genera under 56 families, from Vembanad lake. They reported that out of 139 species examined from the lake, migrants, residents and vagrants were comprised by 77, 45 and 17 species respectively. Except 9 freshwater species, majority of migrants were marine migrants and 78% of them were rare in occurrence while only 22% registered common occurrence in the lake. Of species entering estuary accidentally, only 3 species were of limnetic origin while 14 were of marine origin. Besides finfishes, 14 species of crustaceans and three species of bivalve molluscs were also reported from the lake. Six species of penaeid shrimps viz., *Fenneropenaeus indicus*, *Penaeus monodon*, *P. semisulcatus*, *Melicertus canaliculatus*, *Metapenaeus dobsoni* and *M. monoceros*, five palaemonid prawns viz., *Macrobrachium rosenbergii*, *M. idella* ,*M. equidens*, *M. striatus and M. scabriculum* and three crabs viz., *Scylla serrata*, *Portunus pelagicus* and *P. sanguinolentus* constitute the crustacean fauna of Vembanad lake. *Meretrix meretrix*, *M. casta* and the black clam, *Villorita cyprinoides* represent the bivalve molluscan resources of the lake.

The first concerted effort in estimating exploited fishery production from Vembanad lake was accomplished by the Kuttanad Water Balance Study Project (KWBSP,1990). Kurup et al. (1993) reported that annual fishery production from the lake was 7202.1 tonnes constituted by 2506.1 tonnes of fin fishes, 4383.4 tonnes of shrimps, 181 tonnes of crabs and 131.6 of palaemonid prawns. A total of 115 fin fishes, 6 peaneid shrimps, 4 palaemonid prawns and 3 crab species constituted the fishery. 93% of total annual landings were exploited from northern part of lake while only 7% was only contributed by southern part of lake. The major finfish groups were croakers (8.32%), ambassids (4.69%), cichlids (4.5%), cat fishes (4.34%) and mullets (2.77%). The average annual production per hectare was estimated at 342.14Kg. The maximum landings were made in premonsoon (44.17%) and post monsoon months (34.13%) while monsoon months recorded the lowest landings. Stationary gears like stake net (53.14%) and Chinese dip net (19.4%) contributed bulk of landings while contributions from gill nets (10.15%), seines (9.68%), cast nets (3.49%), hook and lines (2.54%) were low. The status of fishery exploitation of freshwater prawn *Macrobrachium rosenbergii* in Vembanad lake has been extensively studied. This species supported a very lucrative fishery to the tune of 300 tonnes as an annual average landings during 1957-62 (Raman,1967) which dwindled mere 39 tonnes in 1988-89 (Kurup, et al., 1992) . In contrast, during 1994-96 a revival of the stock could be recorded with an average annual landings of 121 tonnes (Harikrishnan and Kurup, 2001). However, the stock sustained further decline to the lowest of 28.86 tonnes in 2000-2001 (Harikrishnan and Kurup, 2006).

A recent estimate of fishery production from Vembanad Lake has been reported by Asha et al. (2014). According to them, annual exploited fishery in the lake during 2012-13 period amounts to a total of 4387.31 tonnes comprising of 3195.14 tonnes of crustaceans and 1192.17 tonnes of fin fishes. Among the fin fish groups, cichlids (28.49%) dominated the fishery followed by cat fishes (19.24%), mullets (16.31%) and cyprinids (10.45%). The maximum landings were made during pre and post monsoon periods (51.16 and 35.77% respectively).

**Capture fisheries in Ashtamudi estuary**

Ashtamudi estuary (8°45'-9°28' N and 75°28'-77°17' E) with an area of 57km$^{2,}$ is the second largest estuary in south west coast of India. This estuary receives freshwater influx from river Kallada and is permanently connected to sea at Neendakara. During monsoon, it almost turns into a near freshwater habitat while remains highly saline during post and premonsoon months. Fish fauna of the estuary are largely influenced by temperature and salinity characteristics. Temperature usually varies between 25 to 29° C whereas high salinity ranges of 29- 32 ppt have been recorded during post monsoon in many parts of central and eastern part of the estuary (Nair, et al., 2001). More than 90 aquatic species have been reported from this lake (Nair et al., 1983; Raj et al., 2014). Raj (2014) reported 68 species of fin fishes, 5 species of crabs, 9 species of shrimps and prawns and 9 species of molluscs from Ashtamudi estuary. However, exploited fishery from this estuary are reported to be comprised of 57 species of fin fish species, 6 species of shrimps, 1 species of palaemonid prawn, 5 crabs and 6 bivalves (Kurup and Thomas, 2001). The fish fauna in the estuary comprises a variety of true estuarine fishes, marine migrants and fishes of limnetic origin. The fin fish fauna dominate fishery during post monsoon months whereas shrimps constitute major landings during premonsoon months.

The annual fish production from the estuary is estimated at 5,700 tonnes (Thomas and Kurup, 2001). 2964 tonnes of fin fishes, 2052 tonnes of shrimps, 627 tonnes of crabs and 57 tonnes of *Macrobrachium rosenbergii* are reported to constitute the fishery in the lake. Mullets, pearl spot, cat fishes, estuarine sprat, gerrieds, goby (*Glossogobius giuris*), ambassids, *Chanos chanos* and *Caranx* spp. constituted bulk of landings. *Fenneropenaeus indicus* and *Metapenaeus dobsoni* dominated the shrimp fishery. Crab fishery was constituted by *Scylla tranquibarica*, *S. serrata* and *Portunus pelagicus*. 57.5 tonnes of Oil sardine juveniles were caught from Ashtamudi estuary during post monsoon months (Harikrishnan and Kurup, 2002). Thomas and Kurup (2004) reported that nearly 400 padals (bush parks) are operated in the estuary to catch juveniles and sub-adults of mullets, pearl spot and shrimps. Anoop et al. (2008) reported a net return of rupees 53.5 million from fishery in Ashtamudi estuary, excluding 13.5 million rupees from clam fishery. According to them, stationary gears stake net (19.2 million) and Chinese net (6.8million) contributed largest shares followed by gill nets (10.8 million rupees) and cast nets (8.80million rupees).

**Capture fisheries of Azhikode estuary**

Azhikode estuary, situated at northern end of Cochin backwaters (9°40' and 10° 12'N; 76° 10' and 76° 30'E) where it is permanently connected to Arabian Sea. It mainly receives freshwater from branches of Periyar and Chalakudy rivers. It is a positive estuary supporting diverse aquatic fauna. Capture fisheries in the estuary has been described by Harikrishnan et al. (2011). Crab fishery in the estuary was reported by Nasser and Noble (1995).

The exploited fishery in Azhikode estuary is constituted by 30 fin fish species, 6 species of penaeid shrimps, 2 species each of palaemonid prawns and crabs and 4 species of bivalves which contribute mean annual landings of 392.2 tonnes. The average production of fishery resources in the estuary was estimated at 1.64 tonnes per hectare; constituted by fin fishes (0.76 tonnes/ ha), clams (0.51tonnes per ha) and crustaceans (0.35 tonnes per ha). Among fin fishes, cat fishes registered highest mean landings (27.5 tonnes) followed by *Gerres* spp. (26.0 tonnes) and mullets (23.5 tonnes). Among crustaceans exploited from the estuary, *Metapenaeus dobsoni* constituted the highest landings (45.8 tonnes), followed by *Fenneropenaeus indicus* (17.5 tonnes) and *Scylla serrata* (10 tonnes). Besides, clams supported a lucrative fishery of 127.5 tonnes, mainly by *Villorita cyprinoides*. Stationary gears like chinese nets and stake nets contributed more than half of the total landings in the estuary. According to Harikrishnan et al. (2011), 106 chinese nets and 59 stake nets operated in the estuary. Gill nets (13%), cast nets (11.5%), crab rings (11%), hook and lines (7%) and seines (3%) were the other major fishing gears employed in the estuary. High saline periods, premonsoon (60%) and post monsoon (27%) contributed highest landings in the estuary.

**Problems in estuarine environment and fishery**

Natural aquatic resources of the state have been subjected to many anthropogenic interventions leading to severe alterations in their physiography, ecology and biodiversity. Estuaries and backwaters are no exception where very serious consequences have been reported (Balchand and Rasheed, 2000; Kurup and Harikrishnan, 2000; Kurup, 2009). Shrinking water spread area continues to be most severe impact of human activities in these water bodies. Unscrupulous extensive reclamation for the benefit of improving agriculture, industry, urban development, domestication, aquaculture etc., undertaken over decades have resulted in severe reduction in water area in many estuaries of Kerala. The total water spread in Vembanad lake has declined by 65% due to reclamation since the beginning of nineteenth century (Kurup,2009). Coupled with this, serious destruction of mangrove areas associated with backwaters and estuaries is another concern which caused considerable loss of nursery grounds for many aquatic organisms which sustained major fishery in these waters. Further, such alterations have caused remarkable variations in the physical features of estuaries like water flow, tidal currents etc. Consequent to heavy deforestation, reclamation and unbridled sand mining, serious alterations have been brought about in river ecosystems. Similarly, construction of dams, barrages and anicuts in river courses reduced considerable reduction in freshwater flows to estuaries. All these factors generally result in reduction in depths of many estuaries and changes in their salinity profiles. Prolonged high salinity incursions favorably influenced higher preponderance of marine fishes (Kurup and Samuel, 1985; Nair et al., 2001; Harikrishnan and Kurup, 2002; Harikrishnan et al., 2011), which however, affected adversely on the limnetic migrants and residents of estuaries. Further, operation of a salinity barrier at Thanneermukkam has been attributed to convert the Vembanad lake into a saline northern part and a freshwater southern part and thereby influencing the abundance of many fishery resources which sustained lucrative fishery in the lake before its commissioning (Kurup et al.,1990). The dwindling stock of *M. rosenbergii* in the lake has been highlighted as the most evident impact of the salinity barrier (Kurup and Harikrishnan, 2000) whereby its breeding stock had to undertake a long downward migration during which majority of them succumb to unscrupulous exploitation (Raman, 1967; Kurup et al., 1992; Harikrishnan and Kurup, 1996; Harikrishnan and Kurup, 1997). Furthermore, its operation has been attributed to obstruct the upward migration of post larvae of this species trapping them in downstream areas where they are prone to large scale mortality owing unfavorable environmental conditions (Kurup et al., 1992; Harikrishnan and Kurup,1998).

Estuaries are known to provide many ecosystem services (Day et al., 1989; Daily et al., 1997;Constanza and Folke, 1997; Fisher et al., 2009). Fisheries as an estuarine ecosystem service hasseverely been affected by decrease in estuarine ecosystem areas. Anoop et al. (2008) while evaluating economic value of use benefits in Ashtamudi estuary reported that fisheries formed the mainstay (87%) of total economic value. In addition to services such as consumptive uses (water supply, food supply, biodiversity), estuarine ecosystems also provide non consumptive uses such as flood control, pollution control, erosion control, recreation etc. (Barbier et al., 2011). Recreation through tourism activities has been a recently developed ecosystem use in estuaries and backwaters of Kerala. Kuttanad and Ashtamudi have been experiencing highest level of backwater tourism with house boats. A recent study reported that house boats operating Vembanad lake far exceeded the carrying capacity of the lake (Rajan et al., 2011). However, the direct and indirect implications of heavy traffic of houseboats in Kuttanad waters have not so far been seriously addressed. Extensive studies are required to throw light on to such issues affecting the estuarine ecosystems and sustaining capture fisheries there.

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# Conservation in murky waters

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**Abstract**

Coastal and marine spaces have been the witnessed tremendous economic growth over the past century, particularly in resource-rich third-world developing nations of the tropics. This growth has, however, been realized at massive ecological, economic and social costs. In developing tropical nations such as India where social and economic inequities are much more prominent, such issues are incredibly complex, undermining the economic and ecological integrity of the coastal and marine systems. The current paper provides a broad overview of some of the major challenges facing effective and equitable management of the key coastal and marine resources in India, existing approaches to address such concerns and the way forward.

**Marine Ecosystems - A socio ecological review**

Tropical marine ecosystems are one of the most ecologically and biologically diverse systems of the world. Our understanding of this diversity and the interactions between species and ecosystems are rudimentary at the best. From costal sand dunes to sub-tidal coral reef ecosystems and sea grass ecosystems, these systems provide home for a millions of species. From supporting a diverse and diffuse fishery that provides livelihood support for millions who live along the coast to providing shelter to coasts, these species assemblages and the ecosystems are critical to the survival of coastal populations for centuries. As convenient spaces that facilitate trade, coasts have also been the focus of development of humankind over centuries.

Establishment of human populations along the coastline has resulted in the development of strong, complex relationships between humans and the coastal and marine systems. These relationships now manifest in the social, economic and cultural fabric of the communities who depend on the coastal and marine spaces for survival. Healthy costal and marine systems have now become a critical part of the survival of these millions.

However, the identification of the economic potential of coastlines has lead to a massive development interest along the coast. From real estate to development of large shipment ports, the thin fringing coastlines in the past century have seen many new infrastructural developments and advent of powerful stakeholder groups. The traditional coastal communities find them becoming increasingly marginalized, leading to intense contests for these narrow spaces. Further, technological developments in the past century that focus on accelerated harvest of marine resources have resulted in the vast destruction of coastal habitats and the marine resources.Unfortunately, most such developments on the coasts have been unsustainable and unscientific, thereby undermining the ecological and economic value of these systems leading to innumerable complex issues that face the sustenance of the people living on the coasts and depending on marine resources for survival.

**Coastal and marine resource management in India- challenges and future**

India, with a coastline of about 8000 km, harbours biologically diverse marine ecosystems and habitats. The mainland coast and islands of Andaman and Nicobar and Lakshadweep together sustain some of the world's healthiest and most diverse coral reefs, mangroves, sea grass, sandy beaches and rocky shores. These natural resources in turn provide livelihood support for about 6 million people who depend directly or indirectly on fisheries and its related activities. The fisheries sector in India has also contributed to foreign exchange earnings with a gross production of about 5.41 lakh tonnes valued at Rs. 7621 crore in 2007-08. They also provide other invaluable ecosystem services, such as providing habitat for fish, as a receptor for wastewater, or to control beach erosion.

The past few decades have witnessed unsustainable exploitation of marine resources, large-scale habitat degradation, pollution, urbanisation along coastal areas, and climate change driven anomalies that have had major impacts on the coastal and marine resources and fisheries structure in the country and globally. Nearly 50% of the earth's coral reefs and mangroves are already lost or under severe anthropogenic and climate driven stress. Over-exploitation of the fishery resources, harmful fishing practices and increasing demand for seafood has lead to serious declines in fish stocks the world over. More than 75% of the global fish stock are either fully fished or overexploited. While direct anthropogenic disturbances like overfishing, pollution, and land-use changes affect coastal and marine ecosystems locally, climate driven sea surface temperature anomalies, sea level rise and green house gas related ocean acidification processes affect them on a global scale. To characterise survival and recovery of marine ecosystems and to manage and sustainably utilise the resources therein, we need to be able to disentangle localised variations from global phenomena.

Marine and coastal ecosystems are complex socio-ecological systems involving several variables. While there is an increasing awareness of the need to conserve, protect and sustainably utilise coastal and marine resources, it has been a relatively neglected area in the development and conservation arena in India. There is considerable disconnect between communities, community based organisations, business/corporate sector, research institutions, state/central government agencies and policy makers that reflects the lack of participation, transparency and accountability.

While the scientific knowledge base is slowly building in the marine field, this has not been effectively communicated to those who utilise or manage these resources. There are multiple sources of information on coastal and marine ecosystems and their management. However much of this is contained in specialist silos with little exchange between stakeholder groups. What exists instead is usually of poor content, ill-designed and of little value as outreach. Pluralistic understanding of ecosystems needs to be communicated using designs and formats that cater to different stakeholders. There is also a need to identify the right vehicles to mobilise outreach and communication strategies.

The subject of sustainable use of coastal and marine resources in India has been a relatively neglected area in the development and conservation arena. Coastal and marine areas are complex socio-ecological systems with several stakeholders claiming stakes over access to resources in these areas. Proportional to terrestrial socio-ecological systems, the existing knowledge base on both coastal-marine ecosystem dynamics and socio-economic systems can at best be described as modest. Given the high human densities in coastal areas and associated developmental pressures, it is critically important to develop and communicate information to government and community groups, to identify key sites where intensive conservation efforts are required, to support suitable agencies in developing community-based marine conservation and to build capacities in managing these sites in an ecologically and economically sustainable manner.

For a more meaningful and coordinated response towards conservation, and to remodel and reconcile conservation and development, a wide variety of research and action is required. Socio-legal research that relates to the interface between conservation and development laws is fundamental to policy change. Some key legal instruments that focus on fisheries regulation are given Annexure I. Applied research, which analyses jurisprudence principles and laws with a focus on aspects such as equity, effectiveness, implementation, compliance, justice delivery etc., is critical to the fledgling arena of socio-legal studies in coastal contexts. Poor development planning can severely limit the success of coastal management, sustainable development and livelihoods programmes. Ensuring that community rights in the planning process are enhanced though legal spaces, advocacy and active participation in existing avenues, can offset this. Emerging conflicts between development, environment and livelihoods/culture demand immediate attention in the developing world, and coastal areas are likely to have more localised implications with issues of global significance like climate change having critical implications for socio-ecological resilience and vulnerability. Addressing these issues is critical in management and sustainable utilisation of resources.

Marine Protected Areas are regions that hold potential for tremendous conservation related conflicts as well as opportunities. In such regions, it is important to ensure adequate information flow (horizontally and vertically) among stakeholders, conservation/research organisations and government agencies on aspects of collective concern, such as regulation, monitoring, and legal spaces for multi-stakeholder decision-making (Annexure II). It is essential that scientific knowledge along with social, policy and legal information is effectively communicated to inform and determine specific interventions. Popularisation of information on environmental laws and policies aimed at multiple stakeholders contributes to effective conservation actions. This should be done through the creation of interactive, legal information repositories and simplified outreach material on relevant laws and policies governing coastal and marine spaces.

Finally, there is a need to create a social and legal framework where communities empowered with knowledge and capacity can take informed decisions with regard to the management of their natural resources and other aspects of their society.

**Annexure I**

Some key legal instruments that focus on fisheries regulation

- The Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976
- Extra-ordinary Gazette Notification No. 736, dated 11 May 2009, on baseline system in India, and notifying the internal waters of India.
- Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, 1981 and the Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Rules, 1982
- Comprehensive marine fishing policy 2004
- Indian fisheries act, 1897
- Coastal Regulation Zone, Notification January 2011
- Corrigendum to Coastal Regulation Zone Notification, April 1st 2011
- Wetlands (Conservation and Management) Rules, 2010
- Coastal Aquaculture Authority Act 2005
- Marine Products Export Development Authority Act, 1972
- The Biological Diversity Act 2002
- The Wildlife (Protection) Act, 1972 (as amended 2002 and 2006)
- Trade Unions (Amendment) Act 2001
- Environment (Protection) Act, 1986
- Merchant Shipping Act 1958

**Annexure II**

Co-management framework as an emerging tool for equitable coastal and marine resource management

Total control by government (agency) Control by government with some input from stakeholders

Equal control by stakeholders and government agency

Control by stakeholders with some input from government

Total control by stakeholders

# Looking beyond the Fish, Social Sciences in Fisheries research. Experiences from transboundary fishing in Palk Bay

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**Abstract**

In 2012, an independent evaluation of the Food and Agriculture Organization's (FAO) support to the implementation of The Code of Conduct for Sustainable Fisheries (the code) recommended that in order to effectively implement the code more attention needs to be given to the "Human Dimension". This observation is very much in line with recent developments in fisheries research that has been more human centric than fish centric. What are these human dimensions? What does it mean to look at the human dimensions of fisheries? And how can they help in sustainable fisheries? In this essay I try to answer these questions by making uses of my experiences from the Palk Bay fisheries. While I try to foreground the need of social sciences in fisheries research I also explore the possibility of how different disciplines can talk to each other.

( *The below text is a modified version of the introductory chapter to my thesis Titled " Fishing for Space; Socio -Spatial relations of Indian Trawl fishers in Palk Bay, South Asia, in the context of trans-boundary fishing" submitted at the University of Amsterdam in April 2015*)

**Introduction**

*"Fisheries management is not about managing fish, but it is about managing fishers"*

Every student of fisheries management worldwide is familiar with the above phrase. The sciences that deal with fishers fall under the category of 'social sciences'. A close look at the syllabus in most of the college's which teach fisheries management show that the social sciences components take a back seat in relation to their counterparts- the 'natural science'. Even within the social sciences that are taught, disciplines such as economics, law, public administration and sociology dominate much of the discussions.

Fisheries Management is an interdisciplinary field and hence it is not surprising that the goals and methods in conventional fisheries management varied according to the disciplines that dominated it. Modern fisheries policies and management over the past century have been dominated by biologists and economists (Urquhart etal., 2014). Biologists are very often interested in understanding and estimating the life in the sea as their primary goal is conserving the environment. Economists largely advised on the optimum economic yield that can be extracted from the sea with the goal of getting the maximum economic benefit from the fish resources (ibid.). This essay is to advocate for more space for social sciences in fisheries management and the need for more interdisciplinary dialogue in fisheries management and governance.

***Why Social Sciences***

F.A.O. in 2012 estimated that about 87% of the commercial fish stocks in the world either being fully exploited or overexploited, it is now clear that conventional management methods that are based on scientific estimates do not adequately address issues related to overfishing and resource depletion. On the other side of the spectrum, there is ample evidence to prove that management of fisheries can be successful if it incorporates and includes fishing communities in the decision making process regarding fisheries management (Berkes, 2010 b ).Considering the current poor state of fisheries worldwide, there has been an increasing awareness to understand, study and incorporate the human component in fisheries management (Fulton et al., 2011). Apart from these utilitarian reasons for incorporating social sciences in Fisheries Management, there is a more important and pressing reason to incorporate social sciences. It is estimated that there are about 58.3 million people worldwide involved directly or indirectly in fishing activities be it either in capture fisheries or in Aquaculture (F.A.O, 2012). Of this 84 % are in Asia. Roughly about 10-12 percentage of the world population depends on fisheries for the livelihood with the bulk of them being in the third world countries. It is therefore a very big responsibility for fisheries scientist to better understand the human dimensions of such large number fishers whose livelihood and well being depends directly of fish resources.

In this regard, there is an urgent need to understand and incorporate various societal factors that influence fishery resources extraction and use in management practices (Urquhart et al., 2014). Though there is a broad consensus among scientists from different disciplinary backgrounds that the current state of world fishery is in bad shape, there is however a lack of consensus on the best way to address the issue (Fulton et al., 2011). While increasing resource rent through means such as Individual Transferable Quotas (ITQ) seems to be the best way forward for economists, social scientists are keen to have fisher communities involved in management by measures such as community based management (CBM), and biologists are more concerned with conserving and preserving nature as they see it with Ecosystem-based Management measures (EBM) (Dengbol et al., 2006).

***Social Sciences in Fisheries***

Even among the social sciences there are divergent views on governance and management of fisheries. There has however been a broad consensus that there is an important difference between management and governance. This in many ways is also a reflection of how social scientists conceive fisheries management as much more than just linear technical fixes. Fisheries management here refers to"a technical issue, something that involves a set of tools that can be applied to solve a concrete task, where the goal is clear and the outcome measurable' (Jentoft & Chuenpagdee, 2009,p. 555). Fisheries governance on the other hand is seen as "the whole of interactions taken to solve societal problems and to create societal opportunities; including the formulation and application of principles guiding those interactions and care for institutions that enable and control them" (Kooiman & Bavinck, 2005,p.17).Management is thus a part of the larger governance framework. Thus the theory on fisheries governance includes a wide range of actors and institutions and it actively tries to reconcile goals of environmental conservation, social justice, livelihoods, economic efficiency and food security (Kooiman et al., 2005; Bavinck & Kooiman, 2013).

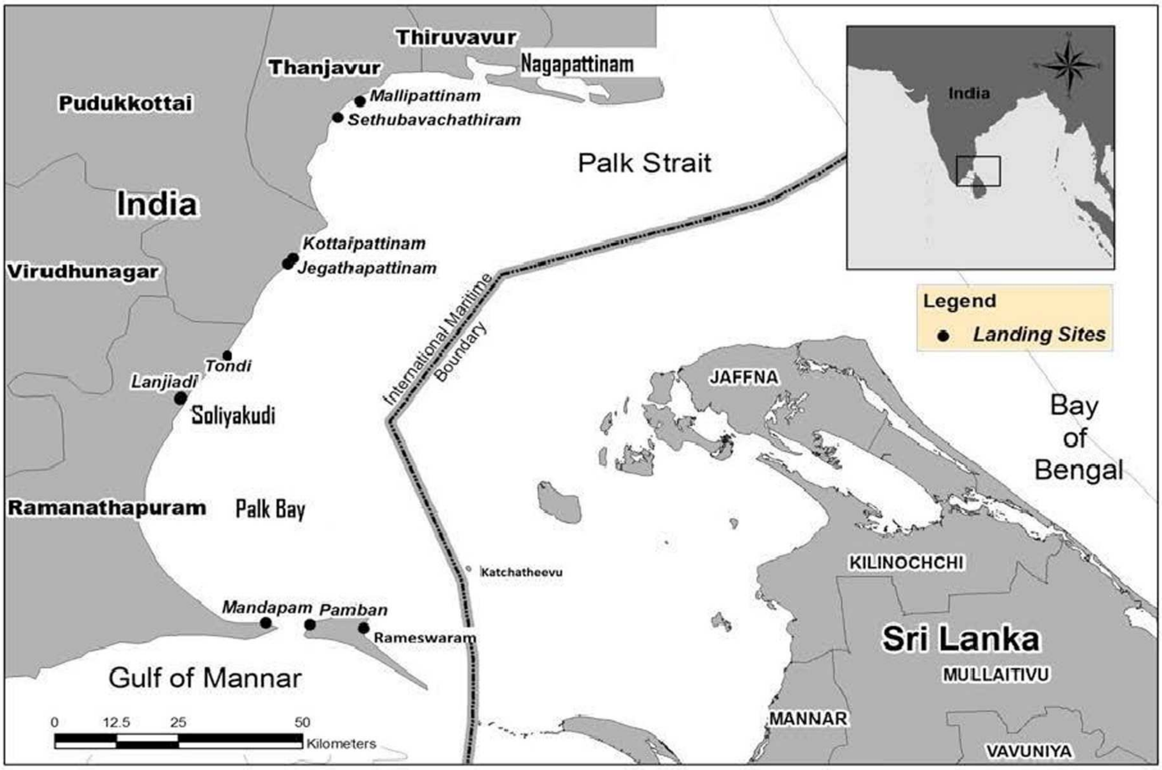
Governance has its origins in political science and governance in fisheries was conceptualized in the 1990s (Kooiman et al., 2005). The interactive governance framework emanated directly from this conceptualization (Kooiman et al., 2005). The thrust in interactive governance was to broaden the policy making community and have a much more interactive decision making process wherein all stakeholders have equal say in the process (Symes, 2014). This was in response to the current state of affairs in world fishery wherein decisions on policy and management are largely centered with one group of scientists or institutions, with little or no participation from the community and other stakeholders.

Co-management, another stream of popular thought in fisheries, evolved on a similar set of principles wherein the thrust was on power sharing among all stakeholders involved in the fisheries. Co-management however is a different level of analysis and is treated as one of the modes of governance (co-governance) as distinguished in interactive governance (Jentoft & Chuenpagdee, 2009; Wilson et al., 2006).

The conceptual framework of interactive governance is made up of three components: elements, modes and orders. Elements included images, instruments and actions, and a mode distinguishes three different modes of governance namely hierarchical governance, self-governance and co- governance (Kooiman & Jentoft, 2009). There are three distinct orders of governance identified in interactive governance theory (Kooiman et al., 2005). The first order is the everyday tasks necessary to be done to operationalize sustainable fishery and is recognized as akin to management, the second order is largely concerned with the institutional and organizational arrangements and the third order is concerned with elaborating values, principles and criteria for policy making. According to interactive governance theory, much attention has been paid to the end stages of decision whereas little or no attention has been paid to the values and principles on which these decisions are made (Symes, 2014). The principles of interactive governance are conceptually based on the various components (elements, modes and orders) of interactive governance and there are nine such derived principles (Kooiman & Jentoft, 2009).These broadly included that of inclusiveness, rationality, social justice and equity and environmental ethics and moral responsibility (Kooiman et al., 2005; Kooiman & Jentoft, 2009). Another set of fisheries management theory that had different origins but later developed into similar ideas was the resilience theory (Nayak et al., 2014). This theory stemmed from that of the ecological resilience theory wherein the resilience of an ecosystem to overcome disturbances and maintain a healthy order was recognized and incorporated when studying and implementing ecosystem-based management measures. Resilience theory in social sciences looks at the ability of the human system to adapt to disturbances especially in regard to changes in the ecosystems (Adger, 2000). The approach includes "...attention to drivers and change processes, treating social-ecological systems as complex adaptive systems characterized by cycles and uncertainty, and social systems and ecosystems as coupled and co-evolving. It is a good fit for contemporary resource management highlighting property rights, participation, interaction of institutions at multiple levels, and experimentation as in adaptive management and interactive governance" (Berkes, 2010,p. 13). The resilience of both the socio-ecological systems are in turn linked to the interactions between the various actors in the system and between them. Some of these ideas of interactions and connectivity also find resonance in the interactive governance frameworks that have been described earlier (Chapin et al., 2009).All the social science based theories discussed here, in many ways challenge conventional goals in fisheries management and policy and complement each other in terms of explaining the complexity and accounting for the ever dynamic social systems.

### *The Case of Palk Bay*

The Palk Bay lies in the southeastern part of Tamil Nadu, India. The western rim of the bay, i.e. the Indian side, has five districts bordering the Bay – namely the southern part of Nagapattinam, the whole of Thiruvarur, Thanjavur and Pudukkottai, and the northern part of Ramanathapuram ( Map 1). Palk Bay is a large geographical area (approximately 250 Km of coastline between the two points) and encompasses immense social and ecological diversity. Palk Bay is witnessing a complex socio-ecological crisis. The bay witnessed one of the most protracted civil wars of recent world history between the Sri Lankan government and the Liberation Tigers of Tamil Eelam (LTTE). During the war, the Tamil fishers of northern Sri Lanka were allowed only restricted fishing for security reasons. Night time fishing was not allowed and during the day they were only allowed to fish very close to the Sri Lankan coast using non-motorized fishing crafts. Indian fishers on the other hand grew in number and invested in larger trawlers and increasingly fished in Sri Lankan waters (Vivekanandan, 2010). Indian trawl fishers have over the years become heavily dependent on the rich resources on the Sri Lankan side of the Palk Bay. This dependence has come at a cost; over 100 fishers have been killed by the Sri Lankan navy over the years.




Map 1: Map of Palk Bay showing all the trawl landing centres.
Source: University of Amsterdam

Since the end of the civil war in 2009, the Sri Lankan fishers (predominantly small scale gillnetters) have resumed their fishing operations. They are however confronted with the trawlers of Tamil Nadu whose operation is incompatible with that of the gill netters. Sri Lankan fishers are losing their livelihood because of the Indian trawl operations (Scholtens et al., 2012). Both the fishing communities are however of the same ethnic group and have had ties for hundreds of years. The situation is becoming increasingly desperate for the northern fishers of Sri Lanka as they don't see a respite in the trawl operations from India in spite of a series of negotiations that have taken place (Stephen et al.,2013) With increasing resource depletion a fishing crisis has now developed in Palk Bay.

The complexity of the present fishing crisis is such that there can be very little progress if one sees this from a conventional view point. In addition to understanding the resource of the place, it involves the understanding of the political ecology and political economy of the region. Moreover the geo-politics and international relations contingent with the social and political history of the region ( Menon et al.,2015) plays a crucial factor in understanding the crisis. This crisis is thus intrinsically tied to the modernization of fisheries in the region, the civil war in Sri Lanka and the politics of ethnic identity. This crisis now manifests itself in the form of a fishing conflict between the Indian trawl fishers and the small-scale fishers of Sri Lanka's Northern Province. A conventional approach would not throw the required light on the situation and could potentially further jeopardize the existing fragile nature the conflict. Any fisheries solution thus will go beyond just fisheries accommodating various other stake holders as well.

### *Conclusion*

The Palk Bay crisis is just one example. Most of the other fisheries issues in India and outside are connected to various other social phenomenons best explained by incorporating various social sciences. Even within social sciences there is a need to move beyond the traditional disciplines of Economics and law. Of late disciplines such as Legal Pluralism ( Bavinck, 2003), Political geography (Stephen,2014), Political ecology (Menon et al., 2015) and Anthropology (Sunder,2011) to name a few have immensely contributed to further our understanding of fisheries governance. There is however a dire needs to have more fruitful dialogues between the various disciplines. This dialogue can happen only if there is mutual respect and understanding of different disciplines. To cultivate this it is however important that in the early stages of education (be it in the Bachelors and Masters level) students are exposed to the importance and need of interdisciplinary studies.

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# On the evaluation of marine finfish resources of Parangipettai coastal waters, Southeast coast of India

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**Abstract**

Fisheries sectors play an important role in the Indian economy by contributing income, exports, food, nutritional security and employment generation. There are only few studies available on the finfish resources of the southeast coast of India. Parangipettai fish landing center is one among important landing centres in the Tamil Nadu coastal waters. The present study was undertaken to assess the finfish resources and to find out the dominant Order, Family and Genera, besides similarity in species composition and diversity of marine finfishes of Parangipettai coastal waters during January 2013-December 2013. Totally 248 species of finfishes were recorded belonging to 20 Orders, 89 Families and 158 Genera. Among them, Order Perciformes dominated with 141 species. The total estimated finfish production was registered 83, 07,795kg. Clupeid fishes were the most abundant group with 61.86% of the total fish catches. Oil sardine (*Sardinella longiceps*) remain contributed the most important single species with 60.08% of the total finfish landings. The estimated landings of Oil sardine was 49, 91,588kg during the study period. The second important resource in terms of contribution towards total landing was the flayingfish *Exocoetus volitans* with 9.72% of the total landings with 8, 08,204kg. Based on the results, resourceful with more diversity of fishes. The maintenance of fish population in natural environment is possible only by variety of techniques for fish stocking and regulation of harvest.

**Key Words:** Marine Finfish Resources, Qualitative, Quantity, Tiny fishes and Diversity

## INTRODUCTION

Fish and Fisheries sectors play an important role in the Indian economy by contributing income, exports, food and nutritional security and in employment generation. Fishes form one of the vital sources of food and man's most important source of high quality protein, providing 16% of the animal protein consumed by the world's population (FAO, 2000). Fish consumption has been increased in many countries and in India, fisheries have emerged as a major industry with an annual turnover of approximately Rs. 220 billion, accounting for 1.4% of the total GDP (Ayyappan and Biradar, 2000).

Fishing down marine food webs along Indian coast indicate the present exploitation pattern are unsustainable and reflect a gradual transition in landings from long-lived, tropical level, piscivovous bottom fish toward shout-lived, low tropical level invertebrates and planktivorous pelagic fishes (Vivekanandan *et al.*, 2005). The marine fish production in India consists of a large number of species and these fishes are captured by using different craft and gears mostly in the depth range of 0-50 meters. Mora *et al.* (2008) used records from the Ocean Biogeographical Information System (OBIS) database to estimate the completeness of the global fish inventory through the extrapolation of species discovery curves. CMFRI (2013) reported that the Annual marine fish landing of India was

3.94 million metric tonnes during the year of 2012. Most fisheries depend on harvesting wild populations whose productivity is derived from biodiversity. The collapse of major fisheries shows that most of marine resources are exhaustible (Knauss, 1992; Hutchings and Myers, 1994). Overfishing is a major threat to biodiversity because it depletes resources that can lead to loss of genetic integrity, local populations, and even species (Boehlert, 1996). Fishing activity alters the ecology, biological structure and dynamics of marine ecosystem (Dayton, 2009). The progress and the problems of marine fishery of India are reviewed by Devaraj and Vivekanandan (1999). The global total number of extinct fishes is estimated was 93 in 2004 (Baille *et al.*, 2004). IUCN Red List out 1275 threatened fish species or 37% of the 3481 fish species that were evaluated during 2008.

Tamil Nadu coastline is about 1076 km (13 % of the county coastline), 1.9 lakh square km of Exclusive Economic Zone (9 % of India EEZ) and a continental shelf of about 41412 square km. the total marine fish landing in Tamil Nadu coast during 2012 was 7.1 lakh tonnes. Pelagic finfishes contributed 51.4%, demersal 34.1% crustaceans 8.7% and molluscs 5.9% to the total landings (CMFRI, 2013). The knowledge of the fish fauna of the EEZ on India is currently lacking, systematic, zoogeographical and vital biological studies of the conventional and nonconventional commercially important ichthyofauna of our waters are needed to assess their stock potential and exploitation. Such information, especially on nonconventional resources of the epipelagic, mesoplagic, bathypelagic and benthic fishes of outer shelf and beyond is highly essential in the present context of stagnating coastal fishery. Therefore, a preliminary attempt was made in the present study to bring out marine finfish recourses of Parangipettai coastal waters southeast coast of India.

## MATERIALS AND METHODS

The present study on fishery resources was carried out in Parangipettai region during January 2013-December 2013, covering the following landing centres

1. Annankoil
2. Mudasalodai

The Parangipettai coastal water is divided into two major fish landing centres; namely Parangipettai and Mudasalodai. Mudasalodai (Lat. 11$^{f}$ 29'00.33''N; Log. 79$^{f}$ 46'28.17''E) fish landing center has been selected for the present study as it is the only trawl landing center. Parangipettai (Lat. 11$^{f}$ 30'08.03''N; Log. 79$^{f}$ 46'18.44''E) landing center support maximum landing in pelagic marine fishes. These two landing centres are situated in the banks of Vellar- Coleroon estuarine backwater complex (Fig 1).

Trawling was introduced in Parangipettai coastal waters in Mudasalodai landing centre only in the year of 1985 (Bavinck, 2001). A total of 72 trawlers were operated during 2010-2011 and in the year of 2011-2012, the trawl fleet number was increased to 80 units (Suresh, 2013). In the present study, a total of 134 crafts were recorded in Parangipettai and similarly 115 crafts in Mudasalodai.


**Fig 1. Map showing the study areas- Parangipettai and Mudasalodai (Courtesy: Google Earth. com)**

**Data collection**

The multi-stage stratified random sampling design (Bal and Rao, 1984) developed by the Central Marine Fisheries Research Institute (CMFRI), Kochi was used in the present study for collecting fish catch data from Parangipettai coastal waters. A month was split up into three clusters of 10 days each. Observations were made for six consecutive days in a cluster of 10 days. During the six days, data were gathered from two landing centers, for two consecutive days at each zone. During the two days, observations were made for six hours i.e. from 12 hours to 18 hours on the first day and from 6 hours to 12 hours the next day. Night landings, if any, were recorded by enquiry from the fishers. Enumerating a zone for 24 hours ultimately means the conduct of three days observation from two landing centers in a cluster of 10 days, that is, nine days of actual observation in a month. As it is rather difficult to estimate the catches from all the boats in a zone, 10 per cent of the boats landed were enumerated when the number was more than 50, 20 per cent when the number was between 21 and 50, 50 per cent when the number of boats were between 11 and 20 and all the boats were observed if they were 10 or less numbers. The number of boats landed was noted down separately. These data were ultimately raised to a month's catch by using the following formula:

$$Y = \left(N_{ijk} / n\right) \sum_{i-1}^{n} y_{ijk}$$

where Y is the estimated catch for a month in both landing centers, N is the total number of landing centre days, n is the actual number of landing centre days observed and y is the catch observed in the centre day. The fishes were collected and preserved in 5% neutralized formalin for their identification and numbers in each collection were recorded. The identification and classification was carried out by following the guidelines of Ramanathan and Natarajan (1980), FAO (1984), Munro (1955) and Ajmal Khan & Murugan (2006).

## RESULTS

In the present study, a total of 248 species were recorded belonging 20 orders, 89 families and 158 genera (Table 1). Among them, Order Perciformes dominated with 141 species followed by Clupeiformes (21), Pleuronectiformes (20), Tetraodontiformes (11), Scorpaeniformes (9), Mugiliformes (7), Myliobatiformes (6), Siluriformes (5), Beloniformes (5), Torpediniformes (4), Charcharhiniformes (3), Anguilliformes (3), Aulopiformes (3), Elopiformes (2), Beryciformes (2), Syngnathiformes (2) and Gonorhynchiformes, Batrachoidiformes, Lophiformes and Gadiformes with one species each.

**Table 1. Checklist of finfishes recorded from Parangipettai coastal waters**

| S. No | Order | Family | Species |
|---|---|---|---|
| 1 | Charcharhiniformes | Carcharhinidae | *Carcharhinus macloti* |
| 2 | | Hemiscylliidae | *Chiloscyllium griseum* |
| 3 | | Sphyrnidae | *Sphyrna lewini* |
| 4 | Torpediniformes | Narcinidae | *Narcine lingual* |
| 5 | | | *Narcine prodorsalis* |
| 6 | | | *Narcine timlei* |
| 7 | | Torpedinidae | *Torpedo* sp |
| 8 | Myliobatiformes | Dasyatididae | *Pastinachus sephen* |
| 9 | | | *Himantura bleekeri* |
| 10 | | | *Himantura gerrardi* |
| 11 | | | *Himantura imbricata* |
| 12 | | | *Himantura uarnak* |

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|---|---|---|---|
| **13** | | Myliobatididae | *Mobula kuhlii* |
| **14** | Elopiformes | Elopidae | *Elops machnata* |
| **15** | | Megalopidae | *Meglalops cyprinoides* |
| **16** | Anguiliformes | Muraenidae | *Gymnothorax randalli* |
| **17** | | Muraenesocidae | *Congresox talabon* |
| **18** | | Congridae | *Ophichthus lithinus* |
| **19** | Clupeiformes | Chirocentridae | *Chirocentrus nudus* |
| **20** | | Clupeidae | *Amblygaster clupeoides* |
| **21** | | | *Anodontosoma chacunda* |
| **22** | | | *Dussumieria acuta* |
| **23** | | | *Escualosa thoracata* |
| **24** | | | *Nematalosa nasus* |
| **25** | | | *Sardinella albella* |
| **26** | | | *Sardinella gibbosa* |
| **27** | | | *Sardinella longiceps* |
| **28** | | | *Tenualosa toli* |
| **29** | | Engraulididae | *Stolephorus commersoni* |
| **30** | | | *Stolephorus indicus* |
| **31** | | | *Stolephorus waitei* |
| **32** | | | *Thryssa dussumieri* |
| **33** | | | *Thryssa malabarica* |
| **34** | | | *Thryssa mystax* |
| **35** | | | *Thryssa polybranchiaalis* |
| **36** | | | *Thryssa setirostris* |
| **37** | | Pristigasteridae | *Ilisha filigera* |
| **38** | | | *Ilisha melastoma* |
| **39** | | | *Opisthopterus tardoore* |
| **40** | Gonorhynchiformes | Chanidae | *Chanos chanos* |
| **41** | Silluriformes | Ariidae | *Arius arius* |
| **42** | | | *Arius maculatus* |
| **43** | | | *Arius sona* |
| **44** | | Plotosidae | *Plotosus canius* |
| **45** | | | *Plotosus lineatus* |
| **46** | Aulopiformes | Synodontidae | *Saurida tumbil* |
| **47** | | | *Saurida undosquamis* |
| **48** | | | *Trachinocephalus myops* |
| **49** | Batrachoidiformes | Batrachoididae | *Batrachomoeus* sp |
| **50** | Lophiformes | Antennariidae | *Antennarius hispidus* |
| **51** | Gadiformes | Bregmacerotidae | *Bregmaceros* sp |
| **52** | Mugiliformes | Mugilidae | *Liza macrolepis* |
| **53** | | | *Liza parsia* |
| **54** | | | *Liza subviridis* |

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|---|---|---|---|
| **55** | | | *Liza tade* |
| **56** | | | *Liza vaigiensis* |
| **57** | | | *Mugil cephalus* |
| **58** | | | *Valamugil buchanani* |
| **59** | Beloniformes | Belonidae | *Strongylura strongylura* |
| **60** | | | *Tylosurus crocodilus* |
| | | | *crocodilus* |
| **61** | | Exocoetidae | *Exocoetus volitans* |
| **62**<br>**63** | | Hemiramphidae | *Hemiramphus lutkei*<br>*Hemiramphus far* |
| **64** | Beryciformes | Holocentridae | *Myripristis* sp |
| **65** | | | *Sargocentron diadema* |
| **66** | Syngnathiformes | Centriscidae | *Centriscus scutatus* |
| **67** | | Fistulariidae | *Fistularia villosa* |
| **68** | Tetraodontiformes | Diodontidae | *Chilomycterus orbicularis* |
| **69** | | Ostraciidae | *Tetrosomus gibbosus* |
| **70** | | Monacanthidae | *Aluterus monoceros* |
| **71** | | Tetraodontidae | *Arothron immaculatus* |
| **72** | | | *Chelonodon patoca* |
| **73** | | | *Lagocephalus guentheri* |
| **74** | | | *Lagocephalus lunaris* |
| **75** | | | *Takifugu oblongus* |
| **76** | | | *Torguigener brevipinnis* |
| **77** | | Balistidae | *Aluterus monoceros* |
| **78** | | | *Odonus niger* |
| **79** | Pleuronectiformes | Psettodidae | *Psettodes erumei* |
| **80** | | Paralichthydiadae | *Pseudorhombus arsius* |
| **81** | | | *Pseudorhombus elevates* |
| **82** | | | *Pseudorhombus triocellatus* |
| **83** | | Bothidae | *Engyprosopon grandisquama* |
| **84** | | | *Crossorhombus azureus* |
| **85** | | | *Laeops guentheri* |
| **86** | | | *Laeops nigrescens* |
| **87** | | Pleuronectidae | *Samaris cristatus* |
| **88** | | Soleidae | *Heteromycteris oculus* |
| **89** | | | *Aesopia cornuta* |
| **90** | | | *Zebrias altipinnis* |
| **91** | | | *Zebrias quagga* |
| **92** | | | *Brachirus orientalis* |
| **93** | | | *Synaptura albomaculata* |
| **94** | | | *Synaptura commersoniana* |
| **95** | | Cynoglossidae | *Cynoglossus arel* |
| **96** | | | *Cynoglossus cynoglossus* |
| **97** | | | *Cynoglossus puncticeps* |
| **98** | | | *Cynoglossus semifasciatus* |

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|---|---|---|---|
| **99** | Scorpaeniformes | Platycephalidae | *Eurycephalus carbunculus* |
| **100** | | | *Platycephalus indicus* |
| **101** | | | *Thysanophrys chiltonae* |
| **102** | | Scorpaenidae | *Apistero carinatus* |
| **103** | | | *Choridactylus multibarbus* |
| **104** | | | *Dendrochirus zebra* |
| **105** | | | *Inimicus filamentosus* |
| **106** | | | *Inimicus sinensis* |
| **107** | | | *Minous monodactylus* |
| **108** | Perciformes | Centropomidae | *Lates calcarifer* |
| **109** | | Ambassidae | *Ambassis commersoni* |
| **110** | | | *Ostorhinchus fasciatus* |
| **111** | | Priacanthidae | *Pariacanthus hamrur* |
| **112** | | Serranidae | *Cephalopholis argus* |
| **113** | | | *Epinephelus bleekeri* |
| **114** | | | *Epinephelus chlorostrigma* |
| **115** | | | *Epinephelus coioides* |
| **116** | | | *Epinephelus diacanthus* |
| **117** | | | *Epinephelus faciatus* |
| **118** | | | *Epinephelus latifasciatus* |
| **119** | | | *Epinephelus radiatus* |
| **120** | | | *Epinephelus tauvina* |
| **121** | | | *Epinephelus undulosus* |
| **122** | | Terapontidae | *Pelates quadrilineatus* |
| **123** | | | *Terapon jarbua* |
| **124** | | | *Terapon puta* |
| **125** | | | *Terapon theraps* |
| **126** | | Apogonidae | *Apogon ellioti* |
| **127** | | | *Apogon fasciatus* |
| **128** | | | *Archamia bleekeri* |
| **129** | | | *Cheilodipterus macrodon* |
| **130** | | Sillaginidae | *Sillago sihama* |
| **131** | | Rachycentridae | *Rachycentron canadum* |
| **132** | | Echeneidae | *Echeneis naucrates* |
| **133** | | Carangidae | *Alectis ciliaris* |
| **134** | | | *Alectis indicus* |
| **135** | | | *Alepes kleinii* |
| **136** | | | *Carangoides* |
| | | | *caeruleopinnatus* |
| **137** | | | *Carangoides headlandensis* |
| **138**<br>**139** | | | *Carangoides oblongus*<br>*Caranx ignobilis* |
| **140** | | | *Caranx para* |
| **141** | | | *Decapterus russelli* |
| **142** | | | *Megalaspis cordyla* |
| **143** | | | *Parastromateus niger* |

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|---|---|---|---|
| **144** | | | *Selaroides leptolepis* |
| **145** | | Coryphaenidae | *Coryphaena hippurus* |
| **146** | | Menidae | *Mene maculata* |
| **147** | | Leiognathidae | *Gazza achlamys* |
| **148** | | | *Gazza minuta* |
| **149** | | | *Leiognathus brevirostris* |
| **150** | | | *Leiognathus daura* |
| **151** | | | *Leiognathus dussumieri* |
| **152** | | | *Leiognathus equulus* |
| **153** | | | *Leiognathus splendens* |
| **154** | | | *Photopectoralis bindus* |
| **155** | | | *Secutor insidiator* |
| **156** | | | *Secutor ruconius* |
| **157** | | Lutjanidae | *Lutjanus argentimaculatus* |
| **158** | | | *Lutjanus ehrenbergii* |
| **159** | | | *Lutjanus fulviflammus* |
| **160** | | | *Lutjanus fulvus* |
| **161** | | | *Lutjanus johnii* |
| **162** | | | *Lutjanus lutjanus* |
| **163** | | | *Lutjanus madras* |
| **164** | | | *Lutjanus malabaricus* |
| **165** | | | *Lutjanus quinquelineatus* |
| **166** | | | *Lutjanus russelli* |
| **167** | | | *Lutjanus vitta* |
| **168** | | | *Pristipomoides typus* |
| **169** | | Caesionidae | *Caesio caerulaurea* |
| **170** | | Lobotidae | *Lobotes surinamensis* |
| **171** | | Gerrediae | *Gerres abbreviatus* |
| **172** | | | *Gerres filamentosus* |
| **173** | | Haemulidae | *Diagramma pictum* |
| **174** | | | *Plectorhinchus ceylonensis* |
| **175** | | | *Plectorhinchus gibbosus* |
| **176** | | | *Plectorhinchus lineatus* |
| **177** | | | *Pomadasys kaakan* |
| **178** | | | *Pomadasys maculatum* |
| **179** | | | *Pomadasys olivaceum* |
| **180** | | Sparidae | *Rhabdosargus sarba* |
| **181** | | Lethrinidae | *Gymnocraninus grandoculis* |
| **182** | | | *Lethrinus lentjan* |
| **183** | | Nemipteridae | *Nemipterus bipunctatus* |
| **184** | | | *Nemipterus japonicus* |
| **185** | | | *Nemipterus nematophorus* |

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|---|---|---|---|
| **186** | | | *Nemipterus randalli* |
| **187** | | | *Scolopsis vosmeri* |
| **188** | | Sciaenidae | *Johnius amblycephalus* |
| **189** | | | *Johnius carouna* |
| **190** | | | *Johnius carutta* |
| **191** | | | *Johnius elongatus* |
| **192** | | | *Nibea maclata* |
| **193** | | | *Otolithes ruber* |
| **194** | | Mullidae | *Upeneus sulphureus* |
| **195** | | | *Upeneus tragula* |
| **196** | | Cichlidae | *Etroplus maculates* |
| **197** | | | *Etroplus suratensis* |
| **198** | | Kyphosidae | *Kyphosus cinerascens* |
| **199** | | Drepanidae | *Drepane punctata* |
| **200** | | Ephippidae | *Ephippus orbis* |
| **201** | | | *Platax tiera* |
| **202** | | Monodactylidae | *Monodactylus argenteus* |
| **203** | | | *Monodactylus kottelati* |
| **204** | | Scatophagidae | *Scatophagus argus* |
| **205** | | Chaetodontidae | *Chaetodon decussates* |
| **206** | | | *Heniochus acuminatu* |
| **207** | | Pomacanthidae | *Pomacanthus imperator* |
| **208** | | Cepolidae | *Acanthocepola indica* |
| **209** | | Polynemidae | *Eleutheronema tetradactylum* |
| **210** | | | *Polynemus plebeius* |
| **211** | | | *Polynemus sextarius* |
| **212** | | Opistognathidae | *Opistognathus rosenbergii* |
| **213** | | Labridae | *Iniistius bimaculatus* |
| **214** | | | *Iniistius cyanifrons* |
| **215** | | | *Iniistius paro* |
| **216** | | | *Xiphocheilus typus* |
| **217** | | Scaridae | *Scarus ghobban* |
| **218** | | Gobiidae | *Amoya madraspatensis* |
| **219** | | | *Ctenotrypauchen microcephalus* |
| **220** | | | *Glossogobius giuris* |
| **221** | | | *Oxyurichthys auchenolepis* |
| **222** | | | *Parachaeturichthys polynema* |
| **223** | | | *Trypauchen vagina* |
| **224** | | Siganidae | *Siganus canculatus* |
| **225** | | | *Siganus javus* |
| **226** | | | *Siganus lineatus* |
| **227** | | | *Siganus vermiculatus* |
| **228** | | Zanclidae | *Zanclus cornutus* |

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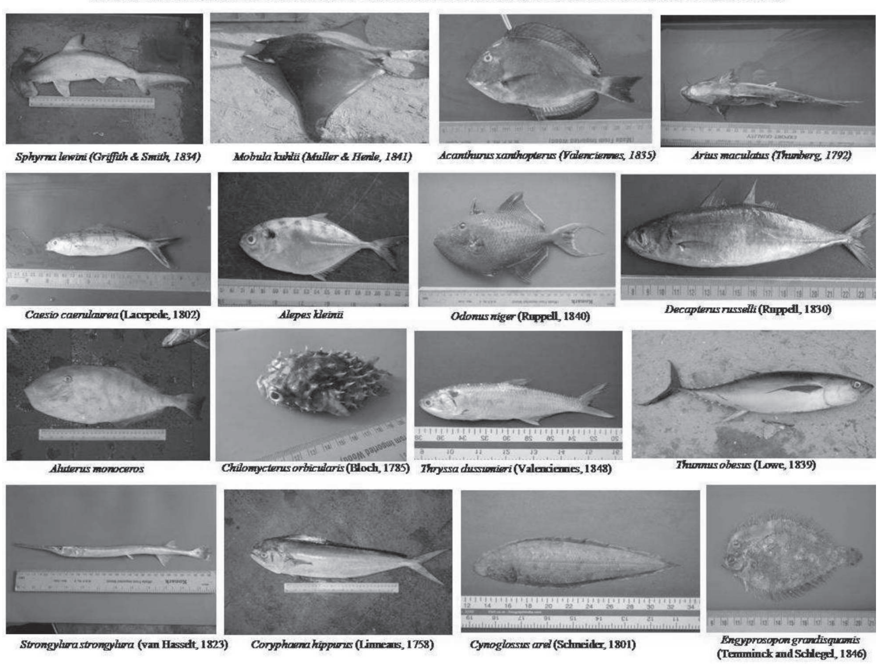
|---|---|---|---|
| **229** | | Acanthuridae | *Acanthurus bleekeri,* |
| **230** | | | *Acanthurus mata* |
| **231** | | Sphyraenidae | *Sphyraena forsteri* |
| **232** | | | *Sphyraena jello* |
| **233** | | | *Sphyraena obtusata* |
| **234** | | | *Sphyranea barracuda* |
| **235** | | Trichiuridae | *Lepturacanthus savala* |
| **236** | | | *Trichiurus lepturus* |
| **237** | | Xiphiidae | *Xiphias gladius* |
| **238** | | Istiophoridae | *Istiophorus platypterus* |
| **239** | | Scombridae | *Acanthocybium solandri* |
| **240** | | | *Auxis thazard* |
| **241** | | | *Euthynnus affinis* |
| **242** | | | *Katsuwonus pelamis* |
| **243** | | | *Rastrelliger kanagurta* |
| **244** | | | *Sarda orientalis* |
| **245** | | | *Scomberomorus commerson* |
| **246** | | | *Thunnus albacares* |
| **247** | | | *Thunnus obesus* |
| **248** | | Stromateidae | *Pampus chinensis* |

**MARINE FINFISH RECORDED FROM THE PARANGIPETTAI COASTAL WATERS**




In Parangipettai coastal waters, evaluation of marine finfish production was made along with the effort by different types of gears. The present study estimated total finfish production of 83, 07,795 kg at the study ares. Clupeidae fishes were the most dominant group contributing 61.86% of the total fish catches followed by Exocoetidae (9.72%), Scombridae (5.75%), Engraulididae (2.61%), Mugilidae (2.23%), Carangidae (2.18%), Ariidae (1.18%) and Nemipteridae (1.44%) respectively (Fig 2).

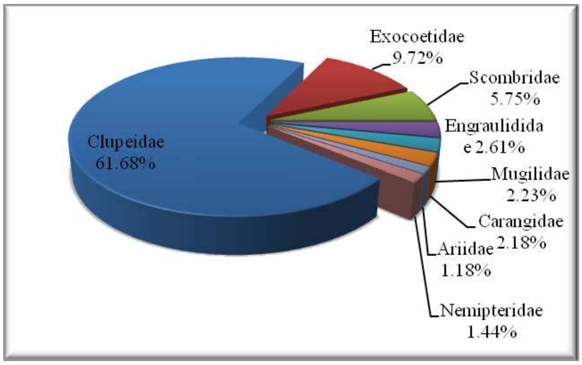



**Fig 2. Dominant familes of fishes (in percentage) from study area**

**Month – wise contribution of finfishes (Qualitative)**

Sharks and rays were recorded maximum during August--November. The flying fish *Exocoetus volitans* was recorded during July-September. *Sphyraena* sp was also recorded during June-September. Fishes such as *Leiognathus* sp, *Secutor* sp (Leiognathidae) fishes were landed throughout the year.

Other groups which constituted the fishery were seabass, milkfish, groupers, threadfins (Polynemidae), glassfishes (Ambassidae), catfishes (Aridae), tiger perches (Teraponidae) and silverbellies (Leiognathidae). Among all these groups' mullets, silver biddies whitings, threadfins and catfishes formed the major part of the fishery. *Terapon puta*, *Sillago sihama*. *Chanos chanos*, *Gerres* sp and *Thryssa* sp were landed less during the study period.

**Month- wise contribution by finfishes (Quantitative %)**

Percentage contribution of varius finfishes to the total landing during 2013 is shown in Table 5. In the month of September, fishes such as the oil sardine *Sardinella longiceps* (74.45%) and *E. volitans* (13.91%) were dominant. The catch during the month was 16.97% of the total. The second most dominant (13.92%) landing was observed during the month of January, *S. longiceps* (61.44%) was the dominant species followed by *E. volitans* (15.04 %). In the month of May (13.03%) again *S. longiceps* was the most dominant fish (57.23%) followed by *E. volitans* (16.86%). In the month of February (10.79%) also *S. longiceps* was the most dominant (80.31%) followed by *Cynoglossus arel* (4.95%). In the month of March (9.31%) also *S. longiceps* was the most dominant (80.12%) followed by *Mugil cephalus* (2.35%). In the month of April (9.02%) the contributer by *S. longiceps* was more (79.98%) followed by *E. volitans* (16.86%). *S. longiceps* landing was maximum throughout the year. Only during November low percentage (2.11%) was noted.

**Contribution of major species**

Oil sardine remained the most important single species contributing 60.08% to the total finfish landings in the Parangipettai coastal waters. The estimated landings of oil sardine were 49, 91,588 kg. The second important resource in terms of contribution towards total landing was *E. volitans* accounting with 9.72% of total landings, the estimate being 8, 08,204 kg. The estimated landing of other important species like *Mugil cephalus* was 178611 kg (2.14%) followed by *Stolephorus commersonii* 1, 32,050 kg (1.58%) and *Euthynnus affinis* 98,768 kg (1.18%). *Rastrelliger kanagurta*, *Terapon jarbua*, *Siganus* sp, *Leiognathus* sp, *Nemipterus* sp and *Pseudorhombus tricellatus* were the fishes caught during in all the months.

**Tiny fishes**

Immature small sized oil sardine was caught in the months of March, April, July, August and September. The size of species ranged from 8 to 11.5cm. Around 20 boats landed the catches per day with the approximate capacity of 1.5 tonnes over 8 to 10 days every month.

**Unusual heavy landing**

Oil sardine (*S. longiceps*) ranged from 8 to 11.5 cm in size weighing about 12 to 25g. During heavy landing, the fishes were exported to Kerala, Karnataka and other States. The excess catch which could not be preserved due to lack of ice was sun dried in the beach or near the shore region.

**Table 2. Diversity indices of finfishes recorded from Parangipettai coast waters during Jan–Dec 2013**

| Months | Taxa_S | Individuals | Dominance | Shannon_H | Simpson_1-D | Evenness_e^ | Menhinick | Margalef | Equitability | Fisher_alpha | Berger-Parke |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 107 | 1156635 | 0.4037 | 1.688 | 0.5963 | 0.05055 | 0.09949 | 7.593 | 0.3613 | 9.105 | 0.6144 |
| Feb | 97 | 896460 | 0.6493 | 1.06 | 0.3507 | 0.02975 | 0.1024 | 7.004 | 0.2317 | 8.376 | 0.8032 |
| Mar | 82 | 773798 | 0.6456 | 1.078 | 0.3544 | 0.03584 | 0.09322 | 5.974 | 0.2446 | 7.067 | 0.8012 |
| April | 111 | 750168 | 0.6419 | 1.189 | 0.3581 | 0.02958 | 0.1282 | 8.131 | 0.2524 | 9.877 | 0.7998 |
| May | 88 | 1083248 | 0.3608 | 1.755 | 0.6392 | 0.06571 | 0.08455 | 6.261 | 0.3919 | 7.399 | 0.5724 |
| Jun | 128 | 559507 | 0.2755 | 2.154 | 0.7245 | 0.06732 | 0.1711 | 9.596 | 0.4439 | 11.9 | 0.4949 |
| July | 91 | 473741 | 0.1491 | 2.59 | 0.8509 | 0.1465 | 0.1322 | 6.887 | 0.5743 | 8.31 | 0.3175 |
| Aug | 90 | 357617 | 0.1228 | 2.627 | 0.8772 | 0.1537 | 0.1505 | 6.96 | 0.5838 | 8.448 | 0.2587 |
| Sept | 94 | 1410204 | 0.5753 | 1.074 | 0.4247 | 0.03114 | 0.07916 | 6.568 | 0.2364 | 7.762 | 0.7446 |
| Oct | 85 | 249022 | 0.3207 | 2.093 | 0.6793 | 0.09538 | 0.1703 | 6.76 | 0.4711 | 8.239 | 0.5547 |
| Nov | 71 | 175559 | 0.127 | 2.648 | 0.873 | 0.199 | 0.1695 | 5.797 | 0.6213 | 7.01 | 0.2876 |
| Dec | 80 | 421825 | 0.43 | 1.592 | 0.57 | 0.06143 | 0.1232 | 6.099 | 0.3633 | 7.296 | 0.6415 |

### Diversity indices

The diversity index values are given in Table 2. Totally 248 finfish species were recorded in this region. The maximum 128 finfish species was recorded in June and the minimum of 71 species in November. Individuals of finfishes varied between 175559 and 1410204. The minimum value was recorded during the month of November and maximum value was in the month of September. Shannon-Wiener index values varied from 1.06 to 2.62. The minimum value was recorded during the month of February and the maximum in August. In Simpson index (1-Lambda') minimum value recorded was 0.350 during the month of February and the maximum value (0.877) during August. The minimum value of Pielou's evenness index (J') was 0.0297 during February and maximum value (0.199) was during month of November. Margalef richness was minimum (5.797) during the month of November and maximum (8.131) during April.

### K-dominance curve

The K- dominance plot drawn clearly demonstrated the diversity pattern in the 12 months. The curve for the November month was lying at the top indicating lower diversity and curve for the June was lying at the bottom indicating higher diversity, the curves for other months were lying in between the above mentioned months. A notable feature of this dominance plot is 'S' shaped curves for all months indicating no disturbance to the diversity of fishes in the coastal waters (Fig 3).

### Cluster analysis

Cluster analysis was done to study the grouping of the various in 12 months. The dendrogram (Fig 4) showed 5 groups. The first group with high similarity was by February and June (52%) followed by January and April (48% similarity), March and May (46% similarity), September & November (42% similarity) and August & October (42%).

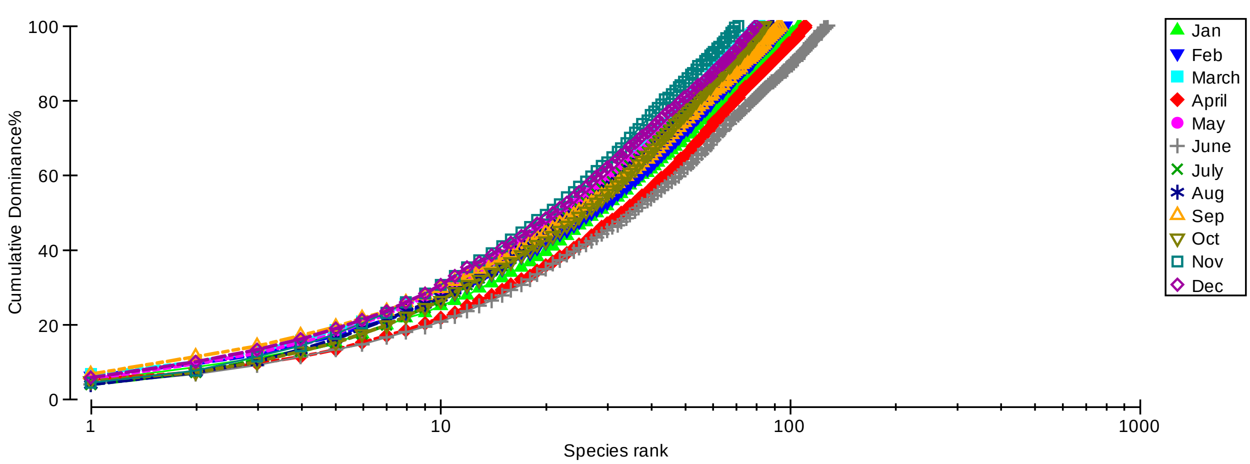



**Fig 3. K- Dominance plot drawn for the 12 months**

**Fig 4. Dendrogram showing similarity in species composition of fishes during the study period**

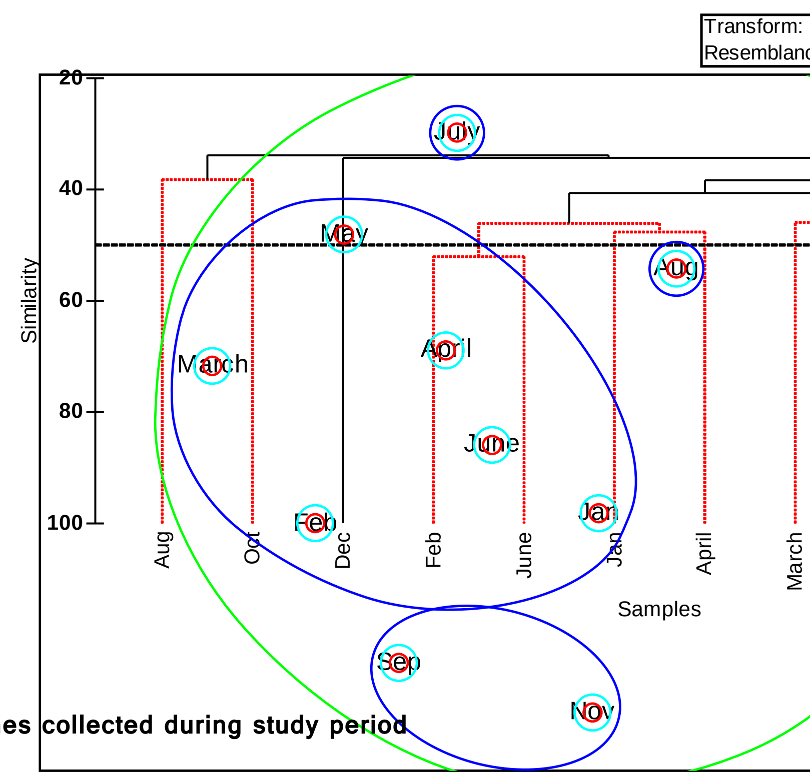



**Fig 5. MDS plot for the finfishes collected during study period**

**MDS (non-metric Multi Dimensional Scaling)**

To confirm the pattern obtained in cluster analysis MDS plot was drawn. The MDS plot showed (Fig 5) the stress value (which overlie on the top right corner of the plot) to be minimum (0.2) signalling the good ordination pattern of species during various months.

## DISCUSSION

In the present study, 248 finfish species belonging to 20 orders, 89 families and 158 genera were recorded from the Parangipettai coastal waters. Many works were carried out in finfishes from the east coast of India. Ramaiyan and Sivakumar (1991) recorded 36 species of Elasmobranches from Parangipettai coastal waters. In Pitchavaram mangroves, 197 species coming under 68 families and 17 orders were recorded (Rao, 1995). Ajmal Khan *et al.* (2008) reported 25 species of coral reef fishes belonging to 16 families were identified from Cuddalore coastal waters. Sixty two species of flat fishes along Indian coasts was recorded by Rajaguru (1987). Senthilkumar (2001) noticed 37 species of Tetraodont fishes with 26 genera of 8 families along the southeast coast of India. A totally 548 economically important marine species belonging to 235 genera covering 88 families from both the coasts of India reported by (Talwar and Kacker, 1984).

In the present study, order Perciformes dominated by 46 families (141 species) and among them Clupeidae family contributed maximum with 21 species. Saravanan *et al.* (2008) reported 77% of Perciformes fishes were recorded from Pondicherry mangroves. Perciformes is the most species rich order, contributing to 40% of fish species (Wazir Singh Lakra *et al.*, 2010). Arunava Mukherjee *et al.* (2012) also found that the order Perciformes which varied among the rivers emerge as most dominant groups among these diverse juvenile fish community from some selective Rivers of Sundarbans in Indian. The dominating taxonomic family among juvenile fin fishes were found to be Clupeidae, Gobiidae, Engraulidae and Sciaenidae respectively. White Head (1972) recorded Clupeidae species 68 in Indian waters. 32 species of clupeiod fishes recorded from Parangipettai waters (Ramaiyan, 1977).

In the present study, Clupeidae (61.86%) were the most dominant family of the total fish catches. Some family species are seasonally landed and also dominance followed by Exocoetidae (9.72%), Scombridae (5.75%), Engraulididae (2.61%), Mugilidae (2.23%), Carangidae (2.18%), Ariidae (1.18%) and Nemipteridae (1.44%) respectively. Balaji (2012) reported the Clupeidae and Scombridae were found to be dominant and Exocoetidae found to be season wise. Jayaprakash (2003) reported that Ariidae, Carangidae, Centropomidae, Chirocentridae, Cynoglossidae, Drepaneidae and Engraulidae were abundant during post monsoon season. Trichiuridae. Stromateidae, Sciaenidae, Serranidae, Teraponidae and Triacanthidae were more during summer Narasimhan (1994). Exocoetidae, Gerreidae, Hemiramphidae, Leiognathidae, Mullidae, Pristigasteridae, Psettodidae and Platycephalidae found high during pre-monsoon (Santhanam and Perumal, 2003). Serranidae. Plotosidae, Scaridae, Scombridae, Sillaginidae and Sphyraenidae were abundant during monsoon (Vijayan, 2002; Antony Raja, 1964). Clupeidae, Channidae, Lutjanidae and Mugilidae were available throughout the year (Antony Raja, 1964; Ganga, 2000).

In the present study, *S. longiceps* was the most dominant species (60.08%) followed by *E. volitans* (9.72%) *Mugil cephalus* (2.14%), *Stolephorus commersonii* (1.58%) and *Euthynnus affinis* (1.18%) respectively. Oil sardine remained the most important single and dominant species contributing 18.2% during 2012 the total marine fish landings in India (CMFRI, 2012). Small size fishes were maximum landed in particular months (March, April and July; August and September) in the study area. Among them tiny size of species were 8 cm to 11.5cm. Its month's 20 boats were landed by per day (Selvin Pitchaikani and Lipton, 2012) reported oil sardine fishery on the southeast coast. The fishing season is from April to December with peak catches during April to June the Tamil Nadu coast. In the present study the approximate capacity of one boat was 1.5 tonnes and per month 8 or 10 days landing. Chaniyappa (2011) reported Bumper catch of oil sardine in purseseine was observed on 9th and 29th at Malpe Fisheries Harbour. The catch rates of oil sardine in purse seine during the days varied from 5 to 15 t per unit (average of 7 t per unit). In the present study, heavy landing time fish were sold in the landing areas Rs 5 per kg. (CMFRI, 2008) also described the oil sardine catch was sold in the local market at Rs 4-5 per kg. Chaniyappa (2011) noticed heavy landings of *S. longiceps* at the time Rate of the fish ranged from Rs. 4-8 per kg, in the present study data was similarly compare to other studies. Otherwise mature fishes have good market value. Nina Tabitha and Gunalan (2012) reported the market value of oil sardine as Rs 20 per Kg. Oil sardine *S. longiceps* fish weighed about 12 to 25g. (CMFRI, 2008) The bumper catches of oil sardine fish was landed from Cuddalore waters and the total size and weight of the fish varied from 118 to 185mm and 14 to 58gm respectively. In the present study more catches of fishes were exported to Kerala, Karnataka and other States. The excess catch which could not be preserved due to lack of ice but they were sun dried in the beach or near the shore region. Chaniyappa (2011) reported oil sardine when landed bulk the fishes were utilized for fish meal production and transported to fish meal plants located at Udyavar, Thottam, Manoor Kota and Pithrodi.

Fishes were maximum recorded 128 species in the month of June and the minimum of 71 species during the month of November. Rajasegar and Sendhilkumar (2009) recorded maximum number of species in Karaikal during post monsoon and minimum was recorded during premonsoon. Balaji, (2012) also reported from this area which was maximum species during February to April and minimum during November to December. Minimum value of individuals of finfishes recorded were (1,75,559) during the month of November and maximum value of (14,10,204) during month of September. This variation may be due to less fishing activity during the monsoon season.

The Shannon-Wiener diversity H' is very widely used for comparing diversity between various habitats (Ajmal Khan, 2008). In the present study the minimum value of 1.06 was recorded during the month of February and the maximum of 2.62 during the month of August. Shannon value of 3 is observed only in healthy biodiversity rich areas (Ajmal Khan, 2008). (Wazir Singh Lakra *et al.*, 2010) The Shannon-Weiner diversity index reported from the five different sampling indicated a strong relationship with overall species richness and showed considerable variation ranging from 1.89 to 3.51. The Shannon index values clearly showed the diverse nature of finfishes in Parangipettai coastal waters.

Simpson index (1-Lambda) minimum value of 0.350 was recorded during the month of February and the maximum value of 0.877 during August. Pielou's evenness index (J') minimum value of 0.0297 was recorded during month of February and maximum value of 0.199 during month of November. (Murugan *et al.*, 2014) reported the Simpson dominance index was on the lower side and varied from 0.01 to 0.03. The Simpson species richness index for the monsoon season with 15 species (0.9) was found to be more than that during summer season (0.8) with 19 species was found to be very narrow Ajmal Khan (2008). The Pielou's evenness (J') index which varies from 0 to 1 (Clarke and Warwick, 2001) was also observed to be on the higher side (0.8-0.84). The highest value was recorded during pre-monsoon season and the lowest during summer. Murugan *et al.* (2014) also reported the minimum value of Pielou's evenness index (J') (0.84) during summer season and the maximum value of 0.92 during post monsoon season.

Margalef richness of minimum value of 5.797 was recorded during month of November and the maximum value of 8.131 during month of Apri1. Ajmal Khan (2008) observed the Margalef (d) species richness index in Cuddalore coastal waters having higher values for all the four seasons (2.2-3.0) similarly. Murugan *et al.* (2014) also observed in Vellar estuary, the minimum value (4.83) of Margalef richness index was also recorded during the monsoon season. However the maximum value (10.13) was recorded during the post monsoon season. The relatively higher values during the dry seasons (post-monsoon, summer and pre-monsoon) in Shannon, Margalef and Simpson indices and comparatively lower values during the monsoon season could be attributed to the rainfall and the subsequent sediment discharge. The inclement weather and cyclonic conditions prevented fishermen from venturing into the sea. The low values recorded during monsoon season may be attributed to less fishing activity resulting in collection of less number of fishes during this season.

Cluster analysis is a technique in which entities are sequentially linked together according to their similarity (or dissimilarity) producing a two dimensional hierarchical structure (dendrogram) (Eric Backer, 1995; Ripley, 1996). The most commonly used clustering techniques are the hierarchical agglomerative methods. These usually take a similarity matrix as their starting point and successively fuse the samples into groups and the groups into larger clusters, starting with the highest mutual similarities then gradually lowering the similarity level at which groups are formed. The process of the dendrograms derived 4 groups; the first group was largest group with high similarity 48.66%. The second group of average was 40%, third group was The third group was formed by the months of August-October with 42%. The fourth group was single cluster formed of December with 37% similarity indicating gradual change in species composition during different months of a year

The MDS ordination derived in the present study revealed the same grouping of zones as in the cluster analysis. The structure within each grouping was in harmony with that revealed by the cluster analysis. The stress values found in the MDS configuration was low (0.2) indicating good representation of the interrelationship between the fauna of each month.

The quantification of biodiversity is fundamental to the identification of changes that may be taking place and in understanding their possible consequences. Biodiversity can be measured at many levels and in numerous ways (Harper and Hawksworth, 1994; Hambler and Speight, 1995). Biodiversity is simply relates to the number of species in an area. The diversity of species is, however not the only measure of diversity. The relative abundances of the different species are also important would be regarded as more diverse than one where the same number of species is desperate abundance. There are many different diversity indices. Having different underlying principles each index has its own strengths and weaknesses. In the present study rich diversity was noticed maximum during all the months and *Sardinella longiceps* was one the most caught small sized fish in the region. This could be an overfishing major threat to biodiversity because it may deplete resources that can lead to loss of genetic integrity, local populations, and even species. Most fisheries depend on harvesting wild populations whose productivity is derived from biodiversity and hence management of resources is very important for sustainable fish production.

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# Catch composition, species checklist, and diversity of deep-water demersal ichthyofauna beyond 1000m depth from the South East Arabian Sea

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**Abstract**

Catch composition, species checklist and diversity of deep-water demersal fishes were investigated during the three successful research expedition of FORV Sagar Sampada (Cruise No: 322, 332 and 342) in the southeast Arabian Sea, off the coast of Kerala in the latitude 7.00$^{0}$E to 15.00$^{0}$E and longitude 76.00$^{0}$E to 74.00$^{0}$E. A structured random sampling was done along southwest Indian EEZ using High Speed Demersal Trawl-Crustacean Version (HSDT-CV), Expow and High Opening Trawl (HOT) during January 2014 November 2015. Operations were carried out in eight stations beyond 1000 metre depth. CPUE of each stations calculated separately and samples were sorted into groups, identified up to lowest possible taxa using standard identification keys. Species composition has been calculated by weighing each group. Total catch were observed to be 1459.02 kg. Highest CPUE observed at Lat.8.53$^{0}$N, Long. 75.27$^{0}$ Off Kollam coast and lowest at Lat.9.27$^{0}$N, Long. 75.290E off Aleppy coast. There were 65 species from 25 families and 16 orders. Major species observed were *Benthobatis moresby*, *Bathyuroconger vicinus*, *Alepocephalus spp.*, *Lamprogrammus niger* etc. A species checklist has been prepared based on the current sampling by following the standard reference and identification keys. The diversity indices calculated using Primer version 6. Diversity indices of each stations calculated separately. The average diversity indices were Shanon index (2.32), Pielou's evenness (0.92), Margalef index (4.88) and it is converses that diversity of Deep Ocean is contented and wholesome.

Key words: Deep oceans, demersal fishes, Indian EEZ, diversity Indices.

**Introduction**

The present exploitation of fishes from the Indian EEZ is about 3 million tons, and the whole contribution is from inshore waters (Anon, 1991; Somavanshi, 1998; Dehadrai, 2006). Most of the deep-sea and oceanic resources are intact (Somavanshi. 1998; Dehanrai. 2006), and the studies on these resources are limited. Fisheries and Oceanographic Research Vessel (FORV) Sagar Sampada of Ministry of Earth sciences (MoES), Government of India has been organizing several experimental investigations in the Indian EEZ. Since 1984, FORV Sagar Sampada is the only fishery survey vessel surveyed upto the 1000m bottom of the ocean.

The deep-sea fishery resources of Indian EEZ, have reported by Nair and joseph (1984), James and Pillai (1990), Sivakami (1990), Panikkar et al.(1993), Khan et al.(1996). In recent decades there were few reports on the abundance and biology of deep-sea fishery resources from the Indian EEZ like Venu and Kurup (2002), Kunjipalu (2004) and Jayaprakash et al. (2007). Apart from the above studies, there is no detailed description of diversity and distribution of deep-sea finfishes from Indian EEZ. In this background we made an attempt in this paper to explore the diversity of deep-sea Ithyofauna beyond the 1000m depth in the South East Arabian Sea.

## Materials and Methods

### Study Area

South East of Arabian Sea between Latitude 8.05$^{0}$N– 12.05$^{0}$N and Longitude 74.55$^{0}$E–78.35$^{0}$E.


Samples for the present study were collected during the Research Expedition of FORV Sagar Sampada Cruise No: 322 and 332. HSDT-CV and HOT trawls used for the experiment. The sea bottom was thoroughly scanned using echo-sounder to determine the suitable trawling grounds. During the above expeditions eight sampling stations were beyond the 1000m.

A systematic sampling strategy used along the southwest costs of Indian EEZ between Latitude 8.00$^{0}$N– 12.00$^{0}$N and Longitude 74.00$^{0}$E–75.00$^{0}$E. The total catch of the haul measured and samples collected and identified to the lowest possible taxa using the standard keys (Goode and Bean, 1895; Alcock, 1899a; Fischer and Bianchi, 1984; Smith and Heemstra, 1986; FAO species catalogues and field guides).The scheme of classification followed in this study was Nelson (2006) as given in the Catalogue of Fishes.

The catch composition, species wise catch and number at each fishing station recorded and the specimens taken to the laboratory for detailed identification. PRIMER v6 software for windows (Clarke & Gorley, 2006) used for the analysis of community structure.

***Shannon – Wiener index (H2  log 2) (Shannon and Weaver, 1949)***

Shannon – Wiener diversity index (H2 ) is defined as H2 = – "Pi loge Pi, Where, H2 = species diversity in bits of information per individual. ni = proportion of the samples belonging to the ith species (number of individuals of the ith species), N = total number of individuals in the collection.

***Pielou's evenness index (J2 ) (Pielou 1966)***

Pielou's evenness index (J2 ) were calculated using the formula J2 = H'/log$_2$S or H'/lns, Where, J' = evenness, H' = species diversity in bits of information per individual and S = total number of species

***Margalef richness index (d) (Margalef 1958)***

Margalef richness index (d) were calculated using formula. d = (S-1) / log N, Where, S = total number of species and N = total number of individuals in the collection.

## Results and Discussion

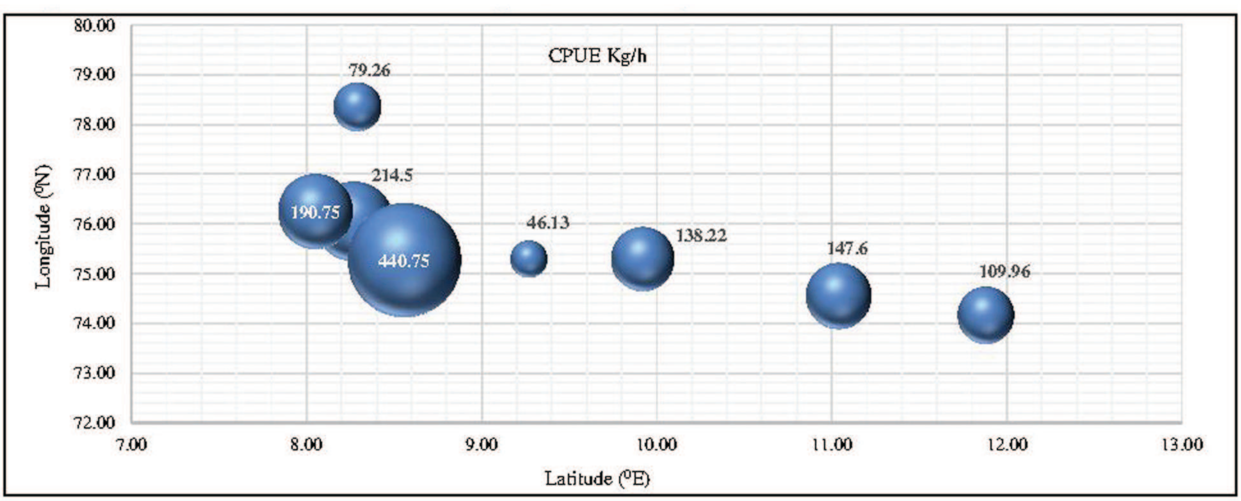
A total catch of 1366.95 kg obtained from eight stations beyond 1000m depth. CPUE ranges from 440.75 kg/h to 79.26 kg/h. Highest catch observed at Lat.8.53$^{0}$N, Long. 75.27$^{0}$ off Kollam coast and lowest at Lat. 9.27$^{0}$N, Long. 75.29$^{0}$E off Alleppy coast. The details of CPUE from all stations beyond 1000m are given in Table1.

Table 1. Details of trawling experiment beyond 1000m from South East Arabian Sea

| Sl No: | Cruise No | Transect | Depth (M) | Lat.(N) | Long.(E) | Gear | Effort (M) | Catch | CPUE |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 322 | Ponnani | 1100 | 11.04 | 74.55 | HSDT-CV | 60 | 147.60 | 147.60 |
| 2 | 322 | Kannur | 1050 | 11.58 | 74.16 | HSDT-CV | 60 | 109.96 | 109.96 |
| 3 | 322 | Kollam | 1150 | 8.56 | 75.27 | HSDT-CV | 60 | 440.75 | 440.75 |
| 4 | 322 | Trivandrum | 1120 | 8.05 | 76.25 | HSDT-CV | 60 | 190.75 | 190.75 |
| 5 | 322 | Tuticorin | 1100 | 8.29 | 78.35 | HSDT-CV | 60 | 79.26 | 79.26 |
| 6 | 332 | Cochin | 1050 | 9.51 | 75.29 | HSDT CV | 40 | 138.00 | 207.00 |
| 7 | 332 | Alappey | 1020 | 9.27 | 75.29 | HSDT CV | 40 | 46.13 | 69.20 |
| 8 | 332 | TVM | 1023 | 8.27 | 76.05 | HOT | 60 | 214.50 | 214.50 |

The catch per unit of fishing effort (CPUE) is a much-used ecological measure for the density of stock. At the same time, it is a proper indicator for the state of affairs in the fishery being a measure for physical and financial productivity: gross proceeds are related to the catch and cost of production and are related to the fishing effort. The Catch per Unit of Effort (CPUE) is already a standard tool among biologists to determine developments in fish stocks. CPUE as an indicator for the efficiency of the fishing operation, the present study reveals that beyond 1000m bottom trawling is not an efficient fishing strategy for commercial trawlers because of the less abundance of resources and huge expenditure in deep-water operations. An analysis of spatial abundance of deep water Ichthyofauna beyond 1000m of the South East Arabian sea is given in Figure.1.

Figure. 1. CPUE calculated for the eight stations beyond 1000m at South East Arabian Sea




The major fauna found in the catches were teleost fishes (70.10%), elasmobranches (12.81%), cephalopods (0.28%) and crustaceans (10.64%). The major finfishes were *Alepocephalus* spp., *Lambrogrammus* spp., *Bathyeuroconger vicinus* etc., Elasmobranches represented by *Benthobatis moresbyi*, *Centrophorus squamosus* etc. Crustaceans were represented by *Aristeus alcocki*, *Heterocarpus gibbosus*, *Heterocarpus woodmasoni* etc. Others include starfishes, holothurians, sponges and glass sponge. The catch composition in the total catch is expressed in Fig.2. One previous study by Govindan et al. (2013) reports the representation of teleost (67%) elasmobranches (14%), crustaceans (13%) and cephalopods (2%). Order- wise and family-wise catch composition is given in Figure.3 and Figure 4 respectively.

Figure. 2. Catch composition of demersal resources >1000m depth of South East Arabian sea.

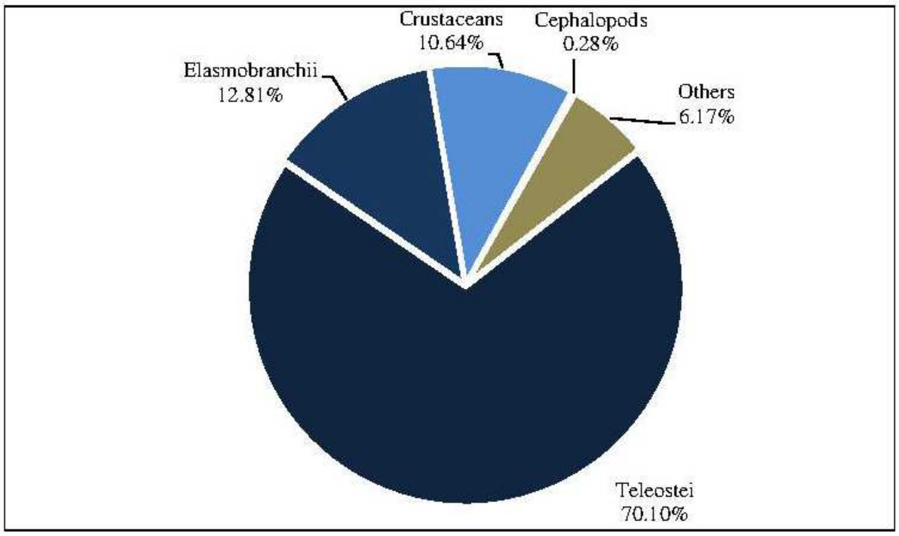



Figure 3. Composition of major orders in the totals catch

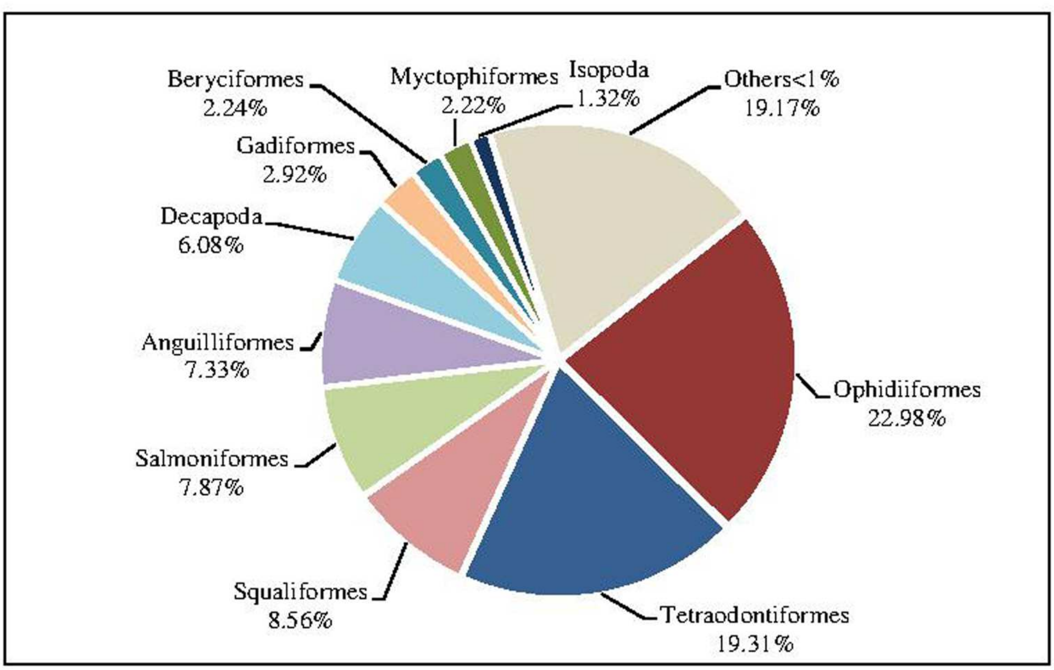
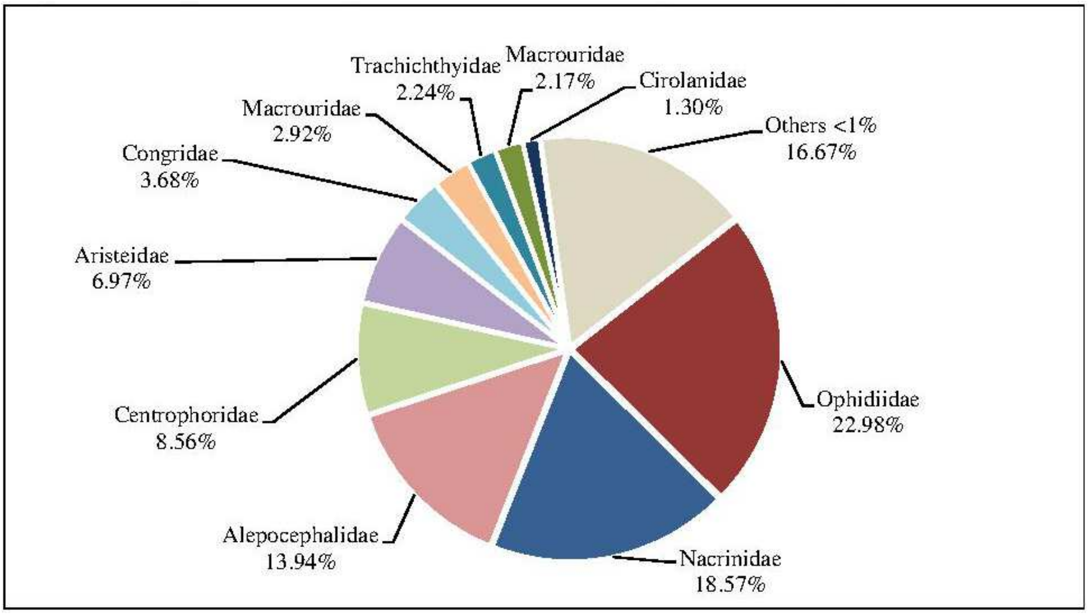
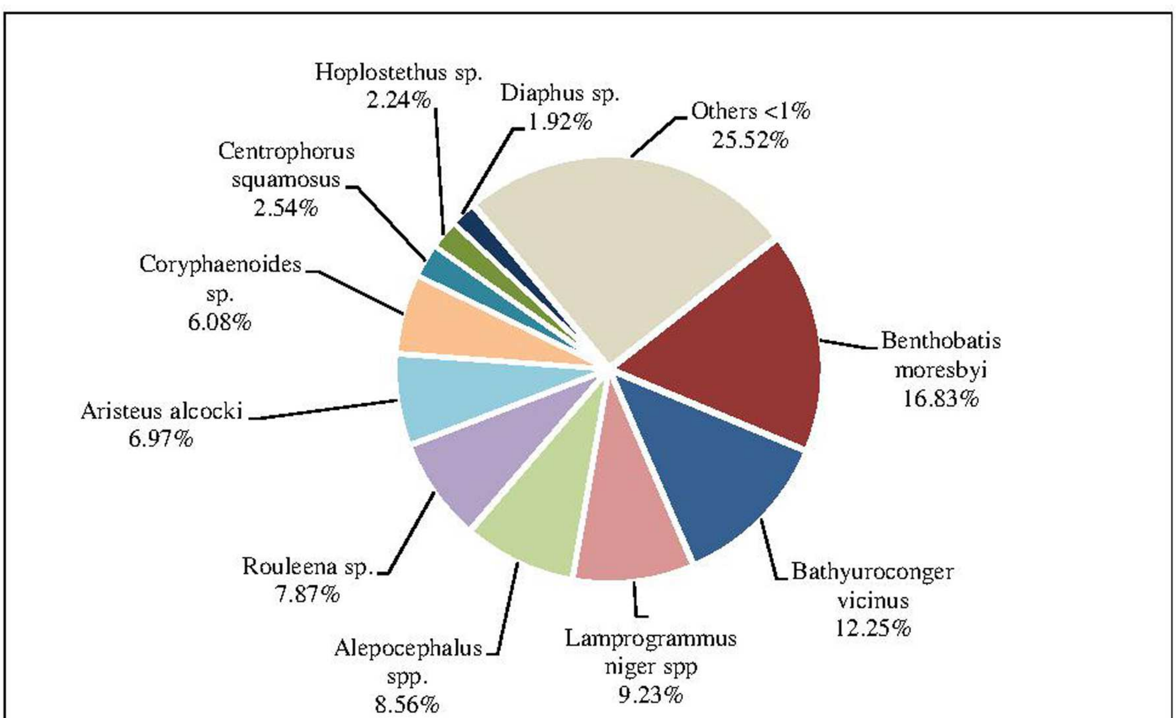


Figure. 4. Composition of major families in total catch beyond 1000m depth




The catch composition of species were as follows *Benthobatis moresbyi* (16.83%), *Bathyuroconger vicinus* (12.5%), *Lamprogrammus niger* (9.23%), *Alepocephalus spp.* (8.56%), *Rouleena.sp* (7.87)

Figure.5. Composition of major species in the total catch beyond 1000m depth



**Species Checklist**

There were 65 species from 25 families and 16 orders. Table 2 contains a checklist of deep-water species of South East Arabian sea.

Table 2. Checklist of Depp-sea Ithyofauna beyond 1000m of South East Arabian Sea

| Order | Family | Species |
|---|---|---|
| Anguilliformes | Congridae | *Bathyuroconger vicinus (Vaillant, 1888)* |
| Anguilliformes | Congridae | *Bathyuroconger braueri (Weber & de Beaufort, 1916)* |
| Anguilliformes | Muraenesocidae | *Gavialiceps taeniola (Alcock, 1889)* |
| Anguilliformes | Nemichthyidae | *Nemichthys scolopaceus (Richardson, 1848)* |
| Anguilliformes | Synaphobranchidae | *Synapobranchus sp.* |
| Aulopiformes | Ipnopidae | *Bathypterois dubius (Vaillant, 1888)* |
| Beryciformes | Trachichthyidae | *Hoplostethus atlanticus (Collett, 1889)* |
| Chimaeriformes | Chimaeridae | *Hydrolagus africanus (Gilchrist, 1922)* |
| Decapoda | Aristeidae | *Aristeus alcocki (Ramadan, 1938)* |
| Decapoda | Galatheidae | *Munidopsis sp* |
| Decapoda | Lithodoidea | *Anomurus crab* |
| Decapoda | Munididae | *Munida sp* |
| Decapoda | Nephropidae | *Nephropsis stewarti (Wood-Mason, 1872)* |
| Gadiformes | Macrouridae | *Coryphaenoides armatus (Hector, 1875)* |
| Gadiformes | Macrouridae | *Coryphaenoides sp* |
| Gadiformes | Macrouridae | *Bathygadus favosus (Goode & Bean, 1886)* |
| Gadiformes | Macrouridae | *Nezumia sp* |
| Gadiformes | Macrouridae | *Gadomus capensis (Gilchrist & von Bonde, 1924)* |
| Isopoda | Cirolanidae | *Bathynomus giganteus (Milne-Edwards, 1879)* |
| Lophiformes | Lophiidae | *Lophious sp* |
| Lophiformes | Melanocetidae | *Melanocetus johnsonii (Günther, 1864)* |
| Lophiformes | Ogcocephalidae | *Halieutaea sp* |
| Lophiformes | Ogcocephalidae | *Ogcocephalus sp* |
| Myctophiformes | Myctophidae | *Diaphus diadematus (Tåning, 1932)* |
| Myctophiformes | Myctophidae | *Myctophid* |
| Myctophiformes | Neoscopelidae | *Scopelangys tristis* |
| Myxiniformes | Myxinidae | *Myxiniformes* |

| | | |
|---|---|---|
| Notacathiformes | Halosauridae | *Halosauropsis macrochir (Günther, 1878)* |
| Notacathiformes | Halosauridae | *Halosaurus ovenii (Johnson, 1864)* |
| Notocanthiformes | Notacanthidae | *Notocanthus sp* |
| Octopoda | Octopodidae | *Octopus sp* |
| Ophidiiformes | Ophidiidae | *Lamprogrammus niger (Alcock, 1891)* |
| Ophidiiformes | Ophidiidae | *Lamprogrammus brunswigi (Brauer, 1906)* |
| Ophidiiformes | Ophidiidae | *Dicrolene filamentosa Garman, 1899* |
| Ophidiiformes | Ophidiidae | *Luciobrotula bartschi (Smith & Radcliffe, 1913)* |
| Ophidiiformes | Ophidiidae | *Dicrolene nigricaudis (Alcock, 1891)* |
| Ophidiiformes | Ophidiidae | *Bassozetus sp* |
| Ophidiiformes | Ophidiidae | *Lamprogrammus sp2* |
| Ophidiiformes | Ophidiidae | *Dicrolene quinquarius (Günther, 1887)* |
| Ophidiiformes | Ophidiidae | *Glyptophidium sp* |
| Ophidiiformes | Ophidiidae | *Glyptophidium oceanium (Smith & Radcliffe, 1913)* |
| Ophidiiformes | Ophidiidae | *Dicrolene tristis (Smith & Radcliffe, 1913)* |
| Ophidiiformes | Ophidiidae | *Lamprogrammus sp 1* |
| Osmeriformes | Alipocephalidae | *Alepocephalus sp* |
| Perciformes | Carangidae | *Gnathanodon speciosus (Forsskål, 1775)* |
| Salmoniformes | Alepocephalidae | *Rouleena sp* |
| Salmoniformes | Platytroctidae | *Normichthys sp* |
| Scorpaeniformes | Psychrolutidae | *Cottunculus thomsonii (Günther, 1882)* |
| Squaliformes | Centrophoridae | *Centrophorus squamosus (Bonnaterre, 1788)* |
| Squalifprmes | Echinorhinidae | *Echinorhinus brucus (Bonnaterre, 1788)* |
| Stomiiformes | Stomiidae | *Chauliodus sloani (Bloch & J. G. Schneider, 1801)* |
| Tetraodontiformes | Monocanthidae | *Monocanthus sp* |
| Tetraodontiformes | Nacrinidae | *Benthobatis moresbyi (Alcock, 1898)* |
| Tetraodontiformes | Nacrinidae | *Narcine timlei (Bloch & Schneider,1801)* |

**Diversity indices**

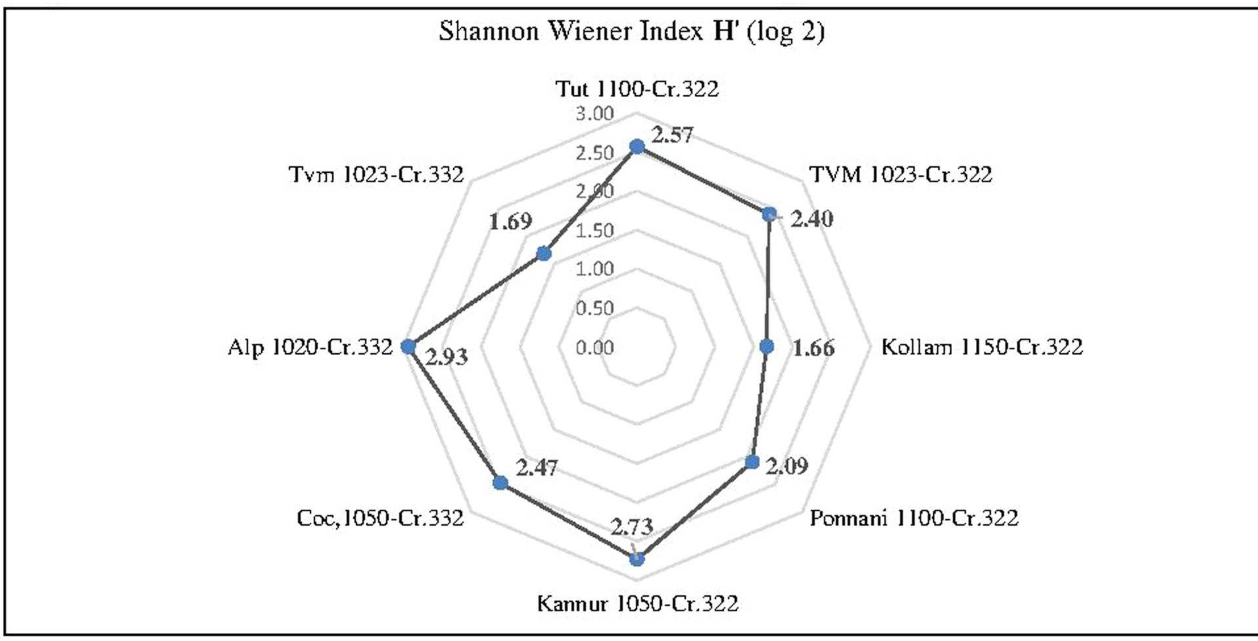
Diversity is one of the most important community attributes, which can determine stability, productivity and migration (Stirling and Wilsey, 2001). A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness; it provides important information about scarcity and normalness of species in a community. Thus provides an ability to quantify diversity, so this is an important tool for biologists trying to understand community structure, and its interactions.

**Shanon-Wiener Diversity index H' (log 2).**

It is a measure of biological diversity and denoted and H', Shanon-Wiener, Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase. The Shannon-Wiener diversity index is a heterogeneity measure that incorporates species richness and evenness (Hollenbeck and Ripple, 2007).

In the present experiment values lies between 1.69 to 2.93 and the average diversity observed is 2.32, Sudhakar et al. (2013) reported 2.11 between 900-1100m depth Shanon-Wiener index (H' log2) of deep-sea fishes was reported to be 2.91 in the South East Arabian Sea >1000m (Hashim 2012). Figure.6. presents Shanon-Wiener Index of all eight stations beyond 1000m depth of the South East Arabian Sea.

Figure. 6. Shanon-Wiener Index of all stations >1000m depth of South East Arabian Sea

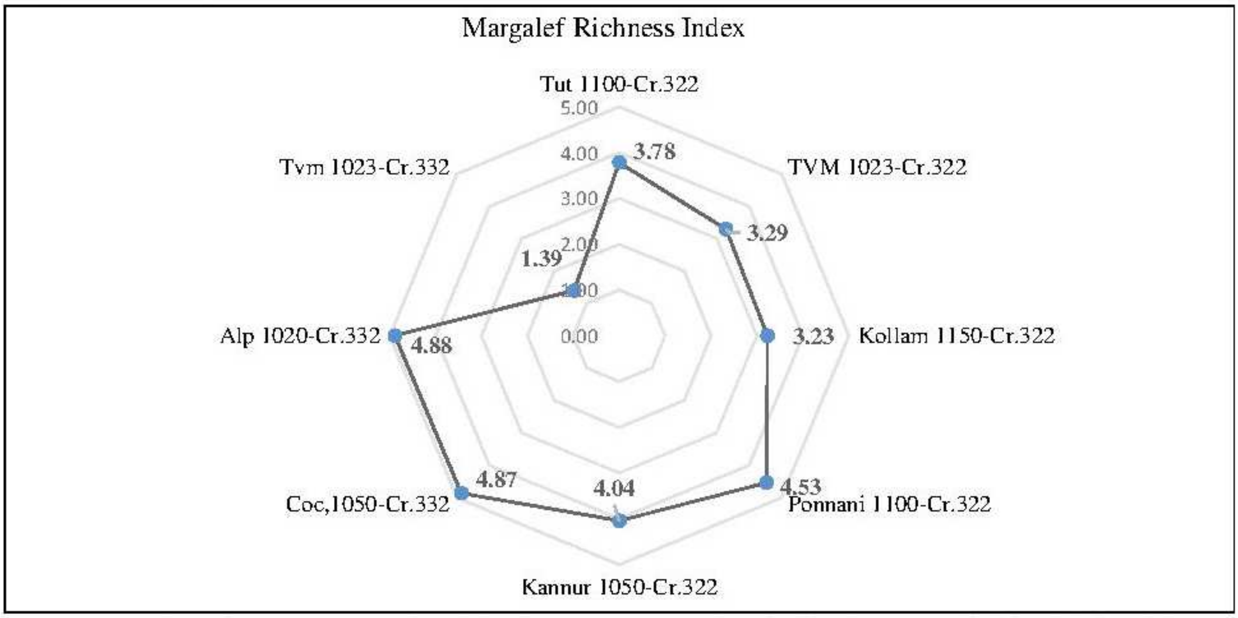



The Margalef index measures species richness and it is highly sensitive to sample size although it tries to compensate for sampling effects (Magurran, 2004).

The majority of studies exploring the causes and consequences of biodiversity have used species richness to represent diversity on account of its apparent simplicity compared to species evenness. However many investigations also indicate that species richness is a common cause of variation in relative abundance and diversity (Magurran AE 1988).

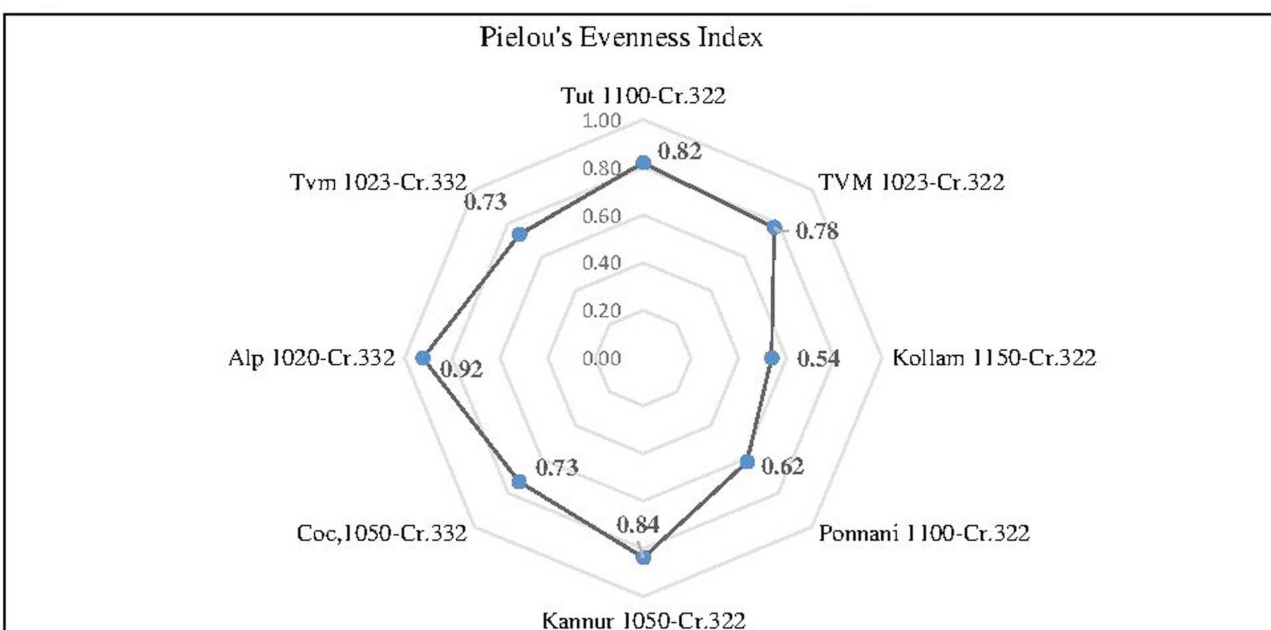
Sudhakar et al. (2013) reported that diversity of deep-sea of South East Arabian Sea 3.20 between 900-1100m depth and Hashim (2012) reported 2.25 at >1000m depth in the South East Arabian Sea. During the present study observes average of Margalef richness index is 3.75 is slightly higher value than earlier reports.

Figure.7. Margalef Richness Index from all stations >1000m depth of South East Arabian Sea




During the present study Pielou's evenness Index is lies between 0.54 – 0.92, with an average value of 0.75, The Pielou's evenness of the South East Arabian Sea reported by Sudhakar et al (2013) is 0.88 at the depth between 900 and 1100m, and Hashim (2012) reported 0.81 at the depth >1000m. Present value of evenness index is 0.75 and it has lower that the earlier reports.

Figure.8. Pielou's Evenness Index from all stations >1000m depth of South East Arabian Sea



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# Distribution and Biology of Indian deep sea Herring *Bathyclupea hoskynii* (Alcock, 1891) from the South east Arabian Sea

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**Abstract**

This paper provides an information about least premeditated Indian deep sea herring *Bathyclupea hoskynii* (Alcock, 1891). The present study was conducted by the research expedition of Fisheries Oceanographic Research Vessel Sagar Sampada in South East Arabian Sea during January 2014 (Cruise No. 322) and December 2014 (Cruise No. 332), between the latitude 8.00$^0$N – 12.00$^0$N and longitude 76.00$^0$E – 74.00$^0$E. The fish samples were collected using deep sea trawls HSDT CV (High Speed Demersal trawl -Crustacean Version) and HOT (High Opening Trawl). Total catch observed to be 11.2 kg. The samples were sorted in to groups and identified using standard Keys, and the random samples were taken for biological studies. From the study it is observed that *B. hoskynii* is distributed at a depth ranging from 350m – 450m. The length ranges from 13.5cm – 19.0 cm and weight ranges from 24.0gm. – 75gm. A total of 160 specimens were analyzed, 136 were females and 24 were males. Analysis of stomach contents revealed that *B. hoskyni* feeds on variety of foods, major food item observed were crustaceans. It is observed that 67% of stomach of fishes were empty and rest of them are having partially digested shrimps, squids and digested matters. Among them shrimps were found to be dominated, which indicates that prawns are the major diet of *B. hoskynii.*

Key Words: HSDT, HOT

**Introduction**

Indian deep sea herring *Bathyclupea hoskynii* (Alcock, 1891) belongs to the family Bathyclupeidae is distributed in the Indian Ocean in the depth at 340-400 meters. Deep sea herring is a poorly studied group of oceanic fishes, whose species composition and distribution in the Indian Ocean remained completely unexplored (Prokofiev, 2014). Exploratory fishery surveys conducted in the deeper waters of the Indian EEZ have indicated the presence of unexploited deep sea resources in the shelf break area, which have great scope for commercial exploitation. Gravely (1929), Venkataraman (1960), Rao (1964), Silas (1969), Joseph et al. (1976), Sudarsan and Somavanshi (1988), James and Pillai (1990), and Venu and Kurup (2002) have reported the existence of rich grounds of deep sea fish resources in the Indian EEZ. Like most of the deep sea organisms, studies on *B. hoskynii* is limited. This study is an attempt to explore the distribution and feeding habits of least studied, *B hoskyni* from the south east Arabian sea.

## Materials and Methods

Fig.1. Map showing study area

Biological data for the present study were collected from cruise survey of FORV Sagar Sampada (Cruise No 322 and 332) during January 2014 and December 2014. Trawl survey was conducted during day time using HSDT-CV and HOT nets in 22 stations along the southeast of Arabian Sea, between (Lat.8.00°-12.00°N and Long. 74.00°-78.00°E) (Fig.1) at depth ranged from 200m to 1100m. During each haul, fishes were collected and the total catch (weight& number) were recorded. Fishes were sorted into groups and identified up to the species level using the standard keys Alcock, (1891) and Smith & Heemstra (1986).

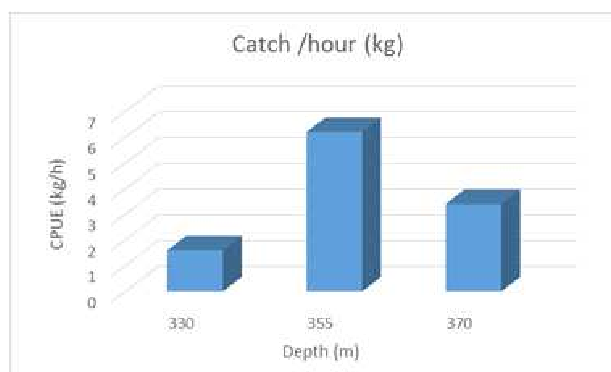
Samples were subjected to biological studies such as length frequency, maturity, sex and gut content analysis. Morphometric measurements were taken using Mitutoyo digital vernier caliper (0.05mm) and using with a metal measuring tape to the nearest centimeter a straight line along the body axis with the caudal fin placed in a natural position following Smith & Hemstra (1986). Total length is measured from the tip of the snout to the tip of the caudal fin. The weight of the fish was measured to the nearest 0.1gm with a digital weighing balance after removing the excess water, weight of both males and females were recorded separately.

The fishes were sexed by macroscopic examination of the gonads. And the maturity stages were marked as I, II. III, IV, V and VI in both sexes. For studying food and feeding habits, the gut were carefully dissected out and contents were examined. The food components were identified, as far as possible up to species or genus or family, depending upon the status of the food and the extent of digestion (Smith and Heemstra, 1986). If the digestion had progressed to an advanced stage and the food organisms were mixed with large quantities of mucus making identification difficult, it was considered as digested matter (Karuppasamy et al, 2008). The gut contents were analysed by visual/microscopic examination after grouping the stomach as full, ¾, $^1/_2$, $^1/_4$, trace and empty (Natarajan & Jhingran 1961 and Pillai, 1952).

**Result and Discussion**

The trawl survey of FORV Sagar Sampada showed that the bathymetric distribution of *B. hoskynii* was observed at 350m – 450m depth. The trawling operations in the two cruises, HSDT-CV and HOT nets operated 22 stations along the southeast Arabian Sea, between (Lat.8.00°-12.00°N and Long. 74.00°-78.00°E) at depth ranged from 200 m to 1100 m. Out of the 22 hauls operated, *B. hoskynii* was found to occur only from 3 hauls. *B. hoskynii* were observed at depth range of 350 - 400 m. The total catch of *B. hoskynii* observed to be 11.2 kg and high representation from 350 m depth at 8.54°N and 75.53°E with total catch 6.2 kg. The bathymetric abundance of *B. hoskynii* are presented in Fig.1. The survey revealed that *B hoskynii* is an important deep sea fish of the continental slope of Indian EEZ. This is not a commercially exploited fish, and there is no consumer demand of any kind.

Fig. 1. Abundance (CPUE) of *B. hoskynii* from the South East Arabian Sea



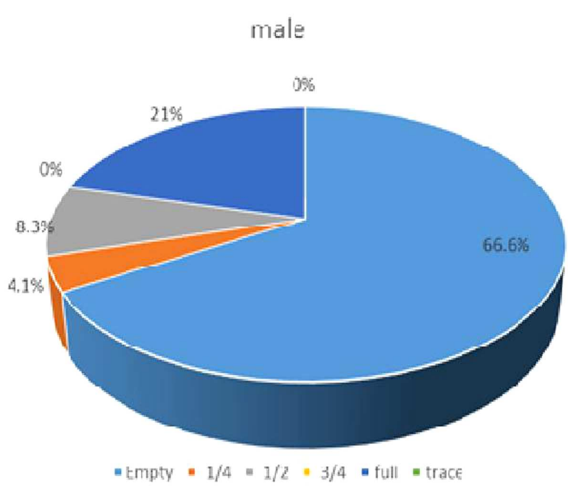

Out of 160 specimens analyzed 136 were females and 24 were males. The length ranged from 13.5 - 19.0 cm and weight ranged from 24.0- 75.0 gm (Table 1). Most of the male fishes were in maturity stages III and IV and females were in stages maturity stages IV and V and matured females in stage VI were also found (11nos).

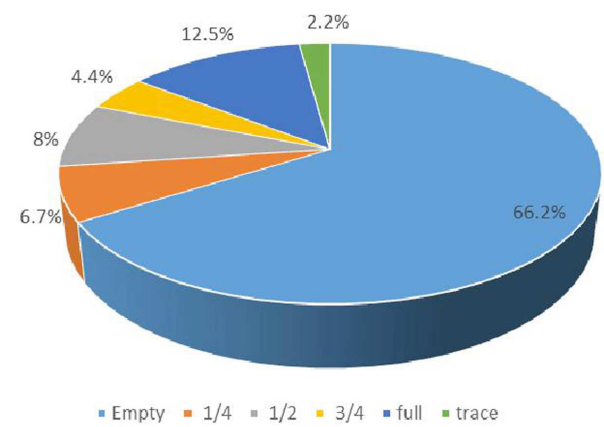
Table 1. Length and weight ranges of *B. hoskynii*

| | sample | Length range (cm) | | Weight (gm) | | Depth (m) |
|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | |
| Male | 24 | 13.5 | 14.8 | 24.5 | 27.4 | 350 |
| Female | 136 | 13.8 | 19.0 | 28.6 | 75.0 | 350 |

Analysis of stomach contents revealed that *B. hoskyni* feeds on variety of foods, which largely feeds on crustaceans. It is observed that 66.6% of stomachs were empty in males and 66.2% in females. It is known that many large predators feed only infrequently, and are often found with empty stomachs (Gartner et al., 1997). Rest of the *B. hoskyni* stomachs were having whole shrimps (Plesionica sp.), partially digested shrimps, squids and digested matters. Full stomach conditions were found in 12.5% in males (Fig. 2) and 21% in females (Fig. 3).

Fig: 2 Fullness of stomach in males
Fig: 3 Fullness of stomach in females




In which shrimps were found to be dominated, which indicates that prawns are the major diet of *B. hoskyni*. According to Alcock (1891), at the time of first description reported that penaed shrimps are the major food of *B hoskynii*.

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# A study on fishing methods in reef of Kerala

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**Abstract**

The survey illustrates the traditional and reef associated fishing methods of Kerala. And the study is not covering the eco friendliness of the each practice. The study was conducted in the reefs of Kovalam and Valiyathura during the period of one year from 2014 to 2015. Data were collected by direct personal interaction with fishers at study sites and videos and photographs has been taken with aid of G15 cannon. Three more strictly reef oriented fishing activities were identified and documented in the present investigation. The study recognizes that fishing on reefs of Mulloor, Vizhinjam, Kovalam and Valiyathura is an important source of income for coastal communities. Among the eight types of fishing methods reported, six of them are strictly restricted in reefs of the study area. And these fishing activities are the main source of seafood for the domestic and foreign people. Most of the fishing methods exercising in these area are species specific (highly selective gear to catch specific species) except gillnet fishery.

Key Words: Reef, Fishing methods, coastal community

**Introduction**

The Trivandrum coast has a unique position the coast of Kerala because of natural rocky reef ecosystems. This is actually due to the geological specialties of the coast. Reef fisheries are an important source of food and livelihood for coastal communities around the world. Coral reefs are one of the most productive and biologically diverse aquatic environments on Earth (Paulay, 1997; Reaka-Kudla, 1997), providing livelihood to the coastal communities by supplying the resources such as fish, crabs, mollusks, seaweed, urchins, and sea cucumbers. A mixer of traditional and modern methods of fishing was practiced by the people. Fishes were mainly caught by traps, spears, pole and line, hook and line, and monofilament gillnets. The catch from the reef fauna around the world was between 0.2 to 44 metric tons/year/km$^2$ at an annual yield of 1.4 – 4.2 million tons (Dalzell, 1996). The major fishing methods practiced in our state around the reefs are, hand picking, trap fishery of lobsters, coconut branching peduncle, diving, spear fishing, hook and line and gill netting for edible invertebrates like octopus, crabs, clams, and gastropods. . But a few traditional practices still persist in some areas of our state especially in Mullor to Valiathura stretch, where the areas in which the above mentioned techniques are not applicable or possible due to rocky shore. Few of these are described in this manuscript. Although some fishers still tend to retain traditional fishing methods, many have welcomed the changes and trend to make alteration in their traditional fishing practices like harpoons to spear guns. Exploitation of marine resources increased along with the population explosion enhanced the improvement of technology (Ault et al., 2013; Cadigan, 2001). As we seek ways to protect coral reefs and other marine resources in the face of climate change, we need to think about how both traditional and modern fishing practices may change.

**Materials and methods**

The survey was conducted in Mulloor, Vizhinjam, Kovalam and Valiyathura coast of Trivandrum, Kerala during 2014 to 2015. Data were collected by direct personal interaction with fishers at the sites and videos and photographs have been taken with aid of cannon G15camera. The above mentioned coastal areas were dominated by the traditional fisher population of the state.

**Results**

The study recognizes that fishing methods at reefs of Mulloor, Vizhinjam, Kovalam and Valiyathura is an important source of income for coastal communities by supplying the priced sea food like lobsters, crabs and squid to the nearby hotels. The present study report may explain the site specific fishing activities of Trivandrum district, because these sites were providing strikingly different reef structure. Mulloor and Kovalam were characterized by the presence of natural rocky reefs. Vizhinjam is a mixture of natural and manmade reef structure. Valiyathura is distinguished by the presence of sandy beaches and bridge pillars and abandoned railway bridges, tracks and other structures. The manuscript gives an account on fishing methods in reef areas, gathering sedentary animals by hand, traps for lobsters, coconut branching peduncle as a fishing gear, fishing by hand held scoop net, mussel collection by diving, spear gun fishery, hook and line and gillnet fishery. Among these, gathering sedentary animals by hand, traps for lobsters, coconut branching peduncle as a fishing gear, fishing by hand held scoop net, mussel collection by diving, spear gun fishery are strictly restricted in the reefs ecosystem. The survey also recognized that a few methods are based on the behavior of the target species i.e. fishing by hand held scoop net especially for collecting carangids and catfishes, coconut branching peduncle as a fishing gear for trapping squids, traps for lobsters.

**Hand Picking**

It is a traditional and age old method of marine exploitation by locals for gathering animals by hand or with a knife or simple spear, anything edible is taken. In the early morning, children and women often walk in to the shore for searching gastropods, echinoderms (sea urchin, sea cucumbers), etc were collected by hand or assistance of sharp tool like spatula or knife during the low tide. It is common that the gatherers not only move their hands over the bottom in order to feel a protruding shell, but they also search through the bottom with their feet, especially in seaweeds where shells cannot be seen, and this practice is commonly noticed in the Mulloor and Koavalm region. The activity is based mainly on the tidal variations during January to April in pre monsoon and November to December in post monsoon

**Lobster Traps**

Lobsters are wide spread crustaceans, inhabiting in shallow water reefs and rocky substrates and are favorite marine delicacy for the people around the world. Enclosed transportable traps are commonly used throughout the world. The types and shapes, vary from rectangular, circular, hexagonal, conical, and semi-cylindrical. The most commonly used trap to catch spiny lobster is the arrowhead trap with a single funnel (Dilrosun, 2000). The commonly used trap in Kovalam is rectangular in shape constructed by using bamboo splits and coconut splits (Fig. I.). The traps have a funnel shape entrance protruding inside, which acts as a valve and also prevents the escape of the trapped animal. These traps were baited with mussel meat which attracts the animal to the trap. Number of catch may vary from zero to 2. It may depends on following factors like food item provided, animal population, size and shape of the traps. Normally a trap measures about 90 to 100 cm in length, 60 to 65 cm height and width. This fishery is mainly carried during the months of January, February, April, May, November and December.

**Coconut branching peduncle (Paddal)**

Paddal or Brush park fishery is an indigenous method widely practiced throughout Kerala especially in backwaters bodies like lakes, estuaries, canals and rivers. In 2004 Thomas and Kurup reported the 'paddal' fishery of Ashtamudi estuary. The coconut branching peduncle collected is festooned with plastic ribbons, 20 to 25 coconut peduncles were beaded in rope and festooned with plastic ribbons made from packing poly bags (Fig. VI.), were anchored with sand filled sacks and deposited at the preferred places of the sea for aggregating the squids. After 1 to 2 week the squids starts to visits these structures and making observations. After this the squids starts to lay the eggs on the paddals. Gradually populations of squids will develop. These would be fished by the aids of locally made squid jig. It is actually fabricating with the assembling of illuminating things like cloths as a lure, freshly cut lead for weight and illuminator, attracting the animal and hooks in a fishing line. Normally 4 to 7 peoples were engaged in the fishing. It's a year round fishery at Vizhinjam. Here the animals aggregating behavior is utilized for the fishery.

**Mussel fishery**

In Mulloor, and Kovalam the mussel fishery is seasonal (October to May) but at Vizhinjam the mussel collection is carried out round the year. Nearly fifty five to sixty eight collection units (units include 2 to 4 persons in non mechanized catamarans) are engaged in the mussel fishery. Usually three people work in each catamaran and four to five men are engaged in motorized canoes. Around 250 to 300 people are engaged in the mussel fishery activities in this area. The harvested fresh mussels are supplied in the domestic market. The collection of the brown mussels is carried out year round. The collection is done by scraping the mussel mat using chisels. Diving is done using locally fabricated mask, and the fishermen engaged in the activity are skilled (Fig. III.). The spatula is used to scrap the mussel meat from the rocky surfaces and collected mussels are gathered in a bag tied at the waist of the collector. The device using for the scraping of mussels from rocky substratum comprises of an iron spatula, fixed on wooden handle and a hook like device is used to maintain the position of fisher in water during the time. A locally made snorkel make them clear vision underwater. The collected catch were kept in a basket tied around the waist of the fisher or some fishers used hand scoop net for collecting the scraped mussel which found more handy than the first one. After each dive the collected mussels will be transferred to the big net bag in the catamaran or canoes. The entire activity may extend up to 3 to 4 hours and the total catch carried to the shore where it is auctioned. The fisher women took the bulk of the mussel catch to the market, which plays a major role in the women empowerment.

**Scoop net fishery**

This is the simplest form of all nets, also the most versatile, with its shape and sizes that allow use by hand, in shallow water, and under water, crevices of rocks and in capturing a great variety of species and size. Reef-related fisheries constitute approximately 9–12% of the world's total fisheries (Smith, 1978) and in some parts of the Indo- Pacific region, the reef fishery constitutes up to 25% of the total fish catch (Cesar, 1996). The fisher took a long breath and make dive to deep of the sea floor up to a depth of 10-15 meter by targeting fish in the water column.

This fishing method demands the highly skilled labours; who acquired this skill by years of experience. In the mean sense the method is practiced only in restricted areas of Trivandrum. Usually "Kattamarams" were used for fishing and locally made scoop net is fabricated with light weight materials like aluminum, which is strengthened by bamboo strips (Fig. IV.). Two to three men were engaged in the entire activity. Fisher has to select the market size fish or the fisher gets a chance to choose the market preferred species and size. Carangids and snappers are the target species. Here the fishers exploit the hiding tendency of the fish.

**Spear gun fishery**

Spear fishing is a highly efficient harvesting gear that selectively targets larger fish relative to other fishing gears and can significantly alter abundance and size structure of target species toward fewer and smaller fish (Chapman and Kramer 1999, Matos-Caraballo et al. 2006). In areas that are spear fished, that activity is believed to be the likely cause of lower fish density and size compared to areas that are not spear fished (Jouvenel and Pollard 2001). Research has shown significantly reduced populations of larger predatory fishes such as snapper and grouper where spear fishing occurs (Bohnsack 1982; Chapman and Kramer 1999; Sluka and Sullivan 1998; Jouvenel and Pollard 2001). Spear fishing has been shown to have a greater overall impact on reef fishes than hook and-line fishing, relative to effort expended (Meyer 2007). Overall, spear fishers remove larger fish and more biomass per outing than fishers using other recreational modes (Morales-Nin et al. 2005; Meyer 2007; Frisch et al. 2008). Although by catch, gear loss (hence, increased debris), and removal of fish biomass as bait are higher with hook-and-line fishing than with spear fishing, the effectiveness and efficiency of spear fishing has resulted in overharvest and restrictions on the fishery, including a ban on spear fishing using scuba, in many other parts of the world (e.g., Coll et al. 2004; Frisch et al. 2008). Limited numbers of persons were engaged in the spear gun fishing at adjacent areas of Vizhinjam, Kovalam. The practice demands skilled persons with swimming efficiency in water. Fisher has the more chance to select his catch (species, size etc.). So the spear fishing is highly selective gear (Fig. V.).

**Hook and line fishery**

Hook and line are entirely different types of fishing tool. It can operate in the areas where the other types of gears not applicable, like rocky and uneven bottom, shallow and very deep waters. About 12% of all the catches in the world are made by hooks and lines (Mathai, 1995). Hand line is the simplest form of fishing line in the areas like Mulloor, Vizhinjam, Valiyathura. Hand line can be operated with or without a pole or rod. A line with a few hooks is operated by a single man paying constant attention to the catch. Hand lines are commonly used to catch squid, siganus sp., damsels, swallow tail dart using a rod with mono-filament fishing line. Hand lining is one of the most selective ways in which to catch fish due to the nature of fish to lure, rather than scooping up fish en-masse.

**Gillnet fishery**

Variety of gillnets were used in reefs of Vizhinjam and Kovalam because of easiness in their handling (Fig. VI.). The net is set along parallel to the reefs targeting the species that visit reef for feeding. Bottom set gillnet and free drifting gillnet were widely used in the area. The main species that are caught includes, lutjanids, caranxgids and siganus species.

**Site wise contribution of the fishery**

All the traditional and modern fishing activities is practiced in Vizhinjam which includes a half dozen of fishing methods like hand picking, coconut branching peduncle as a fishing gear, mussel collection by diving, spear gun fishery, hook and line and gillnet fishery, in this, mussel fishery shared 56% followed by gillnet fishery 34%, coconut branching peduncle fishery 5%, hook and line 4%, hand picking 1% and the spear gun fishing 1% (Fig. VIII.). Valiyathura and Mulloor were noticed by the least fishing activity compared with Vizhinjam and Kovalam, but Valiyathura is highlighted with an interesting and entirely different fishing method - fishing with hand held scoop net and is also devoid of mussel fishery (Fig. VII and X).

Mussel fishery is high in Kovalam by 58% and hand picking with 19%. The survey finds that Kovalam is the only area, practicing the trap fishery for highly priced seafood like lobsters which parting about 23%.

**Table 1: site wise fishing practice and catch composition**

| Name of the Fishing Method | Locality | Target species of each gear | No. of Units in each areas |
|---|---|---|---|
| **Hand picking** | Mulloor,<br>Vizhinjam<br>Kovalam | Molluscan species like gastropods, bivalves,Octopus, Echinoderms. | Local people<br>(5-6 people /day) |
| **Trap fishing of Lobsters Coconut branching peduncle as a fishing gear** | Kovalam<br>Vizhinjam | Spiny and Rock lobster<br>Squids/Cuttile fish | 5-6 people<br>More than 10 units<br>(2- 3 people/ unit) |
| **Mussel fishery** | Mullor<br>Vizhinjam<br>Kovalam | Green and brown mussel<br>Green and brown mussel | 10-15 people<br>250-300 people<br>10-15 people |
| **Fishing by Hand held scoop net** | Valiyathura | Carangids and Snappers | 3-5 units (2-3 people/ unit) |
| **Spear fishing** | Kovalam<br>Vizhinjam | Highly priced fishes like Lutjanids | 3 (skilled person)<br>2 (skilled person) |
| **Hook and line** | Mulloor,<br>Vizhinjam,<br>Valiyathura | Damsels, Siganus, Catfishes, Swallow tail dart, Squids | 5 (Local people)<br>( 10-20 people/ day)<br>( 10-20 people/ day) |
| **Gill net fishery** | Vizhinjam<br><br>Kovalam | Siganus, Lutjanids, Carangids | 30-35 units (4-6 people/unit)<br>20 units |

**Discussion**

A marine ecosystem is common property and people have right to exploit the fishery resources. In areas that are spear fished, that activity is believed to be the likely to cause a decrease in fish density and size compared to areas that are not spear fished (Jouvenel and Pollard 2001).Reefs generate a variety of seafood products such as fish, mussels, crustaceans, sea cucumbers and seaweeds (e.g. Craik et al., 1990; Birkeland, 1997a). As the fishing industry expanded and technology made larger catches possible and more areas of the ocean exploitable, the received wisdom that fisheries were inexhaustible soon became discredited. FAO estimates that 25% of the world's fish stocks are currently being fished at an unsustainable level [FAO, 2007:29], thus risking collapse. A lots of works have been done regarding with fishing methods practiced in open water bodies but here we address the fishing methods of Kerala which is rarely documented. Shaji and Laladhas, (2013) were discussed on Monsoon flood plain fishery and traditional fishing methods in Thrissur district, Kerala. This might be a different attempt to explicit traditional and reef associate fishing techniques in marine water. Among the eight fishing methods observed in the present survey, six of them are strictly reef oriented once. So the study result exploring the traditional fishers and fishing practices of the coast. And it's a virgin attempt to hint the reef associated fishing practices of the coast. It's only a qualitative analysis of the human intervention to a highly diverse and sensitive ecosystem like reefs of the coast. In 2004 Thomas and Kurup were reported '*padal*' fishery of Ashtamudi estuary, pointed that the practice is destructive in nature by reducing the juvenile po. Gracemathew and Venugopal (1990) were reported hook and line fishery of '*Kalava*' at Cochin, discussing the suitability and possibilities of the particular fishery.

**Conclusion**

The survey illustrating the traditional and reef associated fishing methods of Kerala. Among the eight types of fishing methods reported, six of them are strictly restricted in reefs of the study area. And the study is not covering the eco friendliness of the each practice. The study highlighted by reporting couple of rarely considering fishing methods like fishing by hand net and coconut branching peduncle fishery. Result of the site wise contribution of fishing activity, Vizhinjam secured first place by contributing a half dozen of fishing methods (6 no's). The present study report may explain the site specific fishing activities of the district. Because of these sites were providing strikingly different reef structure. It's only a qualitative analysis of the human intervention to a highly diverse and sensitive ecosystem like reefs of the coast.

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# Composition trends of fisheries in Malampuzha Reservoir, Kerala, India

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**ABSTRACT**

Data on reservoir fisheries are rare due to the common property nature of these resources, diverse mode of exploitation adopted by the state governments, scattered nature of the fish landing centres and the remoteness of many reservoirs. More than half of the reservoirs in Kerala remains unutilized or underutilized as far as fisheries are concerned. The Malampuzha, a multi-branched reservoir was commissioned in 1966 located in Bharathapuzha river of Palakkad district, Kerala. No attempts have been made till to quantify the exploited fishery resources of this reservoir. In the present study an attempt was made to quantify the exploited fishery of Malampuzha reservoir based on the data generated from fish landing centres, where regular systematic surveys and sampling were conducted during pre-monsoon, monsoon and post-monsoon seasons. 17 fish species belonging to 6 orders and 17 genera were identified in the exploited fishery of Malampuzha reservoir. The average annual exploited fishery estimated was 61.24 t. The highest landings were recorded during post-monsoon season (38.75 t) and the lowest in pre-monsoon (12.48 t). The major species noted in the landing were *Puntius filamentosus*, *Macrobrachium rosenbergii*, *Hypselobarbus curmuca* and *Puntius sarana*. *Catla catla*, *Cirrhinus mrigala*, *Labeo rohita* and *Oreochromis mossambicus* were the non-native species observed in the landing. Gill net was the predominant fishing gear operating in the reservoir.

**Introduction**

A large number of reservoirs have been constructed in India during the last six decades, with primary objectives of storing water for irrigation and power generation. Although, these water bodies hold tremendous fishery potential, its contribution to the freshwater fish production is less than 3%. Data on reservoir fisheries of India are rare due to the common property nature of these resources, the diverse mode of exploitation adopted by the state governments, the scattered nature of the fish landing centres and the remoteness of many reservoirs (Ghosh and Ponniah, 2001). India has 19,370 reservoirs spread over 15 states with an estimated 3.15 million ha area, which contribute 93,650 tonnes of fishery annually (Sugunan, 1995). But the utilization of the potential available is only 38.2%. The fishery potential of reservoirs was not evaluated until 1970s, when fishery yields were as low as 5 to 8 kg/ha/yr (Sugunan, 1995). There are about thirty reservoirs in Kerala, with total maximum water spread area of about 29,635 ha. Seventeen reservoirs are primarily used for irrigation, and of these fourteen are under the control of Irrigation Department of the Government of Kerala. Deforestation, agricultural activities, plantation and other land use activities in the catchment area of reservoirs have resulted in heavy siltation and sedimentation of these lacustrine water bodies, adversely affecting the quality of the aquatic habitat. Despite the existence of many small reservoirs in the State, no serious attempts have been made yet to develop them on scientific lines for fish yield optimisation.

Bharathapuzha River is the second longest (209 km) and largest (annual discharge of 3.94 $km^3$) among the west flowing perennial rivers in the Kerala (Raj and Azeez, 2012). The river originates from the northern and southern tips of Palakkad gap in the Western Ghats, which later joins and form four major tributaries namely Kalpathipuzha, Gayathripuzha, Thoothapuzha and Chitturpuzha. The river has a total basin area of 6,186 $km^2$ of which 4,400 $km^2$ falls in the Kerala and the rest in Tamil Nadu. The Malampuzha, a multi-branched reservoir was commissioned in 1966, located in the Bharathapuzha river of Palakkad district (Fig 1). The ichthyological investigations in the Bharathapuzha River were carried out by Jerdon (1849), Day (1865), Silas (1951, 1958), Devi and Indra (1986), Easa and Basha (1995), Easa and Shaji (1997), Bijukumar and Sushama (2001) and Sushama *et al*. (2004). Recently Bjiukumar *et al* (2013) reported 117 species from Bharathapuzha river, among them 98 species were primary freshwater and 19 were secondary freshwater species. No effort has been made in the past to quantify the exploited fish and fisheries of Malampuzha reservoir from Bharathapuzha River. The present study was undertaken to quantify the exploited fish diversity and species composition of Malampuzha reservoir.

**Materials and Methods**

The exploited fishery of the Malampuzha reservoir was estimated based on the data generated from landing centre, where regular systematic surveys and sampling were conducted during pre-monsoon, monsoon and post-monsoon seasons. Details of landings were collected from more than 30% of the gears landed, giving emphasis to type of gear, mesh size, species composition and weight, size groups represented in the catch, actual fishing hours and manpower engaged.. The catch from the fisherman who arrived at a landing site on a given time was examined. Fish specimens were preserved in 8% formalin and brought to the laboratory for species level identification following Day (1878), Talwar and Jhingaran (1991) and Jayaram (1999, 2009). Daily landings from each type of gears and fishing methods were computed following Kurup *et al*. (1992).

$$W = (w/n) \times N$$

Where W = total weight of fish, w = total weight of fish from gear sampled

n = number of gear sampled, N = total number of similar gears operated.

Monthly catch was estimated by multiplying daily catch with total number of fishing days in a month. Season wise landing was estimated by multiplying monthly catch with number of months in the season. The annual exploited quantity was calculated by summarizing the landings of three seasons. The biodiversity status of such fishes was assigned following IUCN.


Fig 1. Map of Malampuzha reservoir, Bharathapuzha river, Kerala

**Results**

A total of 17 species under 13 families and 17 genera were recorded in the exploited fishery of Malampuzha reservoir during the study period (Table1). Cypriniformes and Siluriformes were the dominant orders represented in the exploited fishery. Among the 17 fish species recorded, family Cyprinidae was the most dominant group with 7 species followed by Siluridae and Cichlidae (2 species each). Four species of non-native fishes were reported in the landing, of which *Oreochromis mossambicus* is exotic to the country; while the rest were the Indian major carps (*Catla catla*, *Cirrhinus mrigala*, *Labeo rohita*) transplanted from Gangetic plains. The giant freshwater prawn *Macrobrachium rosenbergii* formed the only invertebrate species in the exploited fishery. The landings were represented by one endangered (*Hypselobarbus curumca*) and three near threatened (NT) fish species (*Wallago attu*, *Oreochromis mossambicus* and *Ompok bimaculatus*) (Fig 2).

Table.1 List of commercially important species, their biodiversity status and quantity of landings in Malampuzha reservoir

| Sl No. | Order | Family | Species | Biodiversity status | Quantity(t) |
|---|---|---|---|---|---|
| 1 | Anguilliformes | Anguillidae | *Anguilla bengalensis* | LC | 2.40 |
| 2 | Cypriniformes | Cyprinidae | *Hypselobarbus curumuca* | EN | 7.61 |
| 3 | | | *Puntius filamentosus* | LC | 10.38 |
| 4 | | | *Puntius sarana* | LC | 4.14 |
| 5 | | | *Cirrhinus mrigala* | LC | 3.74 |
| 6 | | | *Catla catla* | LC | 3.98 |
| 7 | | | *Labeo rohita* | LC | 1.25 |
| 8 | | | *Amblypharyngodon microlepis* | LC | 2.40 |
| 9 | Siluriformes | Bagridae | *Mystus cavasius* | LC | 0.31 |
| 10 | | Heteropneustidae | *Heterpneustus fossilis* | LC | 1.11 |
| 11 | | Siluridae | *Ompok bimaculatus* | NT | 0.60 |
| 12 | | | *Wallago attu* | NT | 1.92 |
| 13 | Beloniformes | Belonidae | *Xenetodon cancila* | LC | 0.89 |
| 14 | Perciformes | Ambassidae | *Parambassis dayi* | LC | 4.57 |
| 15 | | Cichlidae | *Etroplus suratensis* | LC | 1.92 |
| 16 | | | *Oreochromic mossambica* | EX | 2.83 |
| 17 | Synbranchiformes | Mastacembelidae | *Mastacembelus armatus* | LC | 1.93 |
| 18 | | | *Macrobranchium rosenbergi* | LC | 9.25 |
| | | | | | 61.25 |

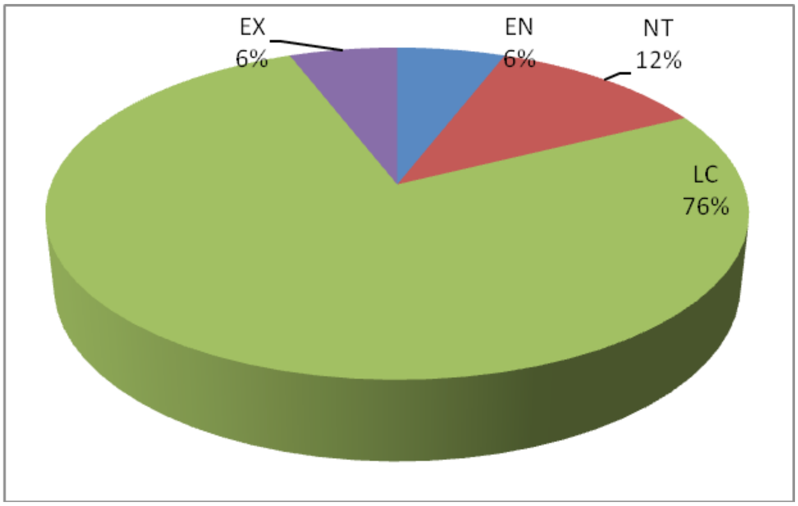


Fig 2 Biodiversity status of exploited fishes from Malampuzha reservoir

The annual exploited fishery of the Malampuzha reservoir estimated was 61.24 t. The highest landing was recorded during post-monsoon season (38.75 t) and the lowest in pre-monsoon (12.48 t). The main catches consist of *Puntius filamentosus*, *P. sarana*, *Macrobranchium rosenbergii* and *Hypselobarbus curmuca*. *Puntius filamentosus* (10.38 t) and *P. sarana* (4.14 t) together contributed to 24% in the landing. *Macrobrachium rosenbergii*, commonly known as 'Giant freshwater prawn' formed 8.49% of total landing. *Hypselobarbus curmuca* and Indian major carps (*Catla catla*, *Labeo rohitha* and *Cirrhinus mrigala*) were contributed 15% and 14% in the total annual landing respectively. Gill net was the predominant fishing gear accounted for 99% of catch.

**Discussion**

Indian reservoirs have a rich variety of fish species and the ichthyofauna of the reservoirs basically represent the faunistic diversity of the parent river system (Sugunan, 1995). Jhingran (1991) has provided a good account of fish and fisheries of the reservoirs associated with the various major river systems of India. He has enumerated the endemic and indigenous fish species harbouring the reservoirs, and observed that in most reservoirs the carps and catfishes contribute to the fisheries. In the present study, 17 fish and one prawn species contribute in the commercial landings of Malampuzha reservoir. Gopinath and Jayakrishanan (1984) reported 17 species of fishes from Idukki reservoir of Kerala. Nair (1969) has reported the presence of three native and seven introduced species, including tilapia from Meenkara reservoir. Piska *et al.* (2000) reported 28 species of fish belonging to four orders from Ibrahimbagh reservoir of Andhra Pradesh. Sakhare (2001) recorded 23 species belonging to 7 orders in Jawalgaon reservoir, Maharashtra. Pawar *et al.* (2003) studied the fish diversity of Shirur dam (Maharashtra) and confirm the occurrence of 11 fish species belong to 5 orders. Mohapatra (2003) recorded a total of 43 fish species in Hirakud reservoir of Orissa. 46 fish species were reported from the Rana Pratapsagar reservoir in Rajasthan by Juyal and Chaudhary (2003). Sakhare (2005) recorded 28 species of fish belonging to 19 genera in Manjira reservoir in Maharastra. Negi (2008) recorded 51 species of fish in Gobindsagar reservoir and 28 species in Pong reservoir (Himachal Pradesh). Shinde *et al.* (2009) recorded 15 fish species represented by 3 orders in the Harsool- Savangi dam in Maharashtra. 52 fish species belonging 7 orders and 13 families were reported from Indira Sagar reservoir in Madhya Pradesh by Vyas et al., (2009). A total of 61 species were reported from Doyang reservoir (Nagaland) by Odyuo and Nagesh (2011). Bera et al. (2014) reported 39 fish species from Kangsabati Reservoir in West Bengal.

In the present study, the total exploited fishery of Malampuzha reservoir was estimated at 61.25 t. *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*, commonly known as 'Indian major carps' (IMC) constituted an important fishery in Malampuzha reservoir contributed to 14% in the landing. Indian major carps were transplanted from the Gangetic plains for stock enhancement and aquaculture. Sreenivasan (1995) reported that introduction of non-native Indian major carps as the major factor leading to the decline of endemic peninsular carps such as *Cirrhinus cirrhosa*, *Labeo kontius*, *Barbodes carnaticus*, *Hypselobarbus dubius* and *H. pulchellus* in South Indian reservoirs. IMC's has eclipsed all indigenous fish fauna including *Labeo fimbriatus*, which dominated the scene by contributing 36% of the catch during the mid 1960s in Santhanur reservoir in Tamil Nadu and *Catla* contributes 80-90% of the total catch at present (Sugunan, 2000). Gopalakrishnan and Basheer (2000) reported the introduction of Indian major carps in Pamba, Manimala and Meenachil Rivers of Kerala and the authors also reported four ripe rohu females from Pamba River which indicates a slow establishment of the fish in wild. The present report on the higher catch of Indian major carps in Malampuzha reservoir focuses on their successful establishment in the reservoir.

Besides, many species of IMC's, the common carp and tilapia were introduced in to many of the reservoirs, contributing substantially to the commercial fisheries. Tilapia was found dominating in Malampuzha reservoir and contributed 2.83 t in the total landing. Panicker (2000) has also made similar observations on the high landing of this fish in the same reservoir. In most of the reservoirs of Kerala and other South Indian states, tilapia has been found to be a dominant species. Tilapia has caused a decrease in catch of *Cirrhinus reba* from 70% to 20% in Kabini reservoir of Tamil Nadu (Murthy *et al.*, 1986). Introduction of tilapia has brought down the population of *Labeo kontius* in Vaigai reservoir and *Puntius dubius* in Amaravathy reservoir (Tamil Nadu) (Natarajan and Menon, 1989). Tilapia out-competed many local species and resulted the reduction in the average weight of Indian major carps in Jaisalmund Lake (Rajasthan) (Lakra *et al.*, 2008). The growth of *Chanos chanos* was restricted to less than 100 g/yr in many water bodies in Tamil Nadu where tilapia was introduced (Singh and Lakra, 2011). Besides tilapia, Indian reservoirs are also reported to harbour a sizable population of trash fishes (Dehadrai, 2002). Most of these trash fishes compete for food with carps tending to reduce the overall fish productivity of the reservoirs (Natarajan, 1976). Many reservoirs in the Bharathapuzha basin have been stocked with the non-native carps as well as the giant freshwater prawn during the last several decades and have even been considered to be one of the success-stories of capture based culture fisheries (Peters and Feustel 1998; Kutty et al. 2008). Bharathapuzha is one of the most degraded and threatened river systems and several anthropogenic factors such as deforestation, dam constructions, pollution, sand mining, non-native species introduction, climate change and destructive fishing practices are threatening the fish diversity.

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# Role Of Natural Food Production In Traditional Fish Farms With Reference To Zooplankton Biomass

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**Abstract**

The diversity and abundance of zooplankton determines the fisheries productivity of any aquatic environment. In fish farms good zooplankton bloom is essential for the proper management of water quality, food, disease and parasites. The present works reviews works on importance of this group in aquaculture and also discuss the results of a case study in four traditional aquaculture ponds situated near Cherthala. The case study was concentrated mainly on analysing the biomass and standing stock of zooplankton. The sizes of the ponds studied were 0.30 hectares (Pond 1), 32.37 hectares (Pond 2), 68.79 hectares (Pond 3) and 24.28 hectares (Pond 4). Zooplankton samples were collected by using specially designed conical shaped monofilament nylon net (Plankton net), preserved in 10% formalin and analysed after bring to laboratory. The biomass of zooplankton was ranged from 7100 to 24200 µg/l. Major zooplankton groups identified were copepods, rotifers, cladocerans, pycnogonids, shrimp larvae etc. The tertiary productivity of this aquaculture farm entirely depends on this natural production by zooplankton. The farm does not depend on artificial feed at any stage of its culture activity.

## Introduction

As the demand for fish protein continues to expand globally and catch from wild aquatic environments decline, aquaculture is recognized as the only way of increasing the supply. Aquaculture in common with the other major food producing sectors, agriculture and animal husbandry, should operate within ecological limits to minimize environmental degradation as the environment provides 'ecosystem services' vital to human welfare and ultimate survival (Millennium Ecosystem Assessment, 2003). Aquaculture is expected to contribute more effectively to global food security, nutritional well-being, poverty reduction and economic development by producing 85 million tonnes of aquatic food by 2030 (Keshavanath, 2014). Boyd and Chainark (2009) outlined the recent evolution of aquaculture technology to intensify pond production: initially manures and chemical fertilizers to increase natural food, followed by pelleted feed to provide more nutrition for the fish. However, the importance of fertilising ponds well in advance of stocking to allow the communities of natural food organisms time to develop has not been adequately documented.

## Status of traditional aquaculture systems

Aquaculture was entirely 'traditional' up to less than 30 years ago in Asia as locally available resources were the only sources of nutritional inputs available to the farmer before the relatively recent agro-industrial manufacture of pelleted feed (Edwards, 2009). It is a myth that rice/fish farming has ever been common or widespread in Asia (Edwards, 2015). Although rice/fish farming has been promoted widely, the degree of sustainable adoption has been rather limited (Nandeesha, 2004), mostly because the culture of aquatic animals in rice fields is mostly not attractive to farmers in terms of return to labour and other expences. It requires considerable time and labour to modify rice fields for fish culture by digging trenches and raising the height of the surrounding dikes; and to maintain adequate water for the fish in the dry season as well as prevent loss of the fish through flooding in the rainy season. Furthermore, rice/fish integration is likely to become even less prevalent with new rice technology promoting less water use in view of the diminishing availability of water (Uphoff, 2007).

In India rice-fish culture is practiced in Arunachal Pradesh, Tripura, Assam, West Bengal, South Bihar, Andhra Pradesh, Tamil Nadu and Kerala (Tripathy, 1984; Saika, 2015). The traditional system of growing tall rice (*Oryza sativa* L.) varieties during the monsoon season and prawn culture (prawn filtration) during summer season, locally known as pokkali, is a sustainable system of production harmoniously blended with natural processes like sea water inundation in the low-lying coastal zones of Kerala (Sasidharan et al., 2012). Additional income, employment generation and utilisation and conservation of wetlands are the main benefits of this system. In Kerala, traditional and extensive shrimp culture is in practice and the total area under traditional farming system is 12,986.6 ha, of which 84% is under pokkali fields (Pillai et al., 2002; Ashamol et al., 2014). But there are lots socioeconomic issues which hinder the survival of this eco-friendly aquaculture practice in Kerala. Most of these pokkali fields are now abandoned, farmers are not interested in uneconomic paddy culture. As the paddy culture is impeded, shrimp culture is also being restricted. Frequent occurrence of diseases, labour problem, pouching etc also caught up this practice.

**Natural live food in aquatic environments**

In nature, most of the organisms subsist on live food consisting of plants and animals obtained from the environment, but some do ingest and possibly utilize detritus along with associated organisms. Natural aquatic environments contain small and microscopic organisms under various taxa which contribute to the diet and biomass of high level organisms like fishes. Microbes are the predominant photosynthetic organisms in most aquatic environments (Qunlan et al., 2009). Microalgae mainly photosynthesize to absorb $CO_2$ and to supply oxygen to aquatic animals. The main role of bacteria and fungi is to decompose organic matter in sediments so as to keep the water clean. In aquaculture ponds, as in other aquatic ecosystems, bacteria have roles in decomposition and nutrient cycling and as trophic links with meiobenthos and prawns (Geoff et al., 1995). There are phytoplankton, zooplankton, benthos, fish and many other organisms in the aquatic ecosystem. Energy flows and material circulates in a balanced ecosystem.

Aquaculture organisms have to obtain all their nutritional requirements, except for part of the mineral requirements, through the food they consume. The initial source of food for many larval aquatic organisms is phytoplankton. This is probably associated with the size of the larvae at hatching. After a certain period of time the larvae of most species can be fed exclusively on zooplankton or a combination of plant and animal matter i.e. plankton.

Plankton play important role in the transfer of matter and energy in pelagic food webs. In the complex network of trophic relations of pelagic food webs, zooplankton organisms play a pivotal role in the transfer of the organic matter produced by microscopic autotrophs (phytoplankton) towards larger organisms exploitable by man. Zooplankton is linked to the microbial side of pelagic food webs through large flagellates, ciliates and small metazoans. Most of the zooplanktonic species are omnivores, and rather than the vegetal, animal or detritic nature of food items, what really matters from a trophic point of view is the size of food particles.

Aquaculture systems that closely resemble natural ecosystems have too low productivity to be attractive to the vast majority of farmers as they have limited input of nutrients from the external environment. So, pond preparation is necessary before stocking the seeds to aquaculture farms for better natural production. The studies Geoff et al. (1995) of illustrate the positive effects of pond preparation on water quality, bacteria and benthos. If the pond is well prepared and fertilized in advance to seed stock of the candidate species, the natural production of phytoplankton, zooplankton and other organisms will flourish. This natural production will be more than enough to feed the fishes in traditional extensive and modified extensive type of aquaculture farms. There are lots of studies where the effect of naturally occurring aquatic organisms to the diet of crop fish is estimated. Reymond and Lagardere (1990) found that in ponds with about 10 prawns/m$^2$, naturally occurring prey were the major food source for *Penaeus juponicus*, despite daily inputs of pelleted feed. Gonzales (1988) estimated that natural pond biota contributed between 51 and 89% of the total food intake for juvenile (0.02 g/prawn) *P. monodon.*

**1. Case study - role of zooplankton**

A study was carried out in four brackishwater fish ponds located in Kerala near Chellanam and Pallithode to understand the biomass and standing stock of zooplankton in aquaculture ponds as they contribute chief live food for aquatic animals. The study site is a wetland area and is well known for aquaculture production and supply of finfishes and shrimps to the local and export market. The ponds located here are tide-fed type and the farmers depend mainly on the natural production of ponds as the source of food for culturing fishes.

**1.1. Plankton collection and preservation**

Plankton samples from each pond were collected in weekly intervals in the forenoon hours by using specially designed conical shaped monofilament nylon net (Plankton net). The mesh size of the plankton net was 90 ìm and the diameter of the net at mouth was 30 cm. Samples were collected from pelagic waters of the ponds from different parts of the ponds. Plankton was filtered from about 100 litters of surface water collected using a plastic bucket. The water passed down through the net and the plankton condensed at the lower end of the plankton net (Welch, 1948) was transferred into glass bottles, preserved with 10% formalin and taken to the laboratory. The preserved samples were later analysed in the laboratory using Olympus compound light microscope and other simple microscopes.

**1.2. Biomass estimation**

Secondary production or biomass of zooplankton in the ponds was estimated following the method suggested by Goswami (2004). Biomass was estimated by both volumetric (displacement volume) as well as gravimetric (wet weight) methods.

In displacement volume method the zooplankton sample was filtered through a piece of clean, dried netting material. The mesh size of netting material was the same as the mesh size of the net used for collecting the samples. The interstitial water between the organisms was removed with the blotting paper. The filtered zooplankton was then transferred with a spatula to a graduated 5ml measuring cylinder with a known volume of 4 % buffered formalin. The displacement volume was obtained by recording the volume of fixative in the measuring jar displaced by the zooplankton. The settled volume was obtained by making the sample to a known volume in the measuring jar. The plankton was allowed to settle for few hours before recording the settled volume.

The gravimetric method was carried out by filtering the zooplankton. The interstitial water was removed by blotting paper by not exerting too much pressure. The zooplankton weight was taken on pre-weighed filter paper on watch glass using an electronic balance with mg configuration. The wet weight was expressed in grams.

**Results and Discussion**

**2.1. Biomass and standing stock of zooplankton**

The area of the ponds presently we studied were 0.30 hectares (Pond 1), 32.37 hectares (Pond 2), 68.79 hectares (Pond 3) and 24.28 hectares (Pond 4). The standing volumes of water estimated in each pond are given in Table 1. The displacement volume of zooplankton from each pond sample of 100 litters and estimated values of zooplankton biomass and standing stock are given in the Table 2.

**Table 1. Details of estimated volume of water in each pond during the study period**

| Pond No. | Area of pond ($m^2$) | Depth of pond (m) | Volume of water in pond (litres) |
|---|---|---|---|
| 1 | 3035 | 1.2192 | 3700272 |
| 2 | 32374 | 2.4384 | 78940760 |
| 3 | 68796 | 3.6576 | 251628200 |
| 4 | 24281 | 2.1336 | 51805940 |

**Table 2. Details of zooplankton biomass and standing stock in each pond during the study period**

| Pond No. | Volume of water in pond (litres) | Displacement volume of zooplankton sample (g/litre) | Estimated Zooplankton Biomass (µg/l) | Estimated Zooplankton Standing Stock (kg) |
|---|---|---|---|---|
| **1** | 3700272 | 0.4 | 7100 | 26.2719312 |
| **2** | 78940760 | 0.275 | 24200 | 1910.366392 |
| **3** | 251628200 | 0.175 | 20500 | 5158.3781 |
| **4** | 51805940 | 1 | 15900 | 823.714446 |

A good zooplankton stock was observed in all the ponds. Zooplankton biomass was observed high in Pond 2 followed by Pond 3, 4 and 1. The production of fishes in these ponds also showed a similar trend in biomass indicated the direct relationship of zooplankton with tertiary production of fishes in farms.

The successful aquaculture farm management depends on natural feed and good water quality management. Basic information regarding plankton especially zooplankton and their growth kinetics is a key factor to make successful fish farming strategy (Park and Shin, 2007). Zooplankton plays an important food item of omnivorous and carnivorous fishes (Alam et al., 1987). The present study was an attempt to understand the contribution of natural live feed production in traditional aquaculture ponds to the fishery production with reference to four traditional fish ponds near Cherthala. The results obtained in the study gives an idea about the biomass and standing stock of zooplankton.

Several works are available regarding importance of zooplankton in aquaculture. According to Alam et al. (1987) the zooplankton contributes about 23% of the food item of shrimp. Mustafa and Ahmed (1979) reported that zooplankton contribute 32% of the diet of *Notopterus notopterus* and according to Menon et al. (1981) it contributes 47% of the *Catla catla* diet and 6.37% of the *Labeo rohita* diet. The larvae of fish especially shrimp mostly feed on zooplankton because zooplankton provide the necessary amount of protein requires for the rapid growth of the shrimp (Bardach et al., 1972). The abundance and diversity of plankton also affect the survival and growth rate of cultured fish. Their abundance and diversity greatly influence the culture system through maintaining oxygen concentration in water, ensuring the balance between $O_2$ and $CO_2$, enhancing the decomposition of organic matters accumulated in the pond, preventing the development of demersal microalgae and pests, stabilizing water temperature in the pond, regulating pH value and the ecosystem of the pond and also minimizing the variation of water quality parameters (Das and Bhuyan 1974).

So, natural production in the pond is important in any kind of aquaculture practice for its success. Here in this work the concept is discussed with literature and a case study which explain the biomass of zooplankton in traditional pokkali fish ponds in Kerala. Traditional fish culture practices are sustainable as it is environment friendly and does not require much expense towards feeding and disease management.

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# Biochemical Composition of Blood Clam *Anadara granosa* from Vellar Estuary Southeast coast of India

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**Abstract**

Seafood is an excellent source of protein of high biological value. Bivalve molluscs comprise major marine fishery resources; they have rich in biochemical compounds. The present study deals with biochemical composition of blood clam *A. granosa*. The proximate composition of protein, carbohydrate, lipid, amino acids, fatty acids, vitamins and minerals were estimated. The results of proximate composition in *A. granosa* showed the percentage of protein was high 23.6%, followed by the carbohydrate 14.21%, lipid 6.18 % moisture 46.51% and ash 9.14%). The total essential amino acids were found to be as 57.61 % and non-essential amino acids were 41.48% in body tissue. Among the EAA and NEAA lysine & tyrosin were found high as 14.52 % and 8.23 % on dry matter basis in bivalve tissue. In the analysis, the fatty acid profile revealed the presence of higher amount SFA (palmitic acid 27.42%) and PUFA (alpha linolenic acid 19.26%). In the present study, vitamin K and E were found in higher levels (41.7 & 15.6 mg/100g). Totally 5 macro minerals and 2 trace minerals were reported. The *A. granosa* body tissue contributed maximum calcium (175.2 mg/100g) and potassium (112.8 mg/100g) of minerals. The evaluation of the biochemical composition of *A. granosa* clearly indicates that the blood clam has higher biochemical composition. The results of this study showed that the samples possessed appreciable quantities of all the dietary elements tested, which could make them partial or complete substitutes for conventional shellfish food.

**Key words:** *A. granosa*, Proximate Composition, Amino acids, Fatty acids, Vitamins and Minerals

**Introduction**

Marine organism forms a good source of minerals. Ash is left out after complete combustion of fish meat and gives a measure of the total mineral content (Gopakumar, 1997). The ash content of fish varies from 0.5-2%. The finfish and shellfish can absorb minerals directly from the aquatic environment through gills and body surfaces. Almost all the elements that occur in sea water are found to some extent in fish and these include Na, K, Ca, P, Al, Ba, Cd, I, Cr, Cu, Pb, Li, Hg, Ag, St, T and Va. The minerals serve as components of bones; soft tissues and co-activators of various enzymes important in human nutrition. Calcium, phosphorus, magnesium and the electrolytes-sodium and potassium are considered as macro elements and iron, copper, zinc, iodine, chromium, cobalt, manganese, molybdenum and selenium are considered as trace elements named after their requirement for normal body functioning. For instance phosphorous acts as key substances for energy release and present in phosphorous acts as a key substance for energy release and present in phospholipids. Sulphur containing amino acids, like cystine and methionine, are main sources of sulphur, copper and iron are important minerals found in fish as respiratory pigments, while cobalt is present in vitamin B12. The more soluble minerals such as Ca, P, Na, K and Cl are involved n the maintenance of acid-base balance and membrane potentials. The calcium and phosphorous together account for 70% to 80% of the minerals in the skeleton of fish (Nair and Mathew, 2000). In recent years, research or the nutritional value of molluscs attracted much attention as they constitute at least 80,000 species and are considered the second largest phylum in the animal kingdom. Molluscs have soft bodies and are found in different ecosystems throughout the world. They are predominantly found in aquatic systems but some are terrestrial. The mollusc includes univalve organisms such as snails and slugs, bivalves such as mussels, oysters and cockles, and cephalopods such as octopus, squid and cuttlefish (Adeyeye, 1996).

Bivalves are one of the important varieties of shellfish and perhaps the most versatile seafood in the world. These edible bivalves are filter feeders; thereby have high conversion efficiency and consequently high levels of biochemical constituents. Clams are high in protein and the nutritive value of several species of clams has been estimated (Dincer, 2006). Shellfish meat, particularly clam meat have been recommended in several dietary regimes for their high protein content, low calorific values, low fat/ cholesterol profile and lower proportions of saturated fat, the presence of good lipids, significant amounts of omega- 3-fatty acids, dietary essential amino acids, vitamin B12 and several important minerals such as iron, zinc and copper (Periyasamy, 2012). Shellfish were often high-status food and their consumption was connected with the treatment or prevention of various health problems and diseases. Later, they began picking clams only for the consumption of meat (Krzynowek *et al*., 1983). The edible and commercially important species *Katelysia opima* and *Meretrix meretrix*, *M. casta*, *Anadara* sp and *Crassostrea* sp is abundantly distributed in the Vellar estuary. The estuarine clam meat is eaten by local fisherfolk mainly in Parangipettai area. The estuarine bivalves also form a good source of food and cheap substitute for variety of man's requirements such as feed and fertilizer. Even though bio-chemical composition of gastropods and cephalopods was extensively studied, only limited studies have been conducted in estuarine bivalves especially in blood clam. The above review of literature clearly indicates the gap in our knowledge on biochemical make up of estuarine clams. Hence, the present work was planned to study the proximate composition of estuarine blood clams *A. granosa* through estimating their biochemical components such as total protein, carbohydrate, lipid, moisture and ash content in the whole body tissue apart from the amino acids, fatty acids profile, vitamins and minerals content.

**Materials and Methods**

The samples of *A. granosa* were collected from Vellar estuary. The samples were mainly collected by hand picking based on one time sampling during low tide period. The specimens were first thoroughly washed with tap water and subsequently with distilled water. The whole body parts were dissected and cut into small pieces. The body parts were kept in petridishes and dried at a constant temperature of 55°C for 24 hours in a hot air oven. the dried martial was powdered thoroughly and required quantity of each dry tissue powder were taken for analyzing proximate composition, amino acids, fatty acids, vitamins and minerals.

**Proximate composition**

The Biuret method modified by Lowry *et al*. (1951) was employed to estimate the total protein content and the values were expressed as percentage (%). For the estimation of total carbohydrate content, the procedure of Dubois *et al*. (1956) using phenol-sulphuric acid was followed and the values were expressed in percentage. The chloroform-methanol extraction procedure of Folch *et al*. (1956) was used to extract total lipid from the body parts. The moisture content of the bivalve was estimated by drying a known weight of bivalve tissue in a hot air oven at 105°C for 24 hrs. The differences in weight before and after drying are the amount of moisture present and the results are expressed in percentage of wet weight of the tissue (AOAC, 2000). The ash content was estimated by incinerating/burning the pre-weighed test sample in a muffle furnace at 560ºC (AOAC, 2000) for a period of 5 hours. The residue was weighed and the percentage was calculated.

**Estimation of amino acid**

The qualitative and quantitative content of amino acids was done using an automatic amino acid analyzer (Shimatzu- High Performance Liquid Chromatography LC 4A). 20µl of the filtered, derived amino acid sample was injected into single/original column and analysed using sodium buffer (Yamamoto *et al*., 1994).

**Fatty acids analysis**

For the fatty acids analysis, the sample was homogenized with chloroform: methanol (2:1 V/V) mixture and the fat were extracted following the method of Bligh and Dyer (1959). After the fat was extracted, it was esterified with 1% $H_2SO_4$ and fatty acids methyl esters were prepared by following the procedure of AOAC (1995). The fatty acid methyl esters of the sample was injected in the Gas chromatography (Hewlett Packard 5890 model) capillary column coated with 5% phenyl silicone at a temperature from 170ºC to 300ºC for 23.33 minutes. Flame ionization time of the different fatty acid sample was identified.

**Estimation of vitamins**

The fat soluble vitamins (A, D, E & K) and water soluble vitamins (B complex $B_1$, $B_2$ $B_6$ and C) were analysed in HPLC (Merck Hitachi L-7400) following the method described by Sadasivam and Manickam (1996). The folic acid was estimated following the colorimetric method of Setti (1977). The pyridoxine and vitamin B12 were estimated by following methods suggested in USP NF 2000 Asian edition.

**Estimation of minerals**

The tissue samples collected were stored in pre-cleaned glass containers, to 5 mg of the tissue sample, mixture of HCl, $HNO_3$ and $HClO_4$ at a ratio 10:5:1 was added for digestion at 300ºC. The digests were filtered suitably and were later aspirated in an Inductively Coupled Plasma Spectrometer (Yvon Model Jy-24, France) after calibrating the instrument with appropriate blank and series of known standards for the estimation of minerals such as Iron, Copper, Phosphorus, Manganese, Magnesium and Zinc (Topping, 1973). The estimation of calcium, potassium and sodium procedure described by method Guzman and Jimenez (1992). To the 5 mg of the tissue sample, mixture of HCl, $HNO_3$ and $HClO_4$ at a ratio 10:5:1 was added for digestion at 300ºC. The digests were filtered suitably and aspirated in digital frame photometer (Model No.CL 22D, Eli Co Pvt. Ltd., and India). The obtained values were expressed in mg/100g.

**Results**

The proximate compositions (%) such as protein, carbohydrate and lipid contents of *A. granosa* were analyzed. The results of the present study revealed that the protein composition were high (23.6%) followed by carbohydrate (14.21%), lipid (6.18%), moisture (46.51%) and ash (9.14%). The percentage compositions of essential and non-essential amino acids are presented in (Table.1) and the total amino acids were compared with standard amino acids (Fig.1, 2). The total essential amino acids were found to be as 57.61 % and non-essential amino acids were 41.48 %. Among the essential amino acids lysine were found high as 14.52 % on dry matter basis and the other essential amino acids percentages were found fluctuating between lysine 14.52 > valine 11.12> arginine 8.93 > isolucine 7.15 > leucine 6.13 > phenyalanine 4.88 > histidine 6.51 > methionine 1.86 > threonine 0.69 > and tryptophan 0.15 in clam tissue. The non-essential amino acids tyrosin were found maximum as 8.23 % on dry matter basis and the other non-essential amino acids percentages were between 8.23 tyrosin > cystine 6.91 > aspertic acid 6.34 > aspartate 5.18 > serine 5.13 > glutamic acid 3.58 > glycine 3.17 > alanine 1.12 > proline 0.93 and glutamate 0.89 % in clam tissue.

**Table 1.** Essential and non essential amino acids of *A. granosa*

| EAA | % of amino acids | NEAA | % of amino acids |
|---|---|---|---|
| Phenylalanine | 4.88 | Glycine | 3.17 |
| Lysine | 14.52 | Serine | 5.13 |
| Histidine | 2.18 | Glutamic acid | 3.58 |
| Methionine | 1.86 | Cystine | 6.91 |
| Arginine | 8.93 | Glutamate | 0.89 |
| Leucine | 6.13 | Alanine | 1.12 |
| Threonine | 0.69 | Proline | 0.93 |
| Isolucine | 7.15 | Aspartate | 5.18 |
| Valine | 11.12 | Tyrosin | 8.23 |
| Tryptophan | 0.15 | Aspertic acid | 6.34 |
| **Total** | **57.61** | **Total** | **41.48** |

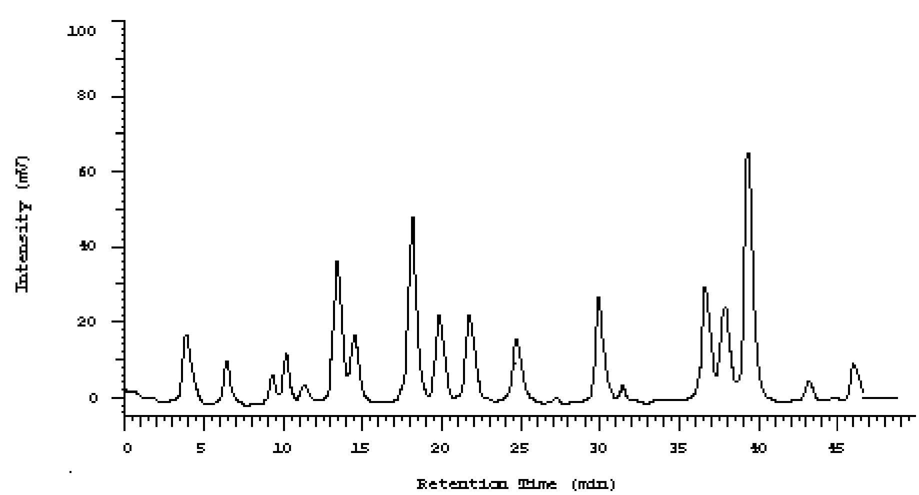


**Fig. 1.** Standard graph for amino acids

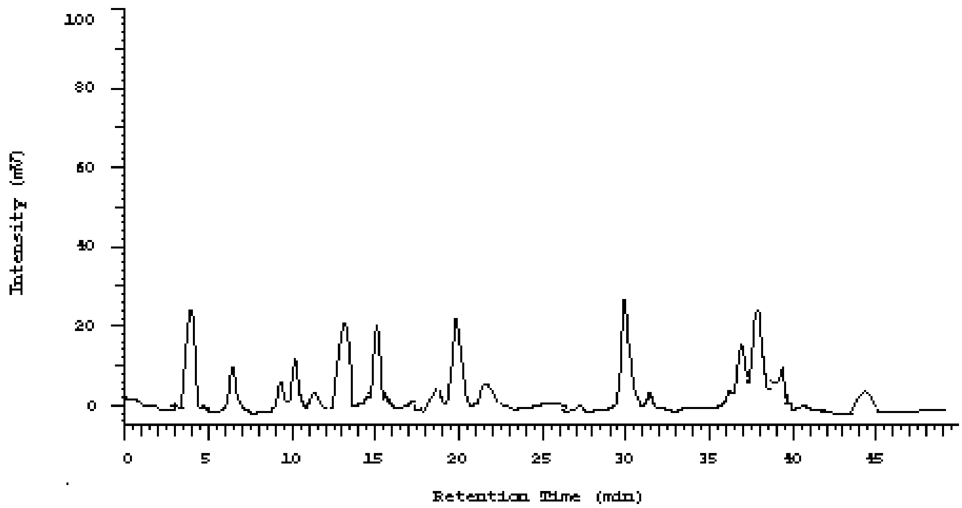


**Fig. 2.** Estimation of amino acids from *A. granosa*

In *A. granosa*, 8 different fatty acids and totally 99.79% were found; they are three saturated fatty acids (SFA), one monounsaturated fatty acids (MUFA) and four polyunsaturated fatty acids (PUFA). Among the SFAs C16:0 were the major acids in 27.42%. In PUFA alpha linolenic acid were the major acids found as 19.26%. The percentage availability of SFA, MUFA and PUFA content was 47.04, 14.63 & 38.12 % in *A. granosa*. The percentages of total fatty acids contents are given in (Table 2) and the total fatty acids were compared with standard fatty acids (Fig.3, 4).

**Table 2.** Fatty acid profile of *A. granosa*

| S. No | Fatty acids | Carbon atom (n) | % of fatty acids |
|---|---|---|---|
| | | **Saturated Fatty Acids** | |
| 1 | Palmitic acid | C16:0 | 27.42 |
| 2 | Margaric acid | C17:0 | 13.95 |
| 3 | Stearic acid | C18:0 | 5.67 |
| | | **Total** | **47.04** |
| | | **Mono Unsaturated Fatty Acids** | |
| 4 | Oleic acid | C18:1 | 14.63 |
| | | **Total** | **14.63** |
| | | **Poly Unsaturated Fatty Acids** | |
| 5 | Linolenic acid | C18:2 | 7.83 |
| 6 | Alpha Linolenic acid | C18:3 | 19.26 |
| 7 | Stearidonic | C18:4 | 2.13 |
| 8 | Eicosatetraenoic acid | C20:4 | 8.9 |
| | | **Total** | **38.12** |

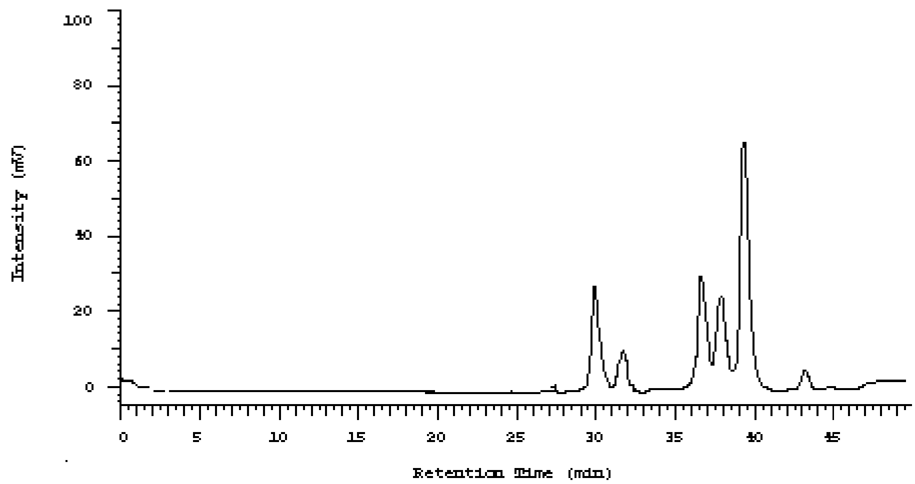


**Fig. 3.** Standard graph for fatty acids

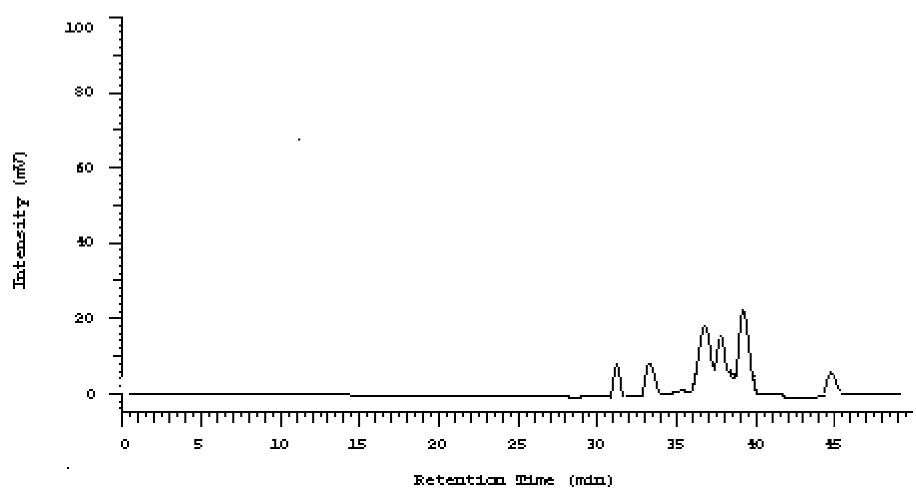


**Fig. 4** Estimation of fatty acids from *A. granosa*

The details of the vitamins detected in *A. granosa* are presented in Table 3. Among them, vitamin K and E were found in higher levels 41.7 & 15.6 mg/100g, whereas folic acid and B12 were noticed as lower levels 0.99 and 0.26 mg/100g, whereas other macro vitamin A were in negligible level 2,250 IU.

**Table 3**. Vitamin content of *A. granosa* (mg/100g)

| S. No | Vitamins | Body tissue |
|---|---|---|
| 1 | Vitamin A (Retinol) | 2,250 IU |
| 2 | Vitamin D (Calciferol) | 127 IU |
| 3 | Vitamin E (Tocopherol) | 15.6 |
| 4 | Vitamin K (Vitamin) | 41.7 |
| 5 | Folic acid | 0.26 |
| 6 | Vitamin B6 (Pyridoxin) | 2.35 |
| 7 | Vitamin B12 (Cynocobalamin) | 0.99 |
| 8 | Vitamin C (Ascorbic acid) | 3.18 |

**IU*- International Unit

The quantity of minerals present in the muscle tissue varied significantly. Totally, 5 macro minerals and 2 trace minerals were detected in Table.4. Among the macro minerals, calcium 175.2 mg/100g, potassium 112.8 mg/100g and copper 0.24 mg/100g were observed at higher and lower levels, whereas other macro-minerals sodium and magnesium were in negligible level. The trace minerals such as iron 0.45 mg/100g and zinc 0.32 mg/100g were also detected in this species.

**Table 4.** Mineral contents of *A. granosa* (mg/100g)

| S. No | Minerals<br>Macro | mg/100g |
|---|---|---|
| 1 | Calcium | 175.2 |
| 2 | Sodium | 42.6 |
| 3 | Potassium | 112.8 |
| 4 | Copper | 0.24 |
| 5 | Magnesium | 15.41 |
| | **Trace** | |
| 6 | Iron | 0.45 |
| 7 | Zinc | 1.32 |

## Discussion

The bivalves are rich sources of protein, carbohydrate, lipid, amino acids, fatty acids, vitamins and minerals. In recent years, the bivalve biochemical components have been recognized as effective factors in human health and nutrition, especially for cardiovascular diseases (Ajayabhaskar, 2002). The nutritive value of a food is determined by the proportions in which essential amino acids are present in the amino acids compositions of its protein. The present investigation revealed that the maximum level of protein content in *A. granosa* was 23.6%. The molluscs are reported to contain a high amount of protein ranging 40-78% (Anadakumar, 1986). The estuarine clam *M. meretrix* was reported to contain a high amount of protein 27.2% (Tamilvanan, 2014). Srilatha *et al.* (2013) observed the total protein content was found to be varied between 45.67% and 30.021% in *M. casta*. The determined in this research showed that estuarine bivalve *A. granosa* tissue is value food due to high quality protein.

The glucogen in shellfish varies greatly according to the time of the year. Since the carbohydrate content of the fish is low, they do not represent a main source of carbohydrate for humans (Okuzumi and Fujii, 2000). In the present study the percentage of carbohydrates in the body tissue of *A. granosa* was 14.21%. Nagabhushanam and Deshmukh (1974) also noticed a fall during mature condition and high level of glycogen content during the period of gonad development in *M. meretrix*. The result of the present study found similar with that of Salaskar and Nayak (2011) who reported the carbohydrate content in oyster *Crassostrea madrasensis* and mussel *P. viridis* was 14.01% to 25.24% and 14.69% to 26.81%.

Lipids are highly efficient as sources of energy and they contain more than twice the energy of carbohydrates and proteins (Okuzumi and Fujii, 2000). In the present study lipid content of *A. granosa* were 6.18 %. The total lipid content of *Crassostrea gigas* ranged from 7.1 to 8.4% of dry flesh as estimated by Piveteal *et al*. (1999). Yambem Tenjing Singh *et al*. (2012) reported that the lipid content of *D. scortum* is presented 9.06 %. In general, the values of the present study are slightly higher and lower than the result the above mentioned studies. All the reports very well support the results of the present study.

In the present study the percentage of moisture and ash content in the body tissue of *A. granosa* was 46.51% 9.14%. Marichamy *et al.* (2011) reported that the proximate composition in some finfishes and shellfishes of Vellar estuary; the moisture level is varied from 11.81 to 20.34%. Shellfish bivalve *Arca noae* meat consists on average of 77.61% water estimated by Dupcic Radic *et al*. (2014). Salaskar and Nayak (2011) noticed that the ash content in oyster *C. madrasensis* and mussel *P. viridis* was 4.21% to 14.82% and 6.18% to 9.02%.

Biological value of protein is obviously reflected upon its essential amino acids concentration. In general, the shellfishes have a balanced distribution of all essential amino acids required for an adult per day. In the present study *A. granosa* showed the percentage compositions of essential and non-essential amino acids were 99.09%. The total essential amino acids were found to be as 57.61 % and non-essential amino acids were 41.48 %. Among the essential amino acids lysine were found high as 14.52 % on dry matter basis in clam tissue. The non-essential amino acids tyrosin were found maximum as 8.23 % on dry matter basis in clam tissue. The total amino acids composition in molluscan, *Perna viridis* 95.76%, *C. madrassensis* 98.4% and *Meretrix casta* 65.17% was reported by (Ajayabhaskar, 2002) and the total EAA of *P. viridis*, *C. madrasensis* and *M. casta* was 52.84, 54.52 & 38 % of its composition. Lysine is the limiting amino acid in cereal based diets of children in developing countries. In the present study the total essential amino acids were found to be as 57.61 % and the essential amino acids lysine were found high as 14.52 % in *A. granosa*. The result revealed that *estuarine clam A. granosa* meat is a potential source for food value due to high quality protein, as well as balanced essential amino acids.

Fats and fatty acids should now be considered as key nutrients that affect early growth and development and nutrition-related chronic disease later in life. In the present study 8 different fatty acids and totally 99.79% were found; they are three saturated fatty acids (SFA), one monounsaturated fatty acids (MUFA) and four polyunsaturated fatty acids (PUFA). Among the SFAs C16:0 were the major acids in 27.42%. In PUFA alpha linolenic acid were the major acids found as 19.26%. The percentage availability of SFA, MUFA and PUFA content was 47.04, 14.63 & 38.12 % in *A. granosa*. The predominant fatty acids were 16:0 and 18:0 in *Mytilus plantensis* (DeMoreno *et al*., 1980). The oyster, *C. madrasensis* exhibited 48.2% of total SFA content and showed a similar trend of fatty acid profile as reported in *C. gigas* (Piveteal *et al*., 1999). Ajayabhaskar (2002) reported a sum of monounsaturated acids 20.47, 24.04 & 23.4% in three species of bivalves. Zhukova and Svetasher

(1986) have observed a sum of polyunsaturated acids from 55.5 to 63.6% in five species of bivalves. Bivalve's polyunsaturated fatty acids are essential nutrients and also, as part of the overall fat supply may affect the prevalence and severity of cardiovascular disease, diabetes, cancer and age-related functional decline.

In the present study, eight vitamins were detected in *A. granosa*. Among them, vitamin K and E were found in higher levels 41.7 & 15.6 mg/g, whereas folic acid and B12 were noticed as lower levels 0.99 and 0.26mg/g, whereas other macro vitamin A were in negligible level 2,250 IU. Srilatha *et al.* 2013 observed the fat soluble vitamins A, D, E and K were 14.40IU, 200IU, 1.18 mg/g and 0.62 mg/g in *M. casta*. Vitamins E and K is an indispensable nutrient required to maintain fresh quality, immunity, normal resistance of red blood corpuscles to haemolysis; permeability of capillaries and heart muscle (Nair and Mathew, 2000). In the present study vitamin K and E were found in higher levels 41.7 & 15.6 mg/g, whereas other macro vitamin A was in negligible level 2,250 IU in bivalve *A. granosa*. Shellfish covered in the present study showed complete vitamin profile as the levels required from good health.

In the present study totally, 5 macro minerals and 2 trace minerals were detected. Among the macro minerals, calcium 175.2 mg/g, potassium 112.8 mg/g and copper 0.24 mg/g were observed at higher and lower levels, whereas other macro-minerals sodium and magnesium were in negligible level. The trace minerals such as iron 0.45 mg/g and zinc 0.32 mg/g were also detected in bivalve *A. granosa*. Coombs (1974) reported more than 40% of soluble copper and zinc in the oyster *Ostrea edulis*. Minerals in different species of pearl shells from South China Sea were rich, particularly in Ca, P and Zn contents (Laihao *et al.*, 1999). Mollusc shells consist mainly of $CaCO_3$, however, so that calcium demand of these animals is big. Jurkiewicz-Karnkowska (2005) showed a significant contribution of organic shell matter to the total shell weight of unionid bivalves. Ca is necessary to maintain an optimal bone development, more of this various being required during childhood and growing stages to prevent rickets and osteomalacia (Salaskar and Nayak, 2011). Shellfish can absorb minerals directly from the aquatic environment through gills and body surface. In the present study bivalve *A. granosa* tissue showed higher level of calcium & potassium and good source of minerals. Thus the present study enlightens the possible role of this clam in the field of human nutrition.

The present study determined the biochemical composition of estuarine bivalve *A. granosa*. The biochemical constituents (protein, carbohydrate, lipid, moisture and ash content), amino acids, fatty acids profile, vitamins and minerals values were evaluated. In general, shellfish food is one of the most nutritionally balanced foods. The shellfish food diet helps to control weight and goes a long way towards preventing heart diseases. Studies on total biochemical composition of commercial shellfish food in India are limited. This might be due to lack of awareness on benefits of these nutrients particularly from bivalve meat. The nutritional values of bivalve are not brought to the limelight so far, so consumption of these nutrient rich bivalves has not attracted attention. The results of the present study provide information about the biochemical composition, but also suggest the consumption of this bivalve, *A. granosa.* It is rich in proximate composition, amino acids (lysine), fatty acids (palmitic acid and alpha linolenic acid), Vitamins (K& E) and minerals (calcium & potassium). The evaluation of the biochemical composition of *A. granosa* clearly indicates that the blood clam has higher biochemical composition comparable to those reported for several other shellfish species. The results of this study showed that the samples possessed appreciable quantities of all the dietary elements tested, which could make them partial or complete substitutes for conventional shellfish food.

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# Impact of Chlorpyrifos on Total Protein Content in Different Tissues of the Black Clam V*illorita cyprinoides* from Vemband Lake

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## ABSTRACT

The indiscriminate use of chlorpyrifos in agriculture fields causes serious pollution problems in aquatic environment. The pesticides thus reach the fresh water systems influence the non-target aquatic species. The present study was carried out to investigate the effect of one of the largest market-selling organophosphorus insecticides, chlorpyrifos on total protein content in different tissues of the black clam, *Villorita cyprinoides* from Vembanad Lake. The clams were exposed to sub-lethal concentration of chlorpyrifos along with one solvent acetone control, and control for 10 days. The results showed a marked decline in the protein content in selected tissues. It indicates that chlorpyrifos toxicity adversely affect the biochemical constituents like proteins in bivalves and also suggests that *Villorita cyprinoides* may be used as a reliable biological indicator for assessing pesticide contamination or other environmental stressors. Thus it is understood that monitoring the protein content of various tissues of bivalves exposed to the toxicants, would be helpful in minimizing the deterioration of the quality and thus the loss in clam production.

**Keywords:** Protein alteration, Chlorpyrifos, *Villorita cyprinoides*.

## INTRODUCTION

Agrochemical poisoning in Kerala has a long history .Currently, there have been multiple episodes of pesticide poisoning reported in Kerala .India is the No. 1 manufacturer of basic pesticides in Asia. The pesticide residues in food in India, especially vegetables, are the highest in the world. Vembanadu is a major Ramsar site, the second largest wetland in the country, which is very close to Kuttanad, often referred to as the rice bowl of Kerala.The lake plays key role in agricultural development of Kuttanad agrosystem.Now it is faced with serious problems of chemical contamination, and pesticide poisoning, which alter the entire water quality of the wetland ecosystem and threaten the survival of aquatic species.

Pesticides are known to disturb the entire metabolism after entry in the body of aquatic organisms.Exposure to pesticides evokes several behavioral, physiological,and biochemical changes that appear to be closely related. To counteract any stress, energy reserves, which might otherwise be utilized for growth,and reproduction will have to be diverted towards enhanced synthesis of detoxifying ligands or expended in order to maintain an elevated efflux of pollutants(Satyaparmeswara *et. al.*, 2006).

The present study was undertaken to evaluate the toxicity of the largest market-selling and multipurpose insecticide chlorpyrifos, which is widely use in paddy fields of kuttanad . Fresh water bivalves amongst the molluscs are economically important hence, an attempt is made to investigate the effect of chlorpyrifos on the total Protein content in different tissues like mantle, foot, gills, adductor muscles of freshwater bivalve clam Villorita cyprinoides which is commonly seen in the freshwater end of the Vembanad Lake.

## MATERIALS AND METHODS

### Materials used for the study

Chlorpyrifos:- Commercially available chlorpyrifos 50% EC (PARABON) used as multipurpose insecticide in agricultural and domestic purposes

**Sampling**

Live and healthy samples of fresh water *Villorita cyprinoides* measuring about 24- 26mm in length were collected from Vembabanadu lake near Muhamma Panchayath in Alappuzha district. Soon after the collection the bivalves were cleaned and transported to the laboratory in well aerated plastic containers and acclimatized in glass holding tanks for five days. The water was continuously aerated with 220V air pumps and changed daily.

**Experimental design for Biochemical analysis**

The LC50 values were calculated using SPSS Probit Analysis (Finney 1971).After determining the LC 50 value of chlorpyrifos (2.30ppb) clams were divided into three groups, with ten clams in each group. GroupI-control, groupII-Acetone contol and and groups III, sub-lethal concentrations of 96hr-LC 50 value of chlorpyrifos1/10(0.230ppb).Tank water was renewed every 24hr and fresh solution of chlorpyrifos was added to maintain pesticide concentration constant.Sampling was done after 10days. Tissues like gills, adductor muscles, mantle, and foot were removed and protein estimation was done by Lowry's Method(1951).

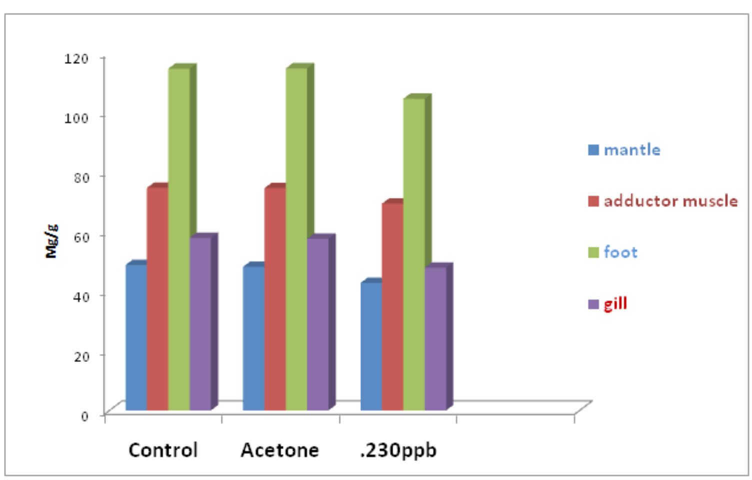
## RESULT AND DISCUSSION

**Table 1.1: Levels of Protein alteration in the Chlorpyrifos exposed tissues of Villorita cyprinoides**

| Tissue | Control | Acetone Control | 0.230 ppb |
|---|---|---|---|
| Mantle | 48.8 ± 0.854 | 48. ± 0.66 | 42.8 ± 0.80* |
| Adductor Muscle | 74.7 ± 0.70 | 74.6 ± 0.97 | 69.4 ± 0.89* |
| Foot | 114.7 ± 0.87 | 113.8 ± 0.90 | 104.6 ± 0.68* |
| Gill | 57.9 ± 0.66 | 56.6 ± 1.22 | 47.9 ± 0.75* |

Values expressed as mg/gm wt. of tissue, (+) or (-) indicate percent variation over control, Each value is the mean of six observations ± S.D., *Significantly different from control

**Figure 1: Bar-chart Showing levels of Protein alteration in Chlorpyrifos exposed tissues of Villorita cyprinoides**




In the present study obtained results demonstrated that, after chronic exposure to pesticides chlorpyrifos a marked depletion in the protein contents in the mantle, foot, gills,and adductor muscles of the experimental bivalve *Villorita cyprinoides* was observed as compared to control. After 10 days of exposure at point 0.280 ppm, protein content of all tissues decreased significantly. Gills showed a decrease in protein content from 57.9 to 47.9 mg gm -

1 weight. Protein content in adductor muscle were found to be decreased from 74.7 to 69.4 mg gm $^{-1}$.Mantle and foot showed a decrease in protein content from 48.8 to 42.8 mg and 114.7 to104.6 gm $^{-1}$ weight respectievely. There was no significant difference in total Protein content in acetone control when compared to control after 10 days of exposure in chlorpyrifos

A marked fall in the protein level in all the tissues indicates a rapid initiation of breakdown of protein. To meet the energy demand during toxic stress, mobilization of protein might have taken place ( Waykar *et al*., 2001). The decrease in average total protein content of tissue after treatment suggests enhancement of proteolysis to meet the high energy demands under toxic stress .Protein may be channelized into TCA cycle through aminotransferace system to cop up with excess demand of energy during toxic stress (Kabeer et al.,1978).

Depletion of protein content in animal tissue after exposure to various pollutants was reported by some previous investigators ( Mahajan and Zambare, 2005; Gulbhile, 2006; Satyaparameshwar *et al*., 2006; Nawale, 2008; Pardeshi and Gapat, 2012). Ramana Rao and Ramamurthi (1978) observed alteration in protein content in tissue of *Pila globosa* after sumithion exposure. Lomte and Alam (1982) reported depletion of protein content in various body tissue of snails, after malation significant decline in protein content in fresh water mussel *Lamellidens marginalis* exposed to metacid.Kharat *et. al*., (2009) observed decrease in total protein content was possibly due to stress condition caused by toxicity of tributyltin chloride on protein metabolism or due to enhanced proteolytic activity . Decrease in protein content was possibly due to stress conditions caused by toxicity of chlorpyrifos on protein metabolism or due to enhanced proteolytic activity as a consequence of increased metabolic demands following exposure to the toxic stress of pesticide. *Villoritta cyprinoids* shows shift in its metabolism for survival and maintenance and additional demand of energy leads to accelerated catabolism of protein this affect the nutritive value of edible organism.

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# Evaluation of Hygiene in Fishing Vessel of Munambam and Cochin Fishing Harbour

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**Abstract**

Hygienic practices and microbial quality of the fishing vessels in Munambam and Cochin fishing harbour were studied and compared. Total Plate Count (TPC) in the fish species like *Megalaspis cordyla*, *Cynoglossus cynoglossus*, *Rastrelliger kanagurta* and *Sardinella longiceps* collected from the fishing vessels of Munambam harbour showed low count than Cochin fishing harbour. Similarly, lowest count for coliforms was also noticed in water, workers hand and deck of the fishing vessel of Munambam harbour. Similarly, better hygienic practices were adopted in personal hygiene, quality of ice and condition of the deck of the vessel in Munambam fishing harbour. These indicate a relationship between hygienic practices and lowest bacterial contaminationin the fishing vessel of Munambam harbour. Hence, implementation of ideal hygienic practices is highly recommended not only in the fishing harbour but also for fishing vessels for maintaining the quality of seafood.

***Keywords:*** Fishing vessels, hygienic practices, TPC, coliforms, quality, fishes

## 1. Introduction

Consumer greatest concern is the quality and safety of the food. Freshness of fish is fundamental to its quality and state of freshness can be distracted by a variety of definite properties of the fish which can be assessed by various indicators. Thus the freshness and quality of the end product are depend on different biological and processing factors, that influence the degree of physical, biochemical and microbiological changes occurring during the postmortem changes in fish (Jaya-Naik *et al.*, 2014). In order to achieve the quality, it is important to popularize good hygiene practices in harvesting and post-harvest handling of food. Post-harvest handling of seafood is the most vital step in the production of high quality finished product (Devadasan *et al.*, 2009). To maintain the quality of seafood the primary fish handlers via, crew of fishing vessels, workers at fishing harbors and fish retailers must be educated on good hygiene and sanitation practices. Most of them are unaware they are potential carriers of pathogenic microorganism and poor personal hygiene makes the fish unsafe for human consumption (Madusudana *et al.*, 2005). The several studies indicated that better knowledge leads to better adoption of hygienic practices (Sanoria *et al.*, 1992). Keeping the freshness of the fish is very important and has become a major concern in the fishing industry. The quality of the product reaching the end-user will greatly depend on post harvest handling of the seafood. Much emphasis has been given on hygienic handling of the fish right from catch, in order to ensure good quality and long shelf life. Primary responsibility for ensuring the quality of landed seafood rests with those who handle it onboard. Many factors affect the quality of seafood onboard such as cleanliness of the deck and fish holds, quality and quantity of water used, temperature at which seafood is maintained, the general handling practices adopted, cleanliness of the equipments and utensils used in handling, packaging and storage and the personal hygiene of the fish handlers. The quality of ice is of utmost importance to preserve fishery products from being spoiled.

The ice should be made of fresh water or portable water to produce good quality ice (Jackie-Singh *et al.*, 2012).

The estimated fisherman population of Kerala is 10.134 lakhs, among this active fishermen are 233206 nos. Marine production of the state is 5.22 lakh tones during 2013-14. The total number of fishing vessels operated in Kerala is approximately 31808. Among this, 26382 are motorized non-mechanical, 3548 motorized mechanized and remaining are npn-motorized. Modern handling and transportation practices introduce several quality control measures and also diversifying the product (Braj-mohan *et al.*, 2003). The present study was designed to evaluate and compare the level of hygienic and sanitary conditions implemented in the fishing vessels and the microbial quality of Cochin and Munambam fishing harbor.

## 2. Materials and Methods

### 2.1. Sample collection

Fresh fish samples were collected from fishing harbour during the early hours of the day. Aseptically, some portion of meat along with skin from the dorsal region of the fish is collected by using sterile scissors and transferred in to sterile containers. Water sample was collected in a sterilized glass bottle and the swab was used to determine the coliforms from workers hand and deck of the vessel. Samples were immediately brought in to the laboratory for microbiological analysis.

### 2.1.1 Microbiological analysis

Total plate count and MPN for coliforms of the samples collected from the fishing vessels of Cochin and Munambam Fishing harbour were determined as per the methodology described by Surendran *et al.*, (2009).

### 2.2 Analysis of hygienic practices

Survey was carried out with the help of a detailed questionnaire randomly from the fishing vessels of Cochin and Munambam fishing harbour, in order to understand the level of implementation hygienic practices. During the survey, the information's were collected from the boat owner, boat operators and fish handlers.

## 3. Result and discussion

### 3.1 Comparison of TPC

Total plate count of *Megalaspis cordylla*, *Cyanoglossus cyanoglossus*, *Rastrelliger kanaguurta* and *Sardinella longiceps* collected from fishing vessels of Manambam and Cochin fishing harbour is depicted in the figure 1, 2, 3 and 4, respectively. Rahman (1980) suggested that TPC is the most common method for the assessment of spoilage of seafood. It was found that, TPC of *M. Cordylla* collected from the fishing vessel of Cochin harbour showed higher count (6.35 $\log_{10}$cfu/g) than the Munambam fishing harbour (5.1 $\log_{10}$cfu/g) (Figure 1). Similarly, TPC showed a count of 5.25 and 4.97 $\log_{10}$cfu/g, respectively in *C. Cyanoglossus* collected from Cochin and Munambam fishing vessel (Figure 2). In the case of *R. Kanagurta* collected from Cochin and Munambam fishing vessel showed a count of 5.7 and 4.12 $\log_{10}$cfu/g, respectively for TPC (Figure 3). Similarly, TPC was 5.98 and 3.81 $\log_{10}$cfu/g, respectively in *S. longiceps* collected from the fishing vessel of Cochin and Munambam fishing harbour (Figure 4). Lowest TPC was noticed in all fishes collected from the Munambam fishing vessel than Cochin fishing vessel. Lashmanan et al. (1984), reported that 66.4% of total landing at Cochin fishing harbour showed a TPC greater than $10^{-5}$ $\log_{10}$cfu/g.

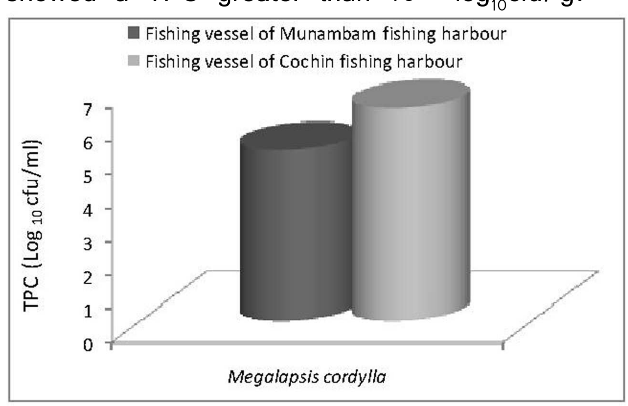


Figure 1: Comparison of TPC in *Megalaspis cordylla* collected from the fishing vessel of Munambam and Cochin harbour.

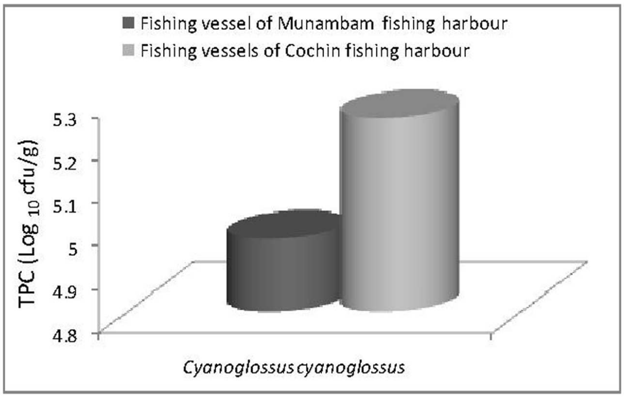


Figure 2: Comparison of TPC in *Cyanoglossus cyanoglossus* collected from the fishing vessel of Munambam and Cochin harbour

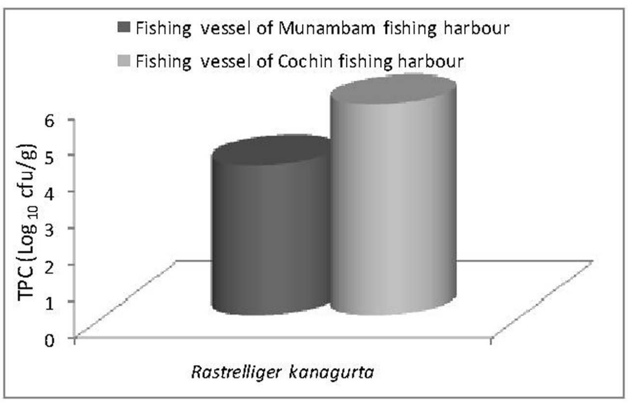


Figure 3: Comparison of TPC in *Rastrelliger kanagurta* collected from the fishing vessel of Munambam and Cochin harbour

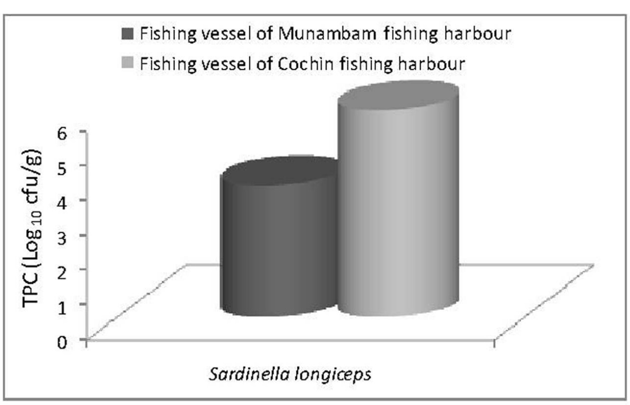


Figure 4: Comparison of TPC in *Sardinella longiceps* collected from the fishing vessel of Munambam and Cochin harbour

### 3.2. Comparison of coliforms

Comparison of the count of coliforms in the water, worker's hand and boat deck fishing vessel of Munambam and Cochin fishing harbour clearly depicted in figure 5, 6 and 7, respectively. It was found that the coliform count for water (800 MPN), worker's hand (1000 MPN) and deck of fishing vessel (120 MPN) of Munambam harbour showed less count than Cochin harbour (*i.e.*, 1400, 1300 and 500 MPN, respectively in boat deck, water and worker hand). High numbers of faecal coliforms during monsoon and post monsoon season have been reported in Cherai beach, Cochin backwaters, Bhavanagar coast, port blair bay, Andamans and Nagore, and east cost of India (Goyal *et al.*, 1977), which was due to land run of continuous dispose of untreated sewage. Ghaly *et al.*, (2010) suggested that seafood is highly perishable than other meats and about 30 % of landed fish are lost through microbial activity alone.

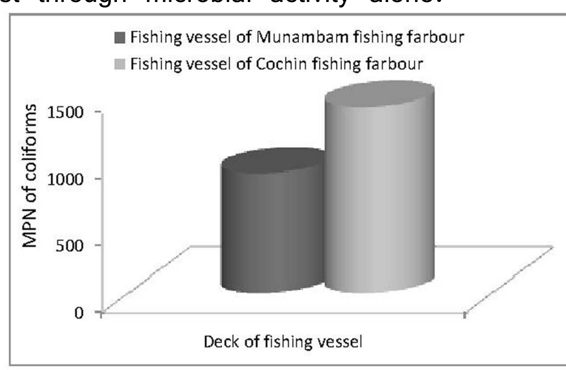


Figure 5: Comparison of coliforms in deck of fishing vessel of Munambam and Cochin harbour.

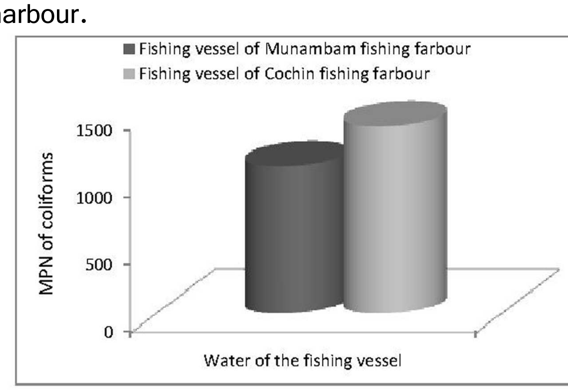


Figure 6: Comparison of coliforms in the water of fishing vessel of Munambam and Cochin harbour

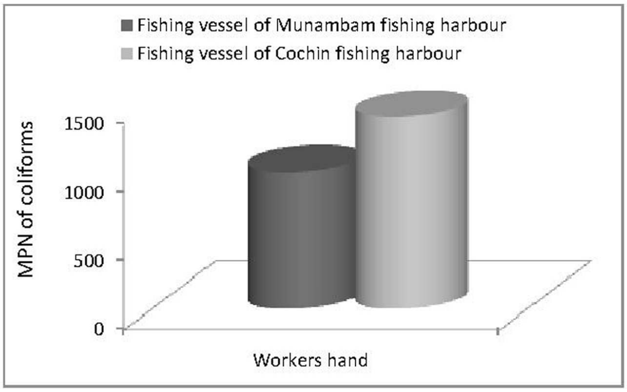


Figure 7: Comparison of coliforms in workers hand in Munambam and Cochin harbour

### 3.3 Comparison of hygienic condition

Findings from the survey clearly revealed that the fishing vessel of Munambam harbour maintained better hygienic practices, i.e. personal hygiene, quality of ice and hygienic condition of the deck than the fishing vessels of Cochin harbour (Figure 8). Better hygienic practices being maintained in the Munambam fishing harbour may be the reason for the lowest TPC in *R. kanagurta*, *C. cyanoglossus*, *M. cordylla* and coliforms in water, worker's hand and deck of fishing vessel. The design and construction of a vessel and the construction materials shall be such as to permit easy and adequate cleaning and disinfecting and to facilitate the maintenance of good hygiene. The design and construction of the vessel shall be such as to obviate the danger of direct or indirect contamination of the product and product contact surfaces, and to facilitate hygienic operations by means of a regulated flow in the process, from the reception of the raw product to the delivery of the final product. Vessels to be converted into factory freezer vessels shall be large enough to accommodate adequate processing and freezing equipment and shall have adequate freezing and frozen storage space. The frozen product processed and stored on board shall be of the same quality as that processed and stored in land-based processing plants.

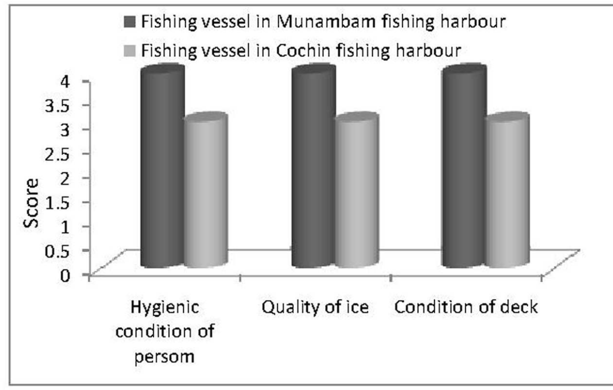


Figure 8: Comparison of hygienic conditions in the fishing vessel of Munambam and Cochin fishing harbour.

## 4. Conclusion

The hygiene and sanitation condition of fishing vessels of Cochin harbour was not meeting the normal level compared to Munambam fishing harbour. This was mainly due to inadequate sanitation and hygienic practices in Cochin fishing harbour. Fish handlers were mainly responsible for the poor state of hygiene and sanitation in the vessel. In order to cater good quality of seafood to both domestic and International market, a well maintained hygienic condition in the fishing vessel is highly necessary. Microbial quality of fishes, water, hands of worker and deck of the vessel of Munambam fishing harbour was satisfactory. Similarly, findings from survey, it was clearly evident that vessels of Munambam fishing harbour were maintaining better hygienic practices. Hence, this experiment can be concluded that adoption of effective hygienic practices is highly mandatory for marinating the quality of seafood not only in the fishing harbour but also in fishing vessel. In order to achieve this, thorough monitoring of hygienic inspector, proper implementation of Hazard Analysis Critical Control Point (HACCP) and conduct awareness programmes to the fish handlers are highly recommended.

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