FISH AND FISHERIES IN VEMBANAD LAKE

Consolidated Report of Vembanad Fish Count 2008- 2011

ATREE
Ashoka Trust for Research in Ecology and the Environment

Community Environmental Resource Centre (CERC), Ashoka Trust for Research in Ecology and the Environment (ATREE)

Supported by

Kerala State Biodiversity Board

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Krishna Kumar K and Priyadarsanan Dharma Rajan

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Forword

Vembanad Lake is the largest tropical wetland in the west coast of India with a length of 96 km. Based on the rich biodiversity and socio economic importance, Vembanad Lake along with adjacent Kole lands was declared as a Ramsar site - a wetland of international importance (Ramsar, 2002). Vembanad Kole wetland and its ten associated drainage basins are characterized by its rich biodiversity of fauna and flora. Vembanad lake was also renowned for its fin and shell fish resources which played a major role in protecting the livelihood security, employment security and food security of population living in the vicinity of this backwaters. This lake is also well known as the home ground of Giant Freshwater Prawn (Macrobrachium *rosenbergii*). I had been involved in conducting various studies on ecology and fisheries of Vembanad Lake over the past four decades. The fishery wealth of this lake has been quantified and the impact of the Thanneermukkom salinity barrage on the ecology and fisheries. have been bought out .More than one hundred and fifty species of fish belonging to 100 genera and 56 families are known to occur in Vembanad Lake. And Southern portion of the lake where Vembanad Fish Count was conducted was known to harbour around 60 Species of Finfishes.

Fish and fisheries were the backbone industry for the rural fishermen residing in and around the lake. The drastic decline in these resources forced the fishermen to undertake various unethical practices which resulted in alarming decline of the fisheries resources. The composition of fish fauna has altered in the past few decades and the habitat degradation is another major consequence. The major habitat alteration that took place in Vembanad Lake was due to the construction of a 1.441 km long bund in 1976 at Thanneermukkom to avert salt water incursion on to the paddy fields of Kuttanad region. The construction of barrage has affected the ecosystem health resulting in decline of primary productivity and fishery resources, growth of macrophytes and degradation in water quality are well documented consequences of this intervention.

The fish count being coordinated by the ATREE, with the collaboration of various government and non-governmental agenecies and Academic institution in and around Kerala assumes greater significance in this context. As the First Vice chancellor of Kerala University of Fisheries and Ocean Studies, I was happy to join the programme in 2011 and inaugurate the program in Alappuzha. The data base generated as part of the Vembanad fish counts would substantially help in the sustainable management of wetland living resources.

The persons and Institution behind the program should be congratulated for their efforts in coordinating and leading the programme. I sincerely appreciate the efforts taken by the Community Environmental Resource Centre, Ashoka Trust for Research in Ecology and Environment in bringing out the consolidated report based on the results of the Fish count carried out during 2008-2011.I hope that this document would be invaluable for the Scientists, academia, administrators and policy makers who are directly involved in various programs related to wet land conservation and the sustainable utilisation of resources.

I wish all success.

17/5/2012

Prof. B. Madhusoodana Kurup
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Executive Summary

- *Vembanad Fish count* 2008-2011 has recorded 67 species of fin fishes and 14 species of shell fishes.

Vembanad Fish Count	Fin fish	Shell fish
2008	50	10
2009	61	14
2010	53	14
2011	44	14

- Six brackish water fish species recorded in 2009 was not observed during 2008, 2010 and 2011.

- The Euryhaline conditions created by the early opening of Thannermukkom barrage which allowed salinity influx, is the reason for high fish diversity in 2009.

- Total of 5 exotics viz; *Pterygoplichthys multiradiatus* (Sucker catfish), *Catla catla* (Catla), *Labeo rohita* (Rohu) *Oreochromis mossambicus* (Tilapia) and *Pangasious suchi* (Suchi catfish) were observed in *Vembanad Fish Count 2009*. No exotic fishes were recorded in 2011.

- A serious decline in the population of the dwarf puffer, *Carinotetraodon travancoricus* was noticed over the past three years, which comprised to 90% of the catch by experimental fishing in 2008, dwindled to 2% in 2009 and was very rare or absent in 2010 & 2011.

- VFC 2008-2010 recorded 67 Species of Finfishes and 14 species of shell fishes and the earlier study Headed by Dr. Madhusoodhana Kurup, Vice Chancelor Fisheries University in 1985 and 1989 recorded 60 species.

- Out of 60 Species reported in the previous studies (Kurup, 1985; Kurup 1989) 23 species are not recorded while 24 species are added in Vembanad fish counts 2008- 2011.

- *Clarias dussumieri, Ehirava fluviatilis, Macrognathus guentheri* and *Ompok bimaculatus* are the four freshwater fishes missing in the lake. Of which *Clarias dussumieri* is completely extruded and may be locally extinct. The reasons for the missing of these species demands further research.

- According to Kurup (1985 and 1985) the fish fauna of Vembanad was dominated by the marine migratory species (56%). During this survey saline tolerant/freshwater species dominates (with 69%) and the marine migrants are reduced to 31%

- Kurup et al (1989) & Kurup and Samuel(1985) recorded 49% of omnivorous fishes, followed closely by 44% carnivores and 4% herbivores and 3% detritivores. Vembanad Fish Count 2008-2011 shows a decline of carnivores (28%) and dominance of omnivores (58%) followed by 6% herbivores, 6% larvivores, and 2% detritivores. This is an indication of organic pollution of the lake.

- Carry bags, bottles and other plastics dumped to the lake settles to the bottom has adversely affected the bottom feeders like gobids, and has also affected the fishes that attach their eggs to the bottom soil as the habitat changed.

- Changes usage of the waterscape and surrounding landscape, Pollution from solid wastes such as plastic thrown to the lake, pesticides & fertilizer runoffs from the paddy fields, loss of mangroves, unsustainable Fishing Practices and exotic weeds and fishes are identified as the major threats to the fishery of Vembanad Lake.

Chapter 1

Introduction

Vembanad Lake (9° 34' 60 N, 76° 25' 0 E) is a transitional ecotone between sea and land having a length of 96 km and a surface area of 1512 km^2. The rich biodiversity and socio economic importance, of Vembanad lake along with adjacent *kole* lands led to the declaration of the lake as a Ramsar site, a wetland of international importance. Ten rivers which originate from the Western Ghats Biodiversity Hotspot drain to the lake and eventually join the Arabian Sea. The mangrove patches and islands in the lake like *Pathiramanal* also provide habitat for resident and seasonal migratory water fowl, otters, fish, clams, shrimps, crabs, aquatic insects and other aquatic organisms. The lake is also famous for its tourism potential, live clam resources and sub-fossil shell deposits, as a habitat for the vulnerable spot billed pelican *Pelicanus philippensis*, large populations of water fowls, besides a high species diversity of finfish and shellfish (WWF 2002). One hundred and fifty species of fish belonging to 100 genera and 56 families are known to occur in Vembanad Lake (Kurup and Samuel 1985). Extensive water and land remodeling efforts in Vembanad Lake has drastically changed the lake's water and landscapes, altering natural habitats of many terrestrial and aquatic fauna and flora. Past economic, agricultural and industrial development has overlooked the importance and necessity of conservation and management of natural

resources. It was generally thought to be a luxury, to be concerned with such matters in the face of prevalent poverty and hunger existed in this most densely populated area of the state of Kerala. The more pressing challenge for the subsequent governments after India's independence was to meet the basic needs of a rapidly amplifying population than conservation of the natural resources. So the major anthropogenic interventions in Vembanad region were focused on to escalate the agricultural production in the reclaimed areas of Kuttanad. An artificial spillway was constructed at Thottappally in 1955 for flood control and to escalate agricultrural production (Gopalan et al., 1983). But the spillway channel was not constructed according to the required dimensions, which resulted in the partial evacuation of the floods. Thaneermukhom Bund, a 1.441 km regulator cum barrage constructed during 1976 to avert salt water incursion on to the paddy fields of Kuttanad, - was another major human intrusion in Vembanad Lake. The decline in primary productivity and fishery resources, growth of macrophytes and degradation in water quality are well documented consequences of this intervention. Of 33 species of fishes reported from Kuttanad area, the catches of several have declined drastically. Large scale fish mortality has also been observed on several occasions (Azis & Nair, 1981). The tidal flushing prevalent in the entire lower Kuttanad region has ceased and there has been a drop in water level in the upstream region. In addition, drop of salinity and the agricultural run offs from the paddy fields has caused an unprecedented growth and spread of noxious aquatic weeds like *Salvinia (Salvinia molesta* D.Mitch.*) and* water hyacinth *(Eichornia crassipes* (Mart.) Solms*)* leading to severe eutrophication of the lake. Apart from adversely affecting the lake ecosystem, this has created problems for paddy cultivation, navigation and fishing. The oligohaline condition created by the Thanneermukhom barrage has caused severe setbacks to the clam production. Vembanad wetland has been widely acclaimed as the 'inland fish basket' of Kerala for centuries. But due to habitat alteration, eutrophication and other anthropogenic stressors the fish production has drastically reduced in the near past. Fish production in the entire wetland has been quantified to 7200 tons per annum. Consequent to ecosystem alterations,an estimate on the exploited catches of the fishes on the southern stretches of the lake has been found to be only 584 tons per annum, (Padmakumar *et al*, 2001), a mere seven percent of the total catch for entire Vembanad lake. Before the construction of the barrage southern stretches were contributing forty to fifty percent of the total catch which obviously indicates the extent of fishery decline due to the construction of the barrage. Apart from the threat posed by the barrage there is extensive overfishing, especially during the monsoon period even from the spawning grounds where they congregate. The high mortality of the broodstock and the juveniles affects the stock for the succeeding years, thereby reducing recruitment and, thus, overall production. (Krishna Kumar *et al. 2008*) In some cases, this has contributed to the local extirpation of certain species like *Clarias dussumieri*.

Traditionally, conservation and management of the resources of Vembanad, especially fishery resources were vested with the local fishing communities. These community-based management systems evolved at the local or grassroots level, and were actively involved in the management of the resources they relied on for sustenance and livelihood security.

There were several customs and traditional practices which were directly or indirectly protecting the fishery resources. Such functions, responsibilities and authority, however, slowly changed hands and are now vested with state government departments. People lost the feeling of ownership and to cope with the increasing living expenses, changed lifestyles and scarcity of resources, they adopted many destructive fishing practices which have accelerated the decline of fishery resources in the lake. In spite of the existence of several rules and regulations for the conservation and management of fishery resources and regulating the use of destructive gears, effective control mechanisms could not be exercised as the fishermen were not convinced of the same.

Vembanad Fish Count (VFC)

Ashoka Trust for Research in Ecology and the Environment (ATREE) initiated the "Vembanad Fish count" in this backdrop as an annual participatory fish assessment during May 2008 and repeating it in every year since then. Several institutions and agencies like the Kerala State Biodiversity Board, Regional Agricultural Research Station (RARS, Kumarakam) of the Kerala Agricultural University, Vembanad Nature Club and various Lake Protection Forums of the fisher folk are the co -organizers of the event. Kerala University of Fisheries and Ocean Sciences (KUFOS, *erstwhile* Fisheries College, Panangad), St Albert's College (Ernakulam) and Environment Science department of the Mahatma Gandhi University are providing the necessary technical support for the event. VFC is a democratic paradigm in research and development which is different from the conventional top-down approaches. It is a stakeholder driven program where the targeted group participates in the entire process, learning about the situation, identifying problems, discussing alternatives, seeking solutions, designing and implementing activities, evaluating and disseminating results. In these processes, fisher folk of Vembanad share their traditional knowledge to identify problems and solutions, ensuring that the poor and uninformed will not be excluded from decision making and development opportunities. Such dialogue initiated during the Vembanad fishcount has lead the foherfolk to organize as Lake Protection Forum(LPF). 14 units of LPFs are now registered and are federated as Federation of Lake Protection Forums. LPFs are taking a leading role in organizing several conservation programs at Vembanad. One of the important activities of LPFs is the *Matsyathaavalam* (fish sanctuaries). Fishermen have created 6 small fish sanctuaries (no fishing area with breeding supports for fishes) based on their traditional knowledge.

Researchers, NGOs, environmentalists and media persons from allover South India and students, fishermen, local self governments, schools, from around the lake are participating in this annual event and are very eager to learn about the status of fishery resources of the lake. This event has helped to consolidate views on the issues and convinced the need for immediate interventions in this sector, especially through participation of the stakeholders. This report acknowledges the efforts of each and every participant of this and appeals all concerned to initiate adequate measures to safeguard the lake and its biodiversity.

Coastal backwaters and inland water bodies are economically efficient systems, now fast declining due to lack of care, improper management, over exploitation and lack of awareness. One of the hopes of backwater conservation lies in the 'active involvement of the dependent communities in the management of the natural resources. This can be made possible only by institutionalizing community rights over protection and harvest of the natural resources. In the last few years, Ashoka Trust for Research in Ecology and the Environment (ATREE) has been trying to address some of the conservation issues faced by Vembanad Lake (Kerala) through a deliberative democratic process (www.vembanad.org). ATREE aims to increase coordination between stakeholders and strengthen their capacity to address the various issues related to Vembanad backwaters and build multi sectoral and multi stakeholder partnerships at the local level to influence decision making.

Objective

The main objective of this participatory assessment is 'to bring attention to the declining status of inland fisheries in the Vembanad Lake and to create a common platform to consolidate attention of all concerned, including the policy makers to discuss conservation issues.

Methodology

Wide media publicity was given about the 'Vembanad Fish Count 2008- 2011, inviting participation of interested individuals. Institutions like Fisheries college, St Albert's College, Ernakulam, Environmental Science department of local Universities, Kerala State Biodiversity Board, Regional Agricultural Research Station, schools and colleges in Vembanad region, Cochin University of Science and Technology, Kerala State Pollution Control Board and Non Governmental Organizations etc. were contacted, invited to participate.

Responding to the call, 120-150 volunteers participated in every fishcount drawn from various universities, colleges, nature clubs, societies and NGO's. The participants were divided into three cruise teams, and each team sampling from one sector of the lake *viz* west bank sector (Mohamma cruise), riverine (Kuttanad cruise) and 'east bank (Kumarakom cruise). Five sampling points were identified in each sector viz. Kavanattinkara, Kumarakom, Nazareth and Pallom in the east bank . 'Punnamada, Pallathuruthy, Kainakary, Nedumudy and Pullincunnu in the riverine stretch. Muhamma Pathiramanal Aryad and Mannachery in the west bank.

Each cruise team was further subdivided to assign responsibilities for 1) experimental fishing, 2) collecting data from landing centres, 3) collecting data from fishermen in the lake and 4) water quality monitoring. One week before the event, a scoping survey was conducted to identify the key landing centers around the lake. Camps were arranged near the landing centres and team left early in the previous evening, to collect data from early morning hours on the fishcount day.

The rest of the cruise teams were flagged off from Mohamma at 6 AM and survey concluded at 3 PM. For fish sampling and inventory of species the methodology of Meeenachil Fish count, 2004 (Padmakumar *et al* 2006) and River fish Monitoring Program (Bijukumar *et al 2010*) was used with due modifications to suit to the estuarine system. At most possible care was taken to ensure that the sampling effort was uniform through out.

Experimental fishing (undertaken by local fishers) was carried out from 4 AM to 12 PM on 30th May 2008, 26th May 2009, 28th May 2010 and 26th May 2011 at the various sampling sites mentioned above using variety of gears including gill net, cast net, drag net and scoop net.

Resource use inventory was carried out wherein the number of sand mining units, shell mining units, house boats , number of fishing units, encroachments, waste dumping activities and extent of weed cover was observed and assessed using detailed observation schedule.

Fishing ground inventory was carried out with the due participation of local fishers who allowed us to check the species, which contributed to their catch on that day. An *Identification key prepared for fish count* was referred to identify the fish. Enquiries were also made on the fishing methods and socio-economic information of the fishers.

Landing centre inventory - The major landing centers around the sampling sites were also visited on 30th May 2008, 26th May 2009, 28th May 2010 and 26th May 2011 and the species diversity of the catches were recorded. The type of gear used and the percentage of commercially important fishes to the catches were recorded in consultation with the fishers.

Water Qualaity

The data generated from the *Jaladarpanam* water quality monitoring program of Lake Protection Forum (LPF) and the data generated during fishcounts also used for the analysis of water quality presented in the chapter 2.

Jala darpanam (Vembanad Water Watch):

The Members of Lake protection forum are now trained in monitoring the water quality of lake, are doing a regular analysis of lake water quality and display it in village information boards set up for this. The data is also made available to the public through India BiodiversityPortal (http://indiabiodiversity.org/layer_info.php?layer_name=lyr_50_vembanad_basinstations). The community is using this information as a tool for better bargaining with authorities for scheduling the operation of the Thanneermukkom bund, which is critical for the paddy cultivation as well as fishery wealth of the lake.

Water quality parameters tested includes parameters like pH, transparency, temperature, D.O, Alkalinity and salinity. pH was determined using pH paper, Transparency using Secchi Disc and Temperature using Mercury Thermometer , Dissolved Oxygen, Alkalinity as $CaCo_3$, salinity were determined using standard procedures at the sampling sites. And the parameters like Chloride, Alkalinity, Hardness, Calcium, Magnesium, Phosphate, Sulphate and Iron was determined by using the water quality analysis kit made by CPR Environment Education Centre.

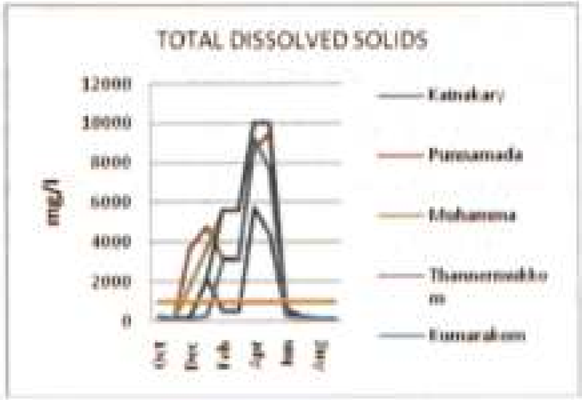
Chapter 2

2.1 Physiochemical Environment

TDS: The expression, "total dissolved solids" (TDS), is the total amount of all inorganic and organic substances – including minerals, salts, metals, cations or anions – that are contained within a volume of water. TDS concentrations are used to evaluate the quality of freshwater systems. TDS concentrations are equal to the sum of positively charged ions (cations) and negatively charged ions (anions) in the water. Sources for TDS include agricultural run-off, urban run-off, industrial wastewater, sewage, and natural sources such as leaves, silt, plankton, and rocks. High concentrations of particulate matter affect light penetration and productivity, recreational values, and habitat quality, and cause lakes to fill in faster. Particles also provide substratum for other pollutants, notably metals and bacteria. While TDS is not considered as a primary pollutant,

Figure 1 . TDS levels in Vembanad lake

(October 2009 to September 2010)



high TDS levels typically indicate hard water. TDS levels more than 1000mg/l is considered to be not favorable for the aquatic organisms.

The TDS in Vembanad lake tend to increase between the month of December to May in all the sampling stations. TDS value is low during the months of June to November. This clearly shows the effect of Thanneermukkom salt water barrier as the TDS shoots up during the season when the bund is closed. The average value of TDS in the lake is around 2500 mg/l and Thanneermukkom shows the maximum TDS in March, April and May. Lowest TDS is observed in Kainakary. The graph (fig. 1) shows the monthly fluctuations in TDS values in Vembanad lake.

Nitrates and Nitrites: Nitrate (NO3) and nitrite (NO2) are produced as a result of biological breakdown of organic wastes containing ammonia such as e, animal feces or fertilizers containing these chemicals.

Although not particularly toxic to aquatic organisms, excess nitrates and nitrites in the water is often used as an indicator of poor water quality. The permissible limit of nitrate is 50 mg/l. Levels exceeding 0.55 mg/l (ppm) nitrite-nitrogen can cause 'brown-blood' disease in finfish.

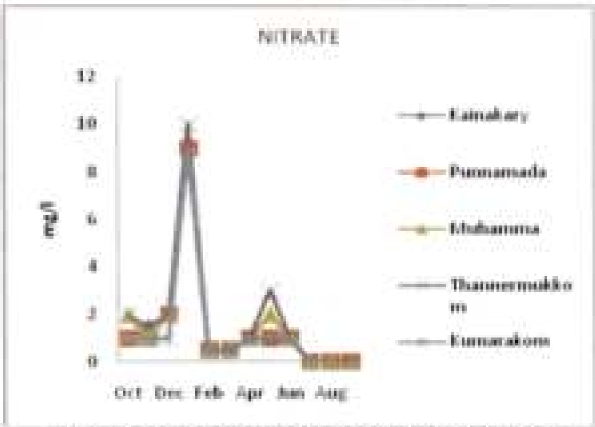


Figure 2 . Nitrate levels in Vembanad lake (October 2009 to September 2010)

Anaerobic conditions may result in the formation and persistence of nitrite. The presence of large quantities of nitrites in Vembanad lake is indicative of water pollution due to possible agricultural run off from the adjoining paddy field in Kuttanad.The primary health concern regarding nitrate and nitrite is the formation of methaemoglobinaemia, which is also known as "blue-baby syndrome." Nitrate is

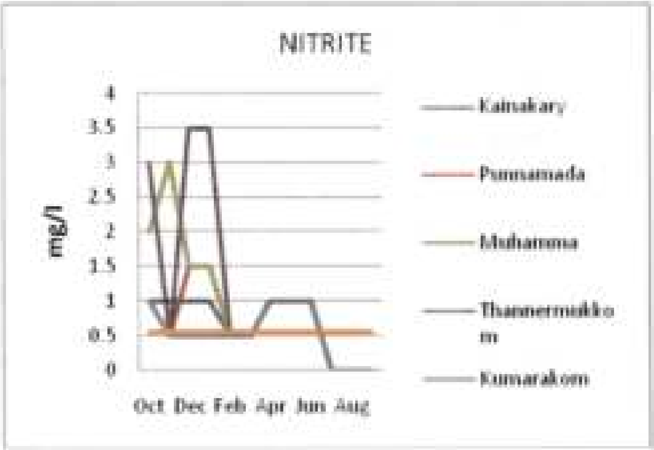


Figure.3 Nitrate level in Vembanad lake (October 2009- September 2010

reduced to nitrite in the stomach of infants, and nitrite is able to oxidize haemoglobin (Hb) to methaemoglobin (metHb), which is unable to transport oxygen. The reduced oxygen transport becomes clinically manifest when metHb concentrations reach 10% or more of normal Hb concentrations; the condition, called methaemoglobinaemia, causes cyanosis (appearance of a blue or purple coloration to the skin due to oxygen deficiency) and, at higher concentrations, asphyxia, a condition of severely deficient supply of oxygen to the body.

The normal metHb level in infants under 3 months of age is less than 3%. The Hb of young infants is more susceptible to metHb formation than that of older children and adults.

The concentration of nitrate and nitrite tend to increase during the months of January and February when the water influx from the rivers is low, and is absent in the lake during the monsoon months of July, August and September. The possible reason for increase of nitrogenous compounds is mainly due to the use of nitrogen based fertilizers in the paddy field. As the flow of water is regulated during the months of December to March these pollutants are integrated with the lake water. (fig 2 & 3)The presence of these pollutants can result in algal blooms and result in further disasters like mass mortality in fish, foul smell in water etc.

Phosphate: High phosphate concentration in surface waters also indicate fertilizer runoff, domestic waste discharge, or the presence of industrial effluents or detergents. If high phosphate levels persist, algae and other aquatic life will flourish, eventually decreasing the level of dissolved oxygen due to the accelerated decay of organic matter.

Algal blooms are encouraged by levels of phosphate greater than 25 micrograms/L. The phosphate level above 0.1 mg/l is regarded as unhealthy. The concentrations of phosphate tend to increase during the months of January, February, March and April and show a declining trend from May. (fig 4)Phosphate is found to be absent in the lake during the months of August, September, October, November and December. The possible reason for increase of phosphate is mainly due to the use of chemical fertilizers. As the flow of water is regulated during the months of December to March phosphate gets blended with the lake water. The presence of excess

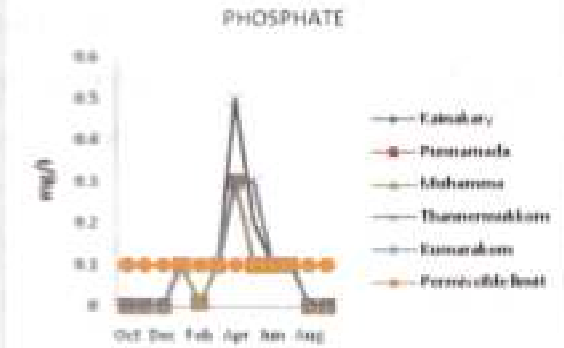


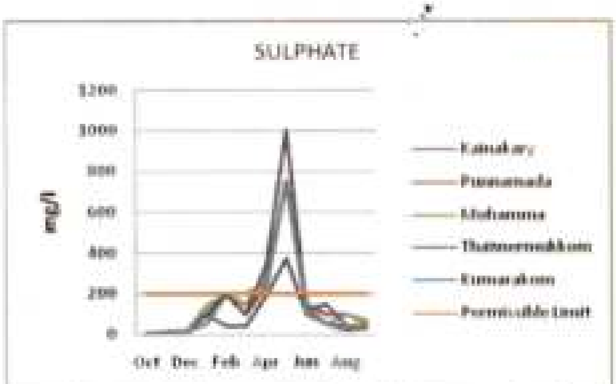
Figure 4 . Phosphate levels in Vembanad lake (October 2009 to September 2010)

phosphate can result in algal blooms and result in

further catastrophe like mass mortality in fish, foul smell in water etc.

Sulphate: The increased concentration of sulphate is due to the flushing off water from the agricultural lands. This can result in the eutrophication a state in which the nutrient content of the system reaches the peak and which results in algal bloom and adversely affect the ecosystem and organisms. The concentration of sulphate tends to increase during the months of March and

Figure 5 . Sulphate levels in Vembanad lake (October 2009 to September 2010)



April and shows a declining trend from May.(fig 5)

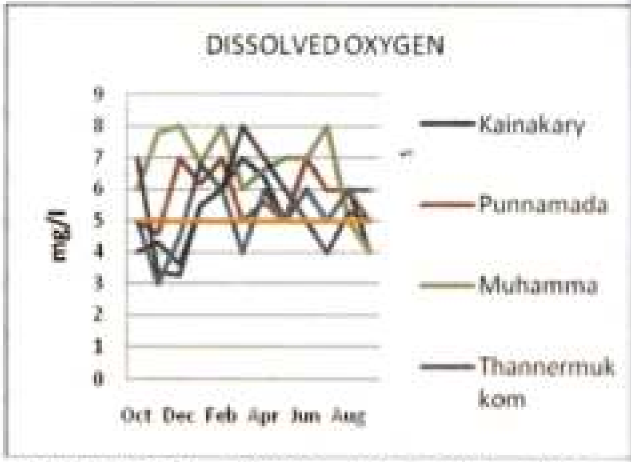
Dissolved oxygen (DO) is the relative amount of oxygen dissolved in water. Oxygen enters the water by diffusion from the atmosphere or through plant photosynthesis. Actual solubility is directly proportional to the partial pressure in the gas phase, to salt concentration and temperature. The dissolved oxygen level in water is constantly changing and represents a balance between respiration and decomposition that deplete oxygen and photosynthetic activity that increases it. So DO is vital to aquatic life. Presence of organic waste in water may overload a natural system causing serious depletion of the oxygen supply that in turn leads to fish kills.

Likewise, eutrophic waters, rich in nutrients, achieve the same result through causing massive proliferation of algae (algal blooms) whose eventual decomposition uses up the available dissolved oxygen.

A DO content of greater than 5 mg/l in water is required for sustaining aquatic Fauna. Like terrestrial animals, fish and other aquatic organisms need oxygen to live. As water moves past their gills (or other breathing apparatus), microscopic bubbles of oxygen gas in the water are transferred from the water to their blood. Like any other gas diffusion process, the transfer is efficient only above certain concentrations.

In other words, oxygen can be present in the water, but at too low a concentration to sustain aquatic life. Oxygen also is needed for many chemical reactions that are important to lake functioning. Oxygen is produced during photosynthesis and consumed during respiration and decomposition. As it requires sunlight, photosynthesis occurs only during daylight hours. Respiration and decomposition, on the other hand, occur 24 hours a day. This difference alone can account for large daily fluctuations in DO

Figure 6 . DO levels in Vembanad lake (October 2009 to September 2010

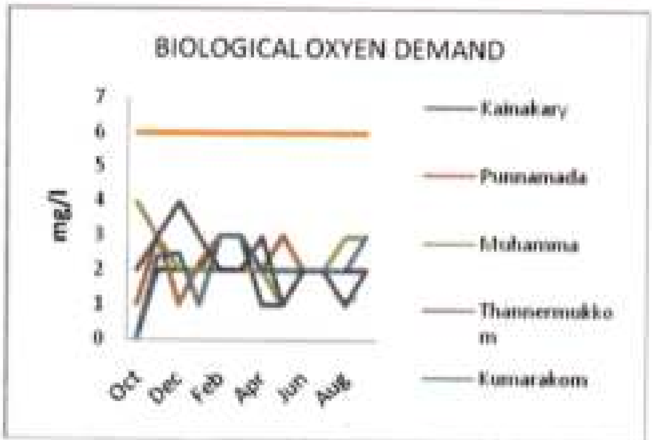


concentrations. During the night, when photosynthesis cannot counterbalance the loss of oxygen through respiration and decomposition, DO concentrations steadily declines.

They are lowest just before dawn, when photosynthesis resumes. To the degree that pollution contributes oxygen-demanding organic matter (like sewage or lawn clippings) or nutrients that stimulate growth of organic matter, causes a decrease in average DO concentrations. If the organic matter is formed in the lake, for example by algae growth, at least some oxygen is produced during the growth to offset the eventual loss of oxygen during decomposition. However, in lakes where a large portion of the organic matter is brought in from outside the lake, the balance between oxygen production and oxygen consumption becomes skewed and low DO may become even more of a problem. The DO found in Vembanad lake is stable and is sufficient for sustaining aquatic life.(fig. 6) A DO of 8mg/l was observed in two sites- Muhamma in February and Thannermukkom in March. The lowest DO was recorded at Kumarakom (3mg/l) in November.

Biological Oxygen Demand (BOD): BOD measures the amount of oxygen utilized by organisms in the biochemical oxidation of organic matter in a wastewater sample in a specified time (usually 5 days), and at a specified temperature. BOD measurements are used as a measure of the organic strength of the water. Although it is not identical to COD, the speed at which one can obtain COD test results, often dictates that this test is used for prescription purposes. Typical natural water has a BOD from 0.8 to 5 mg/l. Anything above 6 mg/l needs to be treated as unsafe as it will rob the water of needed oxygen. Similar to DO, BOD in Vembanad lake also is stable. A BOD of 0mg/l was observed in Kumarakam and Kainakary in October. The Highest BOD (4mg/l) was recorded at Muhamma in October and Thannermukkom in December.

Figure 7. BOD levels in Vembanad lake
(October 2009 to September 2010



2.2 Microbial Pollutants

The quantity of faecal coliform bacteria *Escherichia coli (E. coli)* in the water is a recommended indicator of fecal contamination for waters. *E. coli* is present in high numbers in the gastrointestinal tracts of warm-blooded animals and they can survive in the waste material or water contaminated with feces for a limited time and therefore is a good indicator of fecal contamination of water. Sources of *E. coli* that can impact lake water are numerous and can include combined sewer overflows; sanitary sewer overflows, leaking septic systems, water drained down from Pampa river during Sabarimala pilgrimage seasons, waste discharge by houseboats, storm water runoff, agricultural runoff, wildlife, and domestic pets.Another important source for the increased level of feacal coliforms are illegal house boats without proper bio tanks and the people who discharges human waste directly to the Lake. Most probable number is the method used to estimate the amount of feacal coliforms. The permissible level of coliforms in recreational waters is 400 and is nil for drinking water. But the level of coliforms in the Vembanad lake is far beyond this i.e. above 1100. Although not necessarily agents of disease, fecal coliform bacteria may indicate the potential presence of disease-carrying organisms such as *V. cholerae*, which live in the same environment as the feacal coliform bacteria.

The studies also indicate that the lake is highly polluted during the month of October with bacteria contamination at the sites like Pallathurithy, Punnamada, Muhamma, Thannermukkom and Kumarakom. *Vibrio cholerae* the cholera causing bacterium is found in every site. This is an alarming situation, as there are chances of cholera infection among people who use this water for drinking, washing kitchen utensils and accidental ingestion while bathing and swimming. The lack of proper sewage systems in the lakeside towns and the toilets directly opening to the lake s the reason for high bacterial contamination of the lake. The presence of *V. cholereae* is found at Pallathuruthy region which is fed with water from river Pampa. The extent of *V. cholereae* in Vembanad lake is very high compared to the permissible levels.. An outbreak was reported in 2009 and the chances of cholera outbreak in the fringes of Vembanad lake still exists.

Chapter 3

VEMBANAD FISH COUNT 2008-2011

Vembanad fish 2008-2011has so far has recorded 67 species of fishes belonging to 46 genera and 34 families. The list also includes 2 introduced fishes viz; *Catla catla* (Katla) and *Labeo rohita* (Rohu) and 3 exotic fishes viz; *Pangasianodon hypophthalmus (the* Sutchi catfish*)*, *Oreochromis mossambicus,(* Tilapia*)* and *Pterygoplichthys multiradiatus* (suckermouth catfish). Species list is provided on Table 1 and an annotated check list of fishes of Vembanad is given in Annexure 1.

Table 1. Fish fauna of Vembanad lake and its presence and absence in VFC 2008-2011

Si No	Species	2008	2009	2010	2011
1.	***Alepes djedaba***		√		
2.	***Ambassis ambassis***	√	√	√	√
3.	***Amblypharyngodon melettinus***	√	√	√	√
4.	***Amblypharyngodon mola***	√	√	√	
5.	***Anabas testudineus***	√	√	√	√
6.	***Aplocheilus lineatus***	√	√	√	√
7.	***Aplocheilus panchax***		√		
8.	***Arius maculates***	√	√	√	
9.	***Arius subrostratus***	√	√	√	√
10.	***Balistes capriscus***		√		
11.	***Brachirus orientalis***	√	√	√	√
12.	***Butis butis***			√	√
13.	***Carangoides malabaricus***	√	√	√	
14.	***Carinotetraodon travancoricus***	√	√	√	√
15.	***Catla catla***	√			√
16.	***Channa marulius***	√	√	√	√
17.	***Channa gachua***		√		
18.	***Channa striata***	√	√	√	√
19.	***Chanos chanos***	√	√	√	
20.	***Chelonodon patoca***		√		
21.	***Cynoglossus macrostomus***	√	√	√	√
22.	***Dayella malabarica***	√	√	√	√
23.	***Etroplus maculates***	√	√	√	√
24.	***Etroplus suratensis***	√	√	√	√
25.	***Eubleekeria splendens***	√	√	√	√
26.	***Gerres filamentosus***	√	√	√	√
27.	***Gerres setifer***	√	√	√	
28.	***Glossogobius giuris***	√	√	√	√

29.	*Heteropneustes fossilis*	√	√	√	√
30.	*Horabagrus brachysoma*	√	√	√	√
31.	*Hyporamphus xanthopterus*	√	√	√	√
32.	*Hyporhamphus limbatus*				√
33.	*Johnius dussumieri*		√		√
34.	*Labeo dussumieri*	√	√	√	√
35.	*Labeo rohita*				√
36.	*Labuca dadiburjori*	√			
37.	*Lates calcarifer*		√		
38.	*Mastacembelus armatus*	√	√	√	√
39.	*Mugil cephalus*	√	√	√	
40.	*Mystus armatus*	√	√	√	√
41.	*Mystus gulio*	√	√	√	√
42.	*Mystus vittatus*	√	√	√	
43.	*Nandus nandus*	√	√	√	√
44.	*Ompok malabaricus*	√	√	√	√
45.	*Oreochromis mossambicus*	√			√
46.	*Pangasianodon hypophthalmus*		√		
47.	*Parambassis dayi*	√	√	√	√
48.	*Pseudoambassis ranga*	√	√	√	√
49.	*Parambassis thomassi*	√	√	√	√
50.	*Photopectoralis bindus*	√	√	√	
51.	*Pristolepis rubripinnis*		√	√	√
52.	*Pseudosphromenus cupanus*	√	√	√	√
53.	*Pseudosphromenus dayi*	√	√	√	
54.	*Pterygoplichthys multiradiatus*		√		
55.	*Puntius amphibius*	√	√	√	√
56.	*Puntius filamentosus*	√	√	√	√
57.	*Puntius mahechola*		√	√	√
58.	*Puntius sarana sarana*	√	√	√	√
59.	*Puntius sarana subnasutus*		√	√	

60.	***Puntius ticto***		√	√	√
61.	***Puntius vittatus***	√	√	√	√
62.	***Rasbora daniconius***	√	√	√	√
63.	***Scatophagus argus***	√	√	√	
64.	***Siganus javus***		√		
65.	***Stolephorus indicus***	√	√	√	√
66.	***Wallago attu***	√	√	√	√
67.	***Xenentodon cancilla***	√	√	√	√
	Shell Fishes				
1.	***Metapenaeus dobsonii***	√	√	√	√
2.	***M. monoceros***		√	√	√
3.	***Penaeus monodon***	√	√	√	√
4.	***Fenneropenaeus indicus***	√	√	√	√
5.	***Macrobrachium rosenbergii***	√	√	√	√
6.	***M. idella***	√	√	√	√
7.	***Leptocarpus potamiscus***	√	√	√	√
8.	***Caridina naderjoni***	√	√	√	√
9.	***C. pseudo-gracilirostris***		√	√	√
10.	***Scylla serrata***	√	√	√	√
11.	***S.tranquebarica***		√	√	√
12.	***Villorita cyprinoides***	√	√	√	√
13.	***Lamelliden marginalis***	√	√	√	√
14.	***Pila globosa***	√	√	√	√

3.1 Fish Fauna of Vembanad Lake.

Fishes of Vembanad Lake play a crucial role in sustaining the livelihood of the fishermen residing along the lake and maintaining its ecosystem health of the Vembanad Lake . Lack of data about the status of fishes of Vembanad Lake in public domain raised lot of wrong assumptions about fish fauna of the lake. Swaminathan Commission Report mentions that *"The multiple reports have recorded that 23 species of fishes have become extinct as water body got shrunk, the fish population and diversity got reduced".* Statement like this might mislead as the document doesn't show the list of fishes that got extinct or no supportive evidences are available to establish this. Studies in recent past have demonstrated that any premature claims of local extinction of fish species should be cautiously verified before conservation measures are prescribed (Knight 2010; Knight & Remadevi 2010).

The fishery decline in the lake is due to many stressors like habitat alterations, overexploitation, pollution, introduction of exotic fishes, (Padmakumar *et al* 2001, Krishnakumar *et al* 2008, Krishnakumar *et al* 2011) etc..

More than 30% of the lake's ichthyofauna is represented by catfishes belonging to the family Hetropneustidae, Siluridae and Bagridae (11 Speeies) barbs belonging to the family Cyprinidae with 10 species. Cyprinids unlike most other fish species, increase in abundance in eutrophic conditions. This can be attributed to the abundance of their food resources- the zooplanktons which grazes on the algae which blooms in the eutrophic conditions. Catfishes also can survive in polluted or eutrophic conditions. 3 species of snake heads which can survive in adverse conditions also accounts to the fauna of the lake. The lake also have 4 species of glass fishes which occurs in standing water, and breeds prolifically during the rainy season and feeds on crustaceans, annelid worms, and other invertebrates. The lake has 3 species of cichlids. Once renowned for its mullets and sea bass lost its pride after the construction of the Thanneermukkom. The population of thse fishes has gone down drastically and has become extremely rare in the lake. The stable or mere increase in number of species can not be taken as an indicator of a healthy situation of fishery in Vembanad lake. The stock of many fish species have dwindled in the last decade. Unsustainable fishing methods practiced by the fishers to tackle the scarcity of resources exacerbated the situation resulting in abrupt exhaustion of economically viable fish species.

3.2 **Changes in fish Fauna of Vembanad**

Kuttanad Water Balance study (1985-1989) recorded 60 species of fishes from the southern sector of the lake i.e. the region from Thanneermukkom to Kuttanad. The study also recorded 150 species of fishes from the entire Vembanad Lake. The fish faunal diversity and composition of the lake has changed during 2008-2011 as the number of fishes in the lake has heaved to 67species. Among this 5species added to this list are those got introduced to the lake intentionally (ranching) or unintentionally (accidental escape from culture ponds/aquaria). Tilapia (*Oreochromis mossambicus*) was the only exotic fish that occurred in the lake during 1980's but the scenario changed after two decades 4 introduced fishes was recorded from the lake during 2008-2011. Another alarming fact is that 28 species reported from the lake during 1985-1989 is not recovered during this survey. An analysis of the missing species revealed that 86% (fig 8) of the missing fishes are migratory fishes from the sea to the freshwater zones (for spawning and feeding). Thannermukkom barrier prevents the entry of these marine migrants to the lake. The resident fishes those are missing in the survey includes *Clarias dussumieri, Ehirava fluviatilis, Macrognathus guentheri and Ompok*

Figure 8. Composition of fishes missing in Vembanad Lake after 1989

bimaculatus of which *Clarias dussumieri* is extirpated completely and locally extinct in the lake as there are no records of the species from the lake since 2005. The exact reason behind the local extinction of *Clarias dussumieri* an omnivorous fish is not known. It is widely assumed by the fishery experts that the species didn't recover itself from the *epizootic ulcerative syndrome* that affected the fish fauna of the lake in 1991. Missing of *Ehirava fluviatilis, Macrognathus guentheri and Ompok bimaculatus* in the lake requires further studies. There is considerable chances

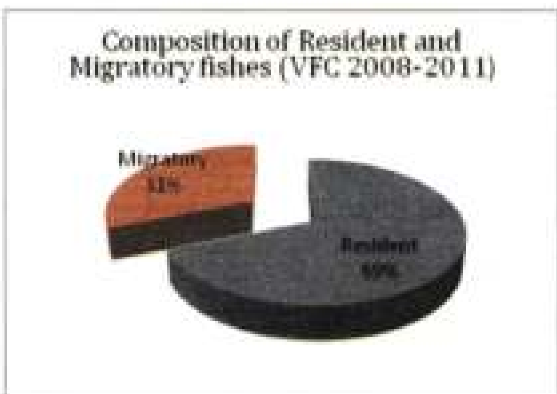
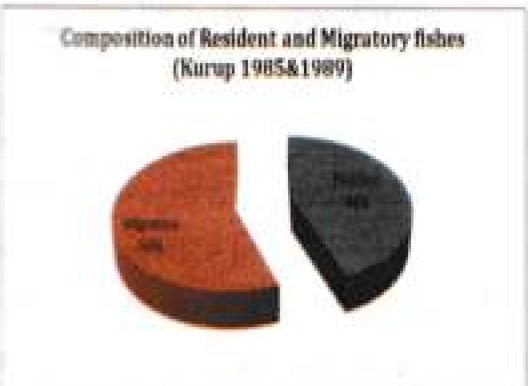


Figure 9. Composition of fishes VFC 2008-2011

of taxonomic error in identifying the species as the some individuals identified as *Mastacembelus arnatus and Ompok malabaricus* may actually have been , *Macrognathus guentheri and Ompok bimaculatus* respectively as both species has been recorded in all previous surveys. 24 fishes were added to the fauna of Vembanad through fish count since the 1989 effort. The list (VFC 2008-2011) is dominated by the freshwater fishes. 69% (fig 9). The southern sector of the lake is enriched with freshwater from 4 rivers that
drain into the lake which makes it an idealhabitat for freshwater fish species

Figure 10. Composition of fishes Kurup 1985 and 1989



In 1985 and 1989 the fish fauna of the lake was dominated by the migratory species (56%). (fig 10) but in the last two decades the trend has got reversed and now the lake is dominated by the resident fish species (69%). (Fig 9)

Among the 24 fishes added, only 6 species constitute the marine migrants and 18

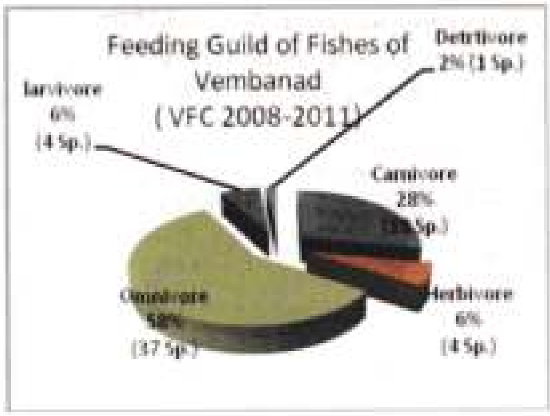
Figure 11. Composition of fishes added to Vembanad Lake after 1989

species are freshwater fishes with minor value to fisheries (Fig 11) while fishes absent in the lake are fishes with high fishery value and in 1980's these fishes played a significant role in sustaining the livelihood of the fisherfolk of the Vembanad.

The fishery wealth of the lake helped to affirm its status as an inland 'fish basket' of Kerala by contributing significantly to the bulk of the inland fishery catch of the state. . This survey during 2008-2011 shows that the the composition of species of lesser or minor fishery importance has become more abundant. Composition shows that the southern side of the barrage is converted to a fresh water lake with occasional influx of salinity which is not certain. The climatic changes also cascades this action as heavy summer rains in the recent years and the prolonged monsoon similar to the one in

2010-2011 prevent saline intrusion into the lake even when the barrier is open

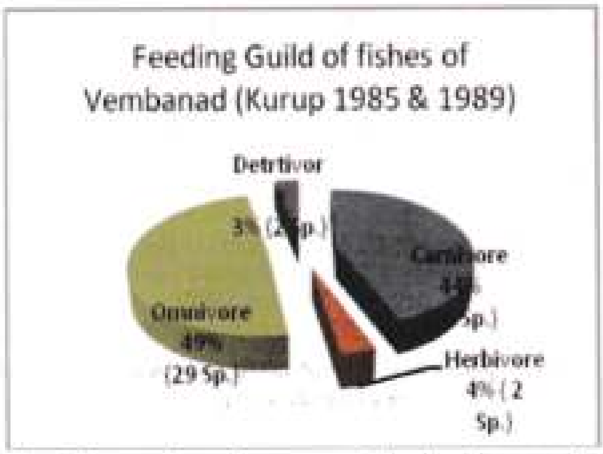
Figure 11.Feeding Guild of fishes VFC 2008-2011



A swing in the feeding guild also is evident in the composition of fishes in Vembanad between 1985 and 2011. as Kurup *et al*(1989) & Kurup and Samuel (1985) have recorded 49% of omnivorous fishes, followed by carnivores 44%, herbivores (4%) and detritivores (3%). (Fig 13) The VFC- 2008-2011 has recorded 58% omnivores 28% carnivores and 6% herbivores, 6% larvivores, and 2% detritivores. (Fig 12)

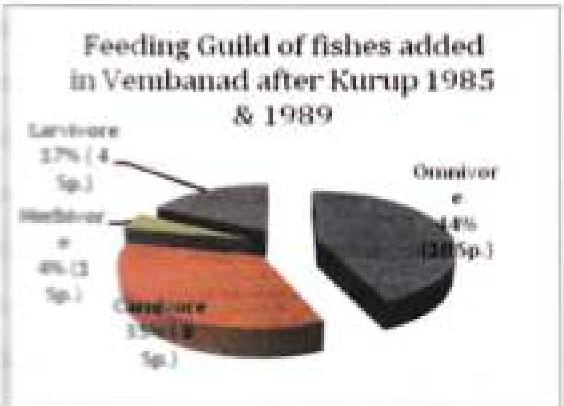
An analysis of the feeding guild of the the 29 species missing after 1989(fig 14) studies shows that 62% of those were carnivores while 35% were omnivores and 3% detritivores. Whereas among the 23 fishes (excluding the exotics) newly reported during subsequent VFC's, omnivores dominate with 44% followed by carnivores (35%) and larvivores (17%) and herbivores (4%).(fig 15.) The presence of carnivores indicates the health of the ecosystem as the ecosystem integrity is often dependent on the functional presence of carnivores. Removal of the predators results in dissolving the ecological boundaries that check competition. By consuming the smaller fishes and other organisms in the lake through selective feeding. Decline in population of Carnivores

Figure 13. Feeding guild of fishes Kurup (1985 and 1989)



has thus reduce the numerical abundance of a competitively dominant prey species (or by change its behavior) and enforce ecological boundaries that allow weaker competitors to persist. If a predator selects from a wide-range of prey species, the presence of the predator may cause all prey species to reduce their respective niches and thus reduce competition among those species, which can help in the survival of the less dominant species. The present state is that the lake is proliferated with smaller barbs and the number of carnivores reduced so that erection of ecological boundary is not easily possible. The contamination of the lake in the past few years has turned the lake into an organic plunk which helped in the proliferation of the omnivorous fishes as they have a wide spectrum of dietary material.

Figure 13. Feeding guild of fishes added to the lake after Kurup (1985 and 1989)



The scenario might intensify in due course as the organic load in the lake is increases the omnivores will proliferate further causing a decline in the diversity and abundance of other fishes. A gradual shift in the abundant fish species in the lake is already evident. Kurup et. al. (1989) has recorded that the southern sector fishery is dominated by the native catfishes, pearl spot and carplets. Subsequent VFCs found that the fishery has shifted to smaller barbs like filamentous barb which proliferated the lake in the high organic condition.

The catfish fishery which was dominant in the lake has considerably reduced to an uneconomical low. The decline in affected the as they along with frogs of Vembanad larvivorous fishes played a significant role in controlling the mosquitoes in the region. The increase in mosquito bone diseases in vembanad region can be attributed to the decline of larvivorus fishes and frogs in the lake.

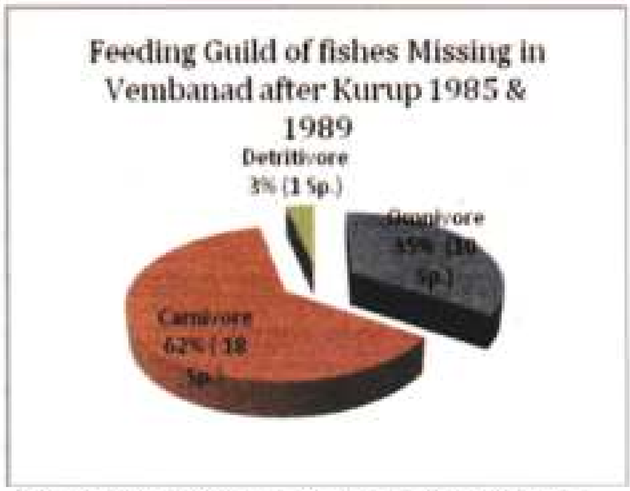


Figure 13. Feeding guild of fishes added to the lake after Kurup (1985 and 1989)

Chapter 4

Threats to Fishes of Vembanad

4.1 Changes in Waterscape & Habitat Alteration

The major threat to fishes of Vembanad is habitat alteration due to changes in waterscape. Thousands of hectares of the waterbody had been converted to land over past 150 years. According to one study (Gopalan *et al.*, 1983), 23000 ha of the lake had reclaimed between 1834 and 1984, mainly for agriculture and aquaculture. The depth of the lagoon has reduced by 40-50 percent in all zones and as a result the drainage capacity of the lake has been reduced to 0.6 km^3 from 2.4 km^3, a decline of 75 percent (James *et al.*, 1997). Illegal Conversion and encroachment of the lake is visible around the lake even today. Conversion for expanding agriculture has slowed down but reclamation still continue for other purposes.

The construction of the Thaneermukkom barrage and Thottappally spillway has changed the physico-chemical conditions of the lake. Another importatn change is the destruction of mangroves and its associates that was abundant on the shores of the lake.

4.1 a Thannermukkom Barrage

The Thanneermukkom barrier was constructed in 1976 (partially completed) to prevent saline water intrusion into paddy fields during the dry season, and thus bolster paddy cultivation. The closing of the barrier stops the tidal effects, stops the flow of water to the south of the barrier, and thus hinders natural flushing out of contaminants. The accumulation of agro-chemical effluents from the southern farmlands and sewage from adjacent areas leads to increased levels of water pollution. Within few decades of its construction, the area south of the bund became a hotspot of vector and waterborne diseases. Preventing the entry of saline water to the paddy fields led to an increase in pests and weeds, which had to be subsequently eradicated through the heavy use of pesticides and weedicides. This has subsequently affected the general health and livelihood of the people, with the worst affected being the fishermen communities due to the decline of many commercially important fishes. The barrier is regulated by a committee headed by the District Collector and supposed to remains closed from mid December to mid March.The operation of the barrage is connected with the crop calendar of and many farmers fail to follow the calendar due to other reasons such as labour shortage, non availability of seeds in time etc. This results in deviations in the operational schedules causing keeping the bund closed for longer periods. The closure of the barrage during the month of December blocks the high tide that occurs in the southern coast of Lakshadeep sea from entering to the southern sector of lake which prevents the entry of migratory fishes to the lake.

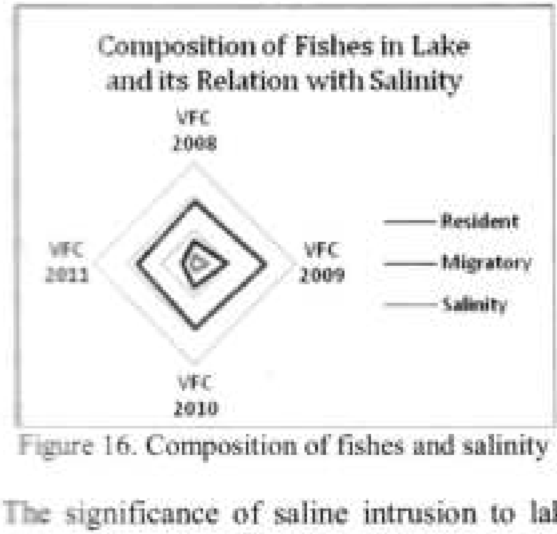
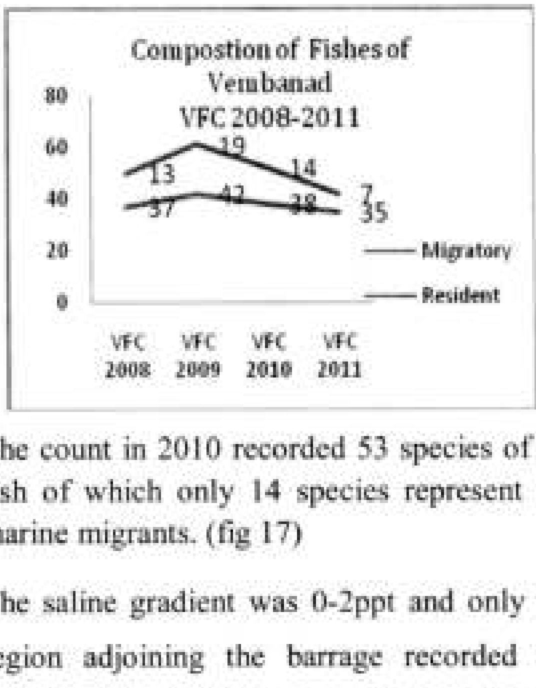


Figure 16. Composition of fishes and salinity

The significance of saline intrusion to lake for fishery evidenced by the data generated from the last four VFCs . As VFC 2008 yielded 51 species of finfish of which 13 species was represented by the marine migrants. *VFC 2009* could identify 61 species of finfish. The increase in the number of species in 2009 was the result of an early opening of Thannermukkom barrage which allowed salinity influx (fig 16) and helped in the occurrence of euryhaline condition. 19 marine migrants was reported in this year even though the salinity gradient of the lake ranged from 1-3 ppt salinity from all the sitses except PallathuruthyIf atleast a saline gradient of 1-3 is maintained in the lake it will help in maintaining the icthyofauna of the lake. Six brackish water fish species recorded in 2009 was

Figure 17 Composition of Fishes

VFC 2008-2011



The count in 2010 recorded 53 species of fin fish of which only 14 species represent the marine migrants. (fig 17)

The saline gradient was 0-2ppt and only the region adjoining the barrage recorded the salinity of 2ppt, while all other zones showed zero salinity. The count in 2011 recorded the least number of migratory fish species (7 sp.) and the salinity was the lowest.The local climatic changes also cascades this action as heavy summer rains prevent saline intrusion into the lake even when the barrage is open and the prolonged monsoon like what we had in 2010-2011 also prevents the saline influx in the southern sector. The construction of the barrage is not complete as per the design. To facilitate an early commissioning to satisfy the pressure lobbies of the farmers the middle of the lake was reclined in haste forming an artificial island. This permanent structure considerably hampered the flushing efficiency of the barrage. Thus reduced flushing out of nutrients and pollutants from the lake causes eutrophication. Moreover the region near the barrage has no saline influx during the months of December to May. Which will bluff the fresh water fishes that breed in April-May Lay eggs in the freshwater zone near the barrage get a salinity shock by the sudden intrusion of salinity, which is fatal for the larvae/eggs.. The Pathiramanl

Island, the only patch were mangrove and associates flourished once is not far from the barrage and Many freshwater fishes of Vembanad are open egg scatters and doesn't show parental care which intensify the issue as the large adults will migrate to the upper reaches of the lake and the eggs and larvae are left over in these zones to face the detrimental effect saline shock.

4.1 b. Agiculture & Reclamation

The main economic activity in this wetland is paddy cultivation. To increase the productivity, farmers depend on heavy use of chemical fertilizers and pesticides, which in turn pollutes the water and environment. Reclamation for agricultural purposes started as a result of severe food crisis existed in India. This resulted in largescale reclamation of Vembanad lake and its backwaters nd resulted in the shrinkage lake area.to 180 km^2 (43% of original) in 1983 (Gopalan et al., 1983). Of the 130 km^2 surveyed in 1998, anotehr 14% (18 km2) has been observed to be reclaimed by both natural and artificial processes (Asharaf, 1998). The reclamation of wetlands for various purposes still prevails in the lake and the need for reclamation shifted from agricultural uses to other economic activities like tourism.

4.1 c Destruction of Mangrove and its associates

Mangrove and its associates are important to fishery as it provides rich source of food, breeding and nursery areas and refuge from predation for shrimp, crustaceans, mollusks, and fishes and provide a.The shores of Vembanad Lake had large extend of mangroves and associates. Large scale removal of these medium height shrubs around the lake has resulted in lack of nursery grounds for the fishes which is detrimental to the fishery wealth. Restoration of mangroves around the lake should be considered as an important activity for lake restoration.

4.2 *Over Exploitation and Unsustainable Fishing Practices*

Overfishing and using unethical fishing methods in Vembanad is another reason thecurrent distress in fishery. It is evident that the Unsustainable fishing practices deployed by the fishers to tackle the scarcity of resources exacerbated the situation resulting in abrupt exhaustion of economically viable fishes. Commons like Vembanad have to face extensive challenges—particularly in terms of resource depletion and conflict between stakeholders. The "Tragedy of the Commons" (Hardin 1968), is true with Vembanad lake also, where individual users see no advantage to conserve or manage the resource sustainably. The op–down management has not resulted in sustainable and socially equitable fisheries. Even though participative co-management arrangements, in which the responsibility of resource management is shared among the state, local resource users, and other stakeholders, incorporating local knowledge, characteristics of the resources and the social groups involved, was found to be successful in forest ecosystems in Kerala. But there are no such efforts to implemet such governance system for managing fisheries.

The traditional *peruvala/ kettu Vala /Adakkam kolli Vala* a seine net having mesh size of 4mm and a length of 50-75m are the most commonly used gears to catch small small fishes. The net don't allow the escape of small fishes ,fry, fingerlings etc. The major fishes exploited by this gear are *Etroplus suratensis Wallago attu, Horabagrus brachysoma, Labeo dussumeiri, Mystus cavasius, Amblypharyngodon mellitinus, Puntius sarana , Puntiius filamentosis , Ompok malabaricus, Ompok bimaculatus, Etroplus maculatusmaculatus, Pristolepis marginata, Nandus nandus*. Even though this gear is banned by Government of India, proper enforcement has not yet been achieved in regulating this gear. The use of this gear is a threat to the biodiversity as it has been observed during post monsoon season(August – September) when a large number of juvenile bye catch were found among the catch.

Many indigenous communities across the globe have been using many poisonous plants as 'fish poisons' for fishing. As time passed, chemical poisons replaced the plant poisons. Fish poisons are used in shallow, stagnant and slow flowing waters. Mass poisoning kills the fishes and larvae, around the major river systems as well as lakes and estuaries. .Root of bamboo as well as fruits of sapindas and entire *Acasia torta* plant are used as fishpoisons. Several kilograms of these plant parts are used in order to catch fishes, the usage at different river systems is based upon the local availability of the plant. Poisons are mainly used to catch fin fishes *like Channa punctatus* , *Channa marulius Channa micropeltes* ,*Channa striatus Horabagrus brachysoma Hetropneustes fossilis* , *Labeo dussumieri* , ,*Wallago attu* , *Puntius sarana* ,*Puntius filamentosus* ,*Etroplus suratensis* etc. Copper sulphate is a chemical used in shallow and lower reaches of rivers. It is not commonly used by the traditional fishermen in Vemband but the migratory fisher groups coming from nearby states Karnataka and Tamil Nadu use it .They use small round boats made of bamboo locally known as kottavallam (coracle). They will set gill net cross the river and from a distance they will put copper sulphate which is wrapped in cloth .The presence of copper sulphate will make the fish run away from the site and while escaping from the region they get entangled on the gill net that has already been set. CuSo4 a strong algicide will affect the water quality of that area and mass destruction of small fishes and other aquatic organisms .This practice is intended to catch *Horabagrus brachysoma Hetropneustes fossilis* , *Labeo dussumieri* ,*Wallago attu* , *Puntius sarana* ,*Puntius filamentosus* ,*Etroplus suratensis* , *Anabas testudineus* , etc. The after effect of using copper sulphate is so adverse as all the fishes inhabiting in that region will eventually die due to the intoxication. In some areas certain pesticides are also use 'fish poisons' for fishing.

4.3 Pollution

The problems faced by organic pollution of the lake is discussed earlier. The inorganic materials like plastics that are dumped to the lake gets settled to the bottom of the lake has adversely affected the bottom feeders like gobids, and has also affected the fishes that attach their eggs to the bottom soil as the habitat changed. Fishes get attracted tothe plastic bags that are thrown to the lake with food remnants get entangled and dies. Many such bags with dead fishes entangles in it were found during the VFCs and according to fisherman fish mortality due to plastic bags are increasing day by day High concentration of plastics in the lake bed affects the fish by destroying its natural environment. Pollution from pesticides, weedicides and fungicides too affect the fishes as the rigorous use of these agrochemicals in to which the fishes are sensitive. Earlier many fishes were using paddy fields as breeding and nursery grounds Than cradles of fshes, the over use of pesticies has eventually converted the paddy fields to a graveyard of fishes Use of these non target chemicals destroys the aquatic invertebrates which prove vital for the survival of many fishes. Use of pesticides and weedicides also resulted in the decline in larvivorous fishes which are known to harbor small canals and channels inside and adjoining the fields.

4.4 Exotic Fishes

A total of 5 exotics are reported from the lake,which includes 2 transplanted fishes viz; *Catla catla* and *Labeo rohita* and 3 aquarium scapes viz; *Pangassious suchi, Oreochromis mossambicus,* and *Pterygoplichthys multiradiatus*. Apart from these two exotics viz; *Clarias garipinus* and *Trichogaster trichopterus* were reported from the lake in an independent study(Krishnakumar *et al*2009, Krishnakumar *et al*2011). These invasive species, i.e. non-native species that spread beyond the introduction site and become abundant (Rejma´ nek et al., 2002) are increasingly recognized as one of the main threats to biodiversity and a global challenge. An invasive alien species is an alien species which becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biological diversity (Williamson 1996; IUCN, 2000; Shine et al. 2000; McNeely et al. 2001). Williamson (1996) has suggested the ''three tens rule'':10% of imported species will be introduced into new environments; 10% of these will become established; 10% of these will become invasives. The introduction of exotic species is, arguably, a more significant anthropogenic stressor than eutrophication or toxic chemicals (Chapman, 1995) and, along with habitat destruction, is the leading cause of extinctions and resultant biodiversity decreases worldwide. Thus the presence of these exotics in Inland water bodies like Vembanad integrates the issue as the native fishes in the lake is facing threats from various sources.

Chapter 5

Conservation Interventions

Fish Sanctuary in Kumarakam

The first engineered fish sanctuary was constructed in Kumarakam by the Regional Agricultural Research Station (RARS). A circular area of 10ha was cordoned off by planting coconut and bamboo piles at close intervals to hinder fishing and obstruct operation of crafts and gears. Since the substratum at this location was muddy, artificial sand hills were formed on the. A variety of artificial 'nest' and 'reef ' substrates were deposited/ installed on the lake floor to provide nesting surfaces for pearlspots (*Karimeen*), as the fish is known to attach their eggs on underwater substrates. While developing this system, the habitat requirements and spawning behavior of this species were also taken in to consideration. Half split coconut shells, large boulders of laterite blocks, specially designed cement concrete tetrapods and coconut piles were used as 'paaru' and 'reefs' simulating breeding habitats for fish, in the open lake sanctuary. (Padmakumar *et al* 2001). The success of this large scale fish sanctuary rushed the government to sanction one more fish sanctuary like this under the Kuttanad package.

Lake protection forums and Fish Sanctuary

As ATREE initiated, the fisher folk of Vembanad is organized as Lake Protection Forum (LPF). 14 units of LPFs are now registered and are federated as Federation of Lake Protection Forums. LPFs are now in the forefront for organizing several conservation programs at Vembanad.

MOne of the important activities of LPFs is the *Matsyathaavalam* (fish sanctuaries). Fishermen have created 6 small fish sanctuaries (no fishing area with breeding supports for fishes) based on their traditional knowledge.

Traditionally 'padal fishing' was used as a method to catch fish. Padals serves as a spawning area and breeding platform for many fishes and fish aggregate at such places. But fishermen when use it as a method for catching fish, it is a destructive practice, as the catch will have more fingerlings and brooders and hence considered as unethical and 'paddal fishing' as such is banned. With slight modification of this practice, fixing up the paddals to serve as breeding ground with the surrounding areas are protected , will serve as a potential bio reserve.'. When making such sanctuaries, protection and management of the same was done by the fishermen that has been proved as the best practice for the revival of fish population. An area of twenty cents was fenced in the 8 sites in the Vembanad lake, using bamboo poles with its branches. This is to hinder fishing and obstruct operation of crafts and gears inside this area. This is covered with nets to prevent weeds flowing in to the area. Another core area of 10 cents was fenced inside this 20 cents , again with bamboo poles and the reef material was deposited in the core area. The reef material was made of branches of locally available trees such as cashew tree trunks etc. The branches of the trees were cut in to piles, each pile with 3 m length and 2 m breath and 1m height. About 50 such piles tied together to form the reef mass, deposited inside the inner fence, immersed in water and is fixed to the poles in the fence. In addition to this some mangrove will also be planted on the edges of the sanctuary.

Matsyathavalam is periodically evaluated by a professional team of experts from the Aquaculture department of St,Albert's college , headed by Dr.Benno Perira. The experience of the fishermen fishing in the lake closeby areas and increased presence of otters and cormonats nearby also certifies the success of *Matsyathavalam* as a breeding haven for fishes . . As recognition of the success of this model in conserving the fishery, the Kerala State Govt has come forward to support more such sanctuaries through the Kuttanad package.

Kuttanad Package

The Ministry of Agriculture, Government of India approved special rehabilitation package in 2004 for the farmers of 31 districts of Andhra Pradesh, Karnataka, Kerala and Maharashtra. Along with this the Government approved a special plan of action for improving farming conditions in Alappuzha and Idukki districts of Kerala. The Government requested M. S. Swaminathan Research Foundation (MSSRF) to suggest programmes for the strengthening the ecological and livelihoods security of Kuttanad wetlands in Alappuzha district with the help of a multi-disciplinary team. The study was directed to develop specific recommendations on (1) Measures for strengthening the ecological security of the Kuttanad Wetland Ecosystem, and (2) Measures for expanding sustainable livelihood opportunities for the people of the area.

Although the first and foremost recommendations was to strengthen the ecological security of the Kuttanad apart from the modernization of Tannermukkam barrage nothing much was mentioned in the report that will help in the conservation the lake. Many activities like strengthening the bunds of the paddy fields with concrete slabs affected adversely the ecology of the lake by hindering the hiding and foraging places for the aquatic fauna like shrimps and prawns. The focus on fisheries and allied sectors was minimal and the package fails to address many issues of the fishermen like deterioration of clam resources. The cluster based cage culture mentioned by the package ended up in a great failure as many cage culture systems failed to work properly due to lack of proper management and resulted in large scale loss, especially in Muhamma region. This failure of cage culture of pearl spot caused the fishermen to culture *Tilapia* in cages which is disputable.

Suggestions for Conservation of Vembanad Lake & Fishery Resources

1. Thanneermukkom Barrage is identified as a major threat to the ecosystem health and fish fauna of Vembanad. Hence the barrage should be kept open atleast for nine months to allow saline influx to the lake. To attain this, definite crop calendar should be followed in Kuttanad and paddy harvesting should be completed before March every year.
2. A comprehensive study on the ecological Impact of Thannermukkom barrage and its further development should be done by keeping the barrage experimentally open for atleast two years.
3. Any non-wetland use of the lake should be strictly regulated.
4. Increase awareness among fishermen in and around Vembanad on ethical fishing practices.
5. Fishery enhancement program adopted by the authorities should be done in accordance with the fishermen and the suggestions by them should be incorporated in any such management plans.
6. Organic pollution from untreated sewage from the nearby towns and house boats and resorts are a major reason of concern. The government should take utmost care not to open any untreated sewage into the lake.
7. Strict measures should be adopted to prevent the deposition of plastic and other solid waste into the lake.
8. Ranching of exotic or transplanted fishes in Vembanad should be stopped as these can affect the diversity of native fishes.
9. Any developmental or modification works on critical fish habitats in vembanad lake should be done with proper impact assessment studies.
10. A democratic institution should be set up with ample representation for the traditional stakeholders and local panchayaths with due legal powers for the governance of the Vembanad lake and associated socio-ecological system.

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Annexure

Check list of Fishes of VFC 2008-2011 with a Note on its Geographical Distribution

Main reference used Catalog of Fishes

(http://research.calacademy.org/redirect?url=http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp)

Family: CLUPEIDAE

1. ***Dayella malabarica*** (Day 1873).

Distribution: Western Indian Ocean, southwestern India.

Family CYPRINIDAE

2.***Amblypharyngodon melettinus*** (Valenciennes 1844)

Distribution India and srilanka

3. ***Amblypharyngodon mola*** (Hamilton 1822).

Distribution: Asia: Pakistan, India, Sri Lanka, Nepal and Bangladesh.

4. ***Catla catla*** (Hamilton 1822).

Distribution: Nepal, India, Bangladesh and Pakistan.

5. ***Laubuca dadiburjori*** (Menon 1952)

Distribution: India.

6. ***Labeo dussumieri*** (Valenciennes 1842).

Distribution: India and Sri Lanka.

7. ***Labeo rohita*** (Hamilton 1822).

Distribution: Asia: India, Pakistan, Nepal, Sri Lanka; introduced widely in Asia

8. ***Puntius amphibious*** (Valenciennes 1842).

Distribution: India.

9. ***Puntius filamentosus*** (Valenciennes 1844)

Distribution: India.

10. ***Puntius mahecola*** (Valenciennes 1844).

Distribution: Kerala, southern India.

11. ***Puntius sarana*** (Hamilton 1822).

Distribution: Asia: Nepal, India, Myanmar, Pakistan, Bangladesh and Sri Lanka.

12. ***Puntius subnasutus*** (Valenciennes 1842)

Distribution India

Currently designated as a junior synonym of *Puntius sarana* (Hamilton 1822).

13. ***Puntius ticto*** (Hamilton 1822).

Distribution: Asia: Pakistan, India, Sri Lanka, Nepal, Bangladesh and Myanmar.

14. ***Puntius vittatus*** (Day 1865)

Distribution: Asia: Pakistan, India and Sri Lanka

15. ***Rasbora daniconius*** (Hamilton 1822).

Distribution: Asia: Nepal, India, Sri Lanka, Laos, Thailand, Malaysia, Bangladesh, Pakistan and Myanmar.

Family: ARIIDAE

16. ***Arius maculatus*** (Thunberg 1792).

Distribution: Northern Indian Ocean and western Pacific/South and southeast Asia: Sri Lanka, Thailand, Indonesia, Philippines and China.

17. ***Arius subrostratus*** (Valenciennes 1840)

Distribution: South and southeast Asia: Pakistan, India, Sri Lanka, Thailand, Singapore, Indonesia and Philippines. Habitat: brackish, marine.

Family: BAGRIDAE

18. ***Mystus armatus*** (Day 1865).

Distribution: Southern central Asia: India, Bangladesh, Myanmar, Pakistan (?).

19. ***Mystus gulio*** (Hamilton 1822).

Distribution: Pakistan, India, Bangladesh, Sri Lanka, Myanmar, Thailand, Malaysia and Indonesia.

20. ***Mystus vittatus*** (Bloch 1794).

Distribution: Southern central Asia: Pakistan, India, Nepal, Sri Lanka and Bangladesh.

21. ***Horabagrus brachysoma*** (Günther 1864).

Distribution: Southern and southeastern Asia.

Family: SILURIDAE

22. ***Wallago attu*** (Bloch & Schneider 1801).

Distribution: South central and southeastern Asia: Pakistan, India, Sri Lanka, Nepal, Bangladesh, Myanmar, Thailand, Indonesia and East Indies.

23. ***Ompok malabaricus*** (Valenciennes 1840).

Distribution: India.

Family: PANGASIIDAE

24. ***Pangasianodon hypophthalmus*** (Sauvage 1878).

Distribution: Mekong, its basin, and Chao Phraya, Thailand; introduced elsewhere in Asia

Family: HETEROPNEUSTIDAE

25. ***Heteropneustes fossilis*** (Bloch 1794).

Distribution: Southern Asia: Iran (introduced), Iraq (introduced), Pakistan, India, Sri Lanka, Nepal, Bangladesh, Myanmar, Thailand and Laos.

Family: LORICARIIDAE

26. ***Pterygoplichthys multiradiatus*** (Hancock 1828).

Distribution: Orinoco River basin, Guyana (?) and Venezuela; Argentina (?); introduced elsewhere, including Taiwan, Hawaiian Islands and Florida..

Family : APLOCHEILIDAE

27. ***Aplocheilus lineatus*** (Valenciennes 1846).

Distribution: India and Sri Lanka.

28. ***Aplocheilus panchax*** (Hamilton 1822).

Distribution: Asia: Pakistan, India, Nepal, Bangladesh, Myanmar, Malaysia, Indonesia and Thailand.

Family : AMBASSIDAE

29. ***Ambassis ambassis*** (Lacepède, 1802)

Distribution Western Indian Ocean: East Africa and South Africa east to Madagascar, Réunion and Mauritius

30. ***Parambassis dayi*** (Bleeker 1874).

Distribution: India

31. ***Pseudambassis ranga*** (Hamilton 1822).

Distribution: Asia: Pakistan, India, Nepal, Bangladesh, Myanmar and Malaysia. Habitat: freshwater, brackish.

32. ***Parambassis thomassi*** (Day 1870).

Distribution: India

Family: SCATOPHAGIDAE

33. ***Scatophagus argus*** (Linnaeus 1766).

Distribution: Indo-West Pacific: India and Sri Lanka east to Society Islands (French Polynesia), north to southern Japan.

Family CARANGIDAE

34. **Alepes djedaba** (Forsskål 1775)

Distribution: Red Sea, Indo-West Pacific: East Africa east to Hawaiian Islands, north to southern Japan, south to northern Australia; Mediterranean Sea (Red Sea immigrant).

35. ***Carangoides malabaricus*** (Bloch & Schneider 1801).

Distribution: Red Sea, Indo-West Pacific: East and South Africa and Madagascar east to Philippines and New Guinea, north to southern Japan, south to Exmouth Gulf (Western Australia) and New South Wales (Australia) at 33°00'S.

Family:LEIOGNATHIDAE

36. **Eubleekeria splendens** (Cuvier 1829).

Distribution: Red Sea, Indo-West Pacific: East Africa, Madagascar and Mascarenes east to Philippines and Fiji, north to Ryukyu Islands and Taiwan, south to Kimberleys (Western Australia), Queensland (Australia) and New Caledonia.

37. ***Photopectoralis bindus*** (Valenciennes 1835).

Distribution: Red Sea, Indo-West Pacific: Gulf of Aden east to Philippines and Fiji, north to Taiwan, south to Western Australia and New Caledonia.

Family: GERREIDAE

38. ***Gerres filamentosus*** Cuvier 1829.

Distribution: Red Sea, Indo-West Pacific: East Africa, Madagascar and western Mascarenes east to Fiji, north to southern Japan, south to Western Australia, Queensland (Australia).

39. ***Gerres setifer*** (Hamilton 1822).

Distribution: Northeastern Indian Ocean: Bay of Bengal and Andaman Sea.

Family: SIGANIDAE

40. ***Siganus javus*** (Linnaeus 1766).

Distribution: Indo-West Pacific.

Family : ENGRAULIDAE

41. ***Stolephorus indicus*** (van Hasselt 1823).

Distribution: Red Sea, Indo-West Pacific: East and South Africa east to Caroline, Mariana and Society islands, north to South China Sea, southeard to Dampier Archipelago (Western Australia), Queensland (Australia) and New Caledonia

Family: SCIAENIDAE

42. ***Johnius dussumieri*** (Cuvier 1830).

Distribution: Indian Ocean.

Family: LATIDAE

43. ***Lates calcarifer*** (Bloch 1790).

Distribution: Indo-West Pacific: Asian Coast and Indo-Australian Archipelago; mostly in brackish and fresh water.

Family: NANDIDAE

44. ***Nandus nandus*** (Hamilton 1822).

Distribution: Southern Asia: Pakistan, India, Nepal, Bangladesh, Myanmar, Thailand and Malaysia.

45. ***Pristolepis rubripinnis*** (Britz, Krishnakumar and Fibin baby 2012)

Distribution: Kerala, South of Palaghat Gap

Family: CICHLIDAE

46. ***Etroplus maculatus*** (Bloch 1795).

Distribution: India and Sri Lanka.

47. ***Etroplus suratensis*** (Bloch 1790).

Distribution: India and Sri Lanka.

48. ***Oreochromis mossambicus*** (Peters 1852).

Distribution: Southeastern Africa; introduced widely elsewhere.

Family : MUGILIDAE.

49. ***Mugil cephalus*** (Linnaeus 1758)

Distribution: Nearly circumglobal in temperate and tropical seas and estuaries (including Mediterranean Sea, Black Sea, Red Sea and Hawaiian Islands); apparently not in the western Atlantic [ref. 30860]; introduced in some lakes

Family CHANIDAE

50. ***Chanos chanos*** (Forsskål 1775).

Distribution: Red Sea, Indo-Pacific and adjacent river systems: East Africa, South Africa, Seychelles, Madagascar and Mascarenes east to Hawaiian Islands and Panama, north to southern Japan, south to Western Australia at 32°05'S, New South Wales (Australia) and Norfolk Island. Mediterraanean Sea immigrant.

Family : GOBIIDAE

51. ***Glossogobius giuris*** (Hamilton 1822).

Distribution: Southern Red Sea, Indo-West Pacific: East Africa, South Africa, Seychelles, Madagascar and western Mascarenes east to Society Islands, north to Philippines, south to Western Australia, New South Wales (Australia) and New Caledonia.

Family ELEOTRIDAE

52. ***Butis butis*** (Hamilton 1822).

Distribution: Indo-West Pacific: East Africa, South Africa, Seychelles and western Mascarenes east to New Guinea, north to South China Sea, south to northern Australia.

Family ANABANTIDAE

53. ***Anabas testudineus*** (Bloch 1792)

Distribution: Indo-West Pacific [native to southeastern Asia from India to Sri Lanka to Indonesia, Philippines and China]; introduced widely elsewhere.

Family: OSPHRONEMIDAE

54. ***Pseudosphromenus cupanus*** (Cuvier 1831).

Distribution: India, Sri Lanka and Bangladesh.

55. ***Pseudosphromenus dayi*** (Köhler 1908).

Distribution: India.

Family : CHANNIDAE

56. ***Channa marulius***(Hamilton 1822).

Distribution: Southern and southeastern Asia: Pakistan to southern China, Thailand, Laos and Vietnam; introduced elsewhere, including southern Florida.

57. ***Channa gachua*** (Hamilton 1822).

Distribution: Southern and southeastern Asia: Afganistan and Iran to China and Malaysia and Indonesia.

58. ***Channa striata*** (Bloch 1793).

Distribution: Southern Asia: Native range Pakistan to China, Thailand, Malayasia and Indonesia; introduced elsewhere.

Family: MASTACEMBELIDAE

59. ***Mastacembelus armatus*** (Lacepède 1800).

. Distribution: Pakistan to China, Taiwan and southeastern Asia.

Family SOLEIDAE

60. ***Brachirus orientalis*** (Bloch & Schneider 1801).

Distribution: Red Sea, Indo-West Pacific: Madagascar and Persian Gulf east to Philippines, north to Taiwan, south to northern Australia. Habitat: brackish, marine.

Family: CYNOGLOSSIDAE

61. ***Cynoglossus macrostomus*** (Norman 1928).

Distribution: Northern Indian Ocean.

Family: TETRAODONTIDAE

62. ***Carinotetraodon travancoricus*** (Hora & Nair 1941).

Distribution: India. Habitat: freshwater.

63. ***Chelonodon patoca*** (Hamilton 1822).

Distribution: Indo-West Pacific: India and Sri Lanka east to French Polynesia, north to southern Japan, south to northern Australia.

Family BALISTIDAE

64. ***Balistes capriscus*** (Gmelin 1789.)

Distribution: Mediterranean Sea, Black Sea, Atlantic.

Family : HEMIRAMPHIDAE

65. ***Hyporhamphus limbatus*** (Valenciennes 1847).

Distribution: Persian Gulf to China along the mainland of Asia: Nepal, India, Bangladesh, Myamar.

66. *Hyporhamphus xanthopterus* (Valenciennes 1847).

Distribution: Eastern Indian Ocean, western Pacific, Asia: India to Thailand and adjacent marine waters.

Family: BELONIDAE

67. *Xenentodon cancila* (Hamilton 1822).

Distribution: Asia: Pakistan, India, Sri Lanka, Bangladesh, Myanmar, Malaysia and Thailand; introduced elsewhere including Hawaiian Islands

Collaborating Institutions and Organizations VFC 2008-2011

Kerala University of Fisheries & Ocean Studies

Kerala State Biodiversity Board Trivandrum

St Albert's College Ernakulam

Regional Agricultural Research Station, Kumarakam

Department of Environmental Sciences M.G. University, Kottayam

Conservation Research Group Ernakulam

Vembanad Nature Club Muhamma

Samyukta Kayal SamrakshanaSamithy Muhamma