REPORT

VEMBANAD FISH COUNT 2016

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Background

Vembanad Lake (Alappuzha, Kerala) and its associated wetlands is the largest tropical wetland ecosystem on the south-west coast of India, covering an area of 1,512 km^2 (Ramsar, 2002) and has been designated as a Ramsar site, a wetland of global importance for its biodiversity values. Four rivers - Pampa, Meenachil, Achankovil and Manimala, originates from the Western Ghats confluence to the southern portion of Vembanad bringing the water and rich sediments and draining into the Arabian sea (Padmalal et al. 2008), thus making Vembanad the "inland fish basket" of Kerala (Padmakumar 2003; Mayaja & Srinivasa 2014). The lake is considered to be the largest fishery production unit in the south-western coast of India after the Arabian Sea. Vembanad Lake is not only home to fisheries but also to numerous migratory and resident birds (Kumar, 2006; S. P. Narayanan, Thomas, & Sreekumar, 2011).

After the Second World War, the need for food security was high due to poverty and malnourishment and with Kuttanad being a fertile land there was pressure to intensify paddy cultivation. However due to high tidal influxes, salinity intruded during the main Punja crop season, making some of the areas uncultivable. Therefore to allow a second cropping season Thannermukkom barrage was constructed and was commissioned in 1976 (Asha, Cleetus, Suson, & Nandan, 2015). This barrage (1.4 km long) constructed during 1976 to avert salt water incursions on to the paddy fields of Kuttanad to promote *Punja* crop (main crop) (Geetha, Chandramohankumar, & Mathews, 2007) was the major human intervention in Vembanad Lake. 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 of contaminants. The deterioration of water quality in the lake can be directly attributed to the construction of Thannermukkom barrage (Geetha et al., 2007). The barrage has altered the fishery resources and clam resources reproduction patterns as some of the fish have to migrate to the northern part for spawning and vis-a-versa (Kurup & Harikrishnan, 2000). Delays in operation of barrage have led to serious ecological changes (Kannan 1979) as the barrage remains closed during the summer season, preventing salt water into the low-lying paddy fields situated in the upstream region (Sathyanathan, 2010). This has led to the decline in fishery resources, water stagnation and growth of water hyacinth (Suseelan 1987; Commission 2008; MSSRF 2007; Manorama & Agricultural 2013).

Since the commissioning of Thannermukkom barrage there has been a drastic decline in the diversity and population of fishes (Kurup & Samuel, 1985; Kurup, et al. 1993; Padmakumar, 2003). Fishery sector is one sector that has been affected adversely due to the commissioning of Thannermukkom barrage. The annual landing of fish from the Vembanad Lake is down from about 16,000 tonnes a year in the late seventies to about 7,200 tonnes in 2000 (Unnithan, Bijoy, & Vava, 2001). Kurup et al. (1993) have reported reductions in the marine fish and prawn migration to the lake for breeding. Although the use of fishing gear leads to mass destruction and the premature catching of inland fish are legally banned, such practices continue out of livelihood needs (CERC ATREE, 2013). Even though many of the studies (Kannan 1979; Kurup & Samuel 1985; Laxmilatha & Appukuttan 2002; Krishna Kumar & Rajan 2012) have pointed out the decline in fishery resources, still the government hasn’t taken any major efforts to revive the fishery.

Vembanad Fish Count

Ashoka Trust for Research in Ecology and the Environment (ATREE) initiated the *Vembanad Fish Count* (VFC) as an annual participatory fish assessment in May 2008 to understand the fishery and ecological trends in Vembanad. Several institutions and agencies like the Kerala State Biodiversity Board, Department of Fisheries, Alappuzha, Government of Kerala, Department of Environment and Climate Change, Government of Kerala., Vembanad Nature Club, and Vembanad Lake Protection Forums are the co -organizers of the event. Kerala University of Fisheries and Ocean Sciences (KUFOS, erstwhile Fisheries College, Panangad), SN College, Cherthala and St Albert's College (Ernakulam) are providing the necessary technical support for the event. Vembanad Fish Count is a democratic approach in resource monitoring which is different from the conventional top-down approaches. It is a stakeholder driven program where the targeted groups participate in the entire process, learning about the situation, identifying problems, discussing alternatives, seeking solutions, designing and implementing activities, evaluating and disseminating results. In this 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 VFC has lead the fisher community here 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). Fisher folk have created 23 fish sanctuaries (no-fishing area with breeding supports for fishes) based on their traditional knowledge.

VFC brings together researchers, NGOs, environmentalists, students and media from Southern India. Fishers, 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. The program consists of two modules; namely action & awareness.

Vembanad Fish Count – 2016, 9th edition of its kind was carried out in two major steps; viz., a participatory workshop and the fish count. In this version India Biodiversity Portal also supported us in live showcasing of the observational database.

Objectives

1. To carry out an extensive survey on the fish diversity of the southern sector of Vembanad Lake.
2. Capacity building to focus attention to issues on lake deterioration and biodiversity decline, into public domain.

Study Area

Vembanad Lake (9° 34' 60" N, 76° 25' 0" E), a transitional ecotone between sea and land is the largest humid tropical wetland on the west coast of India with a length of 96 km and a surface area of 1512km^2. Seven rivers which originate from the Western Ghats Biodiversity Hotspot drain to the lake and eventually join the Arabian Sea. 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. 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 renowned for its live clam resources and sub-fossil shell deposits, large populations of water fowls, besides a high species diversity of finfish and shellfish (WWF 2002). (WWF, 2002). Around two hundred forty-five species of fishes were reported from the whole of Vembanad-Kole wetland since 1960. One hundred fifty species of fishes belonging to hundred genera and fifty-six families are known to occur in Vembanad Lake (Kurup and Samuel,1985). The list also includes vulnerable species such as *Horabagrus brachysoma*, *Carinotetraodon travancoricus* (Molur and Walker 2001). The Thannermukkom Salt Water Barrage divides the lake into two parts – the perennial brackish water part on the North and the southern freshwater fed by the rivers draining into the lake with seasonal salt water intrusion from high tide during non-rainy seasons. These freshwater regions of the lake are facing ecological problems due to rampant propagations of water hyacinths and eutrophication. Unmanaged and unregulated tourism and unethical fishery practices are also posing serious threats to the Vembanad Lake. (Krishnakumar et. al., 2007).

Methodology

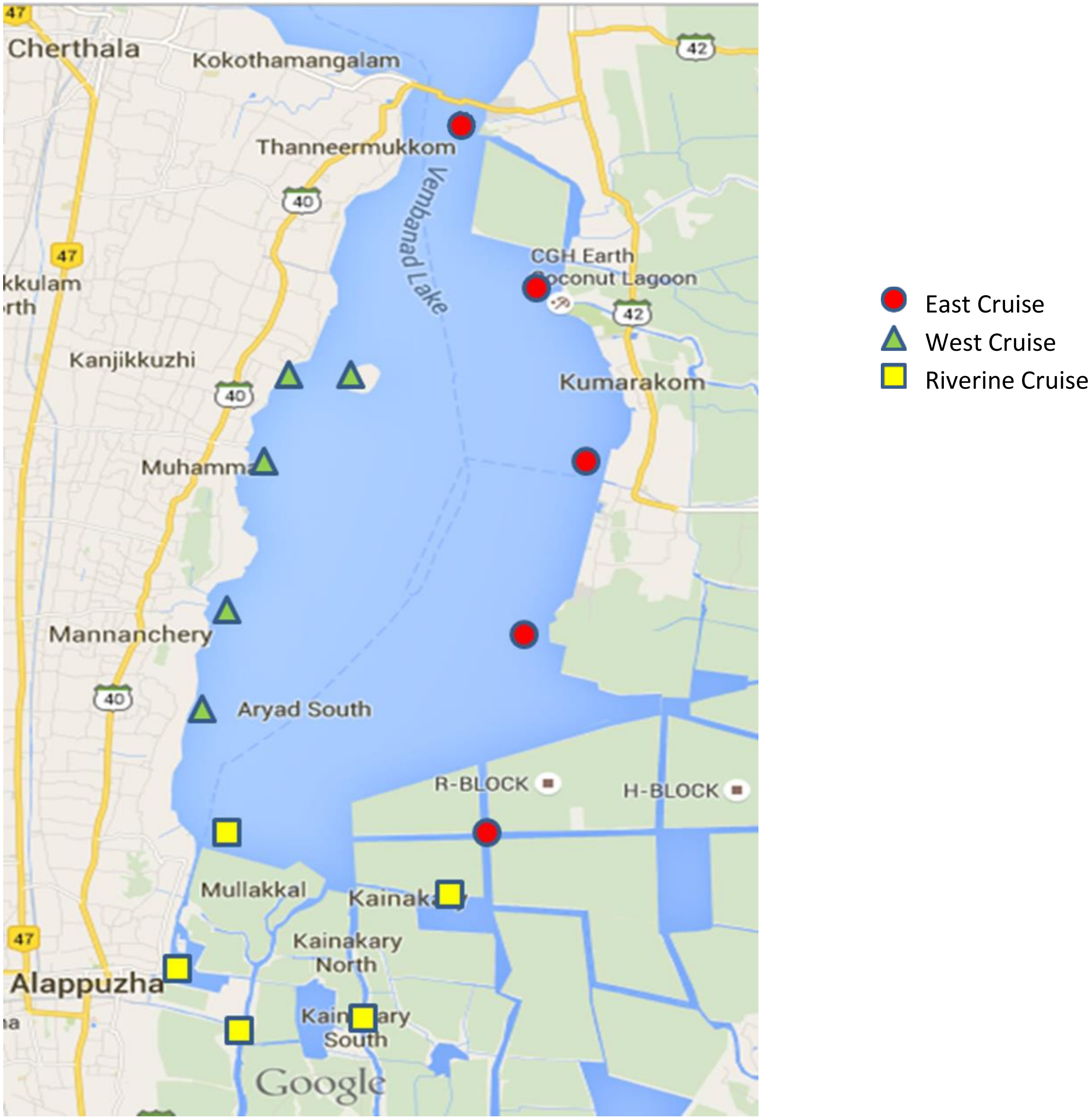
One hundred twenty volunteers from local stakeholders, various colleges, Universities, research institutes and Non-Governmental Agencies participated in VFC 2016. The entire team was divided into three cruise groups: The Kumarakom Cruise (East Bank), Kuttanad (Riverine Sector) Cruise and Pathiramanal Cruise (West Bank) with 35 -40 members in each team. Each cruise team was further subdivided into four in order to assign responsibilities for 1) experimental fishing, 2) collecting data from landing centers, 3) collecting data from fishers in the lake and 4) water quality monitoring. The cruise teams conducted experiments at 15 (5X3) previously identified sampling points.

'East Bank' cruise covered Ambika Market, Kumarakom, Nazreth, Chithira Kayal and R Block. 'Riverine cruise covered Punnamada, Chungam, Kainakary, Aarayiram Kayal and Sai. 'West Bank cruise covered Kayippuram, Pathiramanal, Muhamma, Mannamcheri and Aryad sampling points (Fig. 1). The program commenced from 6 am and extended till 3 pm on 22nd of May 2016.

A week before the survey, an expert team of fish taxonomists explored around the lake for fish landing centre inventory and collected the data from Vaikom and Pallom landing centres during the early morning hours. In addition to this on the day of fish count Ambika Market located near Thannermukkom bund and Punnamada landing centre respectively was also surveyed in the morning by students and experts.

As part of capacity building an orientation workshop (participatory workshop) was arranged on the day before fish count in order to capacitate the participants on their duties and responsibilities and etiquettes to be followed during fish count. A fish identification guide, water quality analysis and collection kit along with GPS were provided to carry out the exercise.

Fig 1: Cruise Map (Site Wise)



Experimental Fishing

This was facilitated with the help of local fishers who accompanied the cruise at all different stations using three major fishing gears, namely;

1. **Gill Net**: Gillnetting is a typical fishing method utilized by commercial and artisanal anglers. Gill nets are vertical panels of mesh commonly set in a straight line. Fish be caught by gill nets in 3 ways: (1) Wedged – held by the mesh around the body (2) Gilled – held by mesh slipping behind the opercula, or (3) Tangled – held by teeth, spines, maxillaries, or different distensions without the body entering the mesh. Usually fish are gilled. A fish swims into a net and passes just part route through the mesh. When it battles to free itself, the twine slips behind the gill cover and averts escape. (Murphy et al., 1996). One gill net each was laid at six locations; i.e., at two sites for each cruise. The nets were laid by around 2am and was retrieved by 6am. The collection was ice preserved till each team arrived for inspection. All entries were made on to the survey forms distributed to the participants

2. **Cast Net**: The net is cast or tossed by hand in such a way, to the point that it spreads out on the water and sinks. This procedure is called net casting or net throwing. Fish are caught as the net is hauled back in. (Dunbar, 2001) This basic gadget is especially successful for small bait or forage fish and has been being used, with different modifications, for thousands of years. Cast net was thrown at five points each at all five sites of each cruise (total = 5X5X3). Entries were made as mentioned above. The specimens obtained were either left back after successful identification and counting or collected in alcohol/formalin depending upon the use to be carried out later on. Alcohol preservation was preferred in case of DNA analysis and formalin in case of further morphological lab examination.

3. **Scoop Net**: Scoop net, additionally called a hand net or plunge net, is a net or mesh basket held open by a loop. It might be on the end of a handle. Scoop nets have been utilized since artifact and can be utilized for scooping fish close to the surface of the water. The basket is made of wire or nylon work, as opposed to fabric work, since crabs/fish fight, chomp, wander aimlessly when they are caught. Scoop net was also carried out five times at each at all five sites of each cruise and the following activities were done as the same as above.

The abundance (number of individuals at each sampling point) and diversity (type of each species) data had been recorded on the respective survey forms provided to the participants. An additional replicate data was also collected this year in order to maintain track of the number of individuals obtained per each netting.

Inventory made from Fishers

This was carried out with the due participation of local fishers who allowed us to check the species, which contributed to their catch on the count day. Enquiries were also made on the fishing methods and socio-economic information of the fishers. The obtained information was recorded to the respective survey forms.

Inventory made from Landing-centers

The major landing centers around the sampling sites viz. Punnamada, Pallom and Vaikom were visited on the two consecutive days prior to fish count and the species diversity 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 Quality Parameters

Water quality parameters were tested onsite as well as offsite.

Onsite*:*

- **pH**: pH is a numeric scale used to specify the acidity or basicity of an aqueous solution. pH was measured using standard pH solution marketed by C.P.R. Environmental Education Centre, Chennai (CPREC). Water samples were collected and analyzed 3 times each to arrive at concordant values. In addition, samples were also taken aboard for confirmatory lab analysis.

- **Transparency**: Transparency of water relates to the depth that light penetrates water. The transmission of light into a body of water is critical since the sun is the essential wellspring of vitality for all organic phenomenon. Light is vital for photosynthesis, a procedure that produces oxygen and food for consumers. It is a regular practice for researchers to consider the depth of the euphotic zone (the upper layers of a body of water into which adequate light penetrates to allow development of green plants) to be 2.7 times (approximately 3 times) the limit of visibility. As light penetrates water, it becomes attenuated and altered in its spectral composition. The change that occurs is from predominantly yellow light at the surface to blue-green at depth in clear water or yellow-green in waters having a high concentration of dissolved organic material. Secchi disk is a simple device used to measure the transparency of water bodies. Water clarity is related to amounts of suspended particles (turbidity) as well as amounts of phytoplankton and zooplankton. Seechi readings were carried out at all sites and valued were recorded on to survey forms.

- **Temperature (atmospheric/water)**: Most aquatic organisms are largely cold-blooded (poikilothermic), meaning they are unable to internally regulate their core body temperature. Therefore, temperature exerts a major influence on the biological activity and growth of aquatic organisms. To a point, the higher the water temperature, the greater the biological activity. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have preferred temperature ranges. Both water and atmospheric temperatures were measured at all sites using alcohol based laboratory thermometers. Results were recorded on to survey forms.

- **Salinity**: Salinity is the amount of dissolved salt substance of the water. Salts are compounds like sodium chloride, magnesium sulfate, potassium nitrate, and sodium bicarbonate which dissolve into ions. Salinity was measured at all sites using a salinometer and the readings were recorded on to survey forms.

Offsite: Water samples were collected in 500ml water bottles to be analyzed at Kerala State Pollution Control Board (KSPCB) affiliated labs. Water samples for estimation of dissolved oxygen was fixed in field using Winkler A and B respectively after which all samples where preserved in ice boxes.

- **Total Hardness**: Total hardness is defined as the sum of calcium and magnesium hardness (Even though Fe^{2+}, Fe^{3+}, Sr^{2+}, Zn^{2+}, and Mn^{2+} may contribute to water hardness, their levels are typically much less than Ca^{2+} and Mg^{2+}. Their levels are not usually included in total hardness measurements) in mg/L as $CaCO_3$. Ideal quality water should not contain more than 80 mg/L of total hardness as CaCO3. (Vernier). High levels of total hardness are not considered a health concern. On the contrary, calcium is an important component of cell walls of aquatic plants, and of the bones or shells of aquatic organisms. Magnesium is an essential nutrient for plants, and is a component of chlorophyll.

- **Dissolved Oxygen (DO)**: Dissolved oxygen (DO) is the amount of oxygen that is present in the water. It is measured in milligrams per liter (mg/L), or the number of milligrams of oxygen dissolved in a liter of water. Samples to be analyzed was collected using Winkler method.

- **Nitrate**: Nitrate salts are found naturally on earth as large deposits, particularly of nitratine, a major source of sodium nitrate. Presence of nitrate in lakes could be from agriculture run-off waters as fertilizers are considerably made of nitrate owing to its high solubility and biodegradability. (Laue et al., 2006). Presence of normal levels of nitrates usually does not have a direct effect on aquatic organisms. However, excess levels of nitrates in water can create conditions that make it difficult for the former to survive. Algae and other plants use nitrates as a source of food. If algae have an unlimited source of nitrates, their growth is unchecked. This could lead to "Eutrophication", anoxia to lake conditions etc. Levels exceeding 50 mg/L (ppm) nitrate-nitrogen are considered unhealthy for lakes.

- **Nitrite**: Nitrites occur in water as an intermediate product in the biological breakdown of organic nitrogen, being produced either through the oxidation of ammonia or the reduction of nitrate. The presence of large quantities of nitrites is indicative of waste water pollution. Levels exceeding 0.55 mg/L (ppm) nitrite-nitrogen can cause 'brown-blood' disease in finfish.

- **Iron**: Concentrations above 1 mg/L will impart a foul taste to the water. High concentrations can indicate runoff from mining operations or industrial effluent and indicate the need for further investigation before prescribing a treatment regimen. Proper lake water limit levels are unavailable.

- **Phosphate**: A phosphate (PO_4^{3-}) is an inorganic chemical and a salt of phosphoric acid. Organic phosphates are important in biochemistry and biogeochemistry (ecology), and inorganic phosphates are mined to obtain phosphorus for use in agriculture and industry. (Headley et al., 1982). High phosphate concentrations in surface waters may 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. Algae blooms are encouraged by levels of phosphate greater than 25 micrograms/L.

- **Others**: Magnesium, Calcium and Sulphate were the other measured parameters.

Orientation Workshop

Orientation workshop for the participants was conducted on 21st May 2016 at Karmasadan, Alappuzha Convent Square at 6 pm. Shri. Jojo T. D (Project Coordinator, ATREE-CERC) delivered the welcome address. Prof. K.V. Jayachandran (Director of Research, KUFOS) chaired the inaugural session. Shri. S. Mahesh (Deputy Director of Fisheries, Alappuzha), inaugurated the function. The orientation for 120 volunteers of Vembanad fish count was given by Mr. Anu Radhakrishnan (Research Associate, ATREE-Bangalore) where he discussed a brief history of Vembanad and CERC's activities, and the objectives of Vembanad Fish Count. Methodology used for data collection and the basic etiquettes and discipline/safety measures to be followed during the cruise. Orientation on data management, archival and uploading was given by Dr. Thomas Vattakavan, (India Biodiversity Portal). Participants for the program were divided into three teams. For each team, a cruise leader was selected, who were assigned the task of making the organizational groups and functional groups for effective conduct of the survey. Fishing gears, resource materials and survey forms were distributed to each team before dispersing for dinner. The three designated teams were East bank (Starting from Kumarakom), West Bank (Kayippuram) and Riverine (Starting from Alappuzha). Dr. Rajeev Raghavan (Assistant Professor, KUFOS), Mr. Anwar Ali (Assistant Professor, KUFOS) and Ms. Maneeja Murali (Senior Research Fellow, KUFOS) were the resource persons for Riverine, East and West cruises respectively.

Vembanad Fish Count – 2016 Report

On 22nd May Fish Count was flagged off by Mr. K. V. Dayal, a noted environmentalist at Kayippuram Jetty, Muhamma; the West bank and East bank cruise started from this point. The other starting point was Punnamada – Alappuzha.

The cruise boats moved towards each sites where the team halted for approximately 35-45mins and conducted experimental fishing with the help of different gears; viz. gill net, cast net and scoop net. Onsite water quality data and water for offsite analysis were also collected along with data pertaining to fish habitats including primary visual data. The team members of each cruise also discussed and compiled the data collected, to make a rough presentation in the concluding session.

All teams returned to the finishing point; boat jetty Alappuzha by 2:00 pm. The concluding session was held at Pulimoottil Trade Centre, Mullackkal, Alappuzha. The returning cruise teams were received and valedictory session was inaugurated by Shri. G. Venugopal (Hon' President, Alappuzha District Panchayat) The meeting was presided over by Dr. Priyadarsanan Dharma Rajan (Senior Fellow, ATREE). Shri. Jojo T.D (Coordinator, ATREE-CERC) delivered the welcome address. The program was felicitated by Mr. Subramaniam (GM, Marari Beach Resort, CGH Group). Dr. Rajeev Raghavan (Assistant Professor, KUFOS) summed up the report during the function, he said this year 37 fish species, 8 crustaceans, and 3 molluscs were found from the fish count. It was less than the last year's fish count. Rare fishes like "Vaaka" (*Channa diplogramme*) were found from Pallom. It was also noted that there was an increase in the number of the Pearl Spot and Prawns. The participants also recorded 19 species water birds during this Fish Count. The salinity marked around 0.5-2 ppt last year has increased to 2-4 ppt this year. Shri. Subrahmanyam. P (CGH Group) felicitated the function and Shri. K. M. Poovu (Secretary, Lake Protection Forum) delivered the vote of thanks.

Results and Discussion

A total of 39 fin-fish species, 8 species of Crustaceans and 3 species of Molluscs were recorded during Vembanad Fish Count – 2016 with a total abundance of 1865 individuals. (Annexure-1).

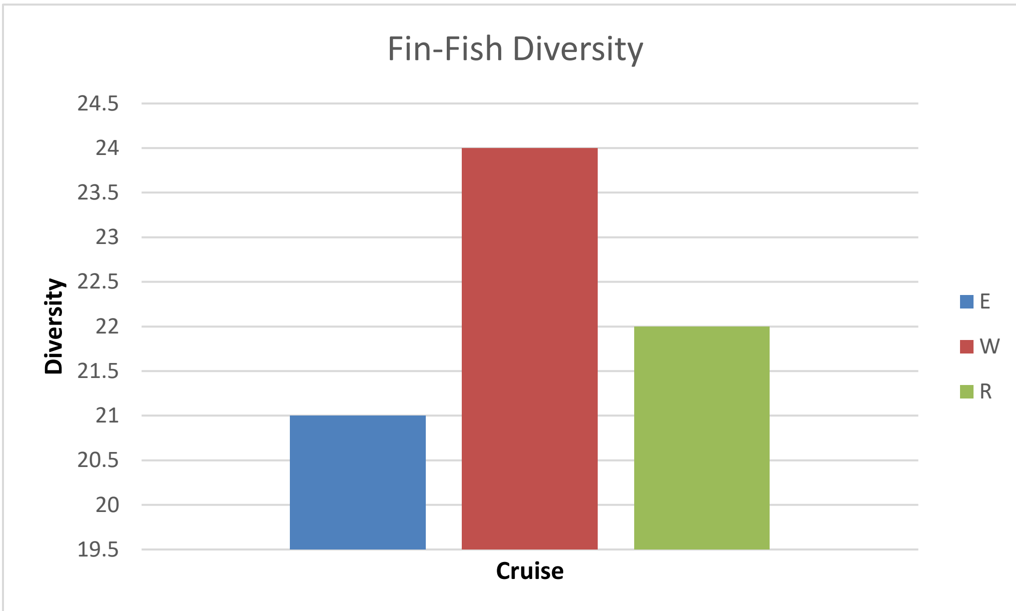


Fig 2: Total Fin-Fish Diversity recorded south of Thannermukkom Bund of Vembanad Lake.

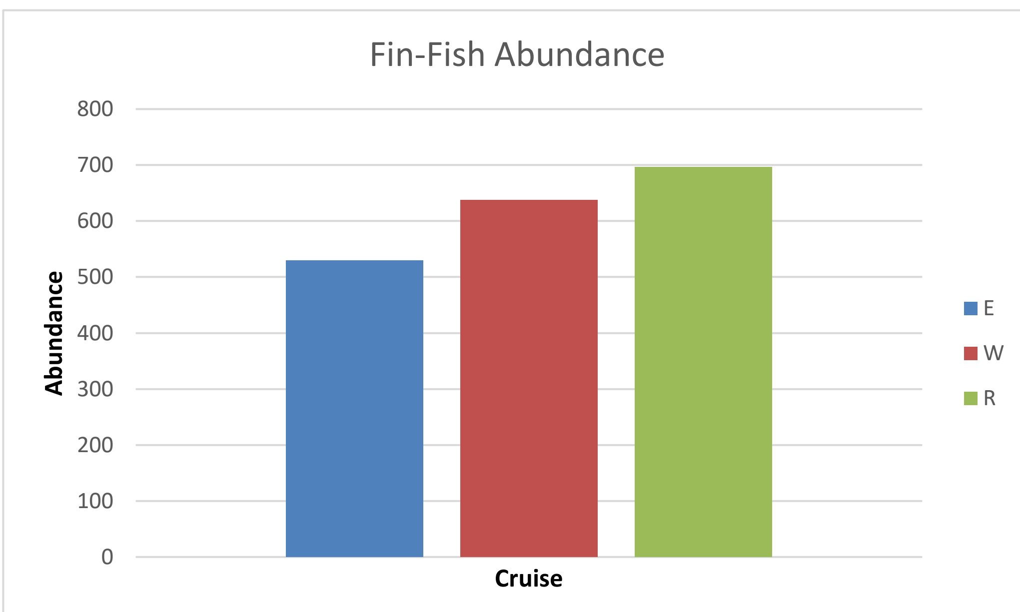


Fig 3: Total Fin-Fish Abundance recorded south of Thannermukkom Bund of Vembanad Lake.

Vembanad Fish count (VFC 2008-2016) has recorded 71 species of fin fishes and 14 species of shell fishes so far (2008-16) from Vembanad Lake.

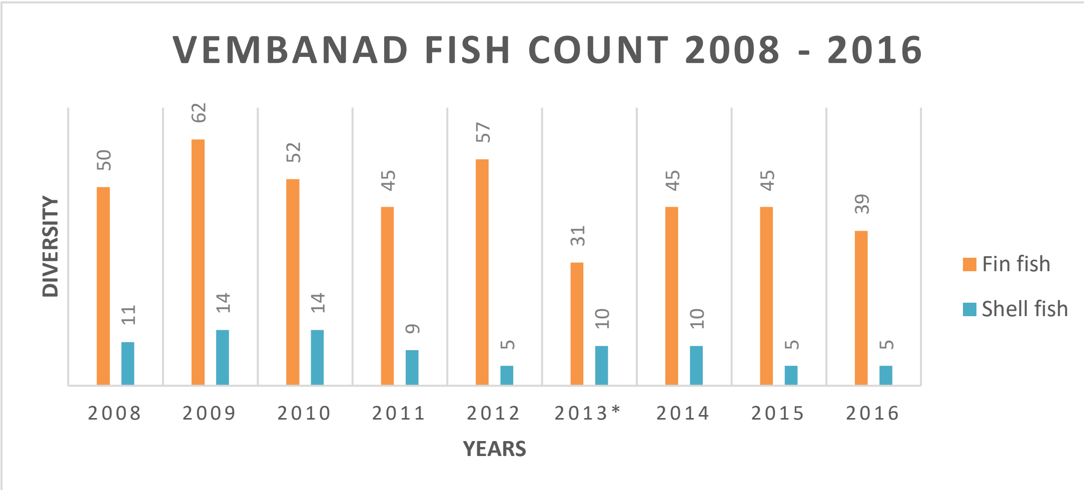


Fig 3: Diversity recorded in VFC 2008-16

Water chemistry of VFC 2016 portrayed an average pH, water temp. and DO (% sat.) of 6.2, 32°C and 55% respectively. A healthy estuarine ecosystem ideally should show a pH b/w 7-9 and DO b/w 80-110% (Water watch Estuary Guide, 2010). 2016 result shows that the health of the ecosystem is at risk; aquatic plants and animals may be at risk. Lower levels of DO can be attributed eutrophication due to the extensive growth of water hyacinth (*Eichhornia crassipes*) along with other algae or elevated levels of pollution. Lake water pollution at Vembanad includes; sewage from municipal areas, sewage and other organic waste discharge from house boats, agricultural run offs, plastic items etc.

The fin fish diversity recorded was 15% lower than the previous year when 45 fin-fish species had been reported. Highest abundance was reported at Punnamada (Site 1 – Riverine cruise) 262 individuals and maximum diversity was seen at Kayippuram (Site 1 – West cruise) 17 varieties. Meanwhile, lowest abundance was reported at Kayippuram and Nazreth (Site 3 – East cruise) 86 individuals and lowest diversity at Chithira Kayal (Site 4 – East cruise) 2 varieties only. pH ranged between 5.5 and 7.2; low pH was depicted with decreased abundance in site 2 & 3 of east cruise, whereas site 3 of riverine cruise despite a lower pH of 5.6, showed an abundance of 120 individuals which lies within average values of the present years count. Diversity at site 4 & 5 of east cruise and site 5 of west cruise was considerably less (less than 10) and coincided with low salinity values of 0 – 2ppt. Atmospheric temperature ranged between 28 & 37, while water temperature showed a range of 31-33. Salinity was low at most places; ranged 0-4ppt. This should be considered significant as breeding of most species at Vembanad requires 7-8ppt. Total hardness ranged 85-1840 ppm, which does not impose any risk in the present scenario.

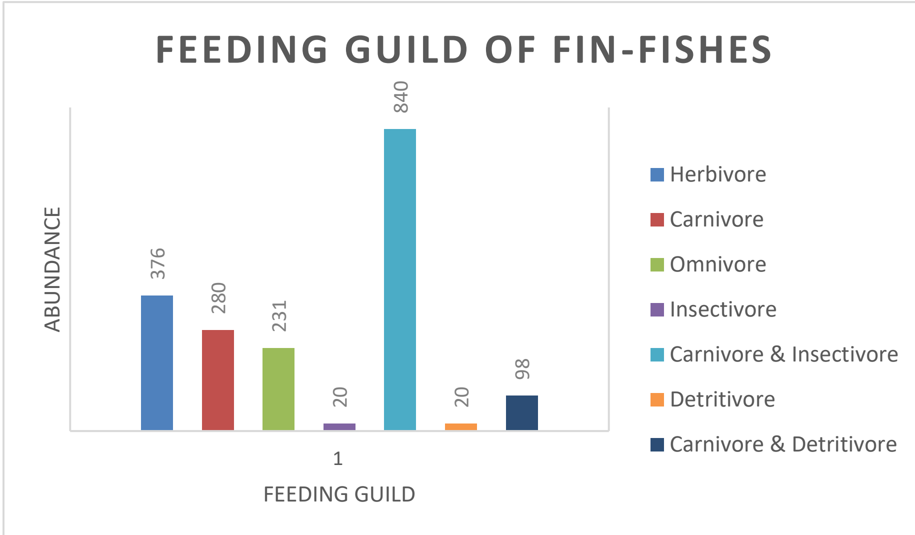


Fig 4: Feeding guild of Fin-Fishes around recorded south of Thannermukkom Bund of Vembanad Lake.

Feeding guild: All fin-fishes recorded had been classified into seven categories; namely – Herbivorous, Carnivorous, Omnivorous, Insectivorous, Carnivore & Insectivore, Detritivore, and Carnivore & Detritivore. Dominance of carnivores and certain omnivores over herbivores is certainly not a good sign of sustainable existence of the ecosystem in the long run.

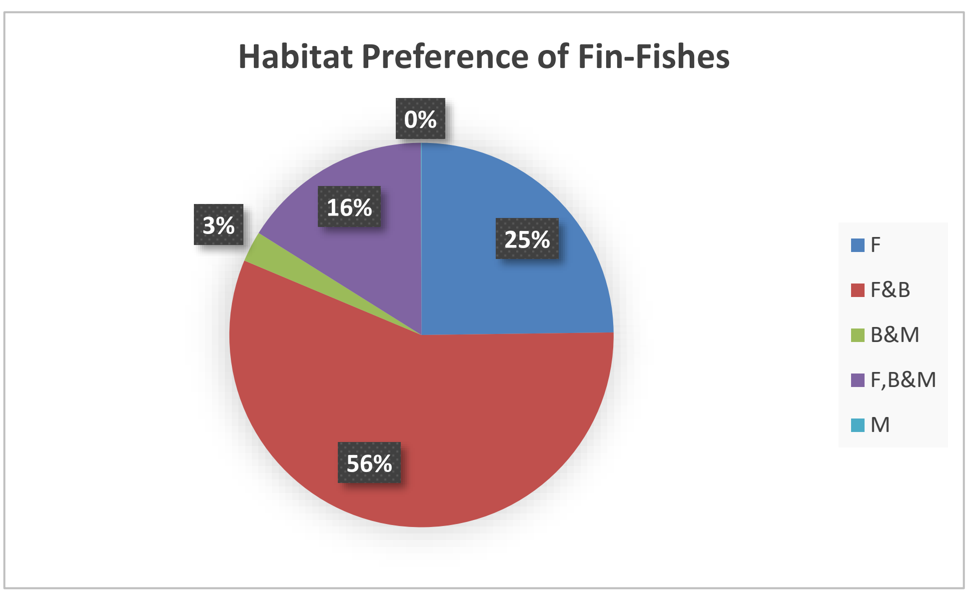


Fig 5: Habitat preference of Fin-Fishes around recorded south of Thannermukkom Bund of Vembanad Lake.

Based on their habitat preference, fishes were classified into Freshwater only (F), Fresh-Brackish (FB), Brackish-Marine (BM) Fresh-Brackish-Marine (FBM) and Marine only (M). FB dominated the count which was followed by F, FBM, BM & M. In summer season the lake remains brackish due less freshwater influx from the rivers and higher in surge of salt water into the system from the sea, resulting in higher FB availability. Abundance of FBM was higher in freshwater zone compared to that of the other two, this trend indicates that the fishes might be migrating to the freshwater zones for its breeding.

Suggestions

1. The state and central Governments should put efforts to sustain the fisheries sector through a holistic approach which includes habitat protection, enforcement of regulations and adoption of co-management strategies. This will lead to improving the livelihoods of fishers and avoiding further degradation and deterioration of habitat quality of the ecosystem.
2. Insectivorous fish viz. *Pseudosphromenus cupanus*, *Pseudosphromenus dayi* & *Aplocheilus lineatus* that are indigenous and voracious insect/larvae feeders should be utilized over exotic species like *Gambusia affinis* and *Poecilia reticulate* for vector control.
3. A systematic feeding guild analysis of the available species of the ecosystem shall provide the present energy flow in the ecosystem.
4. Regular Fish survey and water quality analysis should be conducted during all three seasons viz. Monsoon (June-August), Post-Monsoon (October-November) and Pre-Monsoon (March-April) may be carried out for at least 3 years to make better estimation on fish diversity and ecosystem health of the lake. Long term monitoring mechanism on population dynamics of various fish species which are thought to be declining and study the effect of Thannermukkom Bund on migratory fishes of Vembanad should be taken up through collaborative projects involving various research organizations.
5. Develop an Index for lake conservation like Index of Biotic Integrity (IBI) for Vembanad Lake ecosystem (standards for water quality and the organisms inhabiting the lake indicating ecosystem health) and regular monitoring to ensure its sustainable health.
6. Awareness programs should be conducted within the community inhabiting around the lake and tourists visiting the ecosystem regarding its global importance in sustainable living and existence of all living organisms and the bigger role it could

play in mitigating global climate change and ecological vulnerability if developed as a conservation model.

7. Assistance of fisheries institutes and other research organizations should be sought for large scale seed production and ranching programs of commercially important indigenous fish species.
8. Whenever wherever possible undisturbed areas of Vembanad Lake/Kole should be maintained as such to retain its pristine nature to set itself as control and scale up the health levels of the rest of the areas to a standard point possible.
9. Strict pollution control policies should be developed and implemented in compliance with Wetland and Paddy Conservation Act 2008.
10. A strict fishing policy should be formulated by analyzing various methods currently used in the ecosystem so that only the most sustainable ones are selected for practice in lake.
11. Existing natural habitats and native vegetation like those surrounding Pathiramanal islands, the reclaimed portions of lake at Chithira and Rani Block of kayals should be declared as No Take Zones.
12. Develop breeding and hatchery protocols for fishes that are used in ranching and stock enhancements.
13. Measures should be taken to protect riparian and indigenous macrophytes inhabiting the lake.
14. Ban monsoon flood plain fishery (Ootha piditham) when spawning individuals are largely targeted.
15. Establishing a democratic-management system should be a top priority for fisheries planners in the Vembanad. This should be based on a bottom-up strategy rather than the conventional top-down schemes which have been a failure.
16. Collaborations between various central and state government organizations, research institutes, universities, colleges, non-governmental organizations and cooperatives with due participation of local stake holders should be made and efficient programs for protecting the lake, its resources and the livelihoods of the fishers depending on the ecosystem should be adapted.
17. All house boats should be installed with eco-friendly green toilets in order to check human waste pollution into the lake.
18. Municipal drains should empty to the lake only after proper treatments and the water disposed henceforth should meet the ideal standards of estuarine lake water or freshwater system.

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Annexure – 1 (List)

Fin-Fish Species List of VFC - 2016

1. *Ambassis ambassis* (Lacepède 1802)
2. *Ambassis gymnocephalus* (Lacepède 1802)
3. *Anabas testudineus* (Bloch 1792)
4. *Aplocheilus blockii* Arnold 1911
5. *Aplocheilus lineatus* (Valenciennes 1846)
6. *Aplocheilus panchax* (Hamilton 1822)
7. *Arius maculatus* (Thunberg 1792)
8. *Arius subrostratus* Valenciennes 1840
9. *Brachirus orientalis* (Bloch & Schneider 1801)
10. *Carinotetraodon travancoricus* (Hora & Nair 1941)
11. *Ctenopharyngodon idella* (Valenciennes 1844)
12. *Dawkinsia filamentosus* (Valenciennes 1844)
13. *Etroplus suratensis* (Bloch 1790)
14. *Gerres setifer* (Hamilton 1822)
15. *Glossogobius giuris* (Hamilton 1822)
16. *Haludaria fasciata* (Jerdon 1849)
17. *Horabagrus brachysoma* (Günther 1864)
18. *Horadandia brittani* Rema Devi & Menon 1992
19. *Hyporhamphus xanthopterus* (Valenciennes 1847)
20. *Labeo dussumieri* (Valenciennes 1842)
21. *Labeo rohita* (Hamilton 1822)
22. *Neochela dadiburjori* (Menon 1952)
23. *Mystus gulio* (Hamilton 1822)
24. *Mystus oculatus* (Valenciennes 1840)
25. *Parambassis dayi* (Bleeker 1874)
26. *Parambassis thomassi* (Day 1870)
27. *Photopectoralis bindus* (Valenciennes 1835)
28. *Pseudetroplus maculatus* (Bloch 1795)
29. *Pseudosphromenus cupanus* (Cuvier 1831)
30. *Pseudosphromenus dayi* (Engmann 1909)
31. *Puntius mahecola* (Valenciennes 1844)
32. *Mystus vittatus* (Bloch 1794)
33. *Rasbora dandia* (Valenciennes 1844)
34. *Salmostoma acinaces* (Valenciennes 1844)
35. *Scatophagus argus* (Linnaeus 1766)
36. *Systomus subnasutus* (Valenciennes 1842)
37. *Xenentodon cancila* (Hamilton 1822)

Annexure – 2 (Figures)

Fig. 6. Species occurrence recorded in VFC-2016

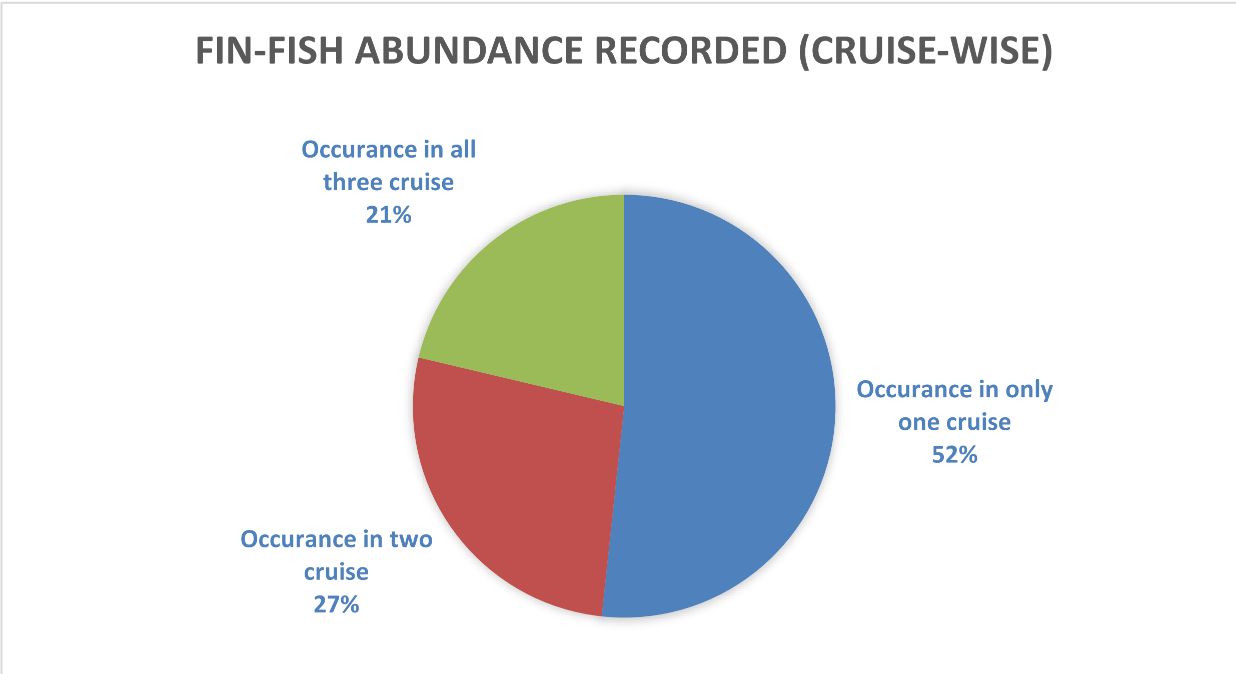


Fig. 7. Relationship between diversity and abundance

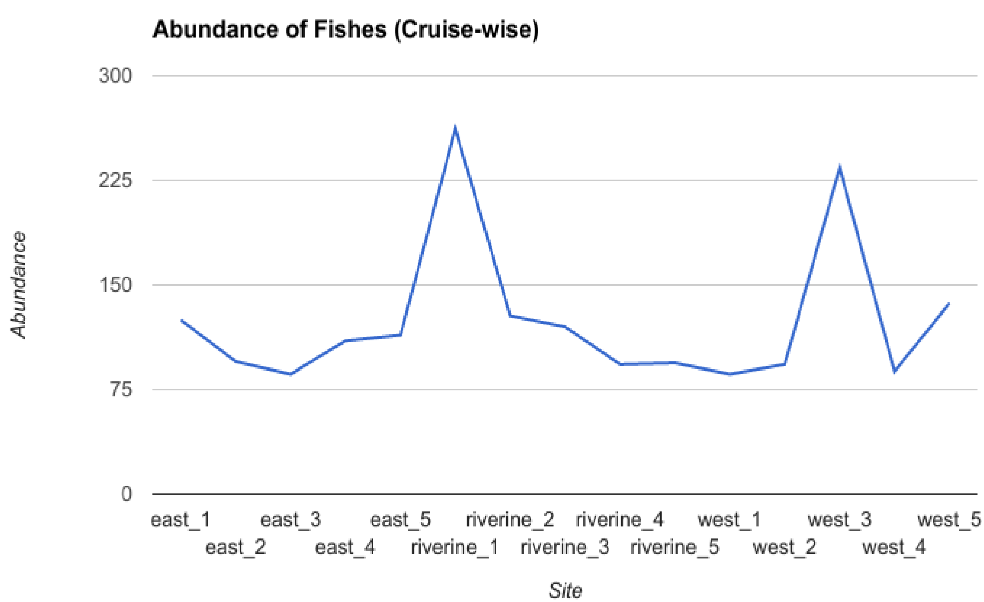
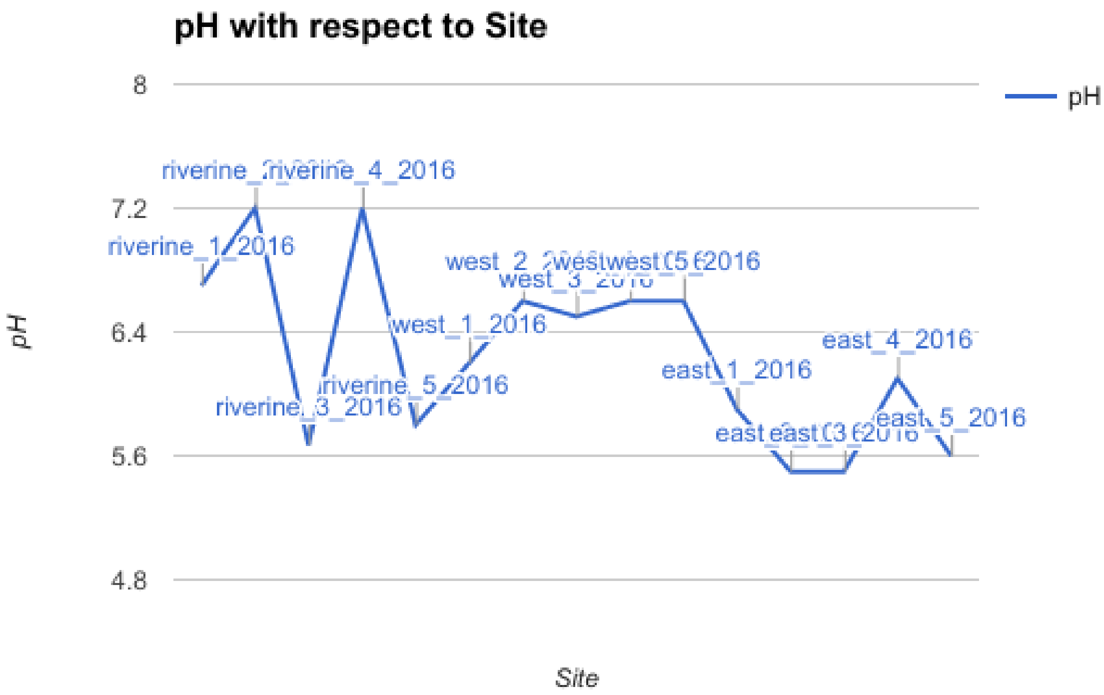


Fig. 8. Correlation of abundance w.r.t pH



Annexure – 3 (Tables)

Table – 1: Water Quality (Onsite)

Cruise_Site_Year	pH	Temp_atm Deg C	Temp_water Deg C	Salinity (ppt)
riverine_1_2016	6.7	31	31	0
riverine_2_2016	7.2	35	31	0
riverine_3_2016	5.67	35	31	0
riverine_4_2016	7.2	35	31	0.2
riverine_5_2016	5.8	37	32	0
west_1_2016	6.2	28	32	2
west_2_2016	6.6	30	31	2
west_3_2016	6.5	32	33	2
west_4_2016	6.6	30	31	1
west_5_2016	6.6	32	33	0
east_1_2016	5.9	29	33	4
east_2_2016	5.5	32	33	1
east_3_2016	5.5	33	33	1
east_4_2016	6.1	32	33	3
east_5_2016	5.6	34	33	2

Table – 2: Water Quality (Offsite)

Cruise_Site_Year	Hardness (p	D.O. (mg/L)	Nitrate (mg/L)	Nitrite (ppm)	Phosphate (ppm)	on as Fe (ppm	Magnesium (ppm)	alcium(ppm	Sulphate(ppm)
riverine_1_2016	280	3.6	1.1	0.028	BDL	0.15	46.4	36.1	300
riverine_2_2016	105	5.6	1.09	0.023	BDL	0.57	15.86	16.03	85.3
riverine_3_2016	85	2.8	0.28	0.02	BDL	0.44	10.98	16.03	56.6
riverine_4_2016	530	5.4	0.84	0.027	BDL	0.14	100.04	48.1	570.2
riverine_5_2016	90	5.2	1.46	0.027	BDL	0.86	12.2	16.03	46.3
west_1_2016	1620	1.8	0.19	0.28	BDL	0.28	317.2	128.3	1582.9
west_2_2016	1380	1.4	0.11	0.006	BDL	0.41	263.5	120.2	1644.7
west_3_2016	980	4	0.29	0.008	BDL	0.68	195.2	72.1	1025.5
west_4_2016	690	5.8	0.62	0.009	BDL	0.47	129.3	64.1	821.3
west_5_2016	380	4.6	1.01	0.022	BDL	0.53	65.9	44.1	370.2
east_1_2016	1840	2.9	0.14	0.003	BDL	0.45	361.1	144.3	1944
east_2_2016	810	4	0.39	0.003	BDL	0.37	156.2	68.1	836.2
east_3_2016	690	3.7	0.49	0.022	BDL	0.46	131.8	60.12	791
east_4_2016	670	4.6	0.5	0.004	BDL	0.57	122	68.1	831.9
east_5_2016	480	4.9	0.66	0.005	BDL	0.55	80.5	60.1	561.7

Table – 3: Habitat Preference of Fin-Fishes at Southern Vembanad

Species	**F**	**F&B**	**B&M**	**F,B&M**	**M**
Aesopia cornuta					1
Ambassis ambassis				1	
Ambassis gymnocephalus				1	
Amblypharyngodon melettinus	1				
Anabas testudineus		1			
Aplocheilus blockii	1				
Aplocheilus lineatus		1			
Aplocheilus panchax		1			
Arius maculatus			1		
Arius subrostratus			1		
Brachirus orientalis			1		
Carinotetraodon travancoricus	1				
Ctenopharyngodon idella		1			
Dawkinsia filamentosa		1			
Etroplus suratensis		1			
Gerres setifer			1		
Glossogobius giuris				1	
Haludaria fasciata					
Horabagrus brachysoma		1			
Horadandia brittani		1			
Hyporhamphus xanthopterus				1	
Labeo dussumieri	1				
Labeo rohita		1			
Neochela dadiburjori	1				
Mystus gulio		1			
Mystus oculatus	1				
Parambassis dayi		1			
Parambassis thomassi	1				
Photopectoralis bindus			1		
Pseudetroplus maculatus		1			
Pseudosphromenus cupanus	1				
Pseudosphromenus dayi	1				
Puntius mahecola	1				
Puntius vittatus		1			
Rasbora dandia		1			
Salmophasia acinaces	1				
Scatophagus argus				1	
Systomus sarana		1			
Xenentodon cancila	1				

Table 4: Vembanad Fish Count Diversity 2008-16

Vembanad fish Count	**Fin fish**	**Shell fish**
1985 & 1989 (Kurup et.al.)	**60**	**-**
2008	**50**	**11**
2009	**62**	**14**
2010	**52**	**14**
2011	**45**	**9**
2012	**57**	**05**
2013*	**31**	**10**
2014	**45**	**10**
2015	**45**	**05**
2016	**39**	**05**

Table 1: No of fishes recorded in each fish count

* A jelly fish was collected from Thannermukkom