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Water Quality and Fishery Yield in the Batticaloa Lagoon Prior to and After Tsunami

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Abstract

A large proportion of the coastal population of the Batticaloa district depends on the Batticaloa lagoon for their daily bread from time immemorial. This has been made possible due to the high degree of biological diversity in the lagoon.

In this study an attempt was made the diversity of fauna with reference to fish and shell fish, diversity of flora in terms of mangroves and also records the diversity of ecological services provided by Batticaloa lagoon to humanity. Eleven sampling points were chosen randomly to collect data from the fish landing centers along the lagoon, regarding the fish catch, water quality. The fish catch statistics for fin fish and shell fish were collected for a long period but to compare the impact of Tsunami upon fisheries the data from 1993 to 1995, 2003-2004 and from 2004 to 2005 are considered in this study. The mean catch per unit effort from the Batticaloa lagoon was recorded as 2.55 kg, 2.14 kg, 2.9 kg and 1.98 kg per person per day for the period from 2004–2005, 2003–2004, 1993-1994 and 1994- 1995 respectively. *Orechromis* spp and *Etroplus* spp dominated the catches. However, during December to February shrimps especially *Penaeus indicus, Penaeus semisulcatus* dominated the catch. The fish catch and its market value showed impacts on the economy and life style of the fishermen.

The analysis reveals that the lagoon water still retains reasonable standards of water quality in many areas except in selected pockets where industries are heavily concentrated. The shocks imposed by the modern stakeholders through industrial activities are unbearable most of the time, but the system does not show any serious signs of collapse due to the free delivery of ecosystem services such as delivery of lagoon consumable products to human. The water quality of different locations was also studied where at some places the nitrate, phosphate levels were higher in Kattankuddy and Thiruperumthurai, where the untreated municipal garbage, industrial wastes are pumped. The scenario is likely to be worsening if proper environmental governance is not adopted by the stakeholders.

Key words: Batticaloa Lagoon, Fin Fish, Shell Fish, Water Quality, Catch per Unit Effort, Tsunami.

Introduction

The total land area of Batticaloa is about 2464.5 square kilometers. The Batticaloa district has about 1,303 hectares of mangroves, 2,196 hectares of salt marshes, 136,822 hectares of lagoons and associated with estuarine basins and 365 hectares of other water bodies [1,2]. The backwaters occur along the eastern coast of Sri Lanka covering an estimated area of around 39,234 ha [3]. An important characteristic of lagoon is its biological diversity, which refers to the diversity of various species of living organisms, plants and animals, the presence of various ecosystem services and genetic diversity. Such diverse combinations of living organisms and ecological services constitute the natural resource entitlements to the local communities.

Apart from these direct tangible flows of economic benefits, lagoon also provides a variety of indirect services to local communities, which enhance economic significance of these ecosystems to many folds. The capacity of lagoon to regulate various gases, climate, water flows and its supply, soil erosion and sedimentation, retention and soil formation, nutrient cycling, waste treatment, pollination and hence control various biological processes is well recognized [4]. Perhaps the lagoon could provide different kind of recreation services and act as the primary pool of genetic resources. In fact, these diverse ecosystem functions along with the direct flow of economical benefits through the supply of various goods and services make these systems valuable to humanity. These services are enjoyed by people almost free of charge or at a price much below the cost of acquiring alternate but similar services.

The economic importance of these ecosystems to the local communities and to the world at large has been recognized in the forums of the Convention of Biological Diversity way back in 1992 and the subsequent Ramsar conventions initiated many programs for the management of estuaries. Despite these initiatives these ecosystems continue to deteriorate all over the globe, due to the inbuilt socio economic and environmental problems associated with their use and misuse. In Sri Lanka, the Ministry of Fisheries and Aquatic Resources Development has also implemented many programmes and legal measures for the sustainable development and management of these ecosystems partly due to international compulsions.

Lagoons, being the largest common property ecosystems, play a dominant role in the economy of Eastern districts, although its economic importance has not been properly recognized both in the academic and policy circles. It is unfortunate that these systems were never the primary targets of planning till now. In eastern Sri Lanka lagoon ecosystems and associated mangroves have not raised much concern over their management or lack of management. Till very recently, it was an environment, left to the socially weaker sections of the society or to the military services to take care of these pristine systems due to the crisis prevailing in the east. A number of fishing families and poor agrarian communities were the major organizers of livelihood activities on this environment.

Fisheries in Batticaloa District are based on three lagoons namely Batticaloa, Valaichenai and Upparu (Vaharai) and adjoining coastal belt [5]. The Batticaloa lagoon is the largest among the three found in the district [5]. The Batticaloa lagoon extending from Kalmunai in the

South to Eravur in the North and opens in to sea at Pallameenmadu (Batticaloa) and Kallar, the lagoon is about 36.8 km and five meters deep, earlier the depth was considered as about seventeen meters through the armature fishermen but now surveys shows that is an average about five meters.

The quality of water in any aquatic system is very important. The physical and chemical parameters support the biological parameter. The lagoon and estuaries mostly contain brackish water.

Batticaloa lagoon has some peculiar features, as any choked lagoon and the water quality is also similar to the choked lagoon [6]. The water quality of Batticaloa lagoon directly depends on the fresh water entry, precipitation, evaporation, seepage and the tidal action [6].

This study has focused mainly on the water quality, harvesting of the standing stock from the unstocked lagoon before and after tsunami. However, the study extends into catch per unit efforts, fish production for the sustainable fisheries with assistances from non governmental agencies for tsunami recovery.

Materials and Methods

Data on fish catch and gear and the value for the catch were collected at fish landing sites and at fishermen's rest camp from the district. The finfish and shellfish were identified with the help of the FAO field identification guide for Sri Lankan Marine fish [7] (FAO, 1994). Data were collected five days a week at randomly selected landing site along with water sample for the water quality parament and a questionnaire distributed among the fisher folks to reveal the method of fishing, total catch and duration of fishing. Catch per unit effort for different fishing gear types were also recorded. The number of canoes operated at the landing site also was recorded

Water quality parameters such as salinity, pH, air water temperature, dissolved oxygen, turbidity, nitrate, nitrite, phosphate and free chlorine were measured biweekly intervals from January 2004 to December 2004. Organic, inorganic compounds, metallic ions and biotic characters were also recorded. The water quality parameters were measured as described by Vinobaba and Shanmugapiriyan [6].

The locations were selected based on the entrance of nutrients, which have an influence on water quality. The choosen locations are as follows Kallady (L_1), Palameenmadu (L_2), Closer to General Hospital (L_3), Urani (L_4), Kattankudy (L_5), Manchanthoduwai (L_6), Vavunathivu (L_7), Arayampathy (L_8), Kowdatheevu (L_9), Paddippalai (L_{10}) and Pankudaweli (L_{11}) (Figure 1).

The flora and fauna was identified using the keys available [8],[9].

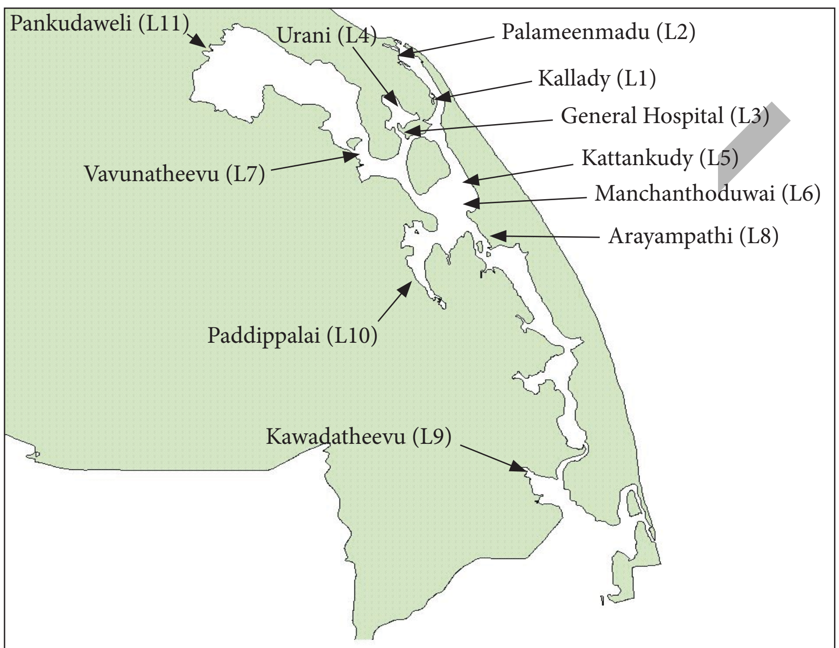

Figure 1: Sampling sites from the Batticaloa lagoon

ANOVA and student-t test were performed for the data obtained to compare the fish production among years.

Results

The analysis of various physical, chemical and biological parameters of the lagoon ecosystem has been studied mainly to draw an idea into the capacity of primary and secondary production. Fishery resources of the lagoon are directly linked to the primary productivity.

Main phytoplankton species available in the lagooon fall under three broad groups, such as diatoms, dinoflagelleates and blue green algae. Diatoms, identified are as follows: *Amphora* sp, *Asterionella japonica*, *Biddulphia mobiliensis*, *Chaetoceros* sp.*Coscinodiscus* sp, *Gyrosigma*, *Navicula* sp., *Pleurosigma* sp, *Pleurosigma Rhizosolenia* sp, *Skeletonema* sp. Dinoflagellates, identified are as follows: *Ceratium* spp., *Dinophysis* sp. and *Peridinium* sp. Blue green algae, *Oscillatoria* sp., *Nostoc* sp. and *Anabaena* sp. were identified (Table1). The species distribution varies with the location and water quality parameters. The primary productivity studied from only three sites in 2005at specified sites where influx and mixing taking place (Table 2).

	Amphora sp	*Asterionella japonica*	*Biddulphia mobiliensis*	*Chaetoceros* sp	*Coscinodiscus* sp	*Gyrosigma*	*Navicula*	*Pleurosigma*	*Skeletonema* sp	*Pleurosigma*	*Ceratium*	*Peridinium*	*Oscillatoria*	*Nostoc*	*Anabaena*
L_1	√	√	×	×	√	√	√	√	√	×	√	√	×	×	×
L_2	√	√	√	√	×	√	√	×	√	√	√	×	×	√	×
L_3	√	√	√	√	√	√	√	√	√	√	√	√		√	√
L_4	×		√	√	√	√	×	√	√	√	√	√	√	√	√
L_5	√	√	√	√	√	√	×	√	√	√	×	√	√	√	√
L_6	√	×	×	√	×	×	√	×	√	√	×	√	√	√	√
L_7	√	√	√	√	√	√	√	√	√	√	×	√	√	√	√
L_8	×	×	×	√	√	√	√	√	√	√	×	√	√	√	√
L_9	√	√	√	√	√	√	√	√	√		×	×	√	√	√
L_{10}	√	×	×	√	√	√	√	√	√	√	×	×	√	√	√
L_{11}	√	√	√	√	√	×	√	√	√	√	×	×	√	√	√

Table 1: Distribution of phytoplankton from the Batticaloa lagoon

(√ - present in the location; × – absence in the location during the study period)

The secondary producers (Zooplankton) depend on phytoplankton for their food and are responsible for the production and growth of tertiary producers such as fishes, shellfishes. The major zooplankton communities are copepods, crustacea larvae, euphausids, mysids, amphipods, cladocera, pelagic tunicates, polychaete larvae, chaetognaths and the larvae of fishes and other organisms. Crustaceans constituted about 93% of the total annual zooplankton counts. Benthic environment forms a link in the food chain of edible resources and plays a vital role in deciding the health of the ecosystem. These non-edible organisms are polychaetes, echiuroids, sipunculids, molluscs, crabs, echinoderms, certain benthic plants, sponges, protozoa and coelenterates.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
L_2	3124	612	716	644	789	503	438	486	715	3600	1034	965
L_4	1615	432	2012	773	1200	360	1010	911	1134	3400	1130	1740
L_5	2035	472	2020	795	1600	560	1060	928	1120	3700	1330	1790
L_7	1825	538	899	1375	719	448	432	561	2548	3900	1850	2880

Table 2: Primary productivity measurements in 2005 (Production mg C/m3/ day)

Mangroves in and around Sathurukondan, Pillayarady are heavily destroyed by man made causes especially for security reason and at Palameenmadu, Thiraimadu, Navaladdy are destroyed recently due to the unprecedented natural disaster tsunami. The major species recorded prior to tsunami in these areas are *Avicennia* sp, *Rhizophora* sp., *Excoecaria* sp., *Acanthus* sp., *Lumnitzera* sp and *Sonnaratia* sp.

Fisheries Activities

There are 11,718 full time fishermen doing their fishing activities in the Batticaloa lagoon. Majority of them (80% of the fishermen) use cast nets in shallow areas of the lagoon by wading or with the assistance of fiber reinforced plastic canoes in the deeper part of the lagoon. Very few people (nearly 20% of fishers) use gill net or drift net in the permitted areas of the lagoon. The fishes frequently caught are shown in Table 3.

Species	Relative abundance (%)	Species	Relative Abundance (%)
Acanthurus sp	0.1	*Hemiramphus*	0.1
Alanetta sp	0.3	*Lates sp*	0.3
Arius sp	13	*Leiognathus sp*	1.2
Arius thalassinus	2.1	*Liza sp*	0.9
Arius bilineatus	2.3	*Lutjanus sp*	0.6
Arius jella	2.6	*Metapenaeus dobsoni*	1.1
Arius maculates	3.8	*Metapenaeus monocerus*	1.8
Arius caletus	2.2	*Mugil cephalus*	1.25
Caranx sp	0.4	*Mystus gulio*	0.8
Chanos chanos	0.9	*Nematalossa nasus*	1.5
Cirrhus mirigal	0.5	*Orechromis mossambicus*	20.3
Etroplus suratensis	19.2	*Penaeus monodon*	0.9
Etroplus maculates	16.5	*Penaeus indicus*	2.1
Harengula ovalis	0.05	*Penaeus semisulcatus*	1.8
Scylla serrata	0.9	*Portunus pelagicus*	0.5

Table 3: The list of fin fish and shell fish caught from the Batticaloa lagoon among the commercial catch from January to December 2005.

Etroplus sp and *Orechromis mossambicus* dominated the catch dHowever, during December to March, shrimps dominated in the catch. The shell fish and fin fish were caught by wading fishermen with cast nets, cast nets from canoes and the drift gill nets in the permitted areas in addition to the trapping devises to catch fin fish and shell fish.

The variation in fishery catches with months from the Batticaloa lagoon for 1994, 1995, 2004 and 2005 is given in the Fig 2. The fishing pressure in the lagoon changes seasonally, with more crafts operating in the lagoon during North East monsoon, when the bar mouth permits the lagoon to reach the open ocean. Further after tsunami the fishermen did not want to go to the deep sea also engaged in lagoon fishing.

The monthly average fish production and total fish production of each are shown below in the Table 4 . The fish production showed significant differences ($p = 0.00 < 0.05$ for ANOVA) over twelve months of years of 1994, 1995, 2003, 2004 and 2005.

Moreover, significant differences were observed in the fish production of twelve months between the years of 1994 and 1995 ($p = 0.00 < 0.05$ for paired student-t test), 2003 and 2004 ($p= 0.011< 0.05$) and between the years of 2004 and 2005 ($p = 0.008166 < 0.05$ for paired student-t test).

Years	Total fish production of year (MT)	Monthly Average (MT) ± SE
1994	3015	251.25 ± 24.04325
1995	4180	348.33 ± 21.82344
2003	5626	468.83 ± 35.007287
2004	7639.4	636.61 ± 62.02797
2005	5460.5	455.04 ± 30.79916

Table 4: Monthly average fish production and total fish production

Variation in fish production can expressed in graphical format as shown in the Fig 2 and variation of catch per unit effort (CPUE) in Fig 3. Variation of average turbidity and average salinity among the sampling localities are shown in the Fig 4 and 5 respectively.

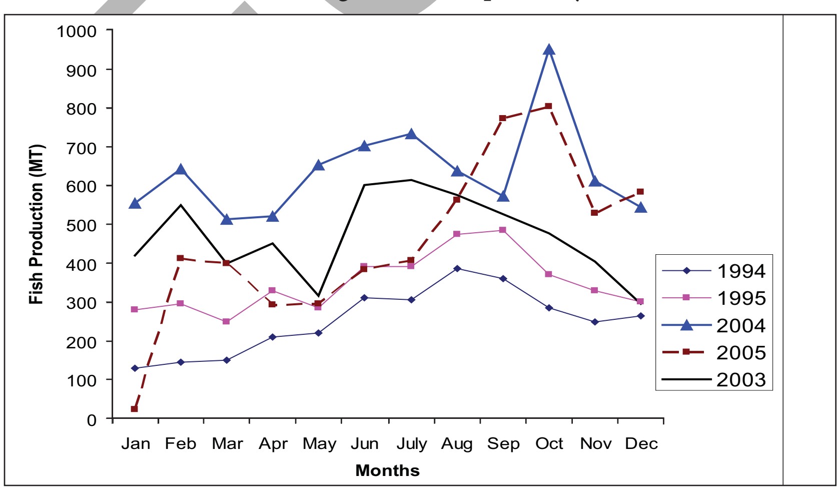

Figure 2: The temporal variation of fish production from the Batticaloa lagoon (in metric tones)

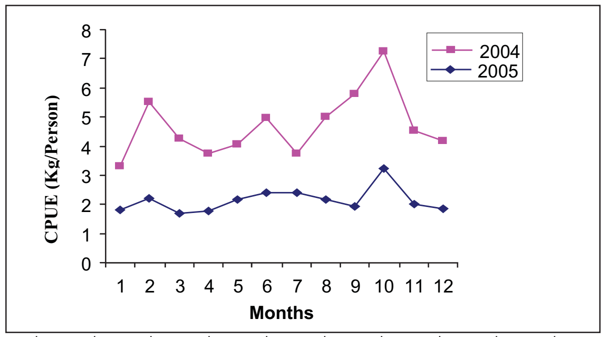

Figure 3: Temporal variation in catch per unit effort (CPUE) for fishing at the Batticaloa lagoon in 2004 and 2005

The catch has increased per month during the study period with the sign of fluctuations. The fishermen earn from SL Rs 150 a day to SL Rs 250 a day depending on the location and gear used.

Water Quality Parameters

Turbidity is high during heavy floods. The highest turbidity was observed in location L1 with a value of 94 FAU.

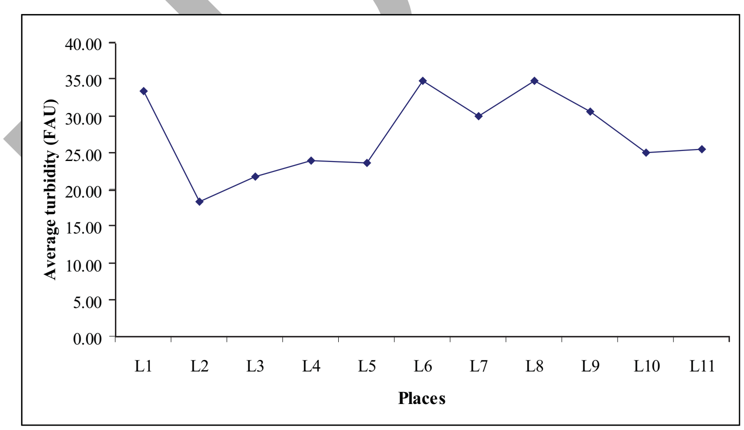

Figure 4: Variation of average turbidity among sampling localities for all months of the year 2004.

In Batticaloa lagoon, salinity varies from the oceanic mouth of the estuary, which is 35 PSU, to 0 PSU at southern and northern ends.

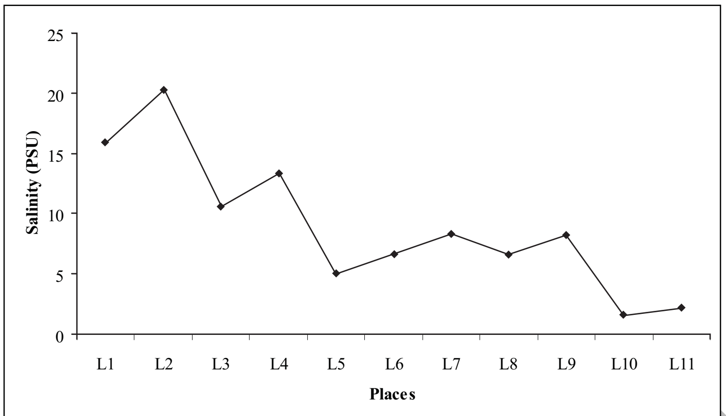

Figure 5: Variation of average salinity among sampling localities for all months of the year 2004.

The pH value of the Batticaloa lagoon is more or less constant even during the rainy season. The pH did not show great variations. In this study low pH of 6.64 and higher value of 8.06 were observed. Temperature is a limiting factor for productivity. During this study the recorded minimum temperature was 28^{o}C. The minimum dissolved oxygen of 4.50 ppm and maximum dissolved oxygen of 5.90 ppm was observed at the beginning of the rainy season. The highest concentration of 4.00 mg/l nitrates was observed in October 2004 and the lowest nitrate concentration of 0.01 mg/l was observed during heavy floods on 25 November 2004. The high concentration of 13 mg/l nitrite was observed close to agriculture lands during heavy floods of 2004 and low level of 1 mg/l concentration of nitrite was observed in bar mouth area in October 2004. However, in most location, the range of 3.00 mg/l to 9.00 mg/l of nitrite was observed. Regarding phosphate high concentration of 1.68 mg/l was observed in the area, which is closer to the agriculture lands. However, in Urani an area of very high amount of phosphate (4.95 mg/l) was observed in October 2004. The low concentration of 0.11 mg/l phosphate was observed in Kallady. Low amounts of free chlorine 0.01 mg/l was observed in most of the sampled sites throughout the study period and high amount (0.75 mg/l) of was observed in Kattankudy and Manchanthoduwai. The Pearson correlation done to check the correlation with water quality parameters to the fish catch during the years of study. It revealed that there is no strong correlation for the fish catch to that of the water quality parameters.

Discussion

The analysis indicates that the ecosystem is retaining its average health expressed through the existence of a diverse floral and faunal composition. However, in certain locations where external interventions are high which may damages the environment. Ecosystem services of lagoon are valuable supporting services, which influence the organization of economic activities. An important function that adds value to estuaries is its tidal functions. When salt water enters into the estuary and mixes with fresh water during high tides, a healthy habitat is created for various living organisms. Similarly, when water recedes during low tide a variety of pollutants and wastes are taken into the oceans. This function in fact subsidies the cost of cleaning for the local population. The fin fish catch, which has increased per month for years of study, was due to the increase in the effort along with the rehabilitation assistance from Government subsidy schemes from 1990 to 2000. The non governmental agencies too embarked into the rehabilitation efforts for donating fishing gear and vessels after the unprecedented natural disaster. Some fin fish and shell fish are residential and some are migratory and the species distribution varies with the locations. Especially after the tsunami irrespective of the number of fishermen who were involved with fishing in the lagoon were provided with assistances. This results in the increased production and during the course of the period from March 2005 to November 2005 it shows a decreasing trend for the catch per unit effort (Fig 3). However, the overall fish production of 2005 was lower than that experienced in 2004, whereas the catch per unit effort has maintained at a lower level with lower degree of fluctuation. The catch per unit effort of 2004 was fluctuates over a wide range, indicates an unsustainable fisheries. The maximum sustainable yield from the lagoon was not estimated. The fishing licenses were issued by the Ministry of Fisheries and Aquatic Resources and in addition the fishermen were provided with the assistances to improve their livelihood in the form of canoes and fishing gears. This may have increased the fish production. However, the continuation of the same without any controls will undoubtedly culminate in a crash in fish production for longer term in the future. Impacts of fisheries on ecosystems are sometimes difficult to separate from environmental effects on ecosystems. Some of these possible fisheries effects include: direct impacts of over fishing, modifying community species composition and genetic diversity through selective targeting on species and particular size classes, impacts on non-target species through low selectivity of certain gears, incidental mortality from lost or abandoned gear, destructive illegal "fishing gear" such as small meshed gill nets, dynamite and poisoning. The ecological equilibrium has therefore been disrupted and the rapid increase in fishing gear and the employment of illegal practices have resulted in, a smaller size at recruitment for the main target species; the destruction of natural spawning grounds; a lower catch per unit effort; more disputes between fisher groups.

Further, the production may have been affected by the outbreak of the fish disease condition created a fear among the consumers as eating such fish will be harmful to human health. This affects the fishermen's socio economy. If the earning will be reduced then it reflects in the life style and the economic status of the fishermen. Since this is the area showed fast resilience after the setback by civil war and the tsunami in the form of lagoon fishing than deep sea going vessels which incur heavy investments. The disease symptom of epizootic ulcerative syndrome appears to found in the period after the heavy rainfall [10] (Vinobaba and Vinobaba, 1999). This aspect of the disease and causative organism has to be studied thoroughly via intensive research to find out the fish disease prevalence and related effects on fish population. Increase in the number of fishermen either part time or full time will also contribute to the increased fish production and later the same will affect the fisheries stock in the lagoon ecosystem. The resource within the lagoon not only the fin fish and shell fish has not been surveyed thoroughly to establish the maximum sustainable yield for each variety. That has to be done immediately without any time delay to preserve this pristine ecosystem for a longer future. Now this lagoon has been categorized into the special area management site (SAM site), for both the aesthetic and biodiversity.

The Batticaloa lagoon has been categorized by the fisheries ordinance under chapter 212 section 33 of the division 2(e) of 1972. According to this section, the lagoon has been divided into three regions; region one is bar mouth to Kallady bridge and east coast of Pulliyanthivu, Erumaithivu and Urani kudah; region two includes Sorruvamunai kadal Manmunai and Kallar; and region three includes east to Onthachimadam and Koddaikallar causeway, from which makes it easier to implement the regulations efficiently. Cast net and any form of line fishing can be carried out at any part of the lagoon through out the year. Cast net is the absolute fishing method to be practiced in the region one and three, usage of other gears are totally prohibited. In region two, no one will be permitted to use drift net with a mesh size below 3 inches. Under any circumstances no one will be permitted to practice fishing with powerful artificial lights like petrolmax only the "sool lantern" can be used. The government agent or the authorized officer can decide where and to what extent the traps can be placed for shrimps and crabs. Only cast net fishing is permitted from the sand bar entrance to the interior of the lagoon for about 200 yard radius.

The existing lagoon ordinance (1972) did not have the legally permitted standard length of a fin fish or shell fish to be caught in the ecosystem. Likewise there is no regulation to control the removal of gravid female and matured male fin fish and shell fish from the lagoon ecosystem. Undersized fin fish or shell fish are being removed from the lagoon as by catch, indicates that we are totally wasting the natural resource from the lagoon. For a country like Sri Lanka we are having more than enough fair amount of regulations but is not being implemented in the way in which it supposed to be, is a major draw back in maintaining sustainable catch. Now the very same lagoon is incorporate into the special area management site. The success depends on the fishermen co-operation into the regulation and management of the resources. The management of the fisheries is not a new development is still existing based on taboos, these customary rules forbade all capture of fingerlings, gravid females or juveniles. They also designated rest days when no one was allowed to fish for fear of incurring the wrath of the gods. But the recent population is not following the age-old indigenous traditions for conservation and preservation of natural resources is a prime cause for the loss of biodiversity.

The ecological services of mangroves in the backwater belt are highly valuable to the domestic communities. The ecotourism values of the lagoon and sport fishing potential are also highly valuable to the domestic and foreigners alike but this is not yet explored. The shore stabilization functions and sedimentation functions are useful in many ways to the people in the coast of the lagoon. Now along with the destruction of the mangroves and the high precipitation intensity there are signs of pronounced erosion on the coastal road and coast to aggravate the sedimentation and siltation into the benthic system of the lagoon.

Water Quality Parameters

Most of the suspended particles enter the lagoon via the agricultural areas, such as L9 (2 FAU) and L7 (82 FAU). The water movement towards the mouth at the Northern end also mixes further and created more turbidity during the rainy season. The process of salt-water inflow, river water inflow and the lagoon water outflow mostly change the salinity during the rainy season and evaporation increases salinity during dry season. Batticaloa lagoon has more fresh water input than the evaporation rate, hence, most of the lagoon experiences a low salinity even in dry season except in the mouth area (Palameenmadu) and semi-closed area (Urani 5 PSU to 27 PSU) due to the unplanned construction of bridges. In Batticaloa lagoon sediment of the lagoon plays a major role in dissolved oxygen (DO) content. However, the water movement too has a major role during the rainy season. With the excess entrance of the solids into the lagoon, the DO decreases during November and December months and depends on the inputs of waste materials in-polluted areas, a low DO was detected. According to Selvadurai (1997) [11], the DO range was 5 to 6 ppm at different sites of the Batticaloa lagoon. This value was also clearly observed in most of the lagoon sites, during the present study. Nitrites are not usually found in surface water, where they are readily oxidized to nitrates. The presences of large quantities of nitrites indicate partially decomposed organic waste in the water [11](Selvadurai, 1997). Black gill and cuticular lesion in cultured shrimp is caused by ammonia and nitrites. Sub acute or chronic exposure to as little as 1 ppm unionized ammonia or 10 ppm of nitrite may result in gill damage and black gill and low level mortalities [12] (Chen *et al*, 1990). Such ammonia and nitrite are communally observed in the pond and tanks [13] (Neal *et al*, 1973). Phosphate occurs in natural water and in wastewater almost solely in the form of Phosphate. Phosphate enters the water supply from agricultural fertilizer run-off, slaughter houses, water treatment and biological wastes and residues.

To protect fish resources, it is necessary to protect the habitats in which fishes live. Fishes spend their entire lives from egg to adult immersed in water and the quality of this water can determine whether they live or die. The agriculture industry next to the lagoon permits the organic chemicals into the lagoon along with the flood either from the rain fall or from flood water from adjoining districts. These poisonous chemicals, such as chlorine, pesticides and petroleum, can kill fishes directly. Other pollutants, such as sewage and organic wastes, pumped into the lagoon especially next to Kattankudy and some other sites of the lagoon, can take up the oxygen which is dissolved in water, denying the fish which need oxygen to survive. The effects of some chemical pollutants, such as pesticides, may be felt in areas far from where the pollutants enter the lagoon. These pollutants are taken up in small amounts by fish which store them in their bodies. If these fish do not die as a result of these poisons, they may be eaten by carnivorous fishes. The carnivorous fishes accumulate more and more of the poison with each contaminated fish they eat and at some point the toxic level can become high enough to kill them or render them hazardous for human consumption.

A healthy, functioning mangrove ecosystem is also a necessary habitat requirement for brackish water fishes. The mangrove ecosystems provides food, shelter and breeding areas for fin fishes and shell fishes and most species are adapted to live in quite specific types of areas. Habitat destruction through destruction of mangroves and illegal fishing may eliminate certain species of fish from these areas. Those who done the damage know the value of the fish they are killing. These habitats take years to recover and during that time they cannot support the fish communities that once lived there.

Pollutants released into lagoon by various cottage industries, shrimp farms and agricultural effluents on the coast of the water body along with flood water have caused severe reduction in the productivity of fishing activities. Dredging of the bottom of may produce severe ecological imbalances but this has been explored and implemented at some places after the tsunami. Sedimentation externalities and improperly constructed bridges have reduced the water holding capacity and water flow in the ecosystem causing water logging and reduced fishing

Conservation is essentially the wise use of natural resources. Conservation involves the management of these resources so that the benefits of food, recreation and economic development can all be realized by the people of Batticaloa today and in the future. Because fish are living resources, they are also renewable resources, if they are wisely managed. Management of fishery resources requires consideration of two factors: 1) ensuring that fish species will be able to reproduce themselves and 2) allowing fish time to grow big enough so that the total weight of the fish caught can be maximized. The first factor (ensuring reproduction) can be achieved by postponing the harvest of fish until they become old enough to reproduce, accomplished by minimum net mesh regulations which is already there as Batticaloa lagoon ordinance from 1972, 1996 and 2001 now due to the realization of the importance this lagoon is placed under special area management site. Further the conservation can be achieved by setting aside certain areas as sanctuaries, where fish can grow to maturity and reproduce without being subject to fishing. Management efforts designed to maximize the weight of the fish catch by regulating the size of adult fish which can be caught require considerable scientific knowledge of growth rates and natural death rates of fish species. Traditionally, there have always been local initiatives to control access and harvesting of the common resource. However with the evolution of modern institution for the creation of new values, that has lead to the erosion of traditional values and related institutions.

The establishment of sanctuaries within which harvesting organisms is forbidden has proved to be a useful management measure. Such sanctuaries permit populations of fish to carry out their normal behaviors unmolested and are valuable tourist attractions as well as popular spots for recreational sites and research study site. Sanctuaries also may allow fishes to spawn more effectively and so serve to provide young recruits to other, overexploited parts of the lagoon.

Environmental economists point out that biodiversity degrades primarily due to the irrational uses of resource by various stakeholders, which result from the failures of market forces to allocate resources and environmental assets efficiently among different stakeholders across generations. It is also caused by various institutional and government failures to regulate such irrational uses through modern environmental governance. The biodiversity degradation in lagoon ecosystems is also related to the nature of weak political and social mobilisations of lagoon fishermen co-perative societies to tackle their problems. In developing countries like Sri Lanka, people's movements play a crucial role in influencing policy at some stage.

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