Preliminary studies on Seagrass habitat water quality and estimation of shrimp fishery productivity in the Negombo Lagoon

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Abstract

The present study was to evaluate the seagrass habitat water quality and shrimp fishery productivity in the Negombo Lagoon. The objectives of the study were to investigate the distribution of seagrass habitats, water quality parameters and to estimate economic value of seagrass ecosystem. Seagrass habitats are providing habitats and also act as nursery grounds for economically and ecologically important shrimp species.

The seagrass habitats located in the Negombo lagoon mainly Kadolkele, Negombo Pitipana, Aluthkuruwa, Thalahena, Sethapaduwa, Liyanagemulla, Katunayake and Kurana were selected for this study. The shrimp population depends on both physical and chemical parameters of the seagrass habitats. Samplings were made fortnightly and salinity, ammoniacal - nitrogen, nitrate - nitrogen, nitrite - nitrogen and phosphate-phosphorous and number of shrimp larvae, total shrimp catch and mean shrimp prices for a period of one year were measured during a period from July 2007 to July 2008.

Kodolkele, Thalahena and Kurana had the highest abundance of seagrass communities. It was found that the abundance of shrimp catch in seagrass habitats areas is higher than in without seagrass habitats areas. The abundance of shrimp larvae in Negombo Lagoon was negatively correlated with salinity and nitrite-nitrogen content in the water and is positively correlated with nitrite - nitrogen, ammoniacal - nitrogen and phosphate- phosphorous content in the habitats.

The seasonality in the shrimp catch and water quality parameters were observed with a peak periods from May/June to October/November, which apparently coincided with the south west monsoon and the onset of north east monsoon of the island respectively.

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Introduction

Negombo lagoon is one of the most productive semi enclosed shallow brackish water estuary in Sri Lanka (Pillai, 1965). It is situated in the Gampaha district on the western coast about 20 km north of Colombo at 7^0 7' N and 79^0 50' E. It is 12 km in length and 3.75 km at its widest point. It is a mixing ground not only for sea water coming in through the tidal inlet and fresh water entering through the river delta, but also for dissolved inorganic and organic constituents and particulate matter, sediment and biomass. Therefore its physical nature, chemical composition and biological diversity are always determined by the diurnal and seasonal changes and the catchments induced freshwater inflow (Silva, 1996). The main fresh water input comes from rivers Dandugam Oya and Ja-ela canal but the lagoon is characterized by a brackish water flora sea grass and some mangrove forests in the northern, eastern and western part. Their productivity is high and they act as a silt trap and provide spawning, nursery, feeding grounds and sheltering for a variety of economically important shrimp species during the juvenile phase of their life cycle.

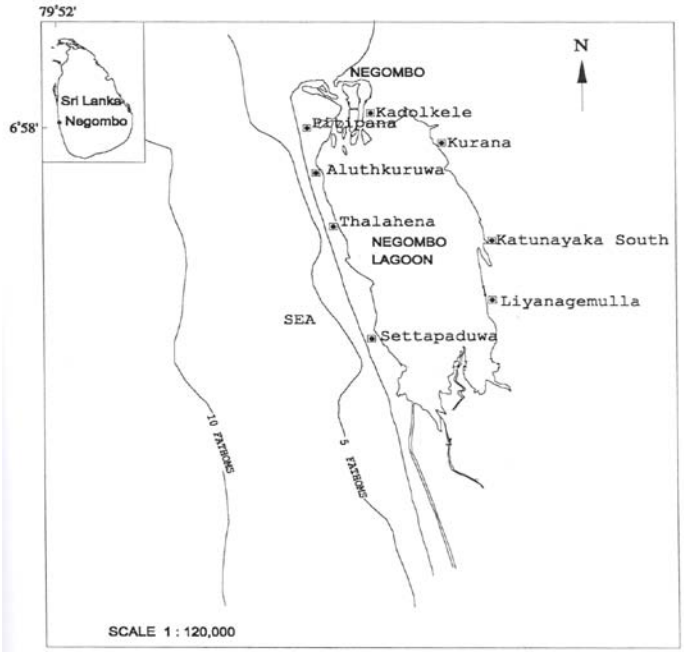

Figure 1 Location Map of the Negombo Lagoon

Sea grass beds cover 22% of the lagoon area and are highly productive, providing habitats for a variety of brackish water organisms including many economically important species of shrimp resources (Jayasuriya, 1991). These sea grass habitats are very sensitive to salinity and nutrients of water. Review of factors influencing distribution of shrimp larvae reveals the

importance of salinity and nutrient content and extent of sea grass cover on the distribution of shrimps in estuaries. The salinity and nutrients gradients in estuaries depend on the relative balance of the following factors are Run-off from the land, Rainfall, Evaporation from the estuary itself and tidal influence and distance from the coast line. (Tookwinas *et al*, 1985). Temperature and salinity variation is found to be greater near the surface than at the bottom. Further, the salinity pattern in the lagoons has been found to influence the survival and growth rate of aquatic organisms.

The shrimps are the major resources of this system and around 20000 people are directly and indirectly dependent for their living. The fisheries in the system are multi gear and multi species. There are four major fishing gears, trammel nets, drag net, brush piles, cast nets used within the lagoon and the associated coastal ecosystem. The scope of the work of the study is limited only to lagoon boundary area of the north western and eastern shore of the Negombo Lagoon. Other Fish species are also dependent on the sea grasses, but here the focus is on the shrimp because it is critically dependent on salinity and nutrient levels.

Objectives

(i). Studying water quality parameters in sea grass ecosystem.

(ii). Estimation of shrimp productivity

METHODOLOGY

Study Site

This study was carried out in the eight sampling locations were chosen within the lagoon, north shore of lagoon in Negombo Pitipana and Kadolkelle, western part of Aluthkuruwa, Thalahena and Sethapaduwa and eastern part of Liyanagemulla, Katunayeke and Kurana area. The collection of existing data pertaining to seasonal changes effect on physico - chemical parameters of water body in the Negombo Lagoon were carried out at the beginning of the south west monsoon in mid May - June 2008, and 2nd inter monsoon October - November and North East monsoon December-April and 1st inter monsoon July-September periods.

Data Collection

Shrimp larval catch

Relative abundance of different species of sea grasses and their coverage at each sampling site was estimated twice a weekly using a one square meter (1m X 1m) quadrate samples, randomly collected in number of shrimp larval catch were counted.

Water Quality

This study recorded the salinity and nutrient measurements of the Negombo Lagoon at eight sampling locations for periods of one year.

Salinity and Nutrient Measurement

Physico - chemical parameters such as Temperature, Salinity and Nutrients measurement were monitored using a Mercury Filled Celsius Thermometer (0^0 C -100^0 C), Refractometer (0 ppt - 100 ppt), Ammoniacal-Nitrogen (Phenate method), Nitrate-Nitrogen (Copper-Cadmium Reduction method), Nitrite-Nitrogen (Colorimetric-diazotization method) and Phosphate-Phosphorus (Ascorbic acid method) analyzes for APHA standard methods were used for the determine to the Ultra - Violet Spectrophotometer.

Shrimp Catch Data

Shrimp catch and effort data were collected from eight sampling sites selected from sea grass habitat near the landing sites around the Negombo Lagoon. Data included catch and effort data of different fishing methods employed to exploit shrimps in the lagoon.

Data Analysis

The data collected was analyzed statistically using a range of methods. These included regression, one way Analysis of variance (ANOVA) followed by the software, Minitab version 14 was used in the statistical analysis.

Analysis of catch and effort statistics

The fishing effort is expressed as the mean number of fishing operations per day with respect to different fishing methods. The number of fishermen involved in fishing operation is also constant and they usually have only one fishing operation per day. The monthly total production (MTP) with respect to each fishing method was estimated as the product of mean

catch in kg per unit effort (CPUE), mean number of fishing crafts operated per day (NFC) and mean number of fishing days for that particular month (MFD).

MTP = CPUE x NFC x MFD

Economic analysis of the sea grass ecosystem

Sea grass ecosystem supports number of functions including fish breeding, nursery, sheltering and nutrient retention etc. The indirect use value of sea grass beds in terms of the estuary use is the net income generated from the shrimp fishery resources.

Net income generated for local use = $\sum$ (P x Q – C)

P = Local market price of product,

Q = Amount of product being collected

C = Cost of collection of product

Results

Table 1 Summary of the mean statistical values of water quality parameters in eight sampling location during the period from July 2007 to July 2008

Month / Parameters	July 2007	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July 2008
Temperature ^{0}C	30.25	29.9	30.41	27.79	27.5	28.0	29.0	29.94	30.5	29.9	28.9	28.0	29.8
Salinity (ppt)	23.4	24.56	25.74	18.88	16.30	18.1	20.0	30.0	31.8	26.4	18.2	20.40	23.48
Ammoniacal	0.222	0.321	0.274	0.216	0.19	0.12	0.16	0.159	0.08	0.31	0.22	0.27	0.225
(mg/l)	0.250	0.305	0.378	0.542	0.437	0.30	0.24	0.389	0.40	0.33	0.55	0.419	0.256
Nitrate-N (mg/l)	0.044	0.065	0.065	0.042	0.020	0.050	0.02	0.144	0.16	0.11	0.05	0.14	0.06
Nitrite-Nmg/l	0.089	0.138	0.148	0.321	0.232	0.16	0.11	0.087	0.12	0.09	0.23	0.303	0.099
Phosphate(mg/l)													

Shrimp larval catch

Shrimp larval catch occurrence (Table 2) was high in September, November and April, June (Figure 1). Among the eight stations the shrimp larval catch occurrence was low in Negombo Piptipana and Sethapaduwa sites. Shrimp larval catch was highest in Kadolkele, Liyanegemulla and Thalahena. Monthly variations of shrimp larval catch (Figure 1), in the Negombo Lagoon reached a maximum during October, November, January and May, June during the south west monsoon season. Lowest level was found in January and July which are the dry season.

Table 2 Summary of the mean statistical values of shrimp catch data in eight sampling location during the period from July 2007 to July 2008

Month Parameters	July 2007	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July 2008
Shrimp Catch (kg)	1080	757.9	1644	1548	1112	147	1632	1262	1560	1841	1288	152	1001
Shrimp Price(RS)	450	375.5	2.45	374	422	541	475	380.1	353	450	463	525	520
Depth (ft)	2.125	2.12	295	2.95	3.36	2.09	1.65	1.6	1.835	1.77	2.0	2.01	2.125
Number of Shrimp Larvae	173	153	198	523	341	157	358	142	197	303	333	47	174

Monthly variations of shrimp larval catch (Figure 1), in the Negombo Lagoon reached a maximum during October, November, January and May, June during the south west monsoon season. Lowest level was found in January and July which are the dry season.

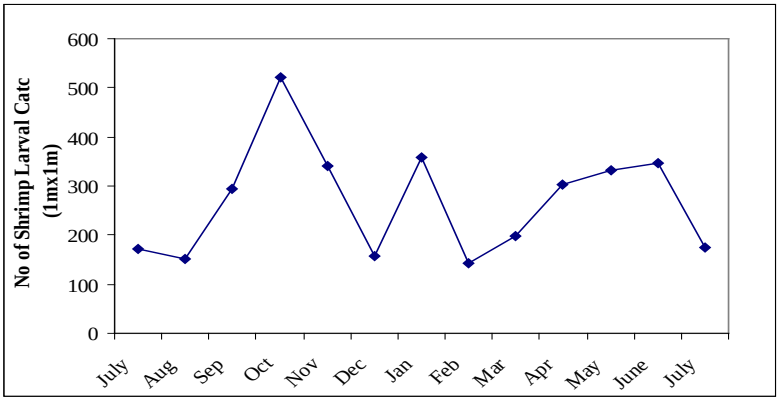

Figure 1 Monthly variations of number of shrimp larval catch

Water Quality Parameters

Temperature

The seasonal variation of the day temperature of the surface water of the Negombo Lagoon at different locations was reported during this study period. The mean monthly water temperature values for each site are given in Table 1. The mean value of temperature at the eight sampling sites during the study period is shown in Figure 2. The data show (Table 1) in some instances surface water temperature range from 27^0C - 30^0C and the lagoon water temperature becomes highest in September, January and March (Figure 2). The water temperatures dropped slightly in October/ November with the onset of the south west monsoonal rainfalls.

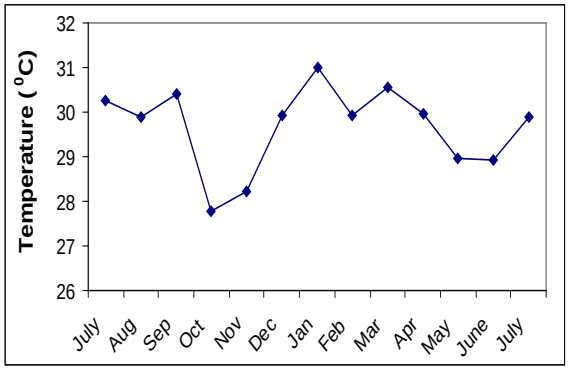

Figure 2 Monthly variations of water Temperature

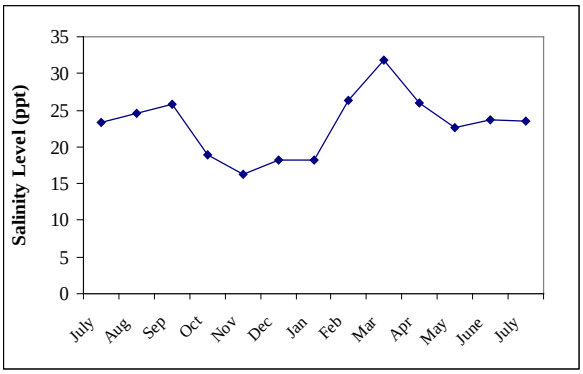

Figure 3 Monthly variations of Salinity level (ppt)

Salinity

The mean monthly salinity values for each sampling site are given in Table 1. The variation of salinity levels of the Negombo lagoon sea grass habitat was highest in sea mouth area of Negombo Pitipana and Kadolkele sites. There was a uniform pattern in the seasonal variations of salinities at all locations of the lagoon (Figure 3). Salinity in the Negombo Lagoon reached a maximum during September and February to April dry season and lowest values were reported in October, November and May, June during south west monsoon season. The salinity gradient was well established during August and September months from the fresh water outfall to the sea mouth and vice versa. Relatively higher salinities were reported in March (32 pot).The acceptable range of salinity values reported for shrimp growth and production is 10-32 ppt.

Nutrients

Nitrate - Nitrogen

Nitrate-Nitrogen in the Negombo Lagoon reached a maximum during October-November and May-June (Figure 4), during the South West monsoon season. Lowest levels were found in January and July during the dry season month. Nitrate-Nitrogen levels were highest in Kadolkelle, Liyanagemulla and Thalahena areas. Acceptable range of Nitrate-nitrogen for shrimp larvae is less than 01mg/l.

Phosphate - Phosphorous

Monthly variations of Phosphate-Phosphorus in the Negombo Lagoon reached a maximum during October, November during south west monsoon season. The lowest Phosphate levels were observed in February and July (Figure 4). Phosphate-Phosphorous levels were highest

in Kurana, Liyanagemulla, Negombo Pitipana and Kadolkele areas. The levels in the sample locations are within the acceptable range less than 01mg/l.

Ammoniacal - Nitrogen

Monthly variations of Ammoniacal-Nitrogen in the Negombo Lagoon reached a maximum during August and April before monsoon season and lowest level in December and March (Figure 4). Ammoniacal-Nitrogen level was observed to be significantly higher in Negombo, Kodolkele and Thalahena. The levels in the sample locations are within the acceptable range less than 01mg/l.

Nitrite - Nitrogen

Monthly variations of Nitrite-Nitrogen in the Negombo Lagoon reached a maximum during February, March and June and minimum was found in October, November, January and May (Figure 4).The levels in the sample locations are within the acceptable range less than 01mg/l.

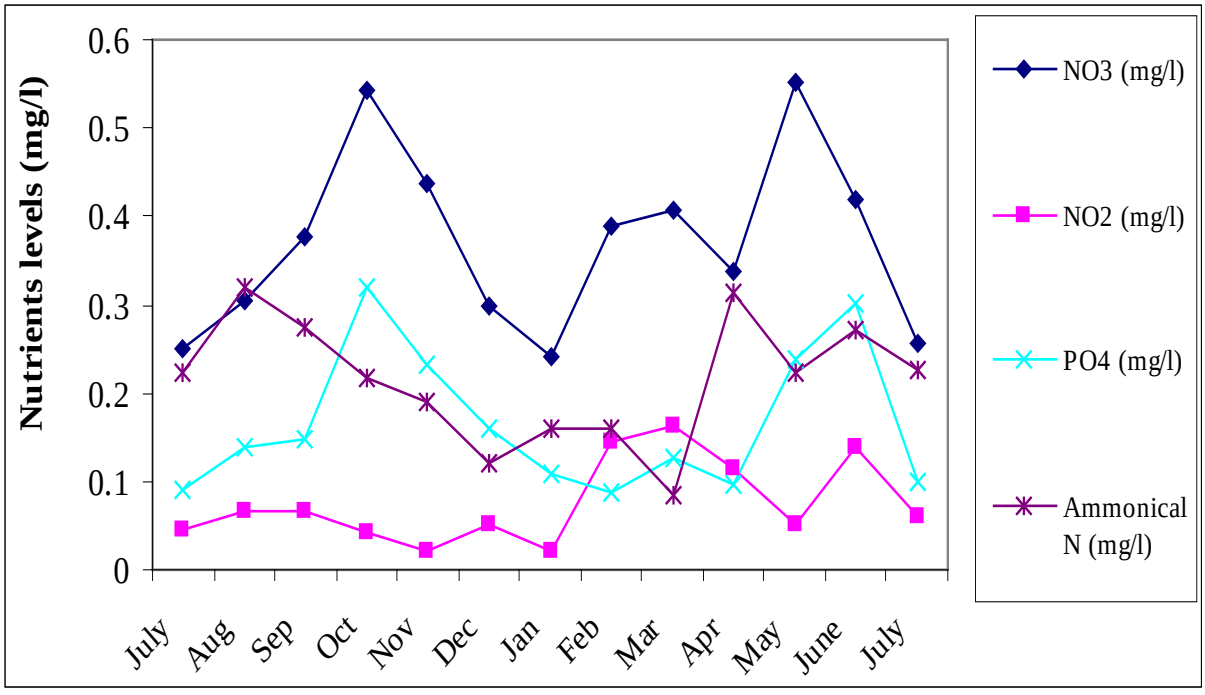

Figure 4 **Monthly variations of Nutrients levels (mg/l) in sea grass habitat in Negombo Lagoon**

Contribution of water quality parameters to shrimp productivity

In order to investigate the contribution of water quality parameters of the sea grass habitats and Shrimp larval catch relationship has been established. Shrimp larval catch was expressed as a function of the different water quality parameters measured. The best fitting regression model states that,

Shrimp larval catch =- 59 + 6.9 Salinity (ppt) + 34 Ammoniacal - N (mg/l) + 638 Nitrate-N (mg/l) - 1550 Nitrite-N (mg/l) + 175 Phosphate -P (mg/l).

Production function (Barbier, 2002), for the sea grass habitats indicate that Ammoniacal-Nitrogen, Nitrate -Nitrogen, and Phosphate-Phosphorous contribute positively to the larval catch while Nitrite-Nitrogen contribute negatively for the shrimp larval catch. The ambient water column concentration of the dissolved inorganic nitrite-nitrogen at all site negatively influence production rate of shrimp larval catch significantly r^2, $p<0.05$.

Shrimp Catch

Using a nets, brush piles, cast nets and drag nets were the major fishing gears employed by the fishermen in the Negombo lagoon regularly targeting shrimps. Most of the fishing in the Negombo lagoon is conducted by trammel nets and brush piles in the central region. Drag nets are also operated almost throughout the year but in the shallow regions. Monthly variations of shrimp catch in the Negombo Lagoon reached a maximum during September, October, January, April and May. Lowest level recorded in August and December. The annual total catch from the shrimp was estimated at 315 MT in the Negombo Lagoon.

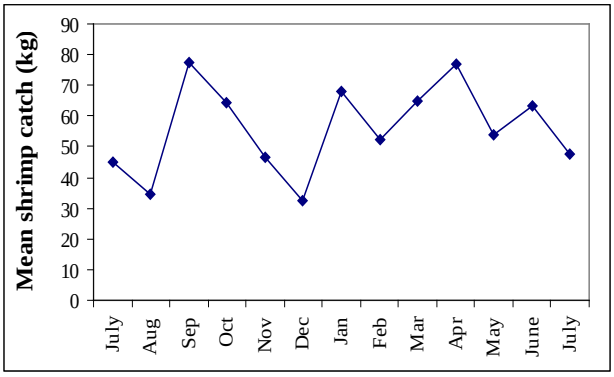

Figure 5 Monthly variations of shrimp catch (kg) rate

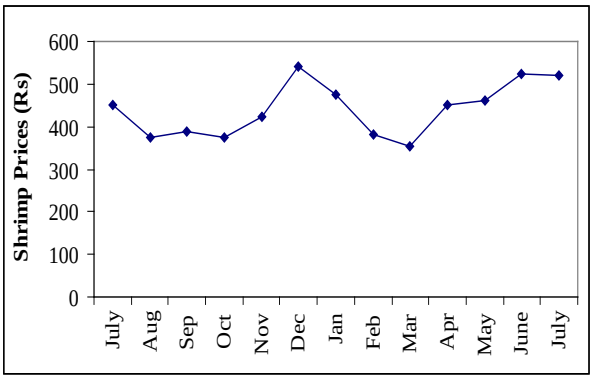

Figure 6 Monthly Shrimp prices (LKR)

Shrimp Income

The fishing costs were typically low for all gear types and daily trip costs were negligible since all boats are hand powered. Monthly variations of Shrimp prices in the Negombo Lagoon reached a maximum during December, June and July.

Net income generated for local use = $\sum (P \times Q - C)$

P = Local market price of product i = 439.72 LKR per kg

Q = Amount of product i being collected = 315 MT

C = Cost of collection of product i = 111,816 LKR

The annual total income from Negombo lagoon was estimated at million 138 LKR.

Table 3 The estimated monthly mean catch variations and the total production of shrimps in the Negombo Lagoon during period from July 2007 to July 2008

Month Sample	**July 2007**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Ju**	**July 2008**
Liyanagemulla	8.5	7.5	38.5	23.3	9.2	30.3	23.5	6.3.0	18.5	25.5	19.0	21.5	8.9
Katunayake	38.5	38.3	78.0	67.3	42.33	28.0	79.0	46.5	48.5	92.5	69.0	76.5	36.8
Kurana	50.0	23.3	75.0	68.0	58.76	45.0	51.85	47.35	60.0	60.0	55.0	60.5	43.0
Kadolkele	25.0	33.0	85.0	82.0	42.13	32.0	68.25	43.25	35.0	92.0	83.5	91.5	26.0
Aluthkuruwa	3.0	30.3	95	96.6	60.83	54.0	126.1	82.6	103.0	128	89.5	96.0	3.0
Sethappaduwa	120	55.5	94.0	63.0	69.93	38.0	73.0	110.5	130.0	76.5	58.0	66.0	126
Negombopitipana	110	82.7	150	110	81.83	28	116	79.25	120.0	134	51.0	86.5	132
Thalahena	5.0	5.80	5.65	5.1	5.7	5.5	5.45	4.75	5.0	5.6	4.25	8.5	6.0
Statistical Average	45.0	34.6	77.7	64.5	46.3	32.6	67.9	52.6	65.0	76.7	53.7	63.4	47.71
Mean number o craft operated / day	12.0	10.0	23.0	18.0	13.0	10.0	22.0	18.0	21.0	23.0	18.0	20.0	13.0
Monthly Total production /kg	**12960**	**8304**	**42890**	**27864**	**14445**	**7824**	**35851**	**22723**	**32760**	**42338**	**22896**	**30432**	**14882**
	Annual Total Production = 315 MT												

***24 fishing days per month was assumed for calculations**

Discussion

Salinity and Nutrients Measurements

The abundance of shrimp larvae in sea grass habitats depends on the environmental parameters such as temperature, salinity and nutrients levels. The salinity level of the water in the eastern part of the lagoon is fairly low (around 15-29 ppt) compared to the southern part and the fresh water inlets fall on to the eastern side of the Lagoon. The salinity level in the

north western part of the lagoon is considerably high (22-34 ppt). It is known that salinity changes in sea water affect the brackish water animals physiologically and ecologically and they are unable to maintain their normal activities when the salinity is below 30 ppt (Nagabhushanam and Bidarkar, 1975). Most of the commercially important shrimps occur in estuarine environments and are therefore, naturally subject to changes in salinity resulted by due to seasonal changes. The sea grass community production and water quality parameters recorded for all of the study sites was within the range reported in the literature for similar sea grass communities. However the values observed were close to the critical limits. A comparison of the data obtained here showed that significant correlation between water column nutrient concentrations and community production despite the fact that there were high levels of both dissolved inorganic nitrogen and soluble reactive phosphorous at all sites. A low concentration of Nitrogen and Phosphorous of dry season months of January to March and July to September. High nutrient loads were common for sites in Negombo Pitipana, Sethapaduwa and Aluthkuruwa area since there are fish landing centers with high number of boats releasing engine oil and other human inputs. Results of the present study indicate that the abundance of shrimp larvae in Negombo Lagoon is negatively correlated with salinity and nitrite nitrogen content in the water and is positively correlated with nitrate, ammonia and phosphate content in the habitat.

Conclusion

The present study intended to investigate the seasonal variations of favorable water quality conditions for shrimp juveniles living in sea grass habitats. The lagoon and adjacent boundary areas function as the major nursery and sheltering ground for many finfish and crustacean groups during the juvenile phase of their life cycle. The observed range of Salinity is acceptable for the survival and growth of shrimp larvae. The observed levels of Nitrate and Nitrites were low, acceptable for the survival and growth of shrimp larvae. The relative abundance of shrimps in Negombo Lagoon was found to be higher and their distribution was positively correlated to Ammoniacal -Nitrogen, Nitrate-Nitrogen, and Phosphate-Phosphorous contents and negatively correlated to dissolve inorganic Nitrite- Nitrogen in the water shrimp juveniles were found consistently in considerable numbers all the juveniles of different species were more abundant in the second inter monsoonal months. Investigation of the suitability of the sea grass beds as breeding and nursery ground could be considered within the acceptable limits in Central Environmental Authority Standard (2001). The sea grass habitat in Negombo

Lagoon constitute the single most important habitat type supporting the exceptionally high shrimp productivity of the annual total catch estimated at 315 MT. The annual total income from Negombo lagoon was estimated at million 138 LKR. The shrimps are mainly exported of the fish generally sold for food in the local market.

REFERENCES

ANON (1994). Conservation management plan: Muthurajawela marsh and Negombo Lagoon. Wetland Conservation Project, Central Environmental Authority (Sri Lanka /Euro Consult Netherlands) 129 p.

AMERICAN PUBLIC HEALTH ASSOCIATION (1998). Standard methods for the Examination of water and wastewater 20th edition, Published by American Water Works Association Washington DC 20005.

Barbier, E. B. (2002), "Valuing Environmental Functions: Tropical Wetlands" Land Economics 70 (2): 155-173.

CENTRAL ENVIRONMENTAL AUTHORITY, Standard (2001). Environmental quality standard and designation of water use in Sri Lanka.

JAYAKODY, D. S. (2001). Traditional Lagoon Fishery in Negombo National Aquatic Resources Agency, Sri Lanka

JAYASURIYA, P. M. A. (1991). The species composition, abundance and distribution of sea grass communities in Puttlam Lagoon. Vidyodaya J. Sci. 3.93-102.

JOHNSON, P. and R. JOHNSTON (1985). Productivity and nutrient dynamics of tropical sea grass communities in Puttlam Lagoon Sri Lanka, Ambio, Vol. 24, 411-417.

NAGABHUSHANAM, R. and D. S. BIDARKAR, (1975). Bulletin of Department of Marine Science University of Cochin, Vol.vii, 2, 409 -417.

PILLAI, T. G. (1965). Brackish water fishery resources.

SILVA, E. I. (1996). Water Quality of Sri Lanka.

TOOKWINAS, S. (1985). Study of water quality of cockle culture areas in some culture beds in Thailand.