Effect of some physico-chemical water quality parameters of sea grass habitat on the abundance of shrimp juveniles in Negombo Estuary

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Abstract

The present study was conducted to evaluate effect of some physico-chemical water quality parameters of sea grass habitat on the abundance of shrimp juveniles in Negombo estuary. The objectives of the study are to investigate salinity and nutrient levels and examine the relationship between the shrimp larvae and environmental factors in sea grass habitats. Sea grass habitats provide habitats and act as nursery grounds for economically and ecologically important shrimp species. The sea grass habitats located in the Negombo estuary mainly Kadolkele, Negombo Pitipana, Aluthkuruwa, Thalahena, Sethapaduwa, Liyanagemulla, Katunayake, and Kurana were selected for this study. The shrimp population depends on the environmental parameters (both physical and chemical) of the sea grass habitats. Data were collected during regular twice weekly field visits on salinity, ammoniacal-nitrogen, nitrate-nitrogen, nitrite-nitrogen, phosphate-phosphorous and number of shrimp larvae, for a period of one year.

The abundance of the shrimp larvae in Negombo estuary is negatively correlated with salinity and nitrite-nitrogen content in the water and is positively correlated with nitrate-nitrogen, ammoniacal-nitrogen and phosphate-phosphorous content in the habitats. Salinity and nutrient levels in the water are within the acceptable limits for survival of shrimps and other in situ water quality parameters lies within the limits of acceptable levels and suitable for survival of shrimp and aquatic life. The seasonality in the shrimp larval catch and salinity and nutrients levels 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.

KEYWORDS: SEA GRASS HABITATS, WATER QUALITY, SHRIMP JUVENILES

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. These zones are very important ecologically as well as economically.

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 body. These grasses are highly productive and provide habitat for a variety of aquatic organisms including many commercially important shrimp species of ***Penaeus indicus*** and ***Metapenaeus dobsoni***. Estuaries are very dynamic environments, where salinity effects habitat

complexity and species distribution of shrimps have a complex life cycle that includes an estuarine phase, when post larvae enter the mouth of estuaries, disperse into the inner reaches, settle and become juveniles, grow for several months and subsequently migrate into the sea as sub adults. Review of factors influencing distribution of shrimp is reported to influence the distribution of shrimps in estuaries. The salinity of coastal and estuarine waters fluctuates of widely during the year. The salinity and nutrient gradients in estuaries depend in the relative balance of the following factors (Tookwinas *et al*, 1985).

(i). Run-off from the land

(ii). Rainfall

(iii). Evaporation from the estuary itself

(iv). Tidal influence and distance from the coast line

The major aim of this study was to determine the level of salinity and nutrients in the estuary boundary area of the north western and eastern shore of the Negombo estuary. So all the fish species are also dependent on the sea grasses, but here the focus was on the shrimp because it is critically dependent on salinity and nutrient levels in water.

The main objective of this study is to

(i). Investigate salinity and nutrient levels of water in sea grass habitat.

(ii). Examine the relationship between the shrimp larvae and environmental factors.

Materials and Methods

The study site

Eight sampling locations were chosen within the estuary, north shore of estuary in Negombo Pitipana and Kadolkelle, western part of Aluthkuruwa, Thalahena and Sethapaduwa and eastern part of Liyanagemulla, Katunayeke and Kurana area (Figure 1) and they represented different environmental conditions in Negombo estuary. The in situ analysis was done for the some parameters due to fluctuation of environmental conditions effect to the results. The water depth where the measurements were carried out was less than one meter at all sites. The collection of existing data pertaining to seasonal changes effect on physico-chemical parameters of water body in the Negombo estuary were carried out at the beginning of the monsoon periods. Water samples and number of shrimp larvae catch were collected twice a week for a period of one year.

Data Collection

Eight sampling locations were chosen within the estuary, north shore of estuary in Negombo Pitipana and Kadolkelle, western part of Aluthkuruwa, Thalahena and Sethapaduwa and eastern part of Liyanagemulla, Katunayeke and Kurana area (Figure 1). The water depth where the measurements were carried out was less than one meter at all sites.

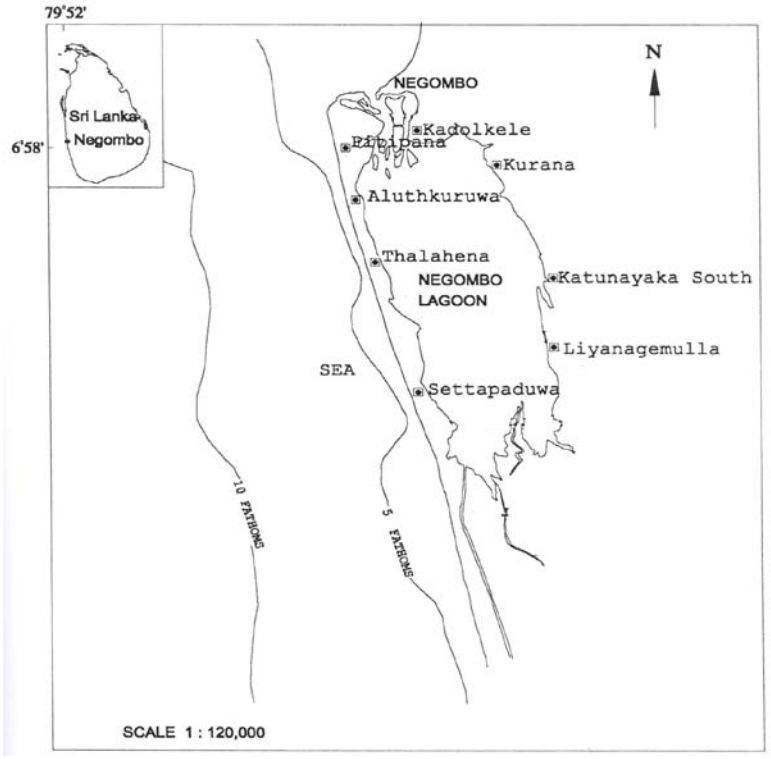

Figure 1 Location Map of the Negombo Estuary

Shrimp larvae catch

Selected sampling site was estimated twice a weekly using a one square meter (1m x 1m) quadrate samples which was subdivided in to 25 squares of equal sizes using nets, randomly collected in number of shrimp larvae catch were counted.

Water Quality

Salinity and Nutrient Measurement

Some important physico-chemical parameters such as Temperature, Salinity and Nutrient measurement were monitored using a Mercury Filled Celsius Thermometer (0 ^{0}C-100 ^{0}C),

Digital Refractometer (0-100 ppt), Ammoniacal-Nitrogen (Phenate method), Nitrate-Nitrogen (Copper-Cadmium Reduction method), Nitrite-Nitrogen (Colorimetric-diazotization method) and Phosphate-Phosphorus (Ascorbic acid method) analyzes using the Ultra Violet Spectrophotometer. Collected samples were analyzed in accordance with the Standard methods for examination of water and waste water (APHA) 20^{th} edition. All collected samples were stored at 4^0C using regifoam containers filled with ice cubes until refrigeration is done transportation.

Data Analysis

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

Results

Mean values calculated for the water quality parameters and the no of shrimp larvae are including in Table 1.

Shrimp larvae catch

Table 1 Table 1illustartes the summary of the mean values of the water quality parameters and the shrimp larvae in the eight sampling locations during from the 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	30.56	29.95	28.96	28.0	29.8
Salinity (ppt)	23.4	24.56	25.74	18.88	16.30	18.1	20.0	30.0	31.85	26.43	18.2	20.40	23.48
Ammoniacal-N(mg/l)	0.222	0.321	0.274	0.216	0.19	0.12	0.16	0.159	0.083	0.314	0.223	0.27	0.225
Nitrate-N (mg/l)	0.250	0.305	0.378	0.542	0.437	0.30	0.24	0.389	0.406	0.339	0.553	0.419	0.256
Nitrite-N (mg/l)	0.044	0.065	0.065	0.042	0.020	0.05	0.02	0.144	0.162	0.115	0.05	0.14	0.06
Phosphate-P (mg/l)	0.089	0.138	0.148	0.321	0.232	0.16	0.11	0.087	0.127	0.096	0.239	0.303	0.099
No of Shrimp Larvae	173	153	295	523	341	157	358	142	197	303	333	347	174

The recorded sea grass species in this area were observed in ***Halodule pinifolia***, ***Halophila minor, Potamogeton pectinatus*** and ***Rappia maritima***. The data shows (Table 1) that the shrimp larvae occurrence was high from September to November, January and April to June (Figure 2). Among the eight stations the shrimp larvae occurrence was low in Negombo Piptipana and Sethapaduwa sites. Shrimp larvae were highest in Kadolkele, Liyanegemulla and Thalahena (Figure 3).

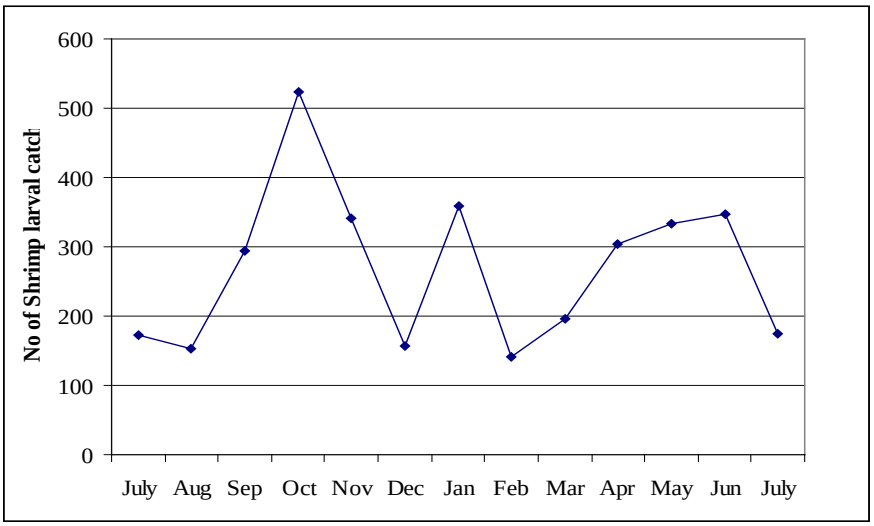

Figure 2 Monthly variations of number of shrimp larvae

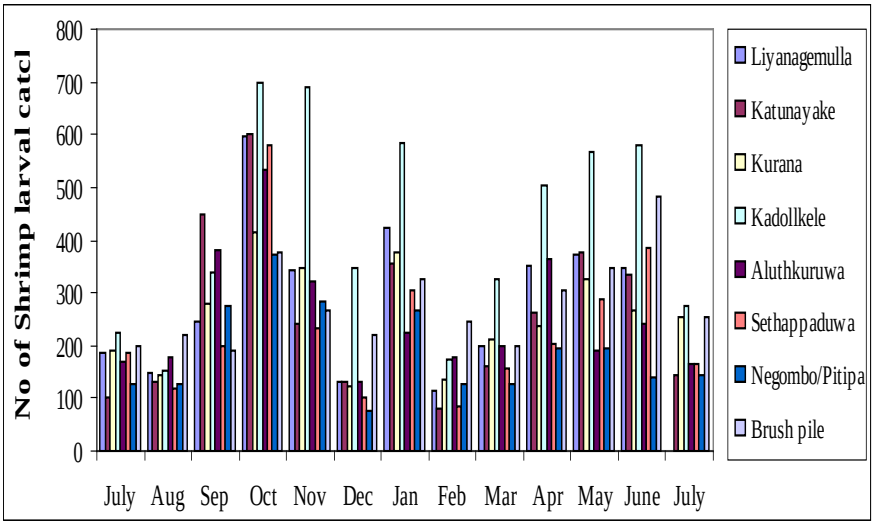

Figure 3 Comparison of number of shrimp larvae in sites

Monthly variations of shrimp larvae (Figure 2) in the Negombo Lagoon reached a maximum during October, November, January, May and June during the monsoon season. Lowest level was found in January and July which are the dry season.

Water Quality Parameters

The results of the studies (Table 1) carried out from 2007 and 2008 were diagnosed to analyze the seasonal changes of the physico-chemical characteristics of the Negombo estuary.

Temperature

Temperature is a measure of how cool or how warm the water is expressed in degrees Celsius (^{0}C). Temperature is a critical water quality parameter since it directly influences the amount of the ion dissolved oxygen that is available to aquatic organisms. The mean monthly water temperature values for each site are given in Table 1. The mean of water temperature at the eight sampling sites during the study period are shown in Figure 4. The data show (Table 1) in some instances surface water temperature range from 27 ^{0}C - 30 ^{0}C and the estuary water temperature becomes highest in September, March and July (Figure 4). The diurnal variation in temperature of the Negombo estuary had been reported for the daily time variations. The mean temperature variation in all location was in the range of 27 ^{0}C - 32 ^{0}C.

Salinity

The mean monthly salinity values for each sampling site are given in table 1. The data show that (Table 1) variation of salinity levels of the Negombo estuary sea grass habitat was observed highest in sea mouth area of Negombo Pitipana and Kadolkele sites. Monthly variations of salinity in the Negombo estuary reached a maximum during September and February to April

dry season and lowest values were reported in October to January and May to July (Figure 4) during monsoon season. The salinity prefer its maximum during the first inter monsoon (February to April) and it led to a condition where the estuary get converted almost into fresh water with the onset of the south west monsoon (May-June). During the intermediate rainy season, pronounced salinity gradient was developed in the estuary. (eg. January, July and December) with a range of salinity varying from 20 ppt to 30 ppt at the mouth to less than 5-10 ppt at the southern part of the estuary. The salinity gradient was well established during August and September from the fresh water outfall to the sea mouth and vice versa. Relatively higher salinities were reported in March (32 ppt). The acceptable range of salinity values reported for shrimp growth and production is 10-32 ppt (CEA, 2001), (Table 3).

Table 2 Standard Deviations and of Temperature and Salinity

Level	**N**	**Mean**	**St Dev**
Temperature (^{0}C)	13	29.230	1.089
Salinity (ppt)	13	22.588	4.417

Pooled St Dev = 3.217

Statistical analysis for Temperature and Salinity

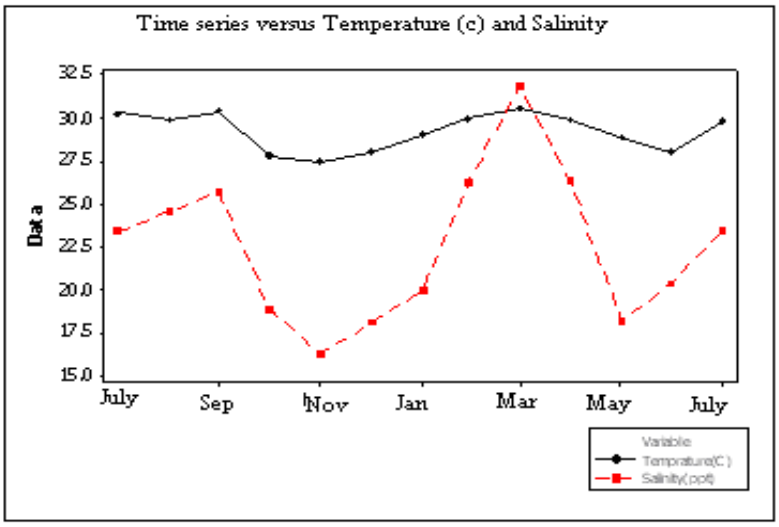

Figure 4 Time series vs. Temperature and Salinity level

Nutrients

Nitrate-Nitrogen

Nitrate is a primary nutrient in estuary environment brackish water with moderate to high salinity,diatoms are the dominant planktonic organisms. Nitrate-Nitrogen in the Negombo estuary reached a maximum during October-November and May-June (Figure 5), during the monsoon season. Lowest levels were found in January and July during the dry season month. The proposed acceptable range of Nitrate-Nitrogen for shrimp larvae is less than 01 mg/l, recommended by Central Environmental Authority in Sri Lanka (CEA, 2001), (Table 3).

Phosphate-Phosphorous

Phosphate-Phosphorous is considered to be one of the important primary nutrients in estuary. Monthly values of Phosphate-Phosphorus in the Negombo estuary reached during October, November and May, June during monsoon season. The lowest phosphate levels were observed in February and July (Figure 5). The proposed acceptable range of Phosphate-Phosphorous for shrimp larvae is less than 01 mg/l, recommended by Central Environmental Authority in Sri Lanka (CEA, 2001), (Table 3).

Ammoniacal -Nitrogen

Ammonia is an important nutrient of phytoplankton of the estuary environment. It is also end product of protein catabolism excreted by aquatic animals. Ammonia in water consists of a unionized (NH_3) and ionized from (NH_4^+). Unionized ammonia can be toxic to fish. Monthly variations of Ammonical-Nitrogen in the Negombo estuary reached a maximum during August and April before monsoon season and lowest level in December and March (Figure 5). The proposed acceptable range of Ammoniacal-Nitrogen for shrimp larvae is less than 01 mg/l, recommended by Central Environmental Authority in Sri Lanka (CEA, 2001) (Table 3).

Nitrite -Nitrogen

Nitrite-Nitrogen is an intermediate product in the nitrification of ammonia to nitrate. It is toxic to fish and therefore is important for aquatic organisms. Monthly variations of Nitrite-Nitrogen in

the Negombo estuary reached a maximum during February, March and April and minimum was found in October, November, January and June (Figure 5). Nitrogen levels as high as 25-100 mg/l are toxic to fish and range of less than 01 mg/l is favorable in aquatic organisms. The proposed acceptable range of Nitrite-Nitrogen for shrimp larvae is less than 01 mg/l, recommended by Central Environmental Authority in Sri Lanka (CEA, 2001), (Table 3).

Table 3 Water Quality Standard for brackish water shrimp

Parameters	Tolerance Limits
Temperature (^{0}C)	<35
Salinity (ppt)	10-32
Nitrite-Nitrogen (mg/l)	<1.0
Nitrate-Nitrogen (mg/l)	<1.0
Phosphate-Phosphorous (mg/l)	<1.0
Ammoniacal-Nitrogen (mg/l)	<1.0

Source: Central Environmental Authority (2001)

Statistical Analysis for Nutrient Levels

ANOVA results from nutrient analysis showed (Figure 5) that there is considerable variation in the total concentration of both dissolved inorganic and organic nutrient between the sea grass communities and the surrounding water column. All sites showed considerable nutrient pooled Standard Deviation of 0.078.

Table 4 Standard Deviations of Nutrient levels

Level	N	Mean	St Dev
Ammoniacal-N (mg/l)	13	0.21338	0.07149
Nitrate-N (mg/l)	13	0.36977	0.10246
Nitrite-N (mg/l)	13	0.06554	0.04653
Phosphate-P (mg/l)	13	0.16562	0.08126

Pooled St Dev = 0.07806

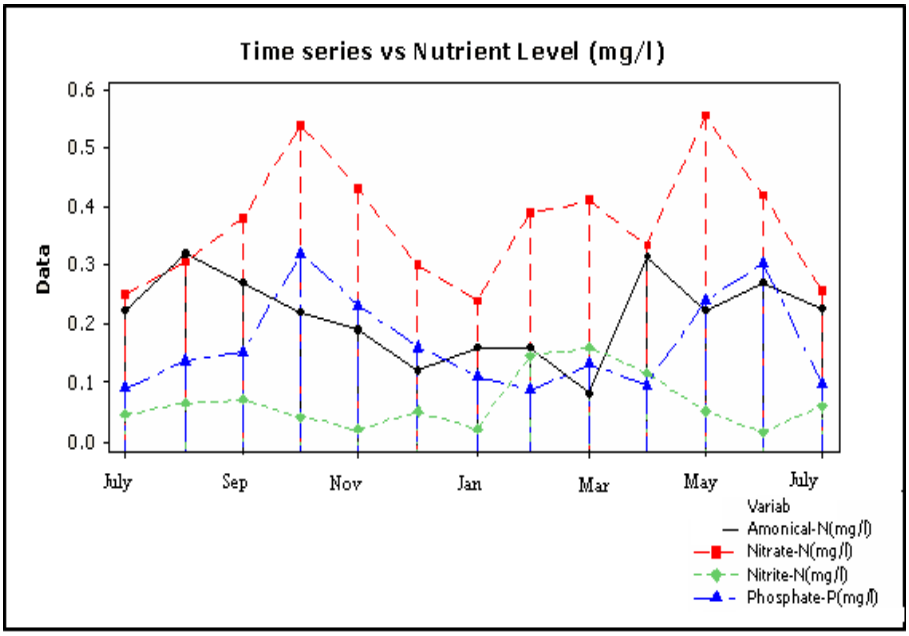

Figure 5 Time series vs. Nutrients levels (mg/l) in sea grass habitat

Contribution of water quality parameters to shrimp productivity

Correlation coefficient

In order to investigate the water quality parameters towards the sea grass habitats and shrimp larval catch, the correlation coefficients between abundance of shrimp larvae and environmental factors were derived. The following section provide the results.

Multiple Regression

In order to investegate the water quality parameters towards the sea grass habitats and shrimp larval catch was expressed as a productivity of the different water quality parameters measured. The best fitting regression model state that,

The regression equation is

Shrimp larvae 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)

Table 5 The values of correlation coefficients between the abundance of shrimp Larvae and Environmental factors

Water quality parameters and shrimp larvae catch	**Standard values of correlation coefficients Pearson correlation P-Values**					
	Temperature (^{0}C)	Salinity (ppt)	Ammonia-N (mg/l)	Nitrate-N (mg/l)	Nitrite-N (mg/l)	Phosphate-P (mg/l)
Salinity (ppt)	0.874 0.000					
Ammoniacal-N(mg/l)	0.034 0.912	0.037 0.904				
Nitrate-N(mg/l)	0.374 0.208	0.230 0.449	0.006 0.985			
Nitrite-N(mg/l)	0.688 0.009	0.851 0.000	0.256 0.398	0.026 0.932		
Phosphate-P (mg/l)	0.765 0.002	0.593 0.033	0.117 0.703	0.761 0.003	0.520 0.069	
Shrimp larvae	0.545 0.054	0.482 0.096	0.181 0.555	0.599 0.031	0.464 0.738	0.738 0.004

Table 6 Probability values of Salinity and Nutrient levels

Water Quality Parameters	N	Coef	SE Coef	T	P
Salinity (ppt)	13	6.93	15.30	-0.19	0.858
Ammoniacal-N (mg/l)	13	33.9	433.8	0.45	0.940
Nitrate-N (mg/l)	13	638.5	719.0	0.08	0.404
Nitrite-N (mg/l)	13	-1550	1919	-0.89	0.446
Phosphate-P (mg/l)	13	175.5	974.2	0.81	0.862

S = 93.8394 R-Sq = 60.3% R-Sq (ad) = 31.9%

The nitrogen levels at all sites existed in the form of ammonia, which occurred in concentration +34 mg/l, while there was nitrate + 638 mg/l, Phosphate concentration +175 mg/l and less nitrite concentration of -1550 mg/l. According to the results of the regression analysis, the equation is significant and the shrimp larvae abundance for the sea grass habitats indicate that Nitrite-Nitrogen contribute negatively while Nitrate-Nitrogen,Phosphate-Phosphorous and Ammoniacal-Nitrogen, contribute positively to the larvae abundance, significantly in $r = 0.78$ and $p<0.05$.

Discussion

Salinity and Nutrient Measurements

The present study intended to investigate the monthly variations of favorable water quality conditions for shrimp juveniles living in the sea grass habitats. The abundance of shrimp larvae in sea grass habitats depends on the environmental parameters such as temperature, salinity and nutrient levels. The salinity level of the water in the eastern part of the estuary is fairly low (around 15-29 ppt) compared to the southern part since fresh water inlets fall on to the eastern side of the estuary. The salinity level in the north western part of the estuary is considerably high (22-34 ppt). Most of the commercially important shrimps occur in estuarine environments and are therefore, naturally subjected to changes in salinity variations due to seasonal changes. The range of salinity levels from 15-32 ppt. High nutrient loads of sites in Negombo Pitipana, Sethapaduwa and Aluthkuruwa areas. Because of the fish landing centers high number of FRP boats release of engine oil in water (Silva, 1996). Nitrogen levels from 0.12 - 0.321 mg/l, Nitrite-Nitrogen range from 0.03-0.163 mg/l, Nitrate-Nitrogen range from 0.25 - 0.553 mg/l and Phosphate-Phosphorous range from 0.089 - 0.321 mg/l.

The Negombo town area of sampling site is highly polluted due to sewage discharged from the households. This part of the estuary was also observed to be very poor sea grass habitats are reported to be rare in heavily polluted waters. A comparison of the data obtained here showed that than is a 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 factor which could explain this difference in 2008 is the initially low concentration of Nitrogen and Phosphorous of dry season months of 2008 January to March and 2007 July to September. Negombo town discharge large percentage of sewage directly into the estuary. However, even the lowest ambient concentrations observed were relatively high for tropical ecosystems and so it appears that the sea grass communities are not nutrient limited at any of the sites studied.

Shrimp abundance relationship between to salinity and nutrient levels

The results of the present study reveal that fluctuations in water quality in the localities studied are not great and perhaps therefore do not exceed the tolerance limits for the shrimp abundance. Regression gives the relationship between salinity and nutrient levels and shrimp larvae show that - 59 + 6.9 Salinity (ppt) + 34 Ammoniacal-Nitrogen (mg/l) + 638 Nitrate-Nitrogen (mg/l) - 1550 Nitrite-Nitrogen (mg/l) +175 Phosphate-Phosphorous (mg/l). Results of the present study indicate that the abundance of shrimp larvae in Negombo estuary is negatively correlated with salinity and nitrite nitrogen content in the water and is positively correlated with nitrate, ammonia cal and phosphate content in the habitat. Toxic metabolites of Ammonia and Nitrites are above favorable ranges for shrimp abundance during the study period of this year. This study has been carried out during the observed of January, April, May and June, September and

October which could be considered as the high levels of shrimp abundance. These coincide with the south-western and north-eastern rainy seasons of the island.

The observed range of Salinity is acceptable for the survival and growth of shrimp larvae. The observed levels of Nitrate, Phosphorous, Ammonia and Nitrites were low, acceptable for the survival and growth of shrimp larvae. The relative abundance of shrimps in Negombo estuary was found to be higher and their distribution was positively correlated to Nitrate-Nitrogen, and negatively correlated to dissolve inorganic Nitrite-Nitrogen in the water. Shrimp larvae were found consistently in considerable numbers all the shrimp larvae of different species were more abundant in the second inter monsoonal months.

Investigation of the suitability of the sea grass habitats water quality as breeding and nursery ground could be considered within the acceptable limits recommended by the Central Environmental Authority Standard (2001). 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.

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