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# **Fisheries and Aquaculture**

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# Impact of morning and evening fishing on herring (*Amblygaster sirm*): A case study in Chilaw, Sri Lanka

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# Abstract

Coastal fisheries are considerably important to Sri Lanka's economy. Since many coastal fish species are heavily exploited at present, it is necessary to carry out research aiming to manage coastal fisheries. The present study was undertaken in Chilaw, Sri Lanka from April 2008 to March 2009 with the aim of investigating the impact of morning and evening fishing conduct by small mesh gillnets. The key target species in small mesh gillnet fishery in the West Coast of Sri Lanka is herring (Amblygaster sirm). Morning and evening fish landings made by Fibre Reinforced Plastic Boats (FRP boats) operated with small mesh gillnets were monitored at the key fish landing sites in Chilaw. This includes collecting information pertaining to the particular fishing operation and recording the total catch of the boat and catch by species. A biological study was also carried out to understand the reproductive biology of A. sirm. Accordingly, fish samples collected during the morning and evening were separately analysed at the NARA laboratory. The sex was determined and monthly averages of Gonadosomatic Index (GSI) were estimated for males and females separately. The results indicated that a longer duration of fishing time is normally taken at the sea for evening fishing. Morning fishing is normally carried out at deeper waters than evening fishing. Two spawning seasons were identified; from April to August and from November to March. Catching of herring before maturity was common in both morning and evening fishing but higher portion was found in the morning catches. From August to January, the morning catch almost comprises of immature fish. However, spawning fish were mostly caught by evening fishing. Since both morning and evening fishing are negatively impacted on the sustainability of small pelagic fish, new regulations are needed to be introduced (eg. mesh size restrictions) for small mesh gillnet fishery in Sri Lanka.

Keywords: Amblygaster sirm, gonadosomatic index, small meshed gillnet

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# Introduction

The marine capture fishery is still the backbone of the commercial fishing industry in Sri Lanka. More than 90 % of the marine fishing fleet is operated within the coastal waters(MFARD, 2016). The coastal fisheries resources are threatened due to over exploitation and present fishing practices are not carried out in a sustainable manner especially regarding small pelagic fish. The key small pelagic fish such as herrings and sardines are among the most highly exploited coastal resources at present (Haputhantri, 2008).

# **Materials and Methods**

Morning and evening fish landings made by Fibre Reinforced Plastic Boats (FRP boats) operated with small meshed gillnets were monitored once a week at the key fish landing centres in Chilaw during the period from April 2008 to March, 2009. On each sampling day, morning and evening fish landings were monitored. Accordingly, total fish catch and species

composition was recorded from randomly selected fishing boats. Other information related to fishing operations such as total fishing time, fishing depth in Fathoms (1 Fathom = 1.83 m), number of gillnet pieces used with eye sizes were also recorded. Random samples of herrings taken from both morning and evening landings were analysed to examine the reproductive biology of *A. sirm*. at the NARA laboratory, total length (to the nearest 0.1cm) and total weight of each individual (to the nearest 0.01g) were measured. Fish were dissected to determine the sex and maturity stages of the gonads. Weight of the gonads of each individual were measured to the nearest 0.01 g to calculate Gonadosomatic Index GSI (gonad weight/body weight \* 100) to identify spawning seasons. Monthly percentages of immature *A. Sirm* in the collected samples were also estimated.

#### Results

**Fishing crafts, gear and operations:** The fishing vessels operated in small meshed gillnet fishery in Chilaw Fisheries District are mainly FRP boats. FRP boats are 5 to 7.4 m in length and fitted with outboard engines 9.9 - 30 horse power. Both morning and evening fishing operations were conducted using small meshed gillnets. Theestimated mean true fishing time was 1.21 h (SD = 0.45) and 1.27 h (SD = 0.47) for morning and evening fishing operations respectively. In addition, morning fishing activities are conducted in relatively shallow waters (average depth =10.7 F) when compared with night fishing activities (average depth =13.6 F).

**Reproductive biology of** *A. Sirm*: Total length of the fish examined at the laboratory for reproductive biology ranged from 8.20 cm to 21.0 cm. There were two spawning peaks with higher GSI values (April to August and November to March) suggesting two distinct spawning periods. Moreover, higher GSI values were observed in evening samples than morning samples showing that more matured fish are caught by evening fishing (Fig. 1). Catching immature fish was common in both fishing activities, but more immature fish were recorded for morning fishing. From August to January, almost all morning fish were immature (Fig.2). Very similar results were obtained in the months of September and October for evening catch. On the other hand, more spawning fishes were always recorded in evening catches than morning catches (Fig. 2).



Fig. 1: Monthly variations of Gonadosomatic Index (GSI) for A. sirm



Fig.2: Monthly variations of immature A. sirm in morning and evening catches

#### Discussion

The spawning stock of herring is exploited by night fishing operations than morning operations. On the other hand, higher percentages of immature fish are mostly caught to morning fishing than evening fishing. This is not a good sign in terms of the sustainability of the herring fishery. Therefore, it might be a useful management measure of banning the evening fishing during the peak spawning months of the year. However, several resource friendly features were observed at the evening fishing operations. Since relatively larger mesh sizes are employed for evening fishing, such fishing operations target relatively larger size herrings. The diversified species composition in the evening catch also supports to ease the fishing pressure on key small pelagic. The fishing pressure on the major small pelagic stocks can further be eased though promoting evening fishing during the non-spawning months.

# Conclusion

Introduction of new management guidelines is necessary for the management of small mesh gillnet fishery in the west coast of Sri Lanka. Closed seasons and minimum mesh size regulations could probably be the best management options. Conducting a comprehensive research study aiming to small pelagic fishery management is however, advisable for proposing the effective management measures.

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MFARD, 2016. Fisheries Statistics – 2015. Ministry of Fisheries and Aquatic Resources Development [February, 2016] http://www.fisheries.gov.lk

# An evaluation of the effect of structural properties of construction materials on the brush parks fishery in the Negombo Lagoon, Sri Lanka.

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#### Abstract

Negombo lagoon (3,164 ha) in the western coastal belt of Sri Lanka supports many species of fish and crustaceans which are important sources of livelihoods for the people around the estuary. Brush parks are a kind of traditional form of fishing method which are installed in shallow areas of the estuary using dense masses of mangrove twigs. In the present study, the effect of structural properties on sustainability and economics of periphyton based brush park fisheries production was evaluated. The duration between installation and harvesting of brush parks ranged from 3 to 89 days and nearly 28 % brush parks were harvested within 29-35 days after installation. Majority of brush parks (36.6%) had 51-75 mangrove twigs and diameter of brush parks varied between 2-12 m. The twig density, expressed as twig dry weight per unit volume of brush parks ranged from 0.02 to 21.03 kg m<sup>-3</sup> with the average twig density ( $\pm$ SD) of 2.01  $\pm$ 3.09 kg m<sup>-3</sup>and 76.1% of brush parks had twig density less than 2 kg m<sup>-3</sup>. The mean monthly yield and catch value of fish and crustacean species were recorded  $0.43 \pm 0.69$  kg m<sup>-2</sup> month<sup>-1</sup> and Rs.1913 ± 1476 respectively. Significant negative relationship (F = 36.95; P<0.001) exhibited between yield and period between installation and harvesting. The relationship between catch value and twig density also showed significant (F = 13.09; P < 0.001) inverse relationship. The mean yield (0.48 kg m<sup>-2</sup> month<sup>-1</sup> and 0.47 kg m<sup>-2</sup> month<sup>-1</sup>) of brush parks during the inter monsoon period (March-April and October-November) were significantly higher (P < 0.001) than the yield (0.36 kg m<sup>-2</sup> month<sup>-1</sup> and 0.44 kg m<sup>-2</sup> month<sup>-1</sup>) recorded during the monsoon period (May-September and December-February). The yield and its catch value of brush parks were related to the period since installation and twig density. Present findings suggest that to achieve maximum brush park yield, the optimal period since installation was about 30 days and the optimal twig density was about 2 kg m<sup>-3</sup>.

Keywords: brush parks, traditional fisheries, mangroves, costal fisheries

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# Introduction

The Negombo lagoon fishing activities are dominated by four major fishing gears as trammel net, drag net, brush parks, cast nets that are used within the estuary and stake net gear fixed at the mouth (Jayawardane *et al.* 2004). Brush parks are a kind of fish and shrimp aggregating device which are widely operated in the Negombo lagoon. The highest total fish catch of 21,668 kg/year came from brush parks, which accounted for about 29 - 41 % of the total landings in Negombo lagoon (Wijeyaratne and Costa, 1987). There were 2,200 brush parks, of a mean area of 51.8 m<sup>2</sup>, cover totally 11.3 ha of the surface water of Negombo Lagoon (Welcomme, 2002). A comparatively higher yield of 12.46 t ha<sup>-1</sup>year<sup>-1</sup> was reported in the lagoon during 1998 (Amarasinghe *et al.* (2002).

The brush park fishery offers a number of biological and economic advantages in management of small scale fisheries in coastal lagoons. However, brush parks could lead to environmental problems, due to requirement of large quantity of twigs mainly mangroves to construct and maintain brush parks. These environmental drawbacks could result in deforestation of mangroves, which would harmfully affect the fish population as well as fauna associated with mangrove ecosystem. Hence, it is important to quantify the minimum resource requirement for maximizing fisheries production of brush parks. Towards this goal, the present study examined the effect of twig density and number of days since installation on brush park yield and catches value.

# **Material and Methods**

Data were collected from 205 brush parks in three major brush park fishing areas (Munnakkaraya, Katunayake and Dungalpitiya) in the Negombo Lagoon from 2014 - 2015 period. One hundred mangrove twigs in four size categories (0-1m, 1-2m, 2-3m and above 3 m length) from each species (*Rhizophora mucronata, Avicenia marina, Lumnitzera racemosa, Bruguiera gymnorrhiza, Excoecaria agallocha*) were used to measure mean diameter of mangrove branches. Length of each mangrove twig was measured to the nearest centimeter and diameter was measured nearest millimeter by using measuring tape and vernier caliper respectively.

Dry weight (DW in g) of mangrove twigs of *R. mucronata* and *A. marina* was determined by following allometric relationship described by Amarasinghe and Balasubramanium (1992).

For *Rhizophora mucronata*;In DW = 4.262+2.103 ln di

For Avicenia marina; In DW = 4.074+2.299 ln di

where, di the mean diameter (in cm) of mangrove twigs in each species and size category.

Dry weight of above ground plant component (branches and leaves) of *L. racemosa* and *B. gymnorrhiza* was determined by according to the relationships presented by Perera *et al.*, (2012).

For Lumnitzera racemosa; Above ground biomass =  $0.114(dbh)^{2.523}$ 

For *Bruguiera gymnorrhiza*; Above ground biomass =  $0.289(dbh)^{2.327}$ 

Dry weight (biomass)of mangrove twigs of *E. agallocha was* determined by the following allometric equation derived by Komiyama *et al.*, (2005).

Biomass =  $0.251 \rho (dbh)^{2.46}$ 

where, dbh is the girth/diameter,  $\rho$  – density of wood

The brush park yield (Y in kg  $m^{-2}$  month<sup>-1</sup>) of fin fish and crustacean species was estimated assuming the shape of the brush park to be cylindrical.

 $Y = (C \times 30) / (3.1416 \times (D^2/4) \times (N))$ 

where, C is the total harvest in kg (fin fish and crustacean) from the brush park, D the diameter (m) of the brush park and N the period of installation of the brush park in number of days.

Dry weights of all mangrove twigs of each species were determined by assuming that different size categories of mangrove twigs hold the above mentioned relationships between dry weight and dbh. Total dry weight (W) was determined by sum of all dry weights of mangrove species in each brush park.

Twig density in brush park (kgm<sup>-3</sup>) was estimated as

Twig density = W /  $(3.1416 \times (D^2/4) \times (H))$ 

Where; H is the height of the brush park (m).

The effect of twig density and number of days since installation on brush park yield and catch value were determined using linear regression analysis. As fish yield is generally known to be log-normally distributed (Gulland, 1983). Since do not conform to a normal distribution, Mann-Whitneynon-parametric test was employed to compare brush park yields during the two seasons (monsoon and inter-monsoon period). Statistical package MINITAB software (release 16) and MS office Excel (2013) were used to carried out all statistical analyses.

#### Results

The duration between installation and harvesting of brush parks ranged from 3 to 89 days and about 28% brush parks were harvested within 29-35 days after installation. Majority of brush parks (36.6%) had 51-75 mangrove twigs and diameter of brush parks varied between 2and 12 m. The twig density, expressed as twig dry weight per unit volume of brush parks ranged from 0.02 to 21.03 kg m<sup>-3</sup>, average twig density ( $\pm$  SD) was 2.01  $\pm$  3.09 kg m<sup>-3</sup> and 76.1 % of brush parks had twig density of less than 2 kgm<sup>-3</sup>. The mean monthly yield and catch value of all species were recorded as 0.43 $\pm$ 0.69 kgm<sup>-2</sup> month<sup>-1</sup> and Rs.1913  $\pm$  1476 respectively. There was a significant negative relationship (F=36.95, P < 0.001) between yield and period between installation and harvesting of brush parks. There was also a negative significant relationship between catch value and twig density (F=13.09, P < 0.001). Positively correlated relationship was observed between catch value and period between installation and harvesting of brush parks (F=8.8, P < 0.05). Results of Mann-Whitney test showed that significantly higher mean yield (0.48kg m<sup>-2</sup> month<sup>-1</sup> and0.47kg m<sup>-2</sup> month<sup>-1</sup>) of brush parks were reported during inter monsoon period than the yield (0.36 kg m<sup>-2</sup> month<sup>-1</sup> and 0.44 kg m<sup>-2</sup> month<sup>-1</sup>) during the monsoon periods (P < 0.001).

#### Discussion

The yield of the brush parks (acadjas) in Dahomey, West Africa increased exponentially with the number of days between implantation and harvesting and also logarithmically with increasing density of branches in the brush parks (Welcomme, 1972). However; such relationships were reported as second order polynomial by Amarasinghe et al. (2002) in Negombo estuary ?. Yield of brush park decreased with the time of installation to an optimum

level (around 30 days) and either stabilized or declined in the present study. This pattern can be interpreted as an increase in population density as fish that are attracted to the park for food and shelter, reaching a maximal level after which they may decline as the quality of the park deteriorates after about a month in the water (Amarasinghe et al. 2002). Brush park fishing takes place year-round whenever favourable weather conditions prevail, except occasional windy days and heavy rains during monsoon seasons.Emigration of fish from brush parks due to high wave action and high water level may have resulted in lower yield during the monsoon season than inter monsoon period.

Though positive relationship revealed between yield and twig density, significantly less catch value (P<0.001) was observed with high twig density (more than 2 kg m<sup>-3</sup>). The reason may be due to assemblage of low trophic level fish species such as *Oreochromissp.,Etroplus suratensis*. *Scatophagus argus, Siganus jarvus* and fishes of family Mugilidae with less economic value possibly due to high abundance of periphyton that served as a food source for such fish. Amarasinghe et al. (2002) also indicated that high crustacean yields were reported in brush parks with less dense twigs.

Present findings suggest that to achieve maximum brush park yield, the optimal period since installation was about 30 days and the optimal twig density was about 2 kg m<sup>-3</sup>. As such, for effective management of brush parks fisheries in the Negombo Lagoon, appropriate mangrove twig density could be used to reduce environmental degradation (mangrove deforestation)while ensuring maximum economic returns for sustainable livelihoods of fisherman.

#### Acknowledgement

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# Survey on fishery in the Nayaru Lagoon, Mullativu, Sri Lanka

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#### Abstract

Lagoon fisheries contribute significantly to the coastal fishery sector in Sri Lanka. The status of the fishery in the Nayaru lagoon and its contribution to local economy has not been assessed before due to civil war related accessibility issues. This study aimed at to assess the present status of the fishery in Nayaru lagoon based on catch data obtained over a period of six months from April to September 2014. Fishery is an important activity in the Nayaru lagoon. Gill nets, cast nets and hook and line are the major fishing gear used by the fishermen. Crab traps are also used on a year round basis. Seventeen species of finfish belonging to 15 families, the mangrove crab Scylla serrata and Fenneropenaeus indicus were harvested from the lagoon. The bulk of the catch was represented by Mugil cephalus (52%); other abundant species were Chanos chanos, Lates calcarifer, Arius bilineatus and Eleuthronema tetradactylum. About 29 % of the total catch was represented by shellfish species of which Scylla serrata was the most abundant. The estimated annual yield of the lagoon was 9.237 kg ha<sup>-1</sup> year<sup>-1</sup> which is a lower amount compared to other shallow coastal lagoons in Sri Lanka.Furthermore, the lagoon exhibits seasonal fluctuations in fish yield due to water level changes. Market price does not seem to fluctuate much in response to catch effort, weather conditions or availability of fish. Thus study showed that the fish production in the lagoon was relatively low hence a proper management plan is proposed to ensure its sustainability.

Keywords: Fisheries, lagoon, yield, sustainability

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#### Introduction

Lagoons are highly productive ecosystems and are important not only for fisheries but also as nursery grounds for a number of species of fin fish and shell fish (Jayawickrema, 1992). Mangrove and lagoon ecosystems in the north and east coasts of the country have not been assessed for the last 30 years due the war however now the areas are accessible to the scientific community and has provided an opportunity to obtain fish catch records from a neglected lagoon. The Nayaru Lagoon is approximately 1,267.3 ha in extent. A wide lagoon mouth is located at the southeastern part of the lagoon. Nay Aru and Palidai Aru are the main freshwater sources to the lagoon and open to the lagoon from its western side. The Mullativu – Kokilai road runs parallel to the eastern border of the lagoon. Eastern shore of the lagoon supports very little mangrove cover, while well-developed mangrove cover is seen on the southern and western shores. Lagoon fishery is the main livelihood of the people living in Nayaru, Chenmalai and Kumulamunai villages.

### **Materials and Methods**

A frame survey was conducted to identify basic characteristics of fishery in the Nayaru Lagoon. The data were collected from April to September 2014. The fish collecting site was visited daily and catch records were taken at the time when individual fishermen catch was weighed at the collecting center. At fish landing sites, data on species composition and weight of each species was collected. Records maintained by fish collectors were also checked to obtain the prices paid to the fishermen and selling prices of the fish.

# Results

Different fishing gear types are used at various places of the lagoon. Among them drifting gill nets and hook and line method are the most common. Cast nets are mainly used to catch Indian prawn (*Fenneropenaeus indicus*) while crab traps are used to catch *Scylla serrata*. In the lagoon area bordering Kumulamunai village, hand picking of Indian prawn was practiced by the villagers. Fiber glass canoes with an outrigger were the main fishing craft used. Seventeen species of finfish belonging to 15 families were harvested as food fish from the Nayaru lagoon. From the percentage weight of monthly average fish yield harvested, more than half was comprised of *M. cephalus* (52 %). The bulk of the catch was represented by finfish (79 %) and 21% was represented by shellfish. Other species such as *Eleuthronema tetradactylum* (9 %), *Lates calcarifer* (5 %), *Chanos chanos* (4 %) and *Arius bilinieatus* (4 %) have a minor importance in the fish catch of the Nayaru lagoon. Among the shellfish caught *Fenneropenaeus indicus* and *Scylla serrata* were more prominent. The overall estimated annual productivity of the lagoon was 9.237 Kg ha<sup>-1</sup> y<sup>-1</sup>. In terms of species abundance, *Mugil cephalus* was the most abundant fish caught from the Nayaru Lagoon. Other abundant species were *Chanos chanos*, *Lates calcarifer*, *Arius bilineatus*, *Eleuthronema tetradactylum*, and *Scylla serrata*.

*M. cephalus* has the highest average catch per day (13.17 Individuals day<sup>-1</sup>). It was caught throughout the sampling period with a higher number of individuals (750) getting captured in July. The second most caught fish *Chanos chanos* does not seem to show a significant variation throughout the month. However, there was a trend that during July most of the fish catch had declined except for *M. cephalus. Scylla serrata* also does not seem to have a significant variation throughout the sampling period. Considerable amount of molted *Scylla serrata* was also caught. According to the data, small crabs are prominent in April, May and June and then decline suggesting that this period may be their breeding period in the lagoon.

#### Discussion

Nayaru Lagoon was surrounded by a well-developed mangrove and is reported to have been supporting a rich prawn fishery. However, due to civil war in the area and the recent development activities resulted in clearing some mangrove patches and constructing a narrow bridge over the lagoon mouth. This changed the hydrological regime of the lagoon drastically resulting in the collapse of the fishery and declining of the mangrove vegetation cover around. From the percentage of monthly average fish yield harvested, more than half the harvest is comprised of *M. cephalus*. The ability of *M. cephalus* to tolerate wide ranges of salinity levels enables them to inhabit in the low saline waters of the Nayaru Lagoon in large schools. Further, the use of limited types of fishing gear may also have an effect on this.

The estimated annual yield of the lagoon was 9.237 kg ha<sup>-1</sup> y<sup>-1</sup>. This is low compared to other lagoons in Sri Lanka. Schuster (1951) estimated the average annual production of Sri Lanka's brackish watersto be less than 22 kg ha<sup>-1</sup> y<sup>-1</sup>. Pillai (1965) has estimated the productivity of Negombo estuary in 1960 to be 72.9 kg ha<sup>-1</sup> y<sup>-1</sup>, indicating that the Nayaru lagoon has a lower yield. However, it has the capacity to become a very productive lagoon if proper sustainable management plan is introduced to ensure wise management and sustainable utilization of this lagoon ecosystem.

# Conclusion

Fishery in Nayaru Lagoon seems to be fairly organized. Its annual yield is comparatively low which means that if proper management plans are introduced productivity could be raised and strengthen livelihoods of the fisher folks residing around the lagoon.

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# Some important features of the East coast Spiny Lobster fishery after implementation of co- management mechanism

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# Abstract

Spiny lobster fishery in the east coastal region of Sri Lanka has been developing among small scale fishes as a lucrative income source. High exploitation rate followed by the demand in the foreign market accelerate the depletion of the resource. Current information of the fishery resources are essential requirement for formulation of the future management. Spiny lobster biology and economic data collected from Okanda to Wakarai in monthly basis. Eighty nine percent of the catch consisted with the Scalloped Spiny Lobster (*Panulirus homarus*) while other species including *P. versicolor*, *P. ornatus* and *P. longipes* represented in small quantities (all together 11 %). Annual length frequency distribution charts of the *P. homarus* revealed that the mature lobsters are heavily exploited and the small lobsters fulfil the gaps in the catch. Small lobsters below the minimum legal size are not in the catch, but berried females (Females having egg mass) are present throughout the year. Peak breeding season of the *P. homarus* is July to January of the forthcoming year. There is no significance difference between the variance of males and females of the population (F =1.63, F Critical one tail 2.97,  $\alpha$  =0.05).

Keywords: Spiny lobster, P. homarus, Fisheries management, East coast

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# Introduction

Spiny lobster fishery in South (Tangalle to Patanangala) and Eastern (Okanda to Oluvil) coastal regions of Sri Lanka play very important role in the small scale fishes economy. (Liyanage and Long 2009; Jayakody, 1993). The fishery in the east coast appears to have grown most rapidly during past decade, that could adversely affect on sustainability of the stock and on livelihood. Preliminary Spiny Lobster research on stock assessment studies including biology, Ecology, distribution have been completed for the South coastal region (Jayakody 1993,1997; Liyanage and Long, 2009; Long et al. 2009;) but rare in east coast. This is the first fisheries dependent survey completed for management of the Spiny Lobster resources in the East coast of Sri Lanka.

# **Materials and Methods**

Spiny Lobster collecting centers in the east coastal region from Panama to Walachchena were visited once a month during year 2014. Those centers are collecting the lobster catch from the Okanda in Kumana National Park to Vakarei. Biological data required for management of the fishery such as species composition, sex, Presence of external eggs or Tar spot (Spermatophore) were recorded. Carapace length (CL) and Total length (TL) of the individuals were also measured to nearest millimeter using a venire caliper. F-test was performed to analysis of variance among the number males and females in the catch.

H0; Monthly variations of the males and females in the catch are similar

H1: Monthly variations of the males and females in the catch are significantly different

# Results

**Species composition of the catch:** Species composition of the commercial catch provide valuable information on the level of abundance of different species. Six Spiny Lobster species were recorded from Sri Lankan coastal waters (De Bruin, 1995). Scalloped spiny lobster *Panulirus homarus* is contributing to the 88.8 percent of the catch in survey area. Other species contributed to the catch as *P. versicolor* 6.9 %, *P. ornatus* 0.7%, *P. longipes* 3.3%. Likewise *P. polyphagus* is absent and the *P. penicillatus* represent 0.5 % of the catch.

**Length frequency:** Length frequencies of the individuals represent in the catch is a good indicator reflecting the status of the stock.



Fig.1: Annual Length frequency distribution of P. homarus and P. versicolor

Since March to July period, majority of the *P.homarus* catch consist with small carapace length classes ranged 6.0-6.9 cm, hence November to January period majority of the catch consisted with bigger length classes of the carapace length 7 cm to above.

Average annual carapace length frequency distribution chart (1.A) of the *P. homarus* clearly shows that representation of the elder lobsters in the catch are rare while newly recruits are fulfil gaps in the catch. *Panulirus versicolor*, the second most abundant species in the East Coast lobster fishery catch shows more or less similar number of individuals represent in each length class reflect the health of the stock.

Females with Eggs or tar spot: Monthly percentage of female brooders having eggs or spermatopore shows seasonal peak in their breeding cycle lying July to January of the forthcoming year. Fishing impacts on the stock has not effected on male female ratio of the population. F test revealed that no significant difference between the variation among sexes. (F = 1.63, F Critical one tail 2.97,  $\alpha = 0.05$ ).



**Fig.2:** Monthly variation of the percentage of berried females of *P.homarus* (berried females to total female of the respective month).

# Discussion

*Panulirus homarus* is the widely distributed and highly available spiny lobster species in waters of Sri Lanka (De Bruin et.al., 1995; Long et.al., 2011). In East coast, it is contributed to the 88.9 percent of the catch exceeding all other lobster areas. P. homarus annual length frequencies results revealed that this species is heavily exploited because of the increasing fishing pressure, removed the matured lobsters and berried females from the stock etc. Further, it revealed that small lobsters are representing the catch in greater extent as (6-7.5 cm in Carapace length) 67 percent and the elder lobsters are found in smaller quantities. Monthly length frequency analysis revealed that the period from November to January is consisted with the bigger size lobsters in the catch while small length classes are dominant during the rest months of the year representing recruitment period. Fishing pressure on the other major species (P. ornatus and P. versicolor) is negligible and healthy status of the population reflect the equal length class frequency distribution patterns. Further, February, September and October months are declared as closed season to the South coast due to the peak breeding season of the year. The current study revealed that the peak breeding season for the study area extend from July to January of the forthcoming year. Catching of berried female adversely impact on the population growth.

# Conclusion

East coast spiny lobster fishery consist with four species and *P. homarus* contribute to 89 percent of the catch. According to the length frequency distribution the stock is overexploited and immediate action must be taken to conservation. Peak breeding season and recruiting seasons of the species are respectively July to January and March to August. Large proportion of the catch consisted with illegal berried females resulted extinction of the stock.

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# Diet composition of Kawakawa (*Euthynnus affinis*) in three major landing sites of Sri Lanka

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# Abstract

Information on the feeding habits of fish is important for understanding the ecological relationships of economically important species. Kawakawa (Euthynnus affinis), is an economically important neritic tuna species targeted as a food fish in Sri Lanka. This study examined the feeding habits of Kawakawa, to provide baseline information for ecosystem based fisheries management. Specimens were collected from the Negombo, Beruwela and Chilaw landing sites from September 2015 to January 2016. A total of 42 fish (21.4 to 50.4 cm total length and 116.7 to 2,228 g) were collected. All samples were collected from single-day boats, which had been fishing around the offshore areas of the sites studied. The stomach contents of specimens mainly consisted of fish (33.3 %), shrimp (19.0 %), a combination of fish and shrimp (14.3%), and a combination of shrimp and cephalopods (7.2%). The stomach contents of three of the fish contained other debris such as plastic and leaves. In all, 26 % of stomachs were empty. The fish species that Kawakawa had been feeding on were anchovies and herrings. The larger size fish have been feeding more on small fish than on other food types and the largest number of empty stomachs were observed in the size range 20.1 to 30 cm. The study indicates that Kawakawa are non-selective feeders, feeding on any food item available in the surrounding waters. The presence of plastic in the stomachs of these fish indicates that the coastal waters in the study area are polluted. Further, studies are needed to determine the consequences of this on the physiological health of kawakawa.

# Keywords: Neritic tuna, Kawakawa, feeding

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# Introduction

Gaining an understanding of the feeding habits of a fish resource helps when developing ecosystem based fisheries management strategies for that resource. In addition, the size increases that are associated with growth of fish are commonly associated with changes in the diet. Therefore, the studying of the feeding habits in relation to the size of the fish is important. Neritic tunas are an important part of the tuna and tuna-like fishery of Sri Lanka. Kawakawa (*Euthynnus affinis*), an important neritic tuna species, is caught in most of the landing sites around the country. It contributes around 10% to the total tuna catch and constitutes about 15% of the total neritic tuna fishery (Haputhantri and Bandaranayake, 2013). Kawakawa has been the second-most abundant species in the total neritic tuna catches of Sri Lanka from 2003 – 2012, while it has dominated the gillnet fishery during this period (Damayanthi, 2014).

# **Materials and Methods**

Kawakawa samples were collected from the 3 major fishery landing sites, namely; Negombo, Chilaw and Beruwela. The samples were placed on ice and transported to the laboratory for further analysis. Weight (to the nearest 0,1 g), Total Length (TL), Standard Length (TL) and Fork Length (FL) (to the nearest 0.1 cm) were measured for each fish. Stomachs were removed from each fish and the stomach contents analyzed. The total weight of each stomach and the weight of each type of food item was recorded.

# Results

Kawakawa were found to primarily consume fish, shrimp, cephalopods and various minor prey items. The main fish types consumed were anchovies and herrings. Fig. 1 shows the percentage of each type of food detected in the stomachs of the fish analyzed.



Fig.1: The percentages of each type of food in the fish analyzed.

Out of the 42 stomachs analyzed, 13 (33.3 %) contained only fish, 7 (19.0 %) contained shrimp and 5 (14.3 %) contained fish and shrimp both. Out of the total, 7.2% of the specimens contained both shrimp and cephalopods. Three of the stomachs which contained shrimp also contained debris items such as plastic and undigested plant leaves. Stomachs of 11 (26.2 %) fish were empty and did not contain any food items. Fig.2 shows the different food types in the different length classes of Kawakawa.



Fig.2: Different food types in the length classes

The smaller size classes have consumes mostly small fish types. Shrimps have been consumed in similar proportion by all size classes.

# Discussion

The fish have been feeding on small fish such as herrings and anchovies as well as on shrimps and cephalopods. This shows that Kawakawa fish are non-selective feeders, feeding on any food item available in the surrounding waters. The high number of empty stomachs in the smaller size groups indicates that there might have been a lack of availability of food items, mainly small fish types, in the areas that the fish were feeding. In addition, it indicates that the fish may be regurgitating their stomach contents during capture due to stress. The occurrence of plastic and plant leaves in the stomachs may indicate that the waters around the areas studied may be polluted to a certain extent.

#### Conclusion

This study shows that small fish types form the dominant prey item of Kawakawa, followed closely by shrimp and that they are non-selective feeders. A large percentage of empty stomachs may indicate that there might be a scarcity of prey around the coastal areas studied.

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# Proximate composition and fatty acid profile of the sea cucumber *Holothuria scabra* collected from two geographical locations in Sri Lanka

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# Abstract

Holothuria scabra, the most valuable sea cucumber species exploited and traded in the tropical areas is considered a highly nutritious sea food. Though H. scabra are not consumed locally, they are widely exploited in the northwest and north coasts of Sri Lanka through skin and SCUBA diving. This study was carried out to analyze and compare the proximate composition and fatty acid profiles of wild H. scabra collected off Kalpitiya and Jaffna areas. Fresh H. scabra samples were collected from major landing sites at Kalpitiva and Jaffna from October to December 2015. Moisture, ash, crude protein and crude fat contents of H. scabra meat were determined and capillary gas chromatography was used to estimate the fatty acid composition. Ash and crude fat contents in H. scabra samples collected from Jaffna were significantly higher than the samples collected from Kalpitiya area (P < 0.05, t-test). Comparatively low amount of fat content (0.2 - 0.4) was observed in both places. However, significantly higher moisture content was reported at Kalpitiya samples ( $82.05 \pm 1.10$ ) than the Jaffna samples ( $75.32 \pm 1.25$ ; P < 0.05, t-test). H. scabra has higher amount of saturated fatty acids than the monounsaturated and polyunsaturated fatty acids. H. scabra samples collected at Jaffna showed the higher level of saturated (35.92±1.09), mono-unsaturated ( $16.25\pm0.54$ ) and polyunsaturated ( $9.85\pm0.41$ ) fatty acids than Kalpitiya samples. H. scabra are rich in Palmitic acid and Stearic acid of saturated fatty acid (SFA), Stearic acid and Octadecatetraenoic acid of monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA's), respectively. The observed differences in proximate composition and fatty acid profiles of H. scabra collected from different geographical locations in Sri Lanka may be due to differences in their dietary composition and further research will be useful in this aspect in the future.

Keywords: Holothuria scabra, proximate composition, fatty acid profile, Sri Lanka

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#### Introduction

Sea cucumbers are one of the export oriented fishery products from Sri Lanka for centuries. *Holothuria scabra* (sandfish)locally known as 'Jaffna Attaya', is one of the 'high-value' species widely distributed in seagrass associated inshore and lagoon areas of Sri Lanka (Dissanayake and Stefanson, 2010). Sea cucumbers are bottom sediment feeders and it is assumed that they should contain high levels of branched chain fatty acids to complement the potential role in wound healing, and therefore, fatty acid profile in sea cucumbers are in great interest (Connad, 1997). Further, it has been reported that food resources can affect lipid contents of some holothurians because of their selective feeding and changes in the food supply of sea environment

Though several studies have been carried out to study the proximate composition and fatty acid profiles of edible fish, very limited studies have been undertaken to study these aspects in sea cucumbers. Therefore, this study was carried out to analyze proximate composition and fatty acid profile of *H. scabra* collected at different geographical locations in Sri Lanka.

# **Materials and Methods**

Wild caught *H. scabra* (n=5) were collected in Gurunagar and Kalpitiya landing sites in the North and Northwest coasts, respectively, from October to December 2015. The length and weight of the collected samples ranged from 15 - 25 cm and 114.0 - 320.0 g respectively. Internal organs including gut amd gut contents, gonads and respiratory trees were removed and flesh of sea cucumbers were homogenized using a mixer grinder in the absence of a solvent. Moisture, Ash, crude protein and total fat were analyzed at Institute of Post Harvest Technology Division in National Aquatic Resources Research and Development Agency (NARA). Moisture and ash contents determined according to AOAC official method were 950.46, 928.08 and 920.15 respectively. The fat content was measured using Bligh and Dyer method and the crude protein was measured by Kjeldahl method. Fatty acid (FA) profiles were analyzed by GC-FID based on fatty acids methyl ester (FAME) synthesis developed by O'Fallon et al. (2007) with slight modification. FAMEs were analyzed on an Agilent Technologies Gas Chromatography 7890A equipped with flame ionization detector (FID).

#### **Results and Discussion**

Growing of Chinese population in Sri Lanka consume *H. scabra* in fresh formdue to economic reasons. That is why we had initial experiment in fresh form of *H. scabra* rather than doing dry form. TheResults of this study showed that *H. scabra* individuals collected from Jaffna area have significantly higher levels of ash and crude fat contents (P < 0.05, t-test) than the individuals collected from Kalpitiya area. Normally sea cucumber gut was in high amount of sand with food. That may be the reason for higher amount of ash content was recorded. However, significantly high level of moisture was reported in *H. scabra* individuals collected from off Kalpitiya than Jaffna (P < 0.05, t-test). Though crude protein content was higher in *H. scabra* collected at Jaffna than individuals collected from Kalpitiya, these values were not significantly different (P > 0.05).

**Table 1.** Proximate composition (mean  $\pm$  SD according to % wet weight basis) of *H. scabra* collected from off Kalpitiya and Jaffna

Category	Moisture (%)	Ash (%)	Crude Protein	Crude Fat (%)
			(%)	
Samplefrom	82.05±1.10 <sup>a</sup>	12.32±1.35 <sup>a</sup>	5.45±1.25	$0.21 \pm 0.05^{a}$
Kalpitiya				
Sample from Jaffna	$75.32{\pm}1.25^{b}$	$18.25 \pm 1.40^{b}$	6.32±1.54	$0.38{\pm}0.50^{b}$

**N.B.** Different superscript letters (a, b) in the same column represent statistical differences among *H. scabra* collected from different areas.

Fatty acid composition of *H. scabra* collected at Kalpitiya and Jaffna areas were computed and compared (Table 2). Saturated (SFA) and monounsaturated (MUFA) fatty acid levels were higher in *H. scabra* collected from Jaffna than that collected from Kalpitiya. Among the saturated fatty acids, Palmitic acid and Stearic acid were predominant in *H. scabra*. Palmitoleic acid was the dominant monounsaturated fatty acid while Octadecatetraenoic acid was the dominant polyunsaturated fatty acid in *H. scabra*. However, unknown two peaks and high levels of unidentified peaks were recorded in GC outputs.

	Type of fatty acids (W/W %)			H.scabra from
No			H. cabra from Kalpitiya	Jaffna
1	Myristic acid	14:00	$2.90\pm0.02$	$3.98\pm0.05$
2	Pentadecanoic acid	15:00	$2.27\pm0.03$	$3.01\pm0.04$
3	Palmitic acid	16:00	$13.79\pm0.50$	$16.88\pm0.60$
5	Stearic acid	18:00	$10.39\pm0.40$	$12.05\pm0.40$
	SFA		$29.35 \pm 0.95$	$\textbf{35.92} \pm \textbf{1.09}$
4	Palmitoleic acid	16:01	$6.38\pm0.40$	$8.74\pm0.40$
6	Oleic acid	18:1 (n-9)	$2.58\pm0.05$	$2.93\pm0.05$
7	Vaccenic acid	18:1 (n-7)	$2.37\pm0.06$	$2.88\pm0.04$
10	Erucic acid	22:1 (n-9)	$1.48 \pm 0.02$	$1.70 \pm 0.05$
	MUFA		$12.81 \pm 0.53$	$16.25\pm0.54$
8	Linoleic acid	18:2 (n-6)	$1.00\pm0.02$	$1.10\pm0.01$
9	Octadecatetraenoic acid	18:4 (n-4)	$8.24\pm0.50$	$8.75\pm0.40$
10	Eicosa-Pentaenoicacid (EPA)	C20:5 (n-3)	$3.34\pm0.50$	$3.15\pm0.52$
11	Docosa-Hexaenoicacids (DHA) ;	C22:6 (n-3)	$3.53\pm0.51$	$3.33\pm0.40$
	PUFA		$17.11 \pm 0.52$	$16.33 \pm 0.41$
12	Unkown 1		$13.70 \pm 0.60$	$6.18 \pm 0.05$
13	Unkown 2		$6.93\pm0.09$	$6.76\pm0.50$
14	Total % of other unidentified Peaks		19.64	18.56

**Table 2.** Mean ( $\pm$  SD) Lipid profile of *H. scabra* from different geographical location in Sri Lanka.

SFA-Saturated fatty acid, MUFA- Monounsaturated fatty acid PUFA- Polyunsaturated fatty acid

#### Conclusion

Proximate composition and fatty acid profile of sea cucumbers can affected significantly according to region and species. Feeding source as the major factor will result in regional variation of the species. There are limited studies in relating to proximate composition of sea cucumber species, Therefore this study was investigated slightly higher moisture content, and

lower fat and protein content for *H. scabra* in both places. Significant differences of moisture, ash and total fat contents were observed in *H. scabra* collected from different geographical locations in Sri Lanka. Saturated fatty acids were higher in *H. scabra* than the monounsaturated and polyunsaturated fatty acids.

# Acknowledgement

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# Food habits of the silky shark *Carcharhinus falciformis* in Sri Lankan waters

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### Abstract

Sharks are among the most common large predators in the marine environment and they play an important role in energy flows through marine food webs. Therefore, knowledge of food habits and feeding behaviour of sharks allows us to determine the effect sharks have on other organisms through predation and competition. This phenomenon can be used in management of shark fisheries too. Further, it provides us information on how changes in shark populations may affect populations of their prey and their competitors. A total number of 122 stomachs of silky shark were analyzed. The total length range of the observed silky shark was 48-248 cm with the mean length being 131.5 cm and weight range 12-125 kg. The diet of silky shark around Sri Lanka comprised of a variety of food items such as fish (53 %), squids (40%), octopus (6%) and others (1%). The great diversity in the food composition was represented mainly by some families of teleost fishes, squids and octopus which indicates that they are non-selective feeders and that feeding depends on prey availability rather than selectivity.

Keywords: silky shark, teleost, predator, Sri Lanka

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#### Introduction

Food preference of predatory fish is complex and influenced by many factors, such as available prey and their mobility, prey abundance and size, seasonal changes and environmental factors (Nieland, 1980; Cabrera et al. 2010). Determining the trophic relationships among species assists us to understanding their community organization and effect on ecosystem (Acuña and Villarroel, 2010). The Silky shark *Carcharhinus falciformis* is a widely dispersed species, which preferably lives in tropical and subtropical waters (Castro, 1983). The silky shark is one of the most abundant species of sharks found in Sri Lanka; it accounts for more than 50% of the catch landed by weight (Hasarangi *et al.* 2012). The present study was undertaken to obtain information on the predatory pressure of silky shark on fish and other prey species in the waters of Sri Lanka.

# **Materials and Methods**

Gut samples of silky shark were collected in 2014, during processing from the Peliyagoda, Chilaw and Negombo fish markets. Before collecting the gut samples, total length and standard length of each individual were measured to the nearest 0.1cm using a measuring tape. Gut samples were transported to the laboratory of Marine Biological Resources Division at National Aquatic Resources Research and Development Agency (NARA) and kept frozen at -20 °C. Each Gut sample was thawed before analysis. The total weight of stomach contents was determined to the nearest 0.01 g using an electric balance. The recognizable prey items were categorized into wide prey classes (fishes, crustaceans, squids and others), which were weighed to estimate their proportions by wet mass in the diet. The identifiable prey items were categorized to the lowest possible taxon. Prey items were measured using standard length (SL; cm) for fishes, the mantle length (cm) for cephalopods, and carapace width for pelagic crabs.

# **Results and Discussion**

The size distribution of the silky shark ranged from 48 cm to 248 cm in total length with the mean length of 131.5 cm. Of the observed specimens in the entire 122 shark stomachs were analyzed, 42 (35 %) were empty while 80 (65 %) stomachs were with food. Diversity in the food composition is represented by about 10 families of teleost fishes, crustaceans and cephalopods, which indicates that they are non-selective feeders and that feeding depends on prey availability rather than selectivity (Fig. 1).



Fig.1: Percentage occurrence of food types in silky shark stomachs analyzed

# Conclusion

The present study revealed that the major food item found in silky shark stomachs is fish. The great diversity in the food composition was represented mainly by some families of teleost fishes, followed by cephalopods and crustaceans, which indicates that they are non-selective feeders and that feeding depends on prey availability rather than selectivity.

# Acknowledgement

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# Length-Length and Length-Weight relationships of Blue Spotted Stingray (*Dasyatis kuhlii*) (Muller and Henle, 1841) from West Coast of Sri Lanka

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#### Abstract

*Dasyatis kuhlii* is a species of stingray of the family Dasyatidae. The body of *D. kuhlii* is dorsoventrally flattened in a disc shape. They are found in shallow estuarine, coastal and shelf regions up to about 90 m. The present study discusses some morphometric relationships of this species including length-weight relationship. The length-weight relationship studies of fish are important for fishery biological investigations and to estimate the biomass of length distribution. Morphometric measurements were obtained from 111 *D. kuhlii* in the west coast of Sri Lanka. Total Length (TL), Disc Width (DW) and Disc Length (DL) of the individuals were measured to the nearest centimeter, whereas the Body Weight (W) was measured to the nearest gram (g). The estimated length-length relationships of combined sexes of *D. kuhlii* were  $DW = 0.516 TL + 0.598 (R^2=0.95)$ ,  $DL = 0.427TL + 0.236 (R^2=0.95)$  and  $DL = 0.842 DW - 0.181 (R^2=0.93)$ . The estimated length-weight relationships for females and males *D. kuhlii* were  $W = 0.007L^{2.93}$  (R<sup>2</sup>=0.91) and  $W = 0.005L^{2.98}$  (R<sup>2</sup>=0.90) respectively. Growth of *D.* kuhlii was negative allometric and length-weight relationships were found to be significantly different between male and female.

**Keywords:** *Dasyatis kuhlii,* morphometric measurements, length-length relationship, length-weight relationship, Sri Lanka.

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#### Introduction

Biological data of fish is important for fisheries management (Hossain, 2009). Also, knowing the length-weight and length-length relationships of fish is useful for fish stock assessments (Hussain et al. 2012). *D. kuhlii* is a species of stingray of the Dasyatidae family. Stingrays are found in all tropical and subtropical seas. Maximum reported total length of *D. kuhlii* is 70 cm (Bray, 2011). Maximum reported disc width is 40 cm in Sri Lanka (De Bruin et al. 1994). D. kuhlii is widely caught in Sri Lanka by single day fishing boats operated using bottom set gillnets (5-6 inches mesh size).

#### **Materials and Methods**

Total 111 *D. kuhlii* individuals were obtained between August and November 2014 at Negombo and Chilaw fish landing sites in the west coast of Sri Lanka. Total Length (TL), Disc Width (DW) and Disc Length (DL) of the individuals were measured to the nearest centimeter and the Body Weight (BW) was measured to the nearest gram. The length-weight (L-W) and length-length (L-L) relationships were obtained using the least squared method.

#### Results

Among the examined specimens, 56 (50.45%) were males and 55 (49.55 %) were females. Table 1 summarizes the length and weight measurements of *D. kuhlii*. The estimated relationships for combined sexes of *D. kuhlii* Disc width (DW), Total length (TL) and Disc length (DL) were: DW = 0.516 TL + 0.598 (R<sup>2</sup> = 0.95), DL = 0.427TL + 0.236 (R<sup>2</sup> = 0.95) and DL = 0.842 DW - 0.181 (R<sup>2</sup> = 0.93). All relationships were significant at 0.01. The estimated L-W relationships for female and male *D. kuhlii* were  $W = 0.007L^{2.93}$  (R<sup>2</sup> = 0.91) and  $W = 0.005L^{2.98}$  (R<sup>2</sup> = 0.90) respectively. According to the t-test, a significant difference was noted between the two L-W relationships estimated for males and females (p < 0.05) (Zar, 1984).

**Table1.** Recorded minimum and maximum total length, disc width, disc length and body weight for male and female *D. kuhlii*.

Sex	TL (cm)		DV	DW (cm)		DL (cm)		BW (g)	
	Min	Max	Min	Max	Min	Max	Min	Max	
Male	29	66	8.8	36	7	30	100	1800	
Female	16.5	77	8.8	39	7	34	50	2400	

#### Discussion

Observed maximum values of the length and weight parameters of female *D. kuhlii* was greater than that of males (Table 1). Carpenter and Niem (1999) reported maximum total length is 67cm and the reported maximum disc width is 38cm in the Western Central Pacific area. Therefore, it can be concluded that larger individuals are still found in Sri Lankan waters. However, previously reported maximum disc width of *D. kuhlii* in Sri Lankan waters (40cm) was slightly higher than this value (De Bruin *et al.* 1994).

The males mature at about 25 cm disc width (Carpenter and Niem, 1999). Accordingly, it can be considered that almost 89 % of the investigated male specimens under the present study are mature. The estimated b values in the L-W relationship for male and female of *D. kuhlii* were 2.98 and 2.93 respectively. Since b values for both sexes are lower than 3, the growth of blue spotted stingray is negative allometric.

#### Conclusion

The present study provides useful information about the length-weight (L-W) and length-length (L-L) relationships of *D. kuhlii*. The results could be used when further assessments on this species are conducted. A detail assessment is required in order to understand the stock status correctly and to propose necessary management measures for the conservation and sustainable use of this species.

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# Optimization of Sterilization of the Explants of *Cryptocorynewendtii* and Selection of a suitable Hormone combination for the Initiation of Shoots from the Explants.

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#### Abstract

*Cryptocoryne* species are important aquatic plants for aquaculture industry. These are indiscriminately harvested from the wild for export market. In order to overcome the problems of species loss and inadequate supply to the local and foreign markets, an *in vitro* method for the micro-propagation of *Cryptocoryne wendtii* has been developed. Contamination of the explants in culture is a major problem in micro-propagation of aquatic plants. However, optimum number of aseptic cultures of *C. wendtii* rhizome segments could be developed by the explants with 40 % Clorox, a commercial bleaching solution followed by 10 minutes and 20 % Clorox solution for 7 minutes. These explants were cultured on Murashige and Skoog basal (MS, 1962) medium, supplemented with 1, 2, 4 or 10 mg/l of BAP (6-Benzyladeninepurine) along with and 1mg/l IAA (Indole-3-acetic acid). The cultures were monitored daily for fourteen days for the shoot initiation. Shoot initiation was the best on the medium containing 4 mg/l BAP and 1 mg/l IAA.

Keywords: Cryptocoryne wendtii, endemic, micropropagation, rhizome, hormone

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#### Introduction

The genus *Cryptocoryne*, a member of the family Araceae is represented by more than 50 species that are distributed throughout South Asia (Wijesundara and Shantha Siri, 2004). More than twenty species of the genus are being used in aquariums. Because of slow propagation by rhizomes and infrequent seed production (due to polyploidy), these species have become endangered. Ten species are endemic to Sri Lanka, and all species are listed in International Union for Conservation of Nature (IUCN) Red Book as endangered species (IUCN Red list 2012). *C. wendtii*s one of the most common and widely used species in aquariums. It is also one of the most variable species with several colour variation. The species has become endangered because of its high demand and its incapability of producing seeds due to its triploid nature (Wijesundara and Shantha Siri, 2004). This study was conducted to develop a micro-propagation protocol for *Cryptocoryne wendtii*, with an immediate objective of optimizing sterilization method for the explants and determine the suitable hormone concentrations and combination for the initiation of shoots from the explants.

#### **Material and Methods**

Rhizome segments of the *C. wendtii*, was excised from the plant stock maintained at plant house in NARA. Four surface sterilization methods were tested in the first experiment (Table 1) and four hormonal combinations were tested using the best sterilization method obtained from

the experiment 1 (Table 2). Murashige and Skoog (MS,1962) medium supplemented with 3% sucrose and gelled with 8 % agar was used as the basal medium, which was supplement with different concentrations of BAP along with 1mg/l IAA. The cultures were incubated at  $24 \pm 1$  °C under16 h photoperiod (1600 Lux). Cultures were observed at regular intervals for fourteen days. Each treatment consisted of ten replicates and the experiments repeated thrice.Different Clorox concentrations were used for treatments. To avoid the fungal contaminations explants were dipped in 0.1 % fungicide (Thiophanatemethyle) for overnight and washed under running tap water for 6 hours. Further to that explants were washed with 0.1 % Mercuric Chloride. TheKruskal-Wallis non parametric test used for statistical analysis.

Table 1. Treatments used for sterilization of the explants of Cryptocoryne wendtii.

Test	T1	T2	T3	T4
Clorox Concentration and time	6 % /15 min and 4 % / 10 minutes	20 % Clorox / 15 minutes	40 % Clorox / 15 minutes	40 % Clorox / 10 minutes+ 20 % Clorox / 7 minute

**Table 2**: The concentrations and combinations of growth regulators used for the induction of shoots from the rhizome explants of *Cryptocoryne wendtii*.

Test	Hormone Combination
T1	$\frac{0 \text{ mg/l } \text{B} \text{A} \text{P} + 0 \text{mg/l } \text{I} \text{A} \text{A}}{1 \text{ A} \text{A}}$
T1 T2	$1 m \pi/1 D A D + 1 m \pi/1 L A A$
12	1  mg/I BAP + 1  mg/I IAA
13	4 mg/l BAP +1 mg/l IAA
T4	10 mg/l BAP + 1 mg/l IAA

#### **Results and Discussion**

The best Surface sterilization procedure was adopted to get around 96% of contaminant-free explants of Cryptocoryne species using T4 treatment (Table 1) and least (6%) contaminant-free explants were observed in the procedure of T1 treatment. Most submerged aquatic plants retain high level of microbes on their wet surfaces. Under warm tropical conditions a higher number of microorganisms are present in the aquatic environments than under temperate conditions. Rhizomes of the *Cryptocoryne* species used in this study have an uneven and a hairy surface preventing contact between the rhizome and the sterilizing agent. This results in retention of microorganisms and ultimately contamination of the culture medium. This is common problem with rhizomes of tropical aquatic plants. (Mohanram and Agrawal, 1999). Dissanayake et al. (2007) obtained successful surface sterilization in C.wendtiiby using 5% Clorox for 15 minutes with vacuum infiltration followed by 95 % ethanol for minute and finally in 0.1 % mercuric chloride for 30 sec. In that study they were able to reduce the percentage of contamination up to 65%. According to Herath et al. (2008) surface sterilization of Cryptocoryne spp was successful using 75 % ethanol for one minute and 20 % Clorox solution for 15 minutes.

The best Surface sterilization procedure was adopted to get around 96 % of contaminant-free explants of *Cryptocoryne* species using T4 treatment (Table 1) and least (6 %) contaminant-free explants were observed in the procedure of T1 treatment. *C. wendtii* are generates new shoots MS supplemented with growth regulators. The best hormone combination was adopted to get around 78 % shoot initiation using T3 treatment (Table 2) and least (3.5 %) shoot initiation were observed in the T1 treatment (Table 2).

The effect of growth regulators for shoot initiation of *Cryptocoryne spp*has been reported by Herath *et al.*(2008). According to them, 5 mg/l BAP with 0.1 mg/l IAA induced maximum number of shoots in *C. beckettii* and *C. bogneri*. According to the Dissanayake *et al.* (2007), maximum number of shoots of *C.wendtii* was regenerated in MS medium supplemented with BAP 44  $\mu$ M and 66  $\mu$ M of Naphthalene acetic acid (NAA) The concentrations of the BAP hormone which above mentioned researchers have used much similar to the results in this study which was 4mg/l.

#### Conclusion

The most suitable surface sterilization for *C. wendtii* explants was obtained with treatment with 40% Clorox solution for 10 minutes and 20% Clorox solution for 7 minutes.*C. wendtii* yielded the highest shoot initiation in the presence of 4mg/l BAP and 1mg/l IAA in the medium.

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# A microbiological study of a local population of *Saccostrea sp.* found in Tangalle

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#### Abstract

Owing to the considerable amount of oyster resources reported in the coastal waters of Sri Lanka, oysters can be popularized as an alternative source of animal protein among Sri Lankans and as an industry. However, the microbiological safety needs to be assessed before routine consumption. The aim of this study was to study the bacterial profile of a local population of oyster sp. commonly found in Tangalle in order to assess its microbiological safety. Oysters were collected aseptically, from a rocky shore at Pallikkudawa beach, Tangalle and the species was identified as *Saccostrea cucullata* based on the morphological features. The soft tissues of each oyster was taken out aseptically and was homogenized using 0.09% saline. Each homogenate was cultured on nutrient agar, MacConkey agar and Thiosulphate Citrate Bile Salts (TCBS) agar and was incubated at 37<sup>o</sup>C overnight. Approximately 5 g of oyster tissue was pre-enriched in peptone water and was then cultured on MacConkey agar. Identification of bacteria was done by studying the colonial morphology, colour changes of the medium, microscopic examination of Gram-stained smears and biochemical tests. *Klebsiella pneumoniae, Proteus* sp., *Vibrio alginolyticus* and *Bacillus* spp. were isolated and identified.

Keywords: Oyster, Saccostrea cucullata, bacteria, Vibrio

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#### Introduction

Oysters are filter-feeding bivalves and the most harvested shellfish in the world (Piyathilaka et al. 2012). Farming oysters for raw or partially-cooked consumption is an emerging and exportoriented industry in Sri Lanka (Indrasena and Wanninayake,1986). Since oysters are filterfeeders, pathogens can be greatly concentrated and microbiological studies are useful in reducing the risk of consuming oysters. The aim of this study was therefore to study the bacterial profile of a local population of oyster sp. commonly found in Tangalle in order to assess its microbiological safety.

#### **Materials and Methods**

Oysters were collected aseptically using a sterile knife, from a rocky shore at Pallikkudawa beach, Tangalle. The population was identified as *Saccostrea cucullata*, based on the morphological features. Samples were collected from October to December, 2015, for a period of two months. Oysters were shucked and soft tissues including gill and mantle and intervalvar fluid were transferred aseptically to sterile bags. The tissues were then homogenized in 0.09% saline, using a bag mixer (Inter Science, France).

Each homogenate was cultured on nutrient agar, MacConkey agar and Thiosulphate Citrate Bile Salts (TCBS) agar and was incubated at 37 °C overnight. Approximately 5 g of tissue from each oyster was pre-enriched in peptone water and was then cultured on MacConkey agar. Organ cultures were also made on MacConkey agar. Identification of bacteria was done by studying the colonial morphology, colour changes of the medium, microscopic examination of Gramstained smears and biochemical tests using Enterobacteriaceae identification test kit (HIMEDIA KB003, India) and Vibrio identification test kit (HIMEDIA KB007, India). Bacterial colonies which were suspected to be Pseudomonas and Salmonella were cultured in TSI agar and was incubated at 40°C 72 hours.

#### **Results and Discussion**

The Enteric bacteria demonstrated the following results (table 1) on culture media, Gramstained smears and with biochemical tests. The large, white, flat colonies with irregular edges which showed chains of Gram-positive rods were identified as *Bacillus* spp. The yellow colonies on TCBS agar were identified as *Vibrio alginolyticus* based on the biochemical tests and demonstration of Gram-negative curved rods. Another type of green colonies were observed on TCBS agar which was also thought to be a Vibrio, however, the species could not be determined by the biochemical tests carried out. Overall, *Klebsiella pneumoniae,Proteus* sp., *Vibrio alginolyticus* and *Bacillus* spp. were isolated and identified in this study. Previous studies have also isolated *V. parahaemolyticus, V. anguillarum, V. harveyi*, and *V. vulnificus* along with other *Vibrio* spp., from *Saccostrea cucullata* (Chen Mei *et al.* 2000). Moreover, *Pseudomonas* spp. and *Bacillus* spp. have been identified in *Crassostre gigas* (Hernandez and Olmos, 2006)

MacConkey agar	Gram-stained	Indole test	Methyl Red	Species
	smears		test/Urease test	
Pink, mucoid colonies	Gram-negative	(-) ve	(-) ve	Klebsiella
	rods			pneumoniae
Pink/colourless colonies	Gram-negative	(-) ve	(+) ve	Proteus spp.
on yellow medium	rods			

Table 1. Results of culturing and biochemical tests for carried out for Enteric t	oacteria
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#### Conclusion

*Klebsiella pneumoniae, Proteussp., Vibrio alginolyticus* and *Bacillusspp.* were present in the local population of *Saccostrea cucullata*. This indicates the need of taking adequate precautionary measures such as relaying & depuration and high-pressure processing before using farmed oysters for consumption.

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# Induced breeding of Tinfoil Barb (*Barbonymus schwanenfeldii*) (Bleeker, 1854) using Ovaprime

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#### Abstract

Tinfoil barb [TFB] of family Cyprinidae, is an attractive popular aquarium fish species native to Southeast Asia. There is no authentic record on its natural spawning in captivity condition in Sri Lanka. In 2015 an experiment was conducted to induce the spawning of captive reared TFB using Ovaprime, which contains sGnRHa hormone. At the initial stage, the sexually matured healthy females of  $0.23 \pm 0.01$  kg average body weight (BW) were subjected to intra-ovarian biopsy. Later on the 18 females with migrating germinal vesicles and the males in oozed milt stage were selected for the experiment. Different dosages of Ovaprime viz. 0.2 ml kg<sup>-1</sup>, 0.3 ml kg<sup>-1</sup>, 0.4 ml kg<sup>-1</sup>, 0.5 ml kg<sup>-1</sup> and 0.6 ml kg<sup>-1</sup> of BW were injected to the selected females while half a dosage was given to the selected males. All uninjected fish were kept as the control. The induced TFBs were kept at 100 l glass tank of preconditioned water at 1:1 male to female ration. In order to determine the ovulation time, after three hours of hormone injection, a gently pressure was given to each female vents at every half an hour to observe easy expression of eggs. The breeding performance of TFBs was determined based on the ovulation time (hrs) and the fertility rate (%). Data was analyzed with one way ANOVA and the Tukey test in SSPS software. The results indicated that minimum ovulation time was  $3.20 \pm 0.17$  hrs at a dosage of 0.6 ml kg<sup>-1</sup> of BW. The fertility rate with particular dosage was  $33.33 \pm 9.07$  %, which was not significant compare to the least fertility rate (27.84 ± 2.36 %) obtained with 0.2 ml kg<sup>-1</sup> of BW dose. However, relatively higher fertility rates i.e.  $73.33 \pm 4.51$  % and  $80.67 \pm 5.13$  % and minimum ovulation times ( $5.43 \pm 0.51$  hrs and  $6.10 \pm 0.17$  hrs) were observed with 0.4 ml kg<sup>-1</sup> and 0.5 ml kg<sup>-1</sup> of BW dosages respectively. In three months experimental period, TFB was not observed to breed naturally. Therefore, it could conclude that maximum fertility rate and relatively lower ovulation time of TFB can be achieved with 0.4 - 0.5 ml kg<sup>-1</sup> of BW Ovaprime for females and half of that for males TFB under captive conditions.

Key words: Tinfoil barb, aquarium fish, induced breeding, ovaprime, ovulation and fertility rate.

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#### Introduction

Production of ornamental fish is a rapidly growing branch of the aquaculture industry (Tlusty, 2001). Exotic ornamental fishes occupy a significant portion of the ornamental fishes produced in Sri Lanka.Tinfoil Barb (*Barbonymus schwanenfeldii*) TFB is an exotic fish originating in South East Asia that has a high demand in the local as well as the international ornamental fish trade. There is no authentic information related to the reproduction of this species in captivity. In the present study, attempts were made to develop the induced breeding methodology for this species within the Sri Lankan environment using the inducing hormone, "Ovaprime" which contains analogue of Salmon GnRH [Ovaprime 1 mL contains 20 µg of GnRH and 10 mg domperidon].

#### **Materials and Methods**

Sexually mature healthy TFB brooders were selected randomly based on their external features. In order to very their maturity, the females were sedated using Tricane Methane Sulphonate [TMS] 65 ppm solution and were subjected to intra-ovarian biopsies. A fine polyethylene tube was inserted into the oviduct to facilitate the removal of a few oocytes. It could see that the germinal vesicle of the oocytes was migrating to the periphery. The males selected were oozing milt when a slight pressure was applied at the vent. Eighteen pairs in the identical stage of maturity and of average body weight (BW)  $0.23 \pm 0.01$ kg were randomly collected, and conditioned. Single doses of Ovaprime were injected intramuscularly at individual of 0.2 ml kg  $^{1}$ , 0.3 ml kg<sup>-1</sup>, 0.4 ml kg<sup>-1</sup>, 0.5 ml kg<sup>-1</sup> and 0.6 ml kg<sup>-1</sup> BW. The hormone was administered to all individuals within one hour. Males received half the dose that injected to the respective females in the each experimental group. The induced TFBs were kept at 100 l glass tank of preconditioned water at 1:1 male to female ration. Each experimental group comprised three replicates. An un-injected group was also kept under same conditions as a control. The breeding performance was determined based on the ovulation time (hrs) and fertility rate (%). In addition, post experimental mortality rate of brooders and water quality parameters in the experimental tanks were monitored. The response time was determined by applying a gently pressure that was given to each female vents at every half an hour to observe easy expression of eggs. The fertility rate was determined by the number of eggs undergoing the first cleavage stage in the embryonic development process. Data analysis was done using one way ANOVA and the tukey test.

#### **Results and Discussion**

The effect of different dosages on the breeding performance of TFB is shown in Table 1. Ovaprime has successfully induced the spawning of TFB. Five different Ovaprime dosages were found to have support the spawning activity and breeding performance of TFB and it was favored by middle inclusion levels of Ovaprimee dosages in the experiment.

Ovaprimee has been used successfully in several fish families (Hill *et al.*, 2005). The present study showed that all fish in the experimental groups respond to the striping trials except for those in the control. The least response time was recorded at a dosage of 0.6 ml kg<sup>-1</sup> of BW Ovaprimee at a time lapse of  $3.20 \pm 0.17$  hrs. The maximum response time was observed at 0.2 ml kg<sup>-1</sup> of BW at a lapse of  $11 \pm 0.51$  hrs. According to the literature surveyed, 0.5 ml kg<sup>-1</sup> of body weight is the standard Ovaprime dose for inducing ovulation in fish (Hill *et al.* 2005). In the case of TFB, the dosage of 0.6 ml kg<sup>-1</sup> of BW Ovaprime showed the minimum response time. However, the respective fertility rate was not different significantly to the lowest fertility rate, which was at the dosage of 0.2 ml kg<sup>-1</sup> of BW. Although, the best dosage with the minimum response time is 0.4ml kg<sup>-1</sup> of BW, but this is not significantly different from that of the group receiving 0.5ml kg<sup>-1</sup> dose.

Dosage/ml kg <sup>-1</sup>	0.20	0.30	0.40	0.50	0.60	Р
of BW						value
Ovulation time/	$11.00 \pm$	9.20 ±	$5.43 \pm 0.51^{\circ}$	$6.10 \pm 0.17^{\circ}$	$3.20 \pm 0.17^{d}$	0.000
hrs	0.51 <sup>a</sup>	0.17 <sup>b</sup>	5.15 ± 0.51	0.10 ± 0.17	$5.20 \pm 0.17$	0.000
Eastility rate 9/	$27.84 \pm$	$50.5 \pm$	$73.33 \pm$	$80.67 \pm$	$33.33 \pm$	0.000
Ferning rate %	2.36 <sup>a</sup>	7.09 <sup>b</sup>	4.51 <sup>c</sup>	5.13 <sup>c</sup>	9.07 <sup>a</sup>	0.000

**Table 1.** Breeding performance of TFB induced with Ovaprimee.

Values are presented as means  $\pm$  S.D., means in each raw with different superscripts are significantly different from each other.

The maximum fertility rate was observed in the fish group receiving 0.5ml kg<sup>-1</sup> of BW of Ovaprime. Thus the range between 0.4ml kg<sup>-1</sup> - 0.5ml kg<sup>-1</sup> of BW could be considered as the best to achieve a higher fertility rate. These values were not significantly different from each other. During the latency period temperature ranged from  $27.4 \, {}^{0}\text{C} - 27.8 \, {}^{\circ}\text{C}$  and pH was measured as 7.3. Therefore, further studies should be carried out to identify the best dosage which falls 0.4 ml kg<sup>-1</sup> - 0.5 ml kg<sup>-1</sup> of BW dosage of Ovaprimee. Spawning was not observed in the tanks in which the control fish group was kept for a three months period. This indicates although they did have viable ova, their spawning could not be complete without the support of inducing hormones in Sri Lankan captive environment conditions.

The survival rate of brooders was 100% after the administration of Ovaprimee and the post spawning period. According to observations, the range of hormone dosages used for the present study is not harmful and there was no any sign of negative effect on the TFB. Achionye and Obaroh (2012) have found that procedure of injection, quality of the hormone and degradation of water quality during holding and handling of fish affect the post inducing mortality of brooders. Proper conditioning and domesticating the fish before injecting, maintaining appropriate water quality, supplying a nutritious feed, using a good quality hormone and reduced handling of fish due to administration of single dose may be attributed for the zero mortality in brood fish. The similar condition has been observed by More *et al.* 2010). There was no any significant difference (P > 0.05) in some water quality parameters such as water temperature, dissolved Oxygen and pH in six different treatment tanks.

Although, successful results could be obtained in this study, future studies which facilitate incubation using hatchery jars with water jets, increase the hatchability as eggs are semi buoyant and are need to be carried out. However, the developed induced breeding technology can be introduced to local commercial fish breeders for mass scale production of TFB.

#### Conclusion

Higher fertility rates and a relatively short ovulation time of TFB can be achieved by injecting dosage of 0.4 ml kg<sup>-1</sup> -0.5 ml kg<sup>-1</sup> of BW Ovaprime to females and half that dosage to the

males at the same time in spawning the TFB in captivity. It is less time consuming and fruitful method for commercial scale fish breeding in Sri Lanka.

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# Healthier water quality parameters ensured acceptable length-weight relationship of *Penaeus monodon* in Batticaloa, Sri Lanka

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#### Abstract

Successful shrimp aquaculture depends on the quality of culture environment. Although shrimp farming in Batticaloa had been practiced since the latter part of 2002, there is a lack of information available on the culture environment. Therefore, a study was conducted to analyze the water quality parameters and growth performance of farmed *Penaeus monodon*. A total of 21 farms were randomly selected to study the management aspects, water quality parameters, and performance of shrimps in Batticaloa. This study showed that mean values of water temperature, salinity, pH, total ammonia, alkalinity and dissolved oxygen were within the tolerable limit. Salinity, pH and alkalinity of pond water weredifferent (P < 0.05) among the farming areas. Condition factor of cultured *P. monodon* was  $0.86 \pm 0.06$  in Batticaloa. As shrimp farmers in the study area follow standard practices regarding pond preparation and management, performance of shrimp aquaculture also was in line with the standards.

Keywords: Penaeus monodon, shrimp culture, condition factor, water quality parameters

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#### Introduction

Shrimp accounts 15% of the total value of internationally traded fishery products in 2012 (FAO, 2014). Shrimp culture is an important industry in developing countries of East and Southeast Asia which contribute around 70% to the global farmed shrimp production (Kumar *et al.* 2012). In Sri Lanka, shrimp aquaculture is concentrated in Northwest province. Recently, the industry has emerged in Batticaloa witha newly established shrimp hatchery in Puthukudirippu. Although the income in this industry is lucrative, high risk is associated in the production processes due to rapid degradation of pond water quality and consecutive disease outbreak on shrimps. As such, successful shrimp culture depends on physical and chemical characteristics of pond water which is highly determined by pond management practices, nature of bottom soil and pond bottom sediments. In this context, there is a lack of information available on the water quality parameters of shrimp culture conditions in Batticaloa. Therefore, a study was conducted to analyse the water quality parameters and growth performance of farmed shrimps to predict the standards of shrimp culture conditions.

#### Materials and methods

The study was carried out in shrimp farming areas of Batticaloa *viz*. Vattawan, Kavathamunai, Eachchantivu and Karaiyakkantivu. A total of 21 farms were randomly selected to collect data on management aspects of shrimps, water quality parameters, and performance of cultured shrimps. Water pH, salinity, temperature and dissolved oxygen were measured using portable meters weekly, whereas measurements on total ammonia and alkalinity, and feed intake were collected from farm records. Survival rate of the shrimps was assumed to be 85%. Live body weight was measured weekly from 48<sup>th</sup> day of growth until harvest. Length-weight relationship was calculated after 120 days of growth. Data were analyzed in SAS software package (Version 9.1) using PROC UNIVARIATE, PROC GLM and PROC REG procedures.

#### Results

*Penaeus monodon* was cultured under semi-intensive system in Batticaloa. Average stocking density of post-larvae (PL) was  $14 \pm 3 \text{ m}^{-2}$ . One paddlewheel was installed for  $0.2 \pm 0.1$  ha of pond. Stocking density and paddlewheel usage was different (P < 0.05) among shrimp farming areas. Mean values of water temperature ( $30.1 \pm 1.0 \text{ °C}$ ), salinity ( $11 \pm 2.4 \text{ ppt}$ ), pH ( $8.3 \pm 0.3$ ), total ammonia ( $0.22 \pm 0.2 \text{ mgl}^{-1}$ ), alkalinity ( $135 \pm 16 \text{ mgl}^{-1}$ ) and dissolved oxygen ( $7.43 \pm 0.73 \text{ mgl}^{-1}$ ) were within the tolerable limit. There was different (P < 0.05) in salinity, pH and alkalinity of pond water among the farming areas. However, pond water temperature and total ammonia concentration were not different (P<0.05). Average body weight of shrimps was  $30.8 \pm 6.4$  g while average length was  $15.3 \pm 0.9$  cm at harvest. Condition factor of cultured *P*. *monodon* was  $0.86 \pm 0.06$  in Batticaloa.

#### Discussion

Average stocking density of shrimp PL is low  $(13 \pm 4 \text{ m}^{-2})$  in some areas of Batticaloa due to absence of electricity which limits the usage of paddlewheel for aeration of ponds. According to degree of pond preparation and management practices, the hatchery supplies PL at a rate of 16 to 18 PL m<sup>-2</sup>, which is within the recommended range (5 to 20 PL m<sup>-2</sup>) for semi intensive culture of *Penaeus monodon*. Water quality parameters of shrimp ponds are maintained within the acceptable range throughout the growth cycle in all areas. As a result, growth and lengthweight relationships are not significantly different from previous studies (Ajani *et al.*2013).

#### Conclusion

The length-weight relationships and condition factor revealed that Batticaloa district is suitable for the culture of *P. monodon*. Shrimp farmers in Batticaloa district take considerable efforts in managing the farm in all aspects, including pond preparation, water quality, feeding, and biosecurity measures throughout the growth cycle.

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### Effect of photoperiod on the growth of fry stage of Xiphophorus hellerii

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#### Abstract

Swordtail fish (*Xiphophorus hellerii*) is a tropical freshwater ornamental fish that can be seen in many countries such as Hawaii, Africa, Sri Lanka and Australia. They belong to class Actinopterygii, order Cyprinodontiformes and Family Poecillidae. It has been found that the photoperiod has a positive effect on the growth rate of some fish species in the same family such as Black Molly (*Poecillia sphenops*) and different family (Centrarchidae ) such as Green Sunfish (*Lepomis cyanellus*). However, information is lack on swordtail fish in this regard. Hence, this study was conducted to investigate the effect of photoperiod on the growth of swordtail fish. Three samples of two weeks old fry were exposed to three different photoperiods during 90 days. Fries were equally divided and reared in nine tanks of 54 liters of volume. Of these, three tanks were exposed 12 hour to daylight and 12 hour darkness (12L: 12D). Three tanks were exposed to 24 hours daylight (24L: 0D) only (with additional florescent illumination). Remaining three tanks were kept in total darkness for 24 hours (0L: 24D). Changes of their Daily Weight Gain (DWG), Specific Growth Rate (SGR), Feed Conversion Ratio (FCR) and Feed Conversion Efficiency (FCE) were determined. No significant differences (P>0.05) were observed for DWG, SGR, FCR, or FCE values amongst the different photoperiods, concluding that there is no obvious effect of photoperiod on the growth rate of swordtail fish of these age classes.

Keywords: photoperiod, specific growth rate, feed conversion ratio, feed conversion efficiency, *Xiphophorus hellerii* 

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#### Introduction

Swordtail (*Xiphophorus hellerii*) which belongs to Family Poeciliidae, is a common tropical fish with a high demand in the ornamental fish industry. They possess different colors such as red, green, neon, pineapple, red tuxedo. (Tamaru *et al.* 2001) and available in many strains. Males have a sword like modification on their caudal fin, making them known as Swordtail fish. Photoperiod has been found to affect the growth rate of fish, which may be varied among species (Downing and Litvak 1999). Black Molly (*Pocellia sphenops*) require 24 hours light for faster growth rates (Jeniffer *et al.* 2012) and Green Sunfish, (*Lepomis cyanellus*) has higher growth in 16 hours day light length (Gross *et al.* 1965). However high light intensity can cause stress (Jeniffer *et al.* 2012). Long photoperiod provide better visual to fish larvae to capturing food. However, the studies on the photoperiod of Swordtail fish is scanty. Therefore, it is very important to reveal this information, which can be very useful in commercial production of swordtail fish.

**Daily Weight Gain** =  $(W_f - W_i) g / Number of days of experiment$ 

Where,  $W_f = final$  weight

W<sub>i</sub><sup>=</sup> initial weight

Specific Growth Rate (% day ) = 
$$\frac{\ln \text{final weight}(g) - \ln \text{initial weight}(g)}{\text{Number of days of experiment}} \times 100$$

**Feed Conversion Ratio** = Dry food fed (g) / Wet weight gain(g)

**Feed Conversion Efficiency** (%) =[(wet weight gain of fish) (g) /weight of dry food fed (g)] X100%

Data were statistically analyzed using one way ANOVA in Minitab 16 and Microsoft Excel software.

#### Results

**Table 1.** Mean  $\pm$  SE of Mean of growth parameters.

Parameter	12L:12D	24L:0D	0L:24D	
Daily Weight Gain	$0.159\pm0.09$	$0.146\pm0.08$	$0.157\pm0.09$	
SGR %	$1.793 \pm 0.084$	$1.806 \pm 0.02$	$1.803 \pm 0.055$	
FCR	$2.708\pm0.214$	$2.790\pm0.078$	$2.684\pm0.089$	
FCE %	$36.92\pm2.92$	35.83±1.01	$37.25 \pm 1.22$	

#### Discussion

No significant difference of any of the four parameters could be seen among the three setups, when exposed to different amounts of photoperiods (p > 0.05). The highest mean daily weight gain was recorded in the tank with 12L: 12D ( $0.159 \pm 0.09$ ) and the lowest value was recorded in the tank with 24L: 0D. ( $0.146 \pm 0.08$ ). The highest SGR value was recorded in the tank with 24L: 0D ( $1.806 \pm 0.02$ ) and the lowest value was recorded in the tank with 12L: 12D. ( $1.793 \pm 0.08$ ). The highest FCR value was recorded in the tank with 24L: 0D ( $2.79 \pm 0.08$ ) and the lowest value was recorded in the tank with 24D: 0L ( $2.684 \pm 0.09$ ). The highest FCE value was recorded in the tank with 24D: 0L ( $37.25 \pm 1.22$ ) and lowest value was recorded in the tank with 24L: 0D ( $35.83 \pm 1.01$ ).

#### Conclusion

Present study concludes that the photoperiod does not affect the growth rate or feed utilization efficiency of Swordtail fish and it may be attributed to the fact that photoperiod may have an effect on other functions such as color development and gonadal development in swordtail fish. Further research in this regards is highly recommended

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#### The occurrence of Cistopus taiwanicus in Sri Lankan waters

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#### Abstract

Cephalopods include a diverse collection of more than 650 species of octopus, cuttlefish, squid and nautilus. Several of these species are commercially important in Sri Lanka. As morphological identification is sometimes difficult, molecular techniques were used to confirm the species of cuttlefish, squid and octopus species found in Sri Lankan waters. Cephalopod samples were collected from Chilaw, Negombo, Beruwela and Kalpitiya. The miotochondrial COI region was amplified and sequenced. The sequences were matched with universal databases to identify each species. The cuttlefish species Sepia aculeata, Sepiella inermis, Sepia pharaonis and Sepioteuthis lessoniana, the squid species, Loligo singhalensis and Loligo (Uroteuthis) duvacelli were identified by this barcoding technique. Two species of octopus, Cistopus taiwanicus and Octopus vulgaris were also identified. A significant finding in this study was that two separate octopus specimens collected from Negombo and Kalpitiya were identified as Cistopus taiwanicus. Four species of Cistopus, namely, C indicus, C. chinensis, C. taiwanicus and C. platinoidus have been recorded in the world. Out of these four species, only C. indicus has been reported from Sri Lanka. Therefore, the species list for Cephalopod species present in Sri Lanka could be updated to include the species Cistopus taiwanicus. Further research is needed to confirm whether C. indicus and C. taiwanicus are both present in Sri Lankan waters or whether C. taiwanicus has thus far been misidentified as C. indicus.

Keywords: Cephalopods, octopus, Cistopus taiwanicus

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#### Introduction

Cephalopods are an ancient molluscan class of animals that include a diverse collection of more than 650 species of octopus, cuttlefish, squid and nautilus. Several of these species are commercially important in Sri Lanka. Morphological identification is sometimes difficult in cephalopods as morphological characters employed for cephalopod identification are influenced by sex, age, growth, sexual maturity and the environment, while some important features appear only in the mature male. Therefore, the availability of methods using molecular techniques would be very useful for the identification of these cephalopod species. In addition, it would help in the accurate identification of these species in sea food products.

#### **Materials and Methods**

Cuttlefish, Squid and Octopus samples were collected from Chilaw, Negombo, Beruwela and Kalpitiya fish landing sites from January 2015 to November 2015. The morphological features of the specimens were noted. Samples for DNA analysis were stored in alcohol and transported to the laboratory. The samples were subject to a standard DNA extraction protocol (Sambrook *et al.* 1992) and the quality and quantity of DNA was determined by agarose gel electrophoresis. Mitochondrial COI PCR reactions were carried out for the extracted DNA and

the purified PCR products were sequenced in an Applied Biosystems automated DNA sequencer. The sequences were analyzed using Bioedit and identified using the Barcode of Life database (BOLD) and the NCBI blast facility.

#### Results

The cuttlefish species identified were Sepia aculeata, Sepiella inermis, Sepia pharaonis, and Sepioteuthis lessoniana and the Squid species identified were Loligo singhalensis and Loligo (Uroteuthis) duvacelli. Two species of octopus Cistopus taiwanicusand Octopus vulgaris were identified using these databases. The significant finding in this study was the identification of a specimen collected from Negombo and another specimen collected from Kalpitiya identified as Cistopus taiwanicus with 99.53% similarity. Both these specimens were identified as C. indicus considering their external morphological appearances (Fig. 1).



Fig. 1: Octopus species identified as Cistopus taiwanicus

#### Discussion

Until 2009, the only described species of *Cistopus* has been *C. indicus*. By 2012, two more species had been described; *C. taiwanicus* (Liao and Lu, 2009) and *C. chinensis* (Zheng *et al.* 2012). In 2015, a new species, *C. platinoidus*, has been described from India (Sreeja *et al.* 2015). Out of these *Cistopus* species, only *C. indicus* has been recorded from Sri Lanka (Bambaradeniya, 2006). The 2 specimens identified as *C. indicus* collected from Negombo and Kalpitiya using the external morphological features, were identified as *C. taiwanicus* by DNA bar-coding. Therefore, this has proved that molecular identification techniques are very useful in identifying species that are difficult to distinguish morphologically.

#### Conclusion

The species *Cistopus taiwanicus* could be added to the list of Octopus species found in Sri Lankan waters. Further research needs to be done to confirm whether *C. taiwanicus* has been misidentified as *C. indicus* or whether both species are present in Sri Lanka.

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# Infection and the histopathological damage caused by Yellow Grub (*Clinostomum complanatum*) in guppies (*Poecilia reticulata*)

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#### Abstract

Guppy (*Poecilia reticulata*) is one of the highly demanded species in the export market. The infection of Yellow grub (*Clinostomum complanatum*) and the histopathological effects caused on guppies were investigated. Samples were collected from fish rearing ponds at the Department of Zoology, University of Ruhuna, Matara, Sri Lanka. The sample consisted of 30 individuals and the prevalence of the parasite was estimated and the number of cysts on each infected fish was counted. Infected fishes were treated with Naguvon and KMnO<sub>4</sub> and kept for three months to determine the possibility of controlling the parasite. Metacercaria larval stage and histopathological damages caused by the parasite were examined. Snails belonging to *Helisoma* sp. were collected from the pond and kept under sunlight to observe the shedding of cercaria larvae. Daily observations were carried out to record the bird species that visit the ponds to determine the definitive host.

Prevalence of the parasite was 20% and among them 66.67% were females. One to five numbers of embedded metacercarial cysts were observed on each fish either in muscles, caudal and pectoral fins, around eye region or inside surface of the operculum. The elongated oval shaped metacercaria possessed small oral and a ventral sucker and vitellaria present in the body. With the time parasites developed inside the cysts and severe histopatholgolical damages were caused shifting internal organs aside. The infection of parasite cause considerable impact on the behavior, appearance as well as economical and ornamental values of the fish. The fork tailed cercaria larvae released by snails were observed. Common heron was determined as the definitive host. Naguvon and KMnO<sub>4</sub> treatments were not capable to control the parasite. With the support of the reported information in the current study, future research could be directed towards the investigation of proper treatment methods to control the damage caused by the parasite.

Key words: Clinostomum complanatum, yellow grub, guppy, Poecilia reticulata, histopathology

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#### Introduction

Guppy (*Poecilia reticulata*) gained considerable attention in the Sri Lankan freshwater ornamental fish industry. The present study investigated the infection and damage caused by infection of internal platihelminth trematode parasite, yellow grub (*Clinostomum complanatum*) on guppy fish. The yellow grub *C. complanatum* is a common parasite mainly in North American countries (Olsen 1962). The metacercarial stage of the yellow grubs embedded intramuscularly (in the muscle) or subcutaneously (under the skin) in fish and it has been reported from many fish species (Hoffman, 1999) such as yellow perch, bass, and sunfish (Olsen, 1962) and also in amphibians (McAllister, 1990). The parasite cysts are highly visible

to the naked eye and consumers do not readily accept the infected fish due to their unsightly appearance (Hoffman, 1999). It has been reported that larvae of yellow grub could be survived for four years inside the cysts of fish (Elliot and Russert, 1949).

The records on damage of *C. complanatum* have not been documented in Sri Lanka so far. The heavy infection of the parasite cause slow moving of the fish and considerable impact on their growth. Even slight infection of the parasite form embedded cysts in the body which damage the appearance of the fish and reject them causing economic loss.

#### Materials and methods

Wild guppies (n = 30) were collected from the earthen ponds of the Department of Zoology, University of Ruhuna, Matara. Fish were observed for the external symptoms of the yellow grub infection. Infected males and females were counted and prevalence of the parasite was calculated using the following formula, Prevalence = (Infected fishes /Total fishes examined) X 100.

Different sizes of metacercarial cysts were pierced by a needle to release metacercaria from the cysts. They were kept in saline for 24 hours and stained with Borax carmine to investigate the morphological structure. Infected guppies were fixed in Bouin's fluid and tissues were prepared for histopathological examinations and damage caused by parasite was observed. The first intermediate host, snails belonging to *Helisoma* sp. were collected and kept under sunlight for shedding of cercaria larvae. Daily observations were carried out to record the visiting bird species to the pond that act as the definitive host visit to ponds. Twenty infected fishes and non infected fishes were separately kept in 1ppm Neguvon bath for 24 hours and then 2.5ppm KMnO<sub>4</sub> and the cysts were examined. Then metacercarial cysts of 20 fishes were removed and they were exposed to 1ppm Neguvon bath for 24 hours and then 2.5ppm KMnO<sub>4</sub>.





#### **Results and Discussion**

Yellow grub cysts were observed on the musculature, on caudal and pectoral fins, around eye region and on inner surface of the operculum, which appeared as yellow coloured, slightly oval spot, about 3 to 6 mm long. The prevalence of the parasite was 20 % and among them 66.67 % were females. Fishes were infected with 1-5 number of metacercarial cysts. Different stages of metacercaria were found. Considerable impact on the internal organs, behavior and appearance

of the fish were observed. After stained with Borax carmine, it was noticed that metacercaria has an elongated oval shaped body. A small oral sucker and a ventral sucker were present close to the anterior side of the body and the vitellaria were present in the body. The observations are consistent with reports presented by Salim and Ali (2010). The treatment, Neguvon and KMnO<sub>4</sub> applied on fish were not responded to metacercaria cyst as metacercaria makes comparatively deep wounds in the body when encysting. Fork tailed cercaria was found in the snails which act as the first intermediate host and the common heron was observed as the definitive host where the adult parasites feed and reproduce. Studies are important to control the damage caused by the parasite.

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# Antibiotic Resistance of Bacteria: Natural Water Bodies vs Commercial Aquaria in Tangalle, Sri Lanka

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#### Abstract

The aims of the present study were to 1) isolate and identify the bacteria inhabiting natural water bodies (NW) and commercial aquaria (CA); 2) to study the antibiotic susceptibility of bacteria in NW for some selected antibiotics; 3) to compare it with that of the bacteria occurring in CA; 4) to investigate whether there is a difference in antibiotic resistance among bacteria isolated from different locations of the natural water body. Twenty-one water samples were collected aseptically from Sitinamaluwa (n = 3), Polonmaruwa (n = 6) reservoirs and two selected commercial aquaria (n=6 each), located in Tangalle, Sri Lanka. Bacteria were isolated using nutrient agar and MacConkey agar and were identified using Gramstained smears and biochemical tests. Kirby-Bauer technique was performed for each distinct bacterial isolate, using amoxicillin (AMO), chloramphenicol (CHL) and oxytetracycline (OTC) disks (30 µg, Himedia, India), on Mueller-Hinton agar. The diameter of each zone of inhibition (ZI) was measured. The ZI demonstrated by each bacterial isolate of NW, were statistically analyzed with that of CA. Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumoniae, and a Serratia sp. were isolated. Almost all bacterial isolates were resistant to AMO while the susceptibility for CHL differed significantly (p < 0.05) between isolates of NW (29.74 ± 1.53 mm) and that of CA (13.47 ± 1.31 mm). Also a significant difference (p < 0.05) was observed between the bacterial isolates of NW (22.45  $\pm$  0.71mm) and that of CA ( $9.22 \pm 0.66$  mm), for OTC. Moreover, there was a significant difference (p < 0.05) between the susceptibility to CHL in isolates collected from the inlet (28.02  $\pm$  1.13 mm) and the outlet (33.19  $\pm$  1.54 mm) and that for OTC (inlet:  $20.63 \pm 0.17$  mm and outlet ( $23.57 \pm 1.45$  mm), of Polonmaruwa reservoir. The highest degree of resistance was evident against AMO, among all resistant isolates.

Keywords: antibiotic resistance, commercial aquaria,, natural water bodies, Tangalle

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#### Introduction

Water is one of the most significant bacterial habitations on earth(Baquero et al. 2008).Freshwater habitats harbour the richest bacterial diversity (Tamames et al. 2010). Antibiotic resistance is a serious concern in the present day world where an increasing number of bacteria has started exhibiting resistance to an array of antibiotics.Antibiotics, which are released and applied into water bodies and commercial aquaria lead to increase resistance of bacteria to antibiotics (Daughton, 1999). In most countries, the use of antibiotics in aquaculture needs Aveterinarian's prescription, thus, their use is therapeutic. However, the situation in Sri Lanka is different where antibiotics can be purchased over the counter. The aims of the present study were to 1) isolate and identify the bacteria inhabiting natural water bodies (NW) and commercial aquaria (CA); 2) to study the antibiotic susceptibility of bacteria in NW for some

selected antibiotics; 3) to compare it with that of the bacteria occurring in CA; 4) to investigate whether there is a difference in antibiotic resistance among bacteria isolated from different locations of natural water bodies.

#### Materials and methods

Twenty-one water samples were collected aseptically, during a period from October to November, from Sitinamaluwa reservoir (n = 3), Polonmaruwareservoir (n = 6) and two selected commercial aquaria(n=6 each), located in Tangalle, Sri Lanka. Samples were collected from the inlet and the outlet of the reservoirs and the surface and the bottom of the tanks, separately. Samples were subsequently cultured on nutrient agar, MacConkey agar and nutrient broth. Bacteria were identified by studying the colonial morphology, Gram-stained smears and biochemical tests. Enteric bacteria were differentiated using Hi25TM Enterobacteriaceae Identification Kit (Himedia, India). Kirby-Bauer technique was performed for each bacterial isolate, using amoxicillin (AMO), chloramphenicol (CHL) and oxytetracycline (OTC) disks (30  $\mu$ g/disk, Himedia, India), on Mueller-Hinton agar. The plates were incubated overnight at 37°C. Thediameter of zones of inhibition (ZI) were measured using a Venire Caliper. The ZI demonstrated by each bacterial isolate of NW, were statistically analyzed with that of CA using Generalized Linear Models (GENLIN) of SPSS version 19.0.



**Fig.1:** Themean ZI (diameter in mm) shown by bacterial isolates obtained from water samples of NW and CA against three types of antibiotics.

#### **Results and Discussion**

*Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumoniae* and *Serratia* sp were isolated in this study. Almost all bacteria isolates obtained from NW as well as CA were resistant to AMO while the susceptibility for CHL differed significantly (p < 0.05) between isolates of NW (29.74 ± 1.53 mm) and that of CA (13.47 ± 1.31 mm). Also a significant difference (p < 0.05) was observed between the bacterial isolates of NW (22.45 ± 0.71mm) and that of CA (9.22±0.66 mm), for OTC. The greater degree of resistance demonstrated by bacteria isolates of CA compared to that isolated by NW could be due to the indiscriminate use of antibiotics in commercial aquaria. Bacterial isolates of samples collected from the inlet (28.02 ±

1.13 mm) and the outlet  $(33.19 \pm 1.54 \text{ mm})$ of Polonmaruwa reservoir showed a significant difference (p>0.05) in their susceptibility to CHL. Moreover, a significant difference (p > 0.05) was observed between samples collected from the inlet  $(20.63 \pm 0.17 \text{ mm})$ and that of the outlet  $(23.57 \pm 1.45 \text{ mm})$ , in their susceptibility to OTC. The significantly higher ZI (p<0.05) shown by CHL and OTCfor the water samples collected from outlet of Polonmaruwa reservoir could be due to the higher bacterial contamination of inlet water due to anthropogenic activities leading to a greater transmission of antibiotic resistance to naturally occurring bacteria inhabiting water. The highest degree of resistance was evident against AMO, among all resistant isolates. Among the three antibiotics tested, the highest incidence of resistance was evident against AMO with zero ZI, while bacteria were less resistant for CHL than OTC.Schwartz *et al* (2003) has also shown the development of AMO-resistant strains of bacteria as a result of excessive use of AMO for longer period of time.

#### Conclusion

Pseudomonas aeruginosa, Bacillus subtilis, Klebsiella pneumoniae, anda Serratia sp. were isolated in this study. Almost all bacterial isolates were resistant to AMO while the isolates of CA were significantly (p <0.05) resistant for CHL and OTC, compared to that of NW. Furthermore, significant differences between the susceptibility to CHL and OTC were observed in isolates collected from the inlet and the outlet of Polonmaruwa reservoir.

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### A preliminary haematological study of Carassius auratus (Goldfish)

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#### Abstract

Haematology is the study of blood which is a valuable tool in disease diagnosis. However, local haematological studies in fish are scarce. The aim of this study were to 1) assess the haematocrit value (packed cell volume/PCV) of Carassius auratus (Goldfish) in order to derive a normal reference range for PCV of C. auratus, for tropical temperatures 2) to derive normal reference ranges for differential blood counts (WBC/DC) of C. auratus. Apparently healthy, mature C. auratus (n = 7) were purchased from a local aquarium and were acclimatized for two days at the University aquarium. Fish were then anaesthetized using NaHCO<sub>3</sub> (60g/L) and an incision was made on the caudo-lateral site immediately anterior to the caudal fin. Blood was allowed collect upto 3/4 of two capillary tubes and the bottom end of each tube was sealed with clay. Two blood smears were also made. Temperature and dissolved oxygen of tank water were also measured. Blood-filled capillary tubes were then centrifuged at 1300 rpm for 5 minutes, using a haematocrit centrifuge (Haematospin, UK). The PCV was then read by the microhaematocrit tube reader (UK). Blood smears were stained with Leishman stain and differential counts were made by microscopic examination. The PCV of C. auratus lied in the range of 43-62 % at a water temperature of 30-34 °C. Significant (p < 0.05) increases in PCV value was seen with the increase of water temperature. Normal reference ranges for the WBC/DC were also derived. Clumping of all white blood cells to one place was a common observation in all blood smears.

Keywords: Carassius auratus, haematocrit value, PCV, differential count

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#### Introduction

Haematology is the science of studying the anatomical and physiological aspects of bloodconcerned with the study, diagnosis, treatment and prevention of diseases related to the blood. The values depend on the fish species, age, the cycle of sexual maturity, health condition, seasonal changes and temperature (Vazquez *et al.* 2007; Houston and Cyr, 1974).

Haemogram evaluation involves the determination of the total erythrocyte count (RBC), total white blood cell count (WBC), haematocrit (PCV), hemoglobin concentration (Hb), erythrocyte indices (MCV, MCH, MCHC), WBC/DC and the evaluation of stained peripheral blood films (Vazquez *et al.* 2007).

Considering the status of haematological studies carried out in fish in Sri Lanka, there is a lack of research knowledge for ornamental fish hematology, and *C. auratus*, in particular. The aims of this presentstudy were to 1) assess the PCV of *C. auratus* in order to derive a normal

reference range for tropical temperatures 2) to derive normal reference ranges for differential blood counts (WBC/DC) of *C. auratus*.

#### Materials and methods

**Blood collection**: *C. auratus* were purchased from a local commercial supplier and were acclimatized for two days at the University aquarium. Fish were maintained in static glass aquaria at a density of approximately 20 l per fish in aerated water at  $32.29\pm1.7$  °C and dissolved oxygen  $6\pm1.41$  mg/l. Seven fish were weighed  $(38.19\pm3.94$  g)and body lengths were measured  $(7.73\pm0.52$  cm). Fish were fed once daily in the morning on commercial pellet. Careful netting and handling was implemented to minimize stress. Fish were anesthetized with sodium bicarbonate (60 g/l) prior to blood collection and an incision was made on a caudo-lateral site immediately anterior to the caudal fin. Blood was allowed to collect up to three-fourths of two separate, heparinized capillary tubes. The bottom end of each tube was sealed with clay. Blood samples were centrifuged at 1300 rpm for 5 minutes using a haematocrit centrifuge (Haematospin, UK). The PCV was then read by the micro-haematocrit tube reader (UK).

**Preparation and staining of blood smears:** Blood smears were prepared on clean, glass slides. Smears were stained with Leishman stain. A differential white blood cell count was performed using zig- zag method, under the light microscope.

#### **Results and discussion**

The haematological analysis revealed a mean PCV value of  $52.86 \pm 6.72$  %. The range of PCV values obtained lied between 43-62 %.

A regression relationship (p<0.05) was observed between PCV (%) values and water temperature (Fig.1). The regression equation for the relationship was PCV = 3.57 temperature + (-62.5).



**Fig.1:** The relationship between PCV (%) values and temperature (°C)

A significant increase in micro-haematocrit values was associated with the increase of water temperature. Previous studies demonstrate haematocrit values of 35 % at 20 °C and 45 % at 35 °C (Houston and Cyr, 1974). Five types of white blood cells, namely lymphocytes, monocytes, neutrophils, basophils, and eosinophils were distinguished and characterized. The differential white blood cell count is shown in Table 1.

	Slide	Side	Slide	Slide	Slide	Mean ± SD	Range	Sample
Lympocytes %	-	1	2	8	3	3.5 ± 3.11	1-8	5
Eosinophils %	15	7	11	12	4	9.8 ± 4.32	4-15	5
Monocytes %	3	2	8	9	6	5.6 ± 3.05	2-9	5
Basophils %	1	4	5	8	5	4.6 ± 2.51	1-8	5
Neutrophils %	2	1	-	2	3	$2.0\pm0.82$	1-3	5
Plasma cell%	-	15	85	28	32	40.0±30.9	15-85	5

Table 1. Mean white blood cell count with standard deviation

#### Conclusion

The PCV of *C. auratus* lied in the range of 43 - 62 % at a water temperature of  $30-34^{\circ}$ C. Significant (p < 0.05) increases in PCV value was seen with the increase of water temperature.Normalreference ranges for the WBC/DC were also derived.

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# Oceanography

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# Bioluminescent marine zooplankton along the east coast of Sri Lanka: Identification and spatial distribution

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#### Abstract

Bioluminescence is the production and emission of visible light by living organisms. Many organisms, including single cell bacteria to large vertebrates representing over 700 genera are known to produce light. Among these, zooplanktons are considered as one of the major bioluminescent organisms in the marine environment. The present study was carried out to identify the bioluminescent zooplankton species and their spatial distribution patterns off the east coast of Sri Lanka. Zooplankton samples were collected at 6 different sites from off Trincomalee to Batticoaloa area (81° 38'E and 82°02'E, 7°56'N and 8°00'N) in November 2015 on board R/V Samuddrika. Zooplankton samples were collected at night and preserved in 5% formalin for laboratory analysis and identified to the lowest possible taxon. Species richness and species abundance (ind.ml<sup>-1</sup>) at each sampling site were calculated. Five bioluminescent zooplankton species; Acrocalanus longicornis, Oncaea conifer, Corycaeus speciosus, Macrostella gracilis and Oikopleura dioica belonging to the two phyla were identified. O. conifer was the most abundant bioluminescent zooplankton species and it was reported at five sampling sites among six (average density of 4 ind.ml<sup>-1</sup>). The highest density of O. conifer was reported at sampling sites 2 and 4 (6 ind.ml<sup>-1</sup>) and the lowest at site 6 (2 ind.ml<sup>-1</sup>) close to near shore station. A. longicornis, and M.gracilis species were reported only at one sampling site with a density of 2 ind.ml<sup>-1</sup>.The highest species richness and Shannon-Winner diversity index were recorded at sampling site 2. Bioluminescence intensity (relative scale) of sampling sites ranged from 20.42±8.18 (site 3) to 35.17±38.78 (site 5). There were no significant differences in nutrients i.e. Nitrate, Phosphate and Silicate and sea surface temperature (P > 0.05, ANOVA) among sampling sites.

Keywords: Bioluminescence, zooplankton, species richness, diversity index

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#### Introduction

Bioluminescence is a rare phenomenon in terrestrial environment but it is ubiquitous in marine environment. It is a result of a chemical reaction which gives light as by product. It has been documented that approximately 1-3 % of biomass in the surface ocean belongs to bioluminescent taxa. These bioluminescent marine organisms range from small single cell bacteria to large vertebrates representing over 700 genera belonging to 16 phyla (Herring, 1987). The major groups of bioluminescent marine organisms include dinoflagellates, ostracods, copepods, euphausiids, radiolarians, cnidarians, ctenophores, cephalopods, decapod shrimps, chetognaths and fish. Among these, zooplanktons are considered as one of the major bioluminescent organisms in the marine environment (Moline *et al.* 2007). Although a handful

studies have been carried out to identify light producing zooplankton species and their spatial and temporal distribution in the Indian Ocean (Lapota *et al.* 1988), no such studies have been conducted in the coastal waters around Sri Lanka. This the first time such a study was carried out to identify the bioluminescent zooplankton species inhabiting the marine waters off the east coast of Sri Lanka and study their spatial distribution patterns.

#### **Materials and Methods**

A set of bio-optical and hydrophysical observations were conducted off the east coast of Sri Lanka from 9th to 11th November 2015 on board R/V Samuddrika to examine bioluminescent zooplankton species. Six different sites from offshore to near shore were sampled at night in the region encompassing 81° 38'E and 82 °02'E, 07° 56'N and 08° 00'N. Zooplankton samples were collected using 150µm plankton net by vertical towing. The collected zooplankton samples were preserved in 5% buffered formalin for later identification and enumeration. At the laboratory bioluminescent zooplanktons were identified to the lowest possible taxon using available keys (Razouls et al. 2016; White et al. 2003). Bioluminescent zooplankton abundance (ind.ml-1) at each sampling site was estimated by taking three sub samples and counting the number of each species using a Sedgwick-Rafter cell. Shannon-Winner diversity index, species richness and species evenness were also calculated with respect to each sampling site.

#### **Result and discussion**

Five bioluminescent zooplankton species; *Acrocalanus longicornis, Oncaea conifer, Corycaeus speciosus, Macrostella gracilis*, and *Oikopleura dioica* belonging to two phyla (Arthropoda and Chordata) were identified during this study (Table 1).

		Average						
Phylum	Species name	1	2	3	4	5	6	density (ind.ml <sup>-1</sup> )
Arthropoda	Acrocalanus longicornis		2					2
	Oncaea (Triconia) conifer	3	6		6	3	2	4
	Macrostella gracilis			2				2
	Corycaeus speciosus		1			2		1.5
Chordata	Oikopleura dioica		1	3			1	1.6

Table 1. Abundance (ind.ml-1) of bioluminescent zooplankton species at each sampling site
Location number	Species Richness	Shannon Winner Diversity Index	Simpson's Index of diversity	Species Evenness	Average Light intensity ±.SD
1	1	0	0	0	29.81±13.99
2	4	1.09	0.59	0.79	28.47±12.96
3	2	0.67	0.51	0.97	20.42±8.18
4	1	0	0	0	25.42±25.58
5	2	0.67	0.51	0.97	31.54±28.51
6	2	0.64	0.49	0.92	35.17±38.78

 Table 2. Variation in species richness, diversity indices, species evenness and average bioluminescence intensity (±SD) of each sampling site

Abundance of bioluminescent zooplankton species was calculated (ind.ml-1) and the *O. conifer* was found as the most abundant species. This species was recorded at five sampling sites out of the six sites with an average density of 4 ind.ml-1. A. longicornis and *M. gracilis* was recorded only at sampling site 1 and 5, respectively. The density of both species at each landing site was reported 2 ind.ml-1 (Table 1). Diversity indices (Shannon-Winner Diversity Index and Simpson's Index of diversity), species richness, species evenness and bioluminescence intensity of sampling site 2 and the bioluminescence intensity ranged from  $20.42\pm8.18$  to  $35.17\pm38.78$  (Table 2).

## Conclusion

Five bioluminescent zooplankton species are present off the east coast of Sri Lanka and their abundance found to vary spatially. However additional species are anticipated with further investigation with variation in bioluminescence intensity a possible indicator of organism spatial distribution and abundance. Further, research on intensity variation of bio-luminous organism would a good indictor to understand vertical distribution of the area.

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## Seasonal variation of sea surface salinity in the Northern Indian Ocean

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## Abstract

The study was focused on sea surface salinity (SSS) variation in the Northern Indian Ocean based satellite and in-situ data during 2010 to 2012. The main data sources were Soil Moisture and Ocean Salinity (SMOS) satellite data, Argo float data, and World Ocean Atlas (WOA) historical data. Two major SSS regimes could be observed in the Bay of Bengal and Arabian Sea. The variations of Northern Indian Ocean SSS are mainly linked with monsoon circulation. Reversals of the monsoon circulation, exchange the water masses between the Arabian Sea and the Bay of Bengal twice a year. The decrease of SSS can be clearly noticed in satellite data derived SSS maps rather than Argo SSS.SMOS satellite derived SSS has more spatial and temporal resolution compare to Argo data. There are significant changes in SSS between SMOS satellite and Argo data in western Arabian Sea .The possible reasons for an abrupt reduction of SSS in the eastern Arabian Sea may be due to the effect of Indian Ocean Dipole event (IOD) occurred during the study period. Whole data sets which were taken for this study shows strongly positive relationship though low strength is appeared in sub sets areas.

Keywords: Seasonal Reversals, Sea Surface Salinity, Northern Indian Ocean, Indian Ocean Dipole

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## Introduction

Salinity in the Northern Indian Ocean is mainly driven by precipitation, evaporation and fresh water influx from the Continental rivers. The Bay of Bengal (BoB) and the Arabian Sea (AS) are more important ocean environments in the northern Indian Ocean. The Bay of Bengal receives higher freshwater influx than the Arabian Sea. As there is a more difference in the evaporation and precipitations in these two basins, it makes hydrological imbalance between Arabian Sea and the BoB. However, seasonal reversals of circulation, the water masses in the basins are interchanged and maintain the salt amount. Salinity is considered as important index of the measurement of global climate system and Ocean salinity and temperature determine the density of the ocean water in the given pressure (Donguy & Meyers, 1996). Apart from the monsoon changes, the SSS in the western equatorial Indian Ocean and south eastern Indian Ocean can be changed significantly due to the Indian Ocean Dipole (IOD) events (Rana, 2008).

Understanding the importance of ocean salinity, researchers developed modern technologies for measuring salinity such as CTD profilers, Argo floats, sea gliders, surface drifters and satellites equipped with salinity sensors. The available in-situ measurements are vital to interpret the accurate SSS in the ocean. However, available in-situ SSS data have less spatial resolution and higher spatial and temporal resolutions can be obtained through satellite measurements.

The objectives of the research were to investigate seasonal changes of sea surface salinity in the northern Indian Ocean and also validate regional salinity products with historical data

## **Materials and Methods**

During the investigations, data were obtained in different sources such as satellite data from SMOS program, climatological data from WOA09 and *in-situ* real time data from Argo floats. Spatial and temporal variations of sea surface salinity in northern Indian Ocean were studied based on four (4) different spatial domains. Ocean Data View (ODV) and MATLAB software were used to present in-situ and satellite data graphically. Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) software.

## **Results and Discussion**

The Fig.1 shows high salinity water inflow to the BoB by summer monsoon current during May to July and conversely low-salinity water to the Arabian Sea due to winter monsoon current in November to February. The Fig. 2shows SSS is higher than 35psu in the Arabian Sea and less than 35 psu is in the BoB throughout the year. SSS increases in the AS from equator towards 20°N and reverse in the Bay of Bengal.

The Argo based study was focused during the period from 2010 to 2011. The data from total numbers of 600 to 900 were analyzed at the beginning of the year (January) and it has changed from 600 to 1000 during middle of the year (May).

The noticeable SSS discrepancies are observed between SMOS and Argo in different spatial and temporal components. The difference is ~0.39 psu considering the whole data set. The significant difference between Argo and SMOS, SSS is appeared closer to the continents. The results were supported by Yan and Youhong's observations in 2014. This difference mainly due to SMOS satellite suffers from land induced contamination, radio frequency interference(RFIs) and orbit orientation (Banks *et al.* 2012). Further, the Argo floats are mostly operated in the deeper waters and lack of Argo located close to the near shore.



Fig.1:Space-time diagram of the mean SSS from April 2010 to March 2011 along

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(a)74.1<sup>°</sup>E and (b)  $82.5^{°}E$ 



**Fig. 2:**The annual SSS maps in the North Indian Ocean from upper panel SMOS Satellite data, middle panel WOA data map and lower panel Argo data.

When smoothing of Argo objective interpolation in the regions where inadequate sampling the SSS salinity may not similar to the actual value. SMOS is showing less SSS than Argo in west of 70°E in April to June. It may be due to the satellite observed instantaneously changed surface salinity byfreshwater input from heavy rain during the summer monsoon period (2010-2014). However, Argos records the data at 5m below as the uppermost salinity sampling level. The 5m salinity is much higher than the surface salinity when there thin fresh water cap forms in the surface layer (Delcroix and McPhaden, 2002). That may be reason for the discrepancy observed between satellite and Argo data.

## Conclusion

Sea surface salinity in the Northern Indian Ocean has spatial and temporal variations. High salinity waters in the Arabian Sea and low salinity waters in the BoB exchange between each other with impact of the reversals of monsoon currents. With abrupt events like Indian Ocean Dipole may change the normal SSS distribution. Argo and SMOS satellite observations can be used to identify the SSS variations. Much finer SSS structures could be observed by SMOS satellite compared to Argo SSS. There are large difference between satellite and Argo SSS in the western Arabian Sea than the BoB. Near coastal regions, both SMOS and Argo SSS deviate from real due to external forces influence on satellite data.

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# Effort to understand sea level variability in the Indian Ocean using Empirical Mode Decomposition method

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#### Abstract

Measuring sea level Variability and understanding their cause has considerably improved in the recent

years With remote sensing observations have become available. As the impacts of sea level rise is potentially large for countries like ours, it's important to keep a track about the sea level rise around us. Here, we determine rates of sea-level rise from the selected tide gauge stations in the Indian Ocean. We also examine sea-level data from AVISO satellite altimeter over 1993-2015. We investigate the sea level variability and rise using Empirical Mode Decomposition (EMD). The sea level data are decomposed into intrinsic mode functions (IMFs) in an attempt to distinguish the trend over this period from the inter-annual variability. The analysis clearly indicates that thesea-level in this region is rising. Ourlongest tide-gauge records at Cochin (1939-2007) and Visakhapatnam (1956-1995) show the sea level rise about 1.445 mm yr<sup>-1</sup> and 1.067 mm yr<sup>-1</sup> respectively where AVISO altimeter data for Said Stations yielded sea level rise haSaccelerated into 2.248 mm yr<sup>-1</sup> and 3.218 mm yr<sup>-1</sup> over the period from 1993 to 2015 respectively. The observed variability from AVISO and tide-gauge data for most locations are similarexcept the record which is too short to estimate an integral time scale and the gauges which is affected by vertical land motion) Colombo and Cochin(.Our analysis found that the average sea-level rises in the regionwith the rate of about 2. 8mm yr<sup>-1</sup> during 1993- 2001 and started accelerating to a rate of 4. 8mm yr<sup>-1</sup> during 2001 to 2015 which is fully explained by thermal expansion.

Keywords: Sea level rise, tide gauge, EMD, AVISO

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#### Introduction

Sea levels are always changing, for many reasons. Recently, it is commonly accepted that global mean sea levels have increased steadily over the past century(IPCC, 2007). For decadal and longer time scales, global mean sea level change results from two major processes that alter the total volume of the ocean. Changes in the total heat content and salinity produce density (steric) changes. The exchange of water between the oceans and other reservoirs (glaciers, ice caps, and ice sheets, and other land water reservoirs)results in mass variations (Eric, 2009).Predicted pattern of sea level will vary slightly with weather conditions such as pressure and wind stress as well. Meantime extreme events such as Tsunamis, storms and El-Niño-southern oscillations have a huge impact on the sea level as well. Alongside with these

variations, mean sea level has begun to increase slightly since the mid 19th century. Rising rate has increased tremendously in the latter part of the 20th century and the projections suggest that sea level rise is likely to increase in the 21st century as well. As we are living on a tropical island, it is important to keep a track on sea level rise around our country. Main objective of this research is to estimate a first order estimate of regional-scale sea level rise towards effective measures to mitigate coastline erosion and iundation problems caused by extreme sea-level events for the inhabitants in the Indian Ocean during the 21<sup>st</sup> century.Several studies have been conducted using Fourier-based methods to investigate sea-level variability. However, due to the non-stationary and non-linear nature of sea-level data, these studies are of limited validity. To overcome these issues, the Empirical Mode Decomposition (EMD) method is developed to analyze non-stationary and non-linear time series to study regional sea-level change. This has been widely used in geophysical studies.

#### **Material and Methods**

Daily averaged observed sea levels from 10 stations in the Indian Ocean were obtained from the Hawaii University of Sea Level Observation Center (UHSLC) and Permanent Service for Mean Sea Level (PSMSL). To estimate sea level rise from 1993 to 2015, daily averaged AVISO satellite altimeter data was used. Monthly averaged sea surface temperature anomaly over the same period was compared with sea level anomaly. We investigate the sea level variability and rise using Empirical Mode Decomposition (EMD). The EMD procedure decomposes a time series y(t) into a number of intrinsic mode functions (IMFs) in the form of,

$$y(t) = ? {??? \atop ???} c_2(t) + r_2(t)$$
, which satisfy certain defining conditions.

Where rn(t) is the residual, which has at most one extremum representing the trend function of the time series and cj(t) is the jth IMF of the original time series, which are extracted through a sifting process (Wu *et al.* 2007). While EMD may decompose the inter-annual variability with different time scales into separated IMFs, we combine the IMFs with the time scales longer than the annual cycle and shorter than the last trend function together to yield the inter-annual variability IMF. The last two IMFs are the focus of this study.For details of the procedure, readers are referred to the original paper by Huang et al. (1998) or more recent applications (e.g., Huang and Wu, 2008).

## **Results and Discussion**

In this paper, we performed the analysis of the sea level change using the EMD method to derive the intrinsic trend of the sea level for both tide-gauge and AVISO sea level data. The observed variability from AVISO and tide-gauge data for many sites is similar as shown in the Fig. 2. Colombo tide-gauge data shows a sea level rise about 12.5 mm yr<sup>-1</sup> over the period from 1993 to 2015 while AVISO gives 1.86 mm yr<sup>-1</sup>. This Colombo tide-gauge value is much over estimated than the global mean sea level rise of IPCC. UHSLC suggest that these stations may

be significantly affected by vertical land motion or local subsidence. Since sea level is measured relative to a datum level, it should be kept intact throughout the measuring period. But, due to many reasons this level will vary as time goes on. So the measured values won't be the exact sea level. Fig. 1 shows the sea level rise estimated for daily average AVISO data over the period of 19



Fig.3:.Map of sea-level trends for AVISO data over the period from 1993 to 2015



**Fig. 4:** Time series of tide-gauge (red) and AVISO altimeter (black) sea level anomaly (mm)over the period from 1993 to 2015 for Indian Ocean sites.

The average rate of sea-level rise over this region (1993-2014) is 2.8 mm yr-1, which is close to the global average rate estimated by Church et al. (2004).

#### Conclusion

The intrinsic trend of the sea level derived by EMD exhibits an accelerated rising period during 1993–2015. This finding highlights the nonlinear and non stationary rising process of the Indian Ocean sea level implies that this intrinsic trend may also change again in the next decade, making he projection of the future sea level change a difficult challenge. The larger differences between the trends from individual tide gauges and the AVISO altimeter are at least partly the result of poorly known vertical land motions and the large inter-annual variability. Clearly sea level in the Indian Ocean is rising, and we expect the direct and indirect (e.g. increased frequency of extreme events) effects of this rise and the observed increase in the rate of rise will cause serious problems for the inhabitants of this region during the 21<sup>st</sup> century. The maximum rate is just over 4 mm yr–1 southwest of Sumatra in the eastern equatorial Indian Ocean.

Station (Tide gauge	From	То	(SLR) mm/year	Station (AVISO data)	(SLR)mm/ year (1993-	(SLR)mm/ year (2001-	
uata)					2014)	2014)	
Chittagong	1979	2000	8.154	Diego Garcia	2.978	4.300	
	2008	2013	3.174	Male	2.708	5.000	
Colombo	2006	2014	12.58	Colombo	1.861	3.600	
Gan	1992	2014	3.115	Gan	2.522	4.700	
Pt La Rue	1993	2014	5.217	Pt La Rue	2.425	6.300	
Sibolga	1987	2014	3.292	Sabang	2.979	4.600	
*Cochin	1939	2007	1.445	Cochin	2.248	4.000	
Coco's island	1993	2014	8.417				
*Visakhapatnam	1956	1995	1.067				
Coco's Island	4.27	9	4.100				
Visakhapatnam	3.218		6.900				

**Table 1.**Locations, time spans and sea-level trends for Indian Ocean for tide-gauge and AVISO

 altimeter for different time spans

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# Phytoplankton abundance in relation to nutrient dynamics during southwest monsoon, southern coast of Sri Lanka

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## Abstract

The southern coast of Sri Lanka is an important transitional passage between the Arabian sea and the Bay of Bengal. Therefore, it is important to asses the productivity of this region through the phytoplankton abundance and chlorophyll-a concentration in relation to the nutrient dynamics. The present study describes the temporal and spatial variations of phytoplankton density, nutrients and chlorophyll-a concentrations in southern coast of Sri Lanka during the southwest monsoon. The phytoplankton are the basis of the marine food webs as they are photosynthetic micro organisms and they require the enough nutrients such as nitrate, phosphate and silicate for their growth and production. Chlorophyll-a concentration is one of the good indicators of the phytoplankton biomass. Field sampling was carried out in Ranna, Matara and Galle for a three month period from August to October of 2015. The study reveals that the mean (Nitrite+Nitrate)-N. Phosphate-P and Silicate-Si concentrations were 0.099 0.083 mg l-1. 0.044 0.024 mg l-1 and 7.427 6.344 mg l-1 respectively. The mean chlorophyll-a concentration was 1.889 1.751 µg l-1. The phytoplankton density of the southern coast ranged from 163.65–315640.00 cells l-1. The total of 56 planktonic flora species were reported with 34 diatoms, 20 dinoflagellates, 1 cyanobacteria and 1 silicoflagellate. Diatoms were the most abundant taxonomic group and Chaetoceros sp. was the most common during the study. The phytoplankton density, nutrients and chlorophyll-a concentrations showed a significant temporal variation in the southern coast of Sri Lanka during the southwest monsoon though spatial variation was not significant. The southern coastal upwelling may enhance the phytoplankton abundance through increasing the nutrient concentrations of southern coastal water.

**Keywords:** Chlorophyll-*a*, Southwest monsoon, phytoplankton density, nutrient, Southern coastal upwelling,

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## Introduction

Phytoplankton are a group of single celled aquatic flora whose size ranges from 0.001 - 2 mm. The phytoplankton are the basis of the marine food webs as they are photosynthetic microorganisms and they require enough nutrients such as nitrate, phosphate and silicate for their growth and production. The main patterns of phytoplankton biomass in oceanic systems are related to light, water-column stratification, nutrient availability, and the intensity of the oceanic water mixing. The Chlorophyll-a concentration is one good indicator of primary production (Verlencar and Desai, 2004). Some oceanic areas experience vastly spread phytoplankton blooms as a response to highly favorable environmental conditions. Those planktonic blooms may have a positive or negative effect on the marine environment. In an oceanographic sense the southern coast of Sri Lanka is an important a transitional oceanic passage between Arabian sea and the Bay of Bengal. Coastal upwelling in the southern coast of Sri Lanka has been studied using ocean colour data, SST and sea surface height derived from various remote sensing methods during the south-west monsoon. However, there are few studies using field data. This study reports the phytoplankton abundance and chlorophyll-*a* concentration in relation to the nutrient variability.

## **Materials and Methods**

Field sampling was carried out at three sites namely Ranna, Matara and Galle off the Southern coast from August to October of 2015. For each site there were three sub sampling stations towards the open ocean at one nautical mile intervals. (Fig.1). A general conical plankton net with a mesh size of 20  $\mu$ m, was used to collect phytoplankton. Phytoplankton enumerations were done using Sedgwick rafter cell under SETI light Microscope. The phytoplankton were identified at either the genus or species level using plankton identification guides (Verlencar and Desai, 2004; Jayasiri, 2009). Surface water samples were collected at each station for nutrients (nitrate, phosphate and silicate) and chlorophyll-*a* analysis by the methods of Strickland and Parsons, 1965, using an Optizen 3220 UV spectrometer.



Fig. 1: Maps of the sampling locations (a) Galle, (b) Matara, (c) Ranna

## **Results and Discussion**

The study showed that the mean±SD (Nitrite+Nitrate)-N, Phosphate-P and Silicate-Si concentrations are 0.099 0.083 mg l-1, 0.044 0.024 mgl-1; and  $7.427\pm 6.344$  mgl-1 respectively off the southern coast of Sri Lanka during August to October. The mean chlorophyll-a concentration of the southern coastal surface water was 1.889 1.751 µgl-1 and the phytoplankton density of the Southern coast ranged from 163.65–315640.00 cells l-1.Two-way ANOVA reveals that the monthly variation of the (Nitrite + Nitrate)-N, Silicate and chlorophyll-a concentrations were significant between the studied months (P< 0.05) but that phosphate did not show a significant difference (Fig. 2).



Fig. 2: Temporal and spatial variations of nutrients and chlorophyll-a; Temporal (a) and spatial

(b) variations of phytoplankton density, different lowercase letters on bars represent the significant difference at p = 0.05

The spatial variation was not significant for all the parameters (P>0.05) off the southern coast of Sri Lanka during the southwest monsoon (Fig. 2). Here, very high values of nutrients, chlorophyll-a and phytoplankton densities of this study would be represented the high influx of

nutrients through the rivers or intensive upwelling phenomenon during the southwest monsoon period. Although the lack of significant spatial variation of those observed parameters give some evidences to realize the high influence of upwelling phenomenon rather than the river input for such increments of the parameters.

Several previous studies have shown that there is a wind induced upwelling phenomenon that occurs around the southern coast of Sri Lanka related to the southwest monsoon (Vinayachandran and Yamagata, 1997; Yapa, 2009). The total of 56 planktonic flora that was recorded comprised of 34 diatoms, 20 dinoflagellates, 1 species of cyanobacteria and 1 species of silicoflagellate. Diatoms formed the most dominant group followed by dinoflagellates, cyanobacteria and Chaetoceros and Talassiosira species compositions were relatively higher during the study period. In addition to that the *Melosirra* sp., *Coscinodiscus* sp., *Skeletonema* sp., *Biddhulphia* sp. and *Pseudo-nitzschia* sp. were comparatively abundant in Southern coastal waters. Dinoflagellates were not significant. There was a phytoplankton bloom condition with very higher abundance of cyanobacteria from Matara and Galle area during October. Further, there was no toxic algal blooms during the study.

## Conclusion

The present study describes significant temporal variations in phytoplankton density, nutrients and chlorophyll-aconcentrations off the southern coast of Sri Lanka during the Southwest monsoon though spatial variation was not significant. The southern coastal upwelling may enhance the phytoplankton abundance through increasing the nutrient concentrations of southern coastal water. Therefore, it is important to conduct further studies on southern coastal upwelling phenomenon with frequent and continuous sampling.

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# Assessment of zooplankton biomass in three commercial harbours of Sri Lanka

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## Abstract

The biomass of the net-zooplankton collected from three Sri-Lankan harbours namely; Galle, Hambanthota, and Trinomalee were investigated from October to November, 2015. Net zooplankton wet weight, dry-weight and ash free dry-weight were examined in order to obtain biomass. Sampling was done towing the zooplankton plankton-net (mesh size of 100  $\mu$ m) vertically from the known depth. One-way ANOVA revealed that the dry weight and ash free dry weight varied significantly among three harbours (P < 0.05). According to the post-hoc test, Trincomalee habour had significantly higher dry weight (0.115  $\pm$  0.032 mg/l) and ash- free dry weight (0.058  $\pm$  0.019 mg/l) than Hambanthota and Galle harbours. Pairwise Pearson's correlation revealed that the ash-free dry weight was significantly correlated with dry weight at p=0.01 and ash-free dry weight was significantly correlated with wet weight at p = 0.05. The highest net zooplankton biomass in the Trincomalee harbour could be due to the runoff of the Mahaweli River, which brings high amounts of nutrient into the sea.

Keywords: net-zooplankton, dry weight, ash-free dry weight, Sri Lanka, harbours

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## Introduction

Zooplankton play a critical role in the marine ecosystem, serving as a link between primary producers and higher trophic levels such as fish. Although zooplankton have a wide range of body sizes, from several µm (e.g. protozoans) to more than 10 cm (e.g. cnidarians), for practical reasons such as sampling, they are often classified into two major groups namely, micro zooplankton and net-zooplankton. The latter can be retained in regular plankton nets (mesh size:  $100-200 \mu m$ ) and the former pass through such mesh sizes and can be collected with water samplers. Micro zooplankton consist of protozoans and small metazoans, while net zooplankton consist entirely of metazoans, such as crustaceans, chaetognaths, larvaceans, cnidarians, larvae of various benthic taxa, etc. It has been identified that net-zooplankton, particularly copepods, are the major consumers of phytoplankton in the sea. Due to constraints in estimation of productivity, there is lack of understanding the role of consumers in the marine ecosystem. A number of techniques such as measurements of settled volume, displacement volume, wet weight, dry weight, ash-free dry weight, Carbon content weight are applied to determine the net-plankton biomass (Omori and Ikeda, 1984). Ash-free dry weight and Carbon content are believed to provide more accurate estimation of zooplankton biomass. Specifically, expression by elemental units such as Carbon or Nitrogen is ideal for study of ecological energetics, whereas dry weight has been often adopted to determine the net-plankton biomass due to its simple procedure. However, in Sri-Lanka, data is lacking on the zooplankton biomass and

secondary productivity in major harbours and how the energy flux goes to higher trophic levels. Therefore, it is important to understand the higher level energy needs and energy functioning of these harbors.

## **Materials and Methods**

Plankton samples were collected from three main Sri Lankan harbours namely; , Galle, Hambanthota and Trincomalee. A total of 30 net-zooplankton samples were collected at 10 sampling stations from each of the three harbours from October to November, 2015, using vertical tows of a 100 µm mesh sized ring net with 40cm opening diameter. Plankton samples were immediately preserved in 5% formalin for laboratory analysis.

Samples were filtered through GF/C filter papers and put in a desiccator and wet weight was taken. Samples were weighed using a microbalance (SARTORIUS model MC 5) and dried at  $60^{\circ}$ C for 48 hrs in an oven dryer. Then, dry weights were measured using the same microbalance and combusted at  $500^{\circ}$ C for 4hrs in a Muffle furnace to determine the weight of the ash. The ash free dry weight was calculated by subtracting the ash weight from the dry weight.

## **Results and Discussion**

Three biomass indices were estimated and one-way ANOVA revealed that the dry weight and ash free dry weights varied significantly among three harbours (P<0.05). According to the posthoc test, Trincomalee habour had the significantly higher dry weight ( $0.115\pm0.032$  mg/l) and ash- free dry weight ( $0.058\pm0.019$  mg/l)than Hambanthota and Galle harbours (Fig. 1). Pairwise Pearson's correlation reveals that the ash-free dry weight was significantly correlated with dry weight at p=0.01 and ash-free dry weight was significantly correlated with wet weight at p=0.05 (Table 1).



**Fig.1:** Mean wet weight. dry weight ( $\pm$ SE), and ash-free dry weight ( $\pm$ SE) of zooplankton in Galle, Hambanthota and Trincomalee harbours (n=10); Different lowercase letters on bars represent the significant difference for dry weight and different uppercase letters on bars represent the significant difference for ash-free dry weight at p=0.05.

Organic contents, within the dry weight depends on the composition of the zooplankton community. Ash contents of zooplankton is highly variable among non-gelatinous zooplankton such as crustaceans (2-37%)(Omori, 1969) and gelatinous zooplankton such as jellyfishes (60–73%)(Clarke *et al.*, 1992) or terrestrial inorganic sediment. The highest average zooplankton biomass could be seen in the Trincomlee harbor, which means that its secondary production is at a higher level. All zooplankton samples were collected from shallow regions close to the coast. The highest biomass in the Trincomalee harbor could be expected since the harbor is situated at a close vicinity to the Mahawali River mouth. Because of that, the harbour waters may contain higher enrichments of inorganic nutrients, which may influence the high primary production in turn zooplankton biomass (Benovic *et al.* 1984). Any of the other harbors does not have that feature. However, this assessment provides only the base line data on biomass indices of net zooplankton.

**Table 1.** Pair-wise Pearson's correlation of wet weight, dry weights and ash-free dry weight of zooplankton in Galle Hambanthota and Trincomalee harbours (n=30).

Data pair	<b>Correlation coefficient</b>	p-value
Dry weight x wet weight	0.32	0.086
Ash-free dry weight x wet weight	0.42*	0.002
Ash-free dry weight xdry weight	0.94**	0.000

\*Significant at p=0.05; \*\*Significant at p=0.01

## Conclusion

This study provides the baseline information on zooplankton biomass using three different indices in three commercial habours. Of the three harbours, Trincomalee habour had higher zooplankton production compared to the other two habours.

## Acknowledgements

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# Spatial and temporal variation in water quality and current status of the sediment assemblage in the Puttalam Lagoon, Sri Lanka.

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## Abstract

Selected physiochemical parameters and sediment distribution in the Puttalam lagoon were studied during this research. The objective was to assess the present status of the water quality and the sediment assemblage of the selected ecosystem. Data collection was conducted in 16 sampling points from May, 2015 to December, 2015. In-situ measurements and laboratory analysis were conducted in accordance with standard methods. Results indicates that the average value for Temperature, Salinity, Dissolved Oxygen (DO), Nitrate, Total Suspended Solids (TSS) and Phosphate as 28.45 °C, 23.99 psu, 6.75 mg/L, 0.96 mg/L, 43.12 mg/L and 0.13 mg/L respectively. According to the results of this study it is concluded that the salinity of the lagoon has decreased and it has become a 'Positive lagoon', which had also been classified as an 'Inverse lagoon' by earlier studies. The mean grain size of the sediments ranges from 1.75 to 8.33 on the phi scale. Considering the selected sampling points, eight locations of the estuary are composed of 'silt' while one location is composed of 'Clay'.

Keywords: water quality, salinity, sediment distribution

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## Introduction

Puttalam lagoon is the second largest lagoon in the country and one of the most productive coastal eco-systems in the Northwest coast of Sri Lanka (Pathirana et al. 2008; Miththapala, 2013). The Puttalam lagoon receives fresh water from two rivers, namely Kala Oya and Mee Oya (Pathirana et al. 2008; Azmy, et al. 2012). Shrimp farms located outside the lagoon border discharge polluting effluents, rich in both nutrients and sediments, into the environment (Miththapala, 2013). Wide variation in 'salinity' has been observed from 34psu to 55 psu (IUCN Sri Lanka and CEA, 2006). Thus it has been classified as 'Inverse Lagoon' based on the water balance (Miththapala, 2013). Further, Miththapala (2013) states that the 'salinity gradient was opposite to that of positive lagoon, so the water density gradient increases landwards'. Sediment characteristics such as grain size in the estuary tend to be modified with time by many anthropogenic activities such as agricultural land use and industrialization. Furthermore, the particle size and morphology of sediments are the major tools to interpret the source or provenance of sediments, transportation modes and depositional environments (Pettijohn, 1984). The combination of measuring the spatial and temporal variation of some important physiochemical parameters as well as the sediment distribution pattern may provide a good indication on the current status of the ecosystem as well as baseline data for new aquaculture practices. The objective of this study was to assess the present status of the water quality and the sediment assemblage of the selected ecosystem.

### **Materials and Methods**

**Site selection:** 16 sites were selected to represent the entire lagoon as well as to compare with the findings of previous studies in order to understand the present trends of the physio-chemical parameters and sediment composition.

Sample analysis: Field samplings were conducted from May, 2015 to December, 2015 on monthly basis. The following physico-chemical parameters were selected for this study to ascertain the quality of water and to ascertain changes and effects. In-situ analyze were conducted for the determination of Salinity, Temperature, DO and Conductivity using the YSI 556 environmental meter. Water samples were collected and kept in the ice (at 4 °C) until transport to the laboratory for analysis. In the laboratory, the concentrations of NO<sub>2</sub>-N, NO<sub>3</sub>-N, PO<sub>4</sub>-P and Total Suspended Solids (TSS) were determined in each sample in accordance with the United States Environmental Protection Agency (EPA) protocols. The collected sediment samples were analyzed to study the sedimentological status of the Puttalam Estuary. They were pretreated to remove organic matter and the calcareous materials with fresh hydrogen peroxide (30% H<sub>2</sub>O<sub>2</sub>) and diluted HCl accordingly. Visual observations were recorded and used to categorize samples in to one of two categories for sieve and pipette analysis. Fine grain samples were prepared for pipette analysis while the rest were prepared for sieve analysis. The results were used to calculate mean grain size and sorting according to formulas defined by Folk and Ward (1957). The 'Kringing' technique of the Arc GIS 9 software was used to prepare the distribution maps of selected parameters.

#### **Results and Discussion**

The results are from the studied physiochemical parameters and sediment characteristics in the selected sixteen sites in the Puttalam lagoon. Considering the salinity distribution of this ecosystem, a salinity gradient which increased toward the sea was identified (Fig. 1). This could be a result of fresh water input exceeding evaporation and hence providing a net outflow to the ocean. A comparative summary of the physio-chemical results is given in the Table 1.

Considering the sediment analysis of the study, the majority of the collected samples were composed of a high silt percentage while the rest contain fine to coarse sand particles and clay (Table 2). Different morphologies of grain were visually observed such as; angular grained, sub angular grained and round grained particles. Some samples carry shell fragments excessively. The mean grain size of the samples varies from 3 - 8 on the phi scale except two locations i.e. 01 and 03. High phi size indicates that the 83% of them are in fine sand to silt range. These results reveal that the sediment in the Puttalam lagoon are well sorted and poorly graded as the samples show small variation of the grain size within the sample i.e sorting varies from 0.35 to 1 in phi scale.



Fig.1: Seasonal and spatial variation in salinity distribution.

Table 1.	Comparative s	summary c	of physioch	emical parameters
	1	2	1 2	1

Parameter	Jayasiri, et al., 2008		Azmy, et al., 2012			Current study (2015)			
	max	min	mean	max	min	mean	max	min	mean
Temperature(°C)	37.49	19.12	28.72	30.0	27.3	28.5	32.99	18.59	28.45
Salinity (psu)	58.48	27.39	49.93	50.0	37.0	30.0	35.44	11.13	23.99
DO (mg/L)	9.57	5.48	8.61	7.82	5.40	6.76	7.73	5.72	6.75
Nitrate (mg/L)	2.72	0.01	0.34	6.84	0.08	1.95	6.69	0.001	0.96
Phosphate (mg/L) ((mg/L)	1.62	0.00	0.29	1.44	0.43	0.87	1.17	0.004	0.13
(mg/L) (mg/L) <u>TSS (mg/L)</u>	-	=	:	<u>66.00</u>	<u>3.60</u>	<u>31.71</u>	<u>130.00</u>	<u>11.60</u>	<u>43.12</u>

Location	Mean Grain size	Sorting		
1	1.88	0.82		
3	1.76	0.86		
4	5.80	1.77		
5	7.11	-1.25		
6	4.98	2.95		
8	8.33	0.46		
10	5.45	0.54		
11	3.06	0.48		
13	6.92	0.32		
14	5.75	0.43		
12	5.46	0.58		
15	5.34	0.43		

 Table 2. Statistical parameters of sediments in study area

## Conclusion

According to the results, the Puttalam lagoon can be classified as 'Positive lagoon' based on the water balance as the salinity thus the density gradient increases seawards. When comparing the salinity results of this study with those of previous works (of which Jayasiri, *et al.* 2008 had used the same sampling points), it can be concluded that the lagoon has become less saline than in 2008 and 2012. This may be attributed to the alteration of freshwater input via Kala Oya and Mee Oya.

Considering the DO and concentration of other nutrients, it is evident that the concentrations of DO have been reduced compared to those in 2008. Further, mean concentrations of nitrate are also higher than those in 2008 and the TSS levels are also higher than that in 2012, which are evidence of increased levels of pollution. This may be attributed to the increase in number of shrimp farms around the estuary. The locations outside the estuary shows larger particle sizes than the other locations as coarser grains remain while the finer ones are transported in to the lagoon with the currents. However, the relationship between the mean grain size, grain morphology and the currents should be studied further to confirm. This spatial and temporal findings could be used not only for assessing the current status of the eco system but also to demarcating sites for proposed aquaculture practices by comparing the tolerance ranges and other ecological data for these parameters of the desired species.

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## Investigation of phytoplankton diversity and abundance in relation to chemical parameters, off Colombo

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### Abstract

Present study was conducted to investigate the diversity, abundance and composition of planktonic flora in relation to some physicochemical parameters from 15 September to 30 October 2015in the sea, off Colombo. The phytoplankton samples using a plankton net (10  $\mu$ m mesh size) and water samples using Ruttner sampler were collected for analysis of phytoplankton and physicochemical parameters. The diversity indices and the bivariate correlations were used to investigate the phytoplankton community structure and its relation to physicochemical parameters of the area. The phytoplankton abundance significantly varied among the four stations at p=0.05 with a significantly higher abundance (7026 ± 3136cells/l) was reported at the Station near the Colombo harbor. Three major phytoplankton groups were documented; centric diatom (88%), pennate diatom (5.5%) and dinoflagellate (6.5%) comprised of forty-one species under nineteen family. The Shannon-Weiner diversity index was estimated and ranged from 1.6 to 2.7 and the evenness ranged from 0.46 to 0.75 in the study area. Though there was no significant difference of total suspended solids (TSS) and turbidity among study sites nitrate, phosphate, silicate and chlorophyll-*a* varied significantly among the stations (p<0.05). The present study provides the information on spatial variation of planktonic flora during the 2<sup>nd</sup> inter-monsoon, off west coast of Sri Lanka.

Keywords: phytoplankton, diversity, physicochemical parameters, Colombo

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#### Introduction

Phytoplankton represent base of the marine food chain and contribute to the total global primary production, producing organic material via photosynthesis through use of nutrients such as nitrate and phosphate. Interactions within plankton community are complex, in very generally phototrophic phytoplankton biomass is controlled basically by physicochemical conditions. Phytoplankton are suitable indicators to evaluate the quality of aquatic environment. Most of the commercially important places such as Colombo harbour, Dikowita fishery harbor, proposed Port City, petroleum exchange facility and other industries are located within the coastal area of Colombo. Further, the study area is important ecologically and socio-economically due to the local fishery. Kelani River, Beira Lake and waste water outlet of Colombo municipality drain into the coastal area off Colombo. The objective of this study was to gather baseline information about the phytoplankton assemblages in this coastal area where there may be a significant impact due to the development projects.

## **Materials and Methods**

The study area consist of 26 sub stations consist of 4 regions (A, B,C and D, Fig. 01).A, B and C regions are located near the area selected for exploration of sand to reclaim the port city. And the D region is located near the proposed Colombo port city and Colombo harbor. Surface water samples were collected by a Ruttner sampler during September and October 2015to measure thephysico-chemical parameters such as turbidity, total suspended solids and nutrients (nitrate, phosphate and silicate), also water samples were collected for chlorophyll-*a* analysis. Nutrients and chlorophyll-*a* were measured using UV-Spectrophotometer (Optizen 3220 UV).

For the qualitative and quantitative analysis of the phytoplankton, samples were collected using a plankton net with 10  $\mu$ m mesh size and preserved with Lugol's iodine solution. Identification was done by using manual of plankton (Jayasiri, 2009).The diversity indices of Shannon-Weiner index and the Evenness, Dominance were estimated. Pairwise correlation was performed among physico-chemical parameters and phytoplankton cell density.



Fig.1: Geographical map of the study area

#### **Results and Discussion**

A total of forty-one phytoplankton species belongings to nineteen families were recorded under three taxonomic groups which are centric diatoms, pennate diatoms and dinoflagellates. Twenty-one centric diatom species under nine families, seven pennate diatom species belongings to four families and thirteen dinoflagellates belongings to six families were recorded. The relative compositions of phytoplankton are given in Fig. 2.





Most abundant phytoplankton species in this study area were, *Skleletonemasp., Thalasiosirasp., Melosirasp, Coscinodiscu spp(Coscinodiscus radiates, Coscinodiscus granii, Coscinodiscuscoscinus), Rhizosolenia sp., Guinardiastriata, Chaetoceros pseudocurvisetus, Biddulphia,Pseudo-nitzschiasp,Ceratiumfurca,Protoperidiniumsp* and *Asterionellopsisglacialis.* 

In comparison with the physicochemical parameters of the area with Australian water quality standards(Anon, 2000) for natural coastal waters, the coastal area off Colombo is not exceeding the most of the guideline values except chlorophyll-a. Though the Kelani River discharges a

vast amount of water to the area only the turbidity and nitrite showed high concentrations around the river mouth and that may not enough for the algal blooms to be formed. The high turbidity suggests low light which would tend to limit phytoplankton growth.

## Conclusion

This study provides the spatial variation of phytoplankton community structure in off Colombo. The information may be useful in the future for studying the impact of development activities in the coastal area off Colombo.

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# Biomass Indices of zooplankton off Southern and North-eastern coasts of Sri Lanka

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## Abstract

The secondary production was evaluated using different biomass indices of zooplankton off the southern and north-eastern coasts of Sri Lanka. Two research cruises were conducted, one in April 2015 off the Southern coast and the other in September 2015 off the north-eastern coast for sampling of zooplankton. One-way ANOVA revealed that the zooplankton abundance, ash-free dry weight and bio-volume were significantly higher in north-eastern area than the southern area at p = 0.05. The sub area II had significantly higher biomass indices than that of other three sub areas. It is speculated that the nutrients availability into that area II might be higher than that of other three areas due to the influx from River Mahaweli which favor high secondary production. The abundance, ash-free dry weight and bio-volume of the north-eastern areas were  $10 \pm 6$  cells/l,  $24.16 \pm 3.55$  mg/l and  $0.98 \pm 0.19$  mm<sup>3</sup>/l respectively. Similarly, one-way ANOVA was performed for the southern coast study area and found that the zooplankton abundance, biovolume and ash-free dry weight varied significantly among sub areas I, II, III and IV at p= 0.05. The sub area III had significantly higher abundance, bio-volume and ash-free dry weight than that of other areas. As station III is located in off Mirissa Bay the available nutrients into that area may be higher than those of other sub areas. Therefore higher secondary production can be expected from area III. Through measurements of various estimating biomass indices of zooplankton we provide evidence that the secondary production in off north-eastern coastal area was higher than that off the southern coastal area.

Keywords: abundance, bio-volume, biomass, Sri Lanka, zooplankton

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### Introduction

Phytoplankton synthesize its own food, as they are primary producers and get grazed by zooplankton which are consumed by higher trophic levels. Zooplanktons play a major role in nutrient recycling and transferring the organic matters from primary producers to secondary consumers. In addition, zooplankton biomass can be taken as an index of the fertility of an area. To determine the net-plankton biomass, a number of techniques such as measurements of settled volume, displacement volume, wet weight, dry weight, ash-free dry weight, carbon content have been applied (Nagao *et al.* 2001). Dry weight, ash-free dry weight and carbon are believed to provide more accurate estimation of zooplankton biomass. Bio-volume is the amount of space a species takes up in a given area or volume and provides a link for determining biomass. It can be used to estimate biomass and can also be more useful than density, because bio-volume is an estimate of mass while density is a measure of abundance. Therefore bio-volume provides information on biomass and energetics whereas density

provides only information on abundance. If there is a change in abundance, there are a variety of abiotic and biotic factors that potentially could be responsible for it.

## Materials and methods

This study was focused to assess the diversity, abundance, distribution, and biomass of marine zooplankton in two study areas. The sites were selected based on abundance of marine mammals such as whales and dolphins (de Vos, 2009). The two study sites are off north-eastern coast and off southern coast of Sri Lanka. Two research cruises were conducted; the first off the southern coast during 22 - 23 April 2015 and the second during 24-28 September 2015 off North-Eastern coast of Sri Lanka to collect zooplankton samples. The sampling was carried out with a zooplankton net of 80 µm mesh size. The sampling stations were grouped into two areas (North-Eastern coast and Southern coast). The study areas off southern and north-eastern areas were subdivided into four areas (I, II, III, and IV) (Fig. 1). Samples were analyzed for zooplankton abundance, composition and diversity. Zooplankton biomass was determined in terms of dry weight, ash-free dry weight and bio-volume. Zooplankton bio volume was calculated using geometric shapes.

## **Results and discussion**

The present study showed that the zooplankton abundance, ash-free dry weight and bio-volume were significantly higher in North-Eastern area than that of southern area. The mean bio-volume of southern and north-eastern coasts were  $0.226 \pm 0.0330 \text{ mm}^3/1$  and  $0.983\pm0.196 \text{ mm}^3/1$  respectively.



Fig. 1:Map of the study area showing sampling stations

The mean  $\pm$  SE ash-free dry weights of southern and north-eastern coasts were 2.41  $\pm$  0.50 mg/l and 24.158  $\pm$  3.55 mg/l respectively. The north-eastern coast gets influx from the Mahaweli

Rivera and the Mirissa bay in southern coast gets influx from the Polathumodara River. The nutrient supply may be higher in Mahaweli River than Polathumodara River. The nutrient available for growth of phytoplankton may be higher in north-eastern coast than that of southern coast hence leading to higher zooplankton biomass. Zooplankton composition analysis showed that the copepods are the most abundant zooplankton in both study areas which are food source for organisms in higher trophic level.



**Fig.2:**Mean ( $\pm$ SE) ash-free dry weight, bio-volume and abundance a) off southern coast (n = 4), b) North-eastern coast; Uppercase, lowercase and lowercase italic letters on bars represent the significant difference for ash-free dry weight, bio-volume and abundance at p=0.05.

One-way ANOVA was performed for the southern coast study area and found that the zooplankton abundance, biov-olume and ash-free dry weight varied significantly among sub areas I,II, III and IV at p=0.05 (Fig. 2). The sub area III had significantly higher abundance,

bio-volume and ash-free dry weight than that of areas I, II and IV. The maximum mean abundance was recorded at sub area III (7.6±1.5 cells/l) while the minimum mean abundance was in area I (1.7±0.5 cells/l). The maximum mean bio-volume of 0.386±0.037 mm3/l was recorded at sub area III while the minimum mean bio-volume was in sub area IV (0.126±0.021 mm3/l) (Fig. 2). As station III is located off Mirissa Bay, the available nutrients in this area may be higher than that of other stations. Therefore high secondary production can be expected from area III. One-way ANOVA was performed for the eastern coast and found that the zooplankton abundance, biovolume and ash-free dry weight also significantly varied among the four stations. The sub area II had significantly higher abundance, bio-volume and ash-free dry weight than that of other three sub areas. The maximum and minimum mean bio-volumes were recorded at sub area II (2.167±0.541 mm3/l) and IV (0.577±0.089 mm3/l) respectively. The maximum and minimum mean ash-free dry weight was recorded at sub area II (46.7±3.9 mg/l) and IV (11.567±3.34 mg/l) respectively (Fig. 3). The area II is situated in off Trincomalee harbor. Therefore, the available nutrients into that area might be higher than that of other three areas due to the influx from River Mahaweli As the available nutrients is high, the abundance of zooplankton may be higher in that area II than that of others.

## Conclusion

Through measurement of various biomass indices of zooplankton we provide evidence that the secondary production off the north-eastern coastal area is greater than off the southern coast and this high secondary production which may favor the trophic transfer of organic matter through the food chain. The information on plankton productivity off the southern and north-eastern coasts may correlate with marine mammal sitting or abundance. Further, the North-Eastern coast is more favorable for capture fishery industry and whales watching.

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# Evolution of coastal sea surface salinity in Trincomalee and Dondra evaluated using sea water samples collected by local fishermen between 2013-2015.

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## Abstract

East Indian Coastal Current (EICC) is a seasonal western boundary current, which flows along the east coast of Indian subcontinent. EICC carries freshwater, discharged at northern Bay of Bengal to Arabian Sea. NARA initiated a weekly sea water sample collection program at Trincomalee (TR) and Dondra (DO) in November 2013. Two local people were trained to collect sea water samples at a knee depth and samples were analyzed using Autosal. This program is an extension of sea water sample collection being conducted at eight locations by CSIR-NIO, India, since 2006.

Winter freshening of coastal waters, an indication of EICC set on, is observed at the beginning of October and Mid September at TR and DO respectively. In all three years, peak freshening is recorded in November. However, freshening at TR in November 2014 is dramatic, salinity has decreased from its averaged salinity of 32.1 to 17.9 PSU. Such a strong freshening is not recorded neither in November 2013 nor in 2015. Quality controlled data by Tukey fences method yielded the salinity decrease at TR in November 2014 as 26.1 PSU. Nagapattinam too reported a similar drop in salinity but a with phase lag of two weeks. However, Rameshwaram and Colachal did not record such a strong salinity drop. The salinity had decrease from 32.79 to 29.08 PSU, at DO, the salinity drop is weaker than that of TR, indicating mixing of EICC with the high saline water masses.

This study concludes, that during the winter, EICC flows along the Indian sub continent and continue along the southern coast of Sri Lanka. It further revels that the EICC does not branch out to flow via the Palk Strait into Gulf of Mannar. Thus, it is recommended to establish monitoring locations at north and north-west coasts of Sri Lanka

Keywords: East Indian coastal current, salinity.

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## Introduction

Sri Lanka is located at the Northern Indian Ocean (IO), between two semi-enclosed water bodies, the Bay of Bengal (BoB) and Arabian Sea (AS). IO is exposed to semiannual wind reversals called as monsoons. During May to September strong southwesterly winds (Southwest Monsoon/SWM) blows across the IO and during November to March, dry northeasterly winds blows (Northeast Monsoon/(NEM). During NEM, East Indian Coastal Current (EICC), which carries accumulated freshwater in the Northern BoB, flows along the east of Indian and Sri Lanka turns at the southern end of Sri Lanka to enter into AS, making its peak speed in November (Schott and McCreary, 2001). EICC is a western boundary current which participate to water mass transport between AS and BoB (Durand *et.al.* 2007). The EICC, fresh water tongue causes seasonal fluctuations of Sea Surface Salinity (SSS) along its passage. So, by

enumerating the SSS, along the coast of India and Sri Lanka, the seasonal flow pattern of the EICC shall be traced. Besides, another important question seeks an answer is whether the EICC bifurcates at Pedro Bank, at the junction between India and Sri Lanka to flow into Gulf of Mannar via Palk Strait.

Council of Scientific and Industrial Research's National Institute of Oceanography (CSIR-NIO, Goa) India commenced a novel in situ coastal SSS observation in 2006 to study the evolution of salinity along the coast. Eight locations along the east and south Indian coast; Paradeep, Visakhapatnam, Perupalem, Chennai, Nagapattinam, Rameshwaram, Tiruchandur, and Colachal, were weekly occupied repeatedly. Local fishermen collected water sample at a depth of knee, the sample were analyzed used laboratory AutoSal.

National Aquatic Resources Research and Development Agency (NARA) has commenced similar program in November 2013 at Trincomalee (TR) and Dondra (DO), added another location in January 2014 at Induruwa, which is later shifted to Beruwala. The discussion of this paper is limited to the time series data of first two locations.

## **Materials and Methods**

Fisherman at the respective coastal village collected a sea water sample per a week in a 100 mL plastic bottle at a depth of knee from TR and DO and stored at a shadow place. Water samples were not collected on the day of rain to avoid contamination of sea water. Sample collection at an additional location is commenced at Induruwa, but later the location was shifted to Beruwala, where the samples were collected by the NARA staff at the Ocean Observation Center, Beruwala.

Samples were analyzed using AutoSal (Guildline 8400B) at NARA, Sri Lanka and NIO, India laboratory. AutoSal gives the Conductivity ratio (Conductivity of the sample/ Conductivity of standard sea water) readings from the AutoSal were converted in to salinity values by a MATLAB computer program.

Time series data are quality controlled by Tukey Fences method (Tukey, 1977) to remove outlier data. Both raw and QC data analyzed using a MATLAB program. Five day mean ocean surface current data are obtained by the Ocean Surface Current Analyses-Real time (OSCAR, available at http://www.oscar.noaa.gov/datadisplay/) and the three hourly rain data are obtained from Tropical Rainfall Monitoring Mission up to January 2015, because the service was terminated then after due to collapse of the mission. (TRMM available at http://giovanni.sci.gsfc.nasa.gov/giovanni/). Wind data at 10 m level for the total period were downloaded by European Center for Median Range Weather Forecast (ECMRWF available at http://apps.ecmwf.int/datasets/data/). All these data are processed and averaged for the time collocation.

#### **Results and Discussion**

During the period from November 2013 to November 2015, total of 144 coastal SSS data are collected at TR. The minimum and maximum salinity value are 17.97 and 34.76 PSU, recorded in November 2014 and August 2015, respectively (Fig. 1). The three year average salinity at TR is 32.07 PSU.

SSS data reveals freshening of coastal waters in November at TR, the freshening is observed in all three years; 2013, 2014 and 2015. The average salinity for November was 28.14 PSU. Nagapattinam, which lies further north of TR also recorded similar freshening event, an average salinity of 23 PSU, however, the freshening at Nagapattinam preceded by more than a month. It clearly reveals that the freshening is associated with EICC, which originates at the northern Bay of Bengal, flows southward along the east coast of Indian subcontinent to reach Nagapattinam and TR in September and November respectively.

A very strong freshening of coastal water up to 17.97 psu is recorded in November 2014, quality control of data to remove local effects, normalized the minimum SSS value at 26.1 PSU, almost similar to the magnitude of freshening as of 2013 and 2015. The OSCAR data reveals that during the month of November 2014, ocean surface currents were directed southward, which nullify the possibility of Mahaweli River water reaching the sampling site, which lies north of the river mouth. Thus, the surface runoff could be the reason for the strong freshening recoded during November 2014 at TR.



Fig.1: Coastal sea surface salinity evolution with time in Trincomalee and Dondra.



**Fig. 2:** Sampling locations of Sri Lanka and their adjacent location in India. Proposed two sites are indicated (Kankasanthurei and Kalpitiya).

However, SSS data at Rameshwaram does not show strong freshening in November as of TR and Nagapattinam. The average salinity for the November is 31.42 PSU at Rameshwaram, which lies within the Palk Strait. It indicates that EICC, which flows along the east coast of India and Sri Lanka does not bifurcate at Pedro Bank to flow into Gulf of Mannar via Palk Strait.

In DO, during the period from November 2013 to November 2015, total of 115 salinity observation are recorded, the two year average salinity is 32.79 psu. Minimum and maximum salinity values of 29.08 and 35.20 PSU are recorded in January 2015 and October 2015 respectively (Fig. 1). DO time series shows an extended period of freshening event (up to 29 psu) from September, 2014 to June, 2015, which is specific to the site and not observed at any other station This phenomena could not be explained due to the lack of longer period of data and limited sampling stations.

## Conclusion

EICC causes freshening along the east of Indian subcontinent, the maximum freshening occurs in November. Observations at Rameshwaram indicates that EICC does not bifurcate at Pedro Bank to enter into Gulf of Mannar via Palk Strait. However, it is necessary to establish another station at Northern Sri Lanka to confirm no flow through Palk Strait. The path of EICC beyond Dondra is not established, another station at Northwestern coast would facilitate to trace the path of EICC beyond Dondra.

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- Tukey, JW. (1977). Exploratory data analysis. Addison-Wesely.
# Study of critical factors on cyclone genesis in the Bay of Bengal during 2010 - 2015

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#### Abstract

Bay of Bengal (BoB) is semi-enclosed basin renown for the seasonal formation of tropical cyclones and depressions (TCs and TDs). Unpredictable severe cyclones with massive destructive powers could cause for the loss of human life and property, unless we prepared with prior notice. When favorable conditions such as Warm Ocean water layer (50-60m), high humidity (> 60 %), low wind shear, Coriolis force, lower and upper air level disturbances combines to form cyclones over the bay, situation becomes more complex. Events like Indian Ocean Dipole (IOD) and El-Nino effect on the cyclone genesis over BoB by altering the normal conditions. During the study period, we have observed highest (8) TCs and TDs in 2013 and lowest (2) in 2015 under normal and El-Nino conditions respectively. In normal conditions the factors contribute for the TCs and TDs genesis shows higher positive correlations and conclude the role of air temperature is the strongest. During the El-Nino conditions higher negative correlations could be observed and conclude the role of sea level pressure is the strongest factor.Cyclone genesis over BoBis not constant due to one or more limiting factors, though the others are favorable. Hence it emphasizes the importance of studying the role of upper water layer (50 – 60 m) on cyclone genesis which will enhance the predictions on TCs and TDs.

Keywords: cyclones, depressions, Bay Of Bengal, El-Nino, upper water layer

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#### Introduction

International Workshop on Tropical Cyclones (IWTC) Statement Report defines Tropical Cyclone (TC) as the generic name for a non-frontal synoptic scale low pressure system over tropical or sub-tropical waters with organized convection and a definite cyclonic surface wind circulation (Holland, 1993, as cited in WMO, 2016). When a cyclone develops over warm sea it prevails longer than a cyclone which develops on land. Genesis of TCs becomes more convenient when they met favorable conditions such as warm sea surface temperatures, low vertical wind shear (McBride, 1995) high humidity (> 60%) integrated with warm (>  $26^{\circ}C$ ) water layer up to a depth of 50 - 60 m, upper air disturbances and Coriolis force.



#### Fig.1: Frequency of Cyclones/Depressions in BoB 2010-2015

BoB which represents the northeast section of the Indian Ocean, is a semi-enclosed basin occupying an area of  $2.172 \times 10^6$  km<sup>2</sup> between 0 - 22° N 80 - 100° E latitudes and longitudes respectively. According to Gray's publication in 1975 based in historical data, about seven percent of global tropical cyclones are formed in the NIO, while the ratio between Arabian Sea and BoB is around 1:4, emphasizing majority lies in BoB. TCs over BoB occur mainly during April-May (pre-monsoon) and October-November (post-monsoon), less during southwest monsoon where wind is stronger though the other conditions are ideal for cyclone genesis.

#### **Materials and Methods**

Ocean data from RAMA (The Research Moored Array for African, Asian, Australian Monsoon Analysis and Prediction) buoys from 2010 - 2015 were used for the analysis of conditions favorable for cyclone genesis over BoB and cyclone data were collected from Indian Meteorological Department (IMD) to study the frequency of cyclones and their conditions. Statements on tropical cyclones and climate change by WMO (World Meteorological Organization) were referred to study the previous studies on TCs. Correlation analysis was done for the selected parameters to study their interactions under normal and the El-Nino conditions.

#### **Results and Discussion**

During the study period we have observed 11 cyclones and 17 depressions over BoB (Fig. 1), highest numbers (8) in 2013 and the lowest (2) in 2015 (IMD 2016). Comparison of surface conditions (sea level pressure (SLP), wind speed (WSPD), relative humidity (RH), surface temperature (SST), sub-surface temperature ( $T_{ss}$ ) and air-temperature ( $T_a$ )) over BoB during 2013 is shown in Fig. 2. Negative SLP and positive RH anomalies were observed from May – October (Fig. 2) during the study period while the  $T_a$  and SST anomalies follows a bimodal pattern where maximum temperature observed during May and November.

Early studies suggest during normal conditions the TCs and TDs formation is higher than El-Nino years and during La-Nino period intensifies the cyclone formation (Wang and Chan, 2002).



**Fig.2:** Frequency of TCs and Ds and the surface conditions in BoB under normal condition during 2013 (Black stripe denotes depressions/cyclones in 2013 and Red stripes 2015).

According to statistics, there is no significant variation of the averages of selected parameters throughout the study period except SLP, but there is a difference between TCs and TDs formation over BoB (Fig. 1). Reduction of low pressure zones over BoB during El-Nino condition may be the reason to observe fewer TCs and TDs during 2015 compared to other years. We have selected the temperature values at 60 m depth ( $T_{ss}$ ), to study the effect of warm water layer (> 26.5 °C) with the surface conditions. During 2013, we have detected higher positive correlations (Table 1) between the parameters and it indicates, under normal conditions  $T_a$  and  $T_{ss}$  are the most significant to provide favorable conditions to TCs and TDs genesis in BoB following a warm water layer ( $T_{ss}$ ). In the El-Nino years (2015) (*NOAA*, 2016) SLP becomes the most significant factor to reduce TCs and TDs genesis in BoB, which shows higher negative correlations (table 2) with the other parameters.

	SLP	WSPD	RH	SST	Ta	T <sub>ss</sub>	
SLP	1.0						
WSPD	0.081	1.0					
RH	$0.609^{**}$	-0.069	1.0				
SST	$0.484^{**}$	-0.084	$0.505^{**}$	1.0			
Ta	$0.788^{**}$	-0.035	0.732**	$0.782^{**}$	1.0		
T <sub>ss</sub>	$0.575^{**}$	0.065	$0.417^{**}$	$0.725^{**}$	0.543**	1.0	

 Table 1. Correlations among selected parameters in BoB (15N 90E) during 2013.

	SLP	WSPD	RH	SST	Ta	
SLP	1.0					
WSPD	-0.527**	1.0				
RH	-0.679**	0.485**	1.0			
SST	-0.472**	-0.075	$0.287^{**}$	1.0		
Ta	-0.616**	$0.147^{**}$	0.473**	$0.890^{**}$	1.0	

Table 2. Correlations among selected parameters in BoB (15N 90E) during 2015 .

(For table 1 and 2; N=365; \*\*. Correlation is significant at the 0.01 level; \*. Correlation is significant at the 0.05 level).

#### Conclusion

SLP, WSPD, RH, SST,  $T_a$  and  $T_{ss}$  shows a combine effect on the cyclone genesis over BoB and the relationship among these parameters indicates variations responding to prevailing conditions such as El-Nino. Under normal conditions RH,  $T_a$  and the warm water layer up to 60 m depth become more significant showing strong positive correlations while SLP become more significant showing strong negative correlations under El-Nino conditions. Warmer conditions in BoB may be the reason to intensify the TCs and TDs genesis frequency during normal years while higher SLP may be the reason to decrease the TCs and TDs genesis frequency during El-Nino years.

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# GIS and Remote Sensing Applications

Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2016

# Temporal changes of surface chlorophyll in the sea of south of Sri Lanka based on satellite data from 2005 to 2015

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#### Abstract

Sri Lanka is located in an unique location in the Indian Ocean and oceanographic conditions around Sri Lanka are highly affected by bi-directional monsoon winds. Study area is located in South of Sri Lanka from latitudes 2.5 °N to 7.5 °N and longitudes 76 °E to 86 °E. Ocean colour images from various satellites have been used to estimate the chlorophyll concentrations as an indicator of the abundance of phytoplankton. The analysis of chlorophyll in southern Sri Lankan waters were based on Globcolour multiple satellite instruments merged monthly data products of 25 km spatial resolution from 2005 to 2015. The spatial mean of surface chlorophyll concentration during the study period shows a strong seasonal cycle with a maximum value in the South West (SW) monsoon (SWM) period and a minimum value during the first inter-monsoon. The seasonal chlorophyll variation study area is bi-model distribution with prominent SW monsoon peak and minor peak in North East monsoon. High chlorophyll content (>5mgm<sup>-3</sup>) has been observed during the SW monsoon period along the southern coast of Sri Lanka. The southern coast of Sri Lanka which has been observed to havea high productivity during SW monsoon, possibly due to upwelling.

Keywords: chlorophyll, upwelling, Sri Lanka, GlobColour

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#### Introduction

Sri Lanka is located in a unique location in the Indian Ocean where Arabian Sea and Bay of Bengal meet. Also oceanographic conditions around Sri Lanka are highly affected by bidirectional monsoon winds. The zonal monsoon circulation in the south of India/Sri Lanka region is a crucial link for the exchange between the northeastern and the northwestern Indian Ocean (Schott et al. 1994). SWM season prevails from mid-Mayto September and North East monsoon from December to February. In between two monsoon seasons: First Inter-monsoon (March-May) and Second Inter-monsoon (October-November) seasons prevail. Study area is located in South of Sri Lanka from latitudes 2.5 °N to7.5 °N and longitudes 76 °E to 86 °E.

Remote sensing technology provides an opportunity to continuous monitoring and studying the marine environment. Ocean colour images from various satellites have been used to estimate the chlorophyll concentrations as an indicator of the abundance of phytoplankton.

The chlorophyll *a* in the upper layer of tropical oceans is, in general, limited by the availability of nutrients (Vinayachandran*et al.*2004). Therefore, oceanic processes that can bring nutrients into the euphotic zone are of prime importance. Nutrients can be brought in by coastal upwelling driven by alongshore winds, open ocean upwelling driven by Ekman spiral,

entrainment due to wind stirring at the base of the mixed layer and by horizontal advection due to ocean currents (Vinayachandran *et al.* 2004).

#### Materials and methods

The analysis of chlorophyll in southern Sri Lankan waters were based on merged monthly data products from multiple satellite instruments with 25 km spatial resolution for a period from 2005 to 2015. The data used in this study were acquired from HERMES web interface (http://hermes.acri.fr/) of Globcolour project. The GlobColour merged products are generated by Garver, Siegel, Maritorena (GSM) model (Maritorena and Siegel, 2005). Monthly mean concentrations of chlorophyll were calculated by averaging all the data in the same month from 2005 through 2015 to characterize the chlorophyll distribution in the southern Sri Lanka. Time series analysis was obtained from monthly mean chlorophyll. Complete analysis was done using R statistical programming (R version 3.2.2, CRAN).

#### Results

Monthly variations of surface chlorophyll in South of Sri Lanka at different months demonstrated that July, August and September (SW monsoon) had the highest and March and April had the lowest amount (Fig.1). The magnitude of the maximum values in August and the lowest in January. The spatial mean of surface chlorophyll concentration during the 2006-2015 period (Fig.2), shows a strong seasonal cycle with a maximum value in SW monsoon and a minimum value in first inter-monsoon. Seasonal chlorophyll variation is bi-model distribution with prominent SW monsoon peak and minor peak in NE monsoon (Fig.1).



Fig.1: Annual variations of surface chlorophyll anomaly in South of Sri Lanka



Fig.2: Time series of chlorophyll content in South of Sri Lanka

#### Discussion

The spatiotemporal pattern of the mean surface chlorophyll reveals an extremely oligotrophic environment for the southern Sri Lanka with surface chlorophyll mean values lower than  $0.1 \text{ mg/m}^3$  during months of March and April. The ocean around Sri Lanka is nearly oligotrophic during the month of March but a dramatic increase in chlorophyll takes place with the onset of the SW monsoon (Vinayachandran, 2009).

High chlorophyll content (>5mgm<sup>-3</sup>) has been observed during the SWM period along the southern coast of Sri Lanka. Vinayachandran *et al.*, (2004) also observed same observation with Ocean Color Monitor (OCM) images from 1998 – 2002. Yapa (2000) also observed high chlorophyll content closer to southern coast during SW monsoon from images obtained from CZCS from 1978 to1986 observed that chlorophyll concentrations reach peak values in the South region of Sri Lanka during June to September.GlobColour merging multi satellite chlorophyll products are very useful to overcome limitations due to lack of data of previousstudies.NE monsoon period has been observed second chlorophyll peak period but the chlorophyll content can be comparatively low (Fig.2). But high chlorophyll content can be observed as a flume closer to southern Sri Lanka throughout the year. This flume may be indication of coastal upwelling due to alongshore currents. Further analysis of the dynamics and various processes are required to confirm and quantification of coastal upwelling process.

#### Conclusion

Seasonal chlorophyll variation is shown bi-model distribution (semiannual cycle). Southern coast of Sri Lanka has been observed high productivity during SW monsoon and possible upwelling zone. Therefore it is important to identify upwelling process to improve the fishery industry and ecotourism focused on marine mammals.

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# Shoreline change detection using remote sensing satellite data: case study in selected area of Hambantota district, Sri Lanka.

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#### Abstract

The coastal environment represents the interface between land and sea. The shoreline is defined as the interface of land and sea at any given moment in time. It acts as a highly dynamic feature. Coastal zone monitoring is an important task in sustainable development and environmental protection. The coastal zone is likely to have more changes in near future as a result of global warming. The process of erosion and accretion affects cultivation, human life and natural resources along the coast. The main objective of this study was to estimate the shoreline changes using satellite images for the period from 1976 to 2014 in a selected area of Hambantota District. Eight shoreline positions were extracted for 1976, 1980, 1990, 1993, 2001, 2005, 2009 and 2014 covering the medium term of 38 year period from Landsat satellite imagery. Image enhancement techniques, image classification and image composite bands have been used to identify the land-water boundary to extract the shorelines using ArcGIS 10.2 software. In order to assess the accuracy (87%) of the status represent erosion and accretion, the ground observations have been followed combined with Google earth satellite images. Digital Shoreline Analysis System (DSAS) was used to detect the shoreline change over the time by casting 130 transacts at simple right angle along the entire coast at 500m intervals. Shoreline change statistics were calculated using End Point Rate (EPR), Shoreline Change Envelop (SCE) and Net Shoreline Movement (NSM). The results show that the shoreline is a highly dynamic feature with average rate of erosion estimated to be about -1.5m/year ±2.48m. Individual rates along some transect reach as high as -24m/year with high NSM related to Hambantota port construction.

Keywords: shoreline, erosion, accretion, coastal, Landsat

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#### Introduction

The coast represents a unique transitional area between land and sea in which atmosphere, hydrosphere and lithosphere meet. (Valerio, 2012 ; Alesheikh *et al.* 2006). Shoreline defined as the line of encounter between land and water body, which characterizes a dynamic system (Winarso *et al.* 2001; Alesheikh *et al.* 2006). According to Addo *et al.*(2008), Over 70% of the world's coastal zones are experiencing coastal erosion and this presents a serious hazard to many coastal regions. Coastal erosion can be defined as the removal of materials from the coast by wave action, wind action, tidal current and/or human activities and this action results in taking away of land from one area and accretion in somewhere else (Cader,2013). Monitoring of the coastal zone and their changes is an important task to environmental management, conservation, protection and development (Alesheikh *et al.* 2006).In Sri Lanka according to Ceylon today (2013) estimated that over 50.55% of the coastal zone areas subjected or at least threatened by coastal erosion. Satellite remote sensing application is a recent technology for the monitoring earth and its resources and in this study various image processing and image

composite method have been developed to extract shorelines using techniques based on Remote Sensing and GIS.

#### **Material and Methods**

**Study area:** The study site of this investigation is Kudawella to Bundala in Hambanthota District. The area is located between 5° 58' 35"N 80° 44' 1"E to 6° 11' 0" N, 81° 16' 0" E. Hambantota District is located on the southeastern coast of Sri Lanka. It has an area of 2,593 km<sup>2</sup> and a very dry climate.

**Data collection:** Landsat Satellite images were downloaded for 1976, 1980, 1990, 1993, 2001, 2005, 2009, and 2014 covering 38 year period from NASA and USGS websites. Magellan GPS machine version 2 was used to obtain Global positioning System (GPS) points for ground observation. Furthermore research papers, reports; articles were referred as the secondary data source.

**Data processing and delineation of shorelines:** Out of the downloaded satellite images, only the subset of cloud free or the images with minimum cloud cover which is not interfering with shoreline extraction were processed for further analysis. Single band image classification (unsupervised) method was applied to the Near Infrared image band to separate land area from the water on the image for each year. The boundary between land and water was used as the shoreline and it was delineated using the digitizing technique. Both true and false colour composites were also used as guides to delineate shorelines through visual interpretation. All prepared shorelines were overlaid on each other layer and subsequently used for analyze. Arc GIS 10.2 software was used for all the image processing & analysis needs.

**Data analysis:** The Digital Shoreline Analysis System (DSAS) was used for rate estimationand identify Shoreline Change Envelop (SCE), Net Shoreline Measurement (NSM) and End Point Rate (EPR) with respect to a manually crated baseline at landward side. Transacts were cast at 500 m intervals in simple right angles from the baseline.

#### **Result and Discussion**

In all, 8 shoreline positions were extracted for change detection (Fig. 1). The results show that there have been significant changes. Ground verification accounts 87% accuracy when considering the status with respect to the erosion and deposition. Overall rates range from - 24m/year to 6m/year where negative values represent the erosion and positive value accretion (Fig. 2). For the entire coastline erosion and accretion rates average at 1.5m/year  $\pm 2.48$ . Using the results about 93% of the entire coastline experienced erosion while the only 7% has experienced accretion. Especially in higher rate (-24m/year) of shoreline change may be due to the project of Hambantota shipping port after the year 2009. The higher erosion also led to destruction of houses and its surrounding community. Apart from this area of Kudawella, Tangalle and Rekawa has become more vulnerable to erosion. Shoreline Change Envelop (SCE) which represents the average of (180  $\pm 131$ m) with the maximum in 925m and minimum in 31.48m explains how far shoreline is dynamic.



Fig.1: Extracted Shoreline Fig.2: Pattern of End Point Rate

Natural factors such as high energy of waves in the area, geographical features, as well as sea level rise account for the high erosion in this area. However these are aggravated by human factors such as the construction of the fisheries and shipping harbor, hotel and other man made constructions. It led to reduction in sediment supply to the area. And also sand mining, mangrove harvesting are other major factors to higher coastal erosion in this area.

#### Conclusion

Result of this study has been useful in revealing the trends of shoreline change along the southern coast of Hambantota District. In this study satellite images were identified as a possible way to detect temporal changes in the shorelines. The study shows that medium resolution Landsat imagery can be used to map and monitor the large and dynamic coast. When extracting the shoreline combination of image classification and colour composites became best method rather than using only image composite band. According to finding it showed that high rate point of shoreline change represents at the area after the construction of Hambantota shipping habour. The results in general could particularly help decision makers to assess protection related problems, to support their decision and to help them prioritize the monitoring and planning.

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# Geospatial technologies for seaweed mapping in Jaffna Peninsula of Sri Lanka.

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#### Abstract

*Kappaphycus alvarezii* is one of the economically important seaweed due to increasing world demand for carrageenan. *K. alvarezii* is very sensitive to even as mall change in environmental factors. This study was designed to identify suitable areas for cultivation of *K. alvarezii* on in the coastal area of Jaffna Peninsula, Sri Lanka. A total of five sites were selected four sites of non-seaweed culturing area and one seaweed culturing area for this study. Data on physicochemical and socio-economic factors were collected by a filed survey. The Geographic Information System (GIS) and Spatial Multi Criteria Evaluation (SMCE) were used to identify most suitable areas for seaweed cultivation. In this study eleven thematic layers were grouped in to two sub models of physicochemical factors and socio-economic factors. A constraint layer was used to indicate the areas from suitability map that cannot be allowed to develop the seaweed culture, including coral reef substrate and sea grass substrate.

The factors were standardized and Analytical Hierarchical Process (AHP) was applied to establish SMCE weights, thereby, finally suitability maps were created through SMCE to identify most feasible areas. The feasibility was classified in to four groups as High, Moderate, Low and Not feasible and it was analyzed for seaweed cultivation through pixel values of suitability raster maps. In this study Chulipuram and Thondaimanaru indicates 100% of area as highly suitable and Mandativu shows 99% of area as moderately suitable for *K. alvarezii* cultivation. Other two Mathagal and Valaipadu indicate 85 % of area moderately suitable with 15% of area not suitable for seaweed cultivation. The results show that Geospatial Technologies can be used as an effective tool for selecting most suitable site for seaweed cultivation.

Keywords: Kappaphycusalvarezii, Sea weed, GIS, SMCE and AHP.

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#### Introduction

Seaweeds are marine algae that are commonly classified as a plant, and they are primitive type of plants lacking true leaves, stems, and roots (Morris *et al.* 1980). Seaweeds are classified according to their pigmentation into brown (Phaeophyta), red (Rhodophyta), and green (Chlorophyta) seaweeds. They are widely used as ingredients in cosmetics and fertilizers, and they are used as raw materials for many productions like agar align and carrageenan (Chan *et al.* 2006).

Global production of seaweed increased from less than 4 million wet tones in 1980 to almost 20 million wet tones in 2010 (FAO, 2013). Seaweed cultivation becomes one of the coastal and marine prospects for improving the national economy. K. alvareziiis very sensitive to small changes in environmental factors, and depends on socio-economic activities and bottom

features of the farming area. The factors can result in reduced productivity and eventually decline the economic viability of farming project; it is leading to decreased profitability and discouragement of farmers to continue farming activity (Msuya, 2006). Therefore, to ensure sustainable seaweed farming development, there is a need to identify suitable locations in northwestern coastal regions of Sri Lanka. In order that, to meet world demand and avoid undesirable effects on the environment, and ensure profitability of the operation. Based on the above factors, this research demonstrates the feasibility of Geospatial technologies to find out the most suitable areas for community-based farming of *K.alvareziito* make easy to planning and decision-making.

#### **Materials and Methods**

**Study area:** The Jaffna peninsula is situated in the Northern extreme of Sri Lanka. It is geographically confined to the North and East by the Indian Ocean and the West by the Palk Strait. It is at 90.66" and 800.16" (Fig. 1). Jaffna peninsula covers an area of 1,023 km<sup>2</sup> including inland waters. The Jaffna peninsula has many coastal areas and land locked areas, it has a coastline of about 160 km. another study area is Valaipadu. It is at 09°016"N and 80°005"E that is situated in Mannar Basin.



Fig.1: Study Areas

#### Spatial Multi Criteria Evaluation (SMCE)

**Generating the Criteria Tree:** Initially the object was defined as suitable site selection for seaweed farming. The factors were grouped into two groups in criteria tree, such as physico-chemical and socio- economic. The physico-chemical factors contain pH, Temperature, Salinity, Depth, and Wave action. The socio-economic factors contain Fisheries activity,

Community density, Waste water input, Waste material discharge, Peoples opinion and Tourism. The leaves of the tree are indicators that are represented by separate raster maps of factors which impact on seaweed farming. Those thematic maps are the spatial representation of the criteria. A Constraint was used to indicate the areas from suitability map that cannot be allowed to develop the seaweed culture. Live Coral bottom substrates were considered as unsuitable condition due to disturbance which can be occur on coral reef environment while practicing seaweed farming.

**Standardization:** The values in various input maps have different units that represent different units of measurements. In order to make criteria comparable with each other all units need to be standardized. The values range between 0 and 1 commonly used in ILWIS. This is denote that areas with a value of 0 are not suitable for seaweed farming development and areas with a valueof 1 most suitable. Intermediate values between 0 and 1 indicate the levels of suitability. Therefore each of the input factor raster maps was normalized to values between 0 and 1.

**Weighing:** Assigning weight is needed in order to indicate the relative importance of these factors with respect to the main objective, which is to find most suitable area for seaweed farming or to optional sub goals which are physicochemical factors, and socio-economic factors. Weights value has been given in a range, between 0 and 1. According to that, the factors with in a group, the sum of the weights of the factors equals to 1. Pair-wise comparison method was chosen for weighting the Physic-chemical factors.



#### **Results and Discussion**

Fig. 2: Final Suitability map for Site 01 and Site 05 to seaweed cultivation.

The overall suitability of each pixel in the Composite Index map (final output map) for seaweed farming, presented in the scale between 0 and 1 for the whole area of interests In this map each pixel is  $1m^2 (1m*1m)$  with a Composite Index between 0 and 1. The higher the index, the more suitable the area is. Areas with suitability value 0 are denoted with the red color. When suitability increases, the color gradually transits to yellow, and then to green as suitability gets closer to 1. Likewise above SMCE steps Composite index map was created to all five study areas.

#### **Conclusion and Recommendations**

The applications of the developed Geographic Information Systems show that it works effectively to establish spatial models for identifying the most suitable areas for *Kappaphycus alvarezii* culture in Jaffna peninsula. As expected, most of the area at the peninsula had high feasibility percentages, such as Chulipuram (site 1) and Thondaimanaru (site 3); both areas show 100% feasibility for seaweed culture. This is because; most of the factors in the study area are favorable for *Kappaphycus alvarezii* culture. Mandativu (site 4) area shows moderate feasibility for *K. alvarezii* culture. The Mathagal (site 2) and Valaipadu (site 5) areas indicate that approximately 85% of the selected area is moderate suitability and 15% area shows that not suitable for *K. alvarezii* culture. This study shows that with appropriate Geospatial Technologies in mapping is a powerful tool for selection and decision-making.

In this study carried out from September to Decemberof 2015, due to that limitation study period small area was covered for data collection. As more data become available either remote sensing or field measurements, the usefulness of this study increase and can be covered the coastal areas of Jaffna peninsula, and this study provide a range of functions that can be helpful for optimum site selection.

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# **Aquatic Food Technology**

Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2016

# Extraction of agar from locally grown *Gracilaria verrucosa* and development of gelatine free set-yoghurt product using agar

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#### Abstract

Seaweed agar is an important healthy food item. Currently seaweed agar is not extracted at commercial level in Sri Lanka. This study investigated an agar extraction method that render high agar yield and development of agar incorporated gelatine free yoghurt targeting the needs of vegetarian communities. Agar was extracted using *Gracilaria verrucosa* under optimum conditions: Dried *G. verrucosa* was soaked at pH 5 for 30 min; soaked *G. verrucosa* was pressure-cooked with 45 times volume of water for 20 min; the agar extract was allowed to set in trays for 6 h at  $25 \pm 2$  °C; the resulted gel layers were frozen for 8 h; and frozen agar layers were thawed for 4 h at  $25 \pm 2$  °C. The melted water was drained out from gel layers and then, gel layers were cut into strips. Gel strips were dried at 45 °C for 36 h and dried agar were ground to obtain fine agar powder. A gelatine free set-yoghurt product was developed using extracted agar as a texture stabilizer. The developed yoghurt (0.25% agar) which scored high for sensory quality attributes, showed similar sensory properties as in gelatine (0.61 %) containing yoghurt (p > 0.5).

The pH and titratable acidity of the seaweed yoghurt were 4.5 and 0.85 % (w/w) respectively on  $15^{\text{th}}$  day of storage at  $4 \pm 2$  °C. Agar extracted from *G. verrucosa* contained 80.1 % (w/w) of dietary fibre. It was found that seaweed yoghurt contains 0.18 % (w/w) of dietary fiber content while it was not detected in gelatine yoghurt. Agar contained set yoghurt consists of 77.34, 3.40, 3.10, 0.75 and 22.66 % (w/w) of moisture, protein, fat, total ash and total solid content, respectively. The technologies developed, in this study, to extract of food grade agar from *G. verrucosa* and to produce agar incorporated yoghurt has potential to commercialize as an industry.

Keywords: Glacilaria verrucosa, agar extraction, agar based set yoghurt, technology, gelatine free

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#### Introduction

*Gracilaria* sp., *Gelidium* sp., *Saragassum* sp., *Turbinaria* sp., *Ulva* sp., *and Caulerpa* sp. have been identified as economically valuable seaweed species that are available in Sri Lanka. Currently *Gracilaria verrucosa* are collected mainly from naturally grown stocks near shore at Kinniya in Trincomalee. Agar is extracted from red seaweeds, predominantly, from *Gracilaria* species and used as a gelling agent in different industries such as bakery, confectionary, dairy, pharmaceutical, biomedical and other fields. Agar has a wide variety of uses. Food grade agar is an excellent source of dietary fiber and has a growing demand as a health food type.Presently, gelatine free set-yoghurt products are not commercially manufactured in Sri

Lanka and also not available in local markets. Dynamic rheological experiments showed that yoghurts with added gelatine exhibits more solid like behaviour than the yoghurts prepared without it (Fiszman *et al.* 1999). Gelatine containing products are not acceptable for some communities, especially, for vegetarians. The aim of this study was to develop a method to extract agar from *G. verrucosa* and to develop a seaweed agar incorporated set-yoghurt product that has similar sensory properties to gelatine containing set-yoghurt targeting the vegetarian community.

#### **Materials and Methods**

**Collection and preparation of agar from** *G. verrucosa*: *Gracilaria verrucosa* samples were collected from natural seaweed beds in Trincomalee and agar was extracted using an acid digestion method. Briefly, washing and sun bleaching of seaweed repeatedly for 3 times until obtain light yellow colour pure material; soaking seaweed in a pH 5 acetic acid solution for 30 min; neutralization of soaked seaweed by washing with running water; addition of water to soaked seaweeds (45 times based on initial dry weight of seaweeds); pressure cooking of seaweeds for 20 min under low flame; filtering the cooked seaweed mass through a cheese cloth using a screw press; allowing setting seaweed sols for 6 h to retain layers (2 cm thickness) in aluminium trays under room temperature; freezing the gel layers for 8 h (-18 ± 2°C); thawing of frozen gel layers for 4 - 5 h at room temperature; draining of melted water from gels; cutting of gel in to strips and drying in a drying cabinet until moisture content become less than 18% (50 ± 5°C for 36 h) and milling/grinding of dry agar sheets into a powder.

**Characterization of agar powder:** The colour of the powder was decided using the Munsell Colour Guide 2005 (Munsell Colour Science Laboratory, Rochester Institute of Technology). Moisture, dry matter, ash content, were analysed as described in the (AOAC, 1995). Total fibre content was analysed using enzymatic gravimetric method (Prosky *et al.* 1983). Gel strength of 1.5 % gel was measured using Instron texture analyzer 4465. Melting point of 1.5 % gel was measured using method as described by (Marshall and Newton, 1949). The sol- gel transition temperature of 1.5 % agar solution was measured as described by (Esquivel *et al.* 2008).

**Development of agar incorporated set yoghurt:** Trial and error method was used to formulate the set yoghurt product that has similar textural properties as gelatine containing set yoghurt. The method included following a standard method by substituting agar powder in place of gelatine. Other ingredients used were fresh milk, milk powder, egg yolk colour (E102 and E122), vanilla essence and activated starter culture containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Veterinary Research Institute, Peradeniya, Sri Lanka).

#### **Results and Discussion**

Quality of agar is measured by means of gel strength, setting temperature and melting temperature. The highest agar yield ( $37.25 \pm 0.8\%$ ) was obtained by soaking dried moss of *G. verrucosa* in acidic solution of pH 5 compared to that of in 6 other different acid treatments in the range pH 3 - 12.7. Ratio of seaweed to water at 1:45 was selected as the best dilution factor

while other processing conditions at constant: Soaking of seaweed at pH 5, pressure cooking of seaweed for 20 min under low flame, freezing of gel layers for 8 h (-18  $\pm$  2°C), thawing of frozen gel layers for 4 h at room temperature, and drying of thawed gels at 50±5°C for 36 h in a drying cabinet.

Pressure cooking under low flame for 20 min yielded high agar percentage (38.45%) compared to boiling for 20 min and pressure cooking for 10 min. Pressure cooking may have caused to rupture cell walls and expedite the release of more agars trapped in the cell walls of *G. verrucosa* than that of cooking in an open pan. Freeze-thaw method used to purify the agar by removing water soluble impurities and to accelerate the drying process. Among different freezing times (2, 4, 8,10,12,17 h), 8 hour freezing time that resulted in ash content comparable to ash contents of gels frozen for 8, 10, 12, 17 hr (p>0.5). Proximate and physical testing values of agar-agar powder are given in Table 1.

**Table 1.**Specifications of *Glacilaria verrucosa* agar-agar powder extracted from the developed method

Parameter	Value
Mesh size	<u>≤</u> 200 μm
Colour	8/2.5 Y
Moisture content	17.45±0.1% (w/w)
Total ash	2.07±0.1 % (w/w)
Total fibre	80.10±0.7% (w/w)
Gel strength (1.5 % gel at 25 °C)	793.67±10 g/cm <sup>2</sup>
Melting point of 1.5 % gel	86.3±0.82 °C
Setting temperature	38.6±0.56 °C
Solubility	2 .5 min under medium power of a microwave
	oven (1.5% agar solution)

Screening of most acceptable yoghurt formula: According to the spider web diagram and statistical analysis flavour, appearance and overall acceptability of both agar yoghurt and gelatine yoghurt were not significantly different (p>0.5). Texture of the agar yoghurt was better than the gelatine yoghurt and bit more preference was gained by the aroma of gelatine yoghurt than the aroma of agar yoghurt. Proximate composition of developed yoghurt was within the recommended range and additionally agar incorporated yoghurt contained 0.18% dietary fibre where it was zero in gelatine yoghurt.

Shelf life determination of agar incorporated yoghurt: According to the SLSI standards when consider about the hygienic quality it should be free from coliforms, less than 1000/g yeasts and less than 1/g moulds. Microbiological counts of both seaweed agar incorporated yoghurt and gelatine yoghurt were complied with SLSI standards (P < 0.5) during 15 days of storage time. The pH of yoghurt decreased from 4.8 to 4.2 during the refrigerated storage for 20

days. Titratable acidity of yoghurt during the refrigerated storage retained steady at 0.85% increased to 0.9% on  $15^{\text{th}}$  day. Based on these data, shelf life of the seaweed agar incorporated yoghurt was determined as 16 days.

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# Seaweed extract as a natural food coloring agent in Jelly desserts on chemical, microbial and sensory quality

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#### Abstract

Edible pigments can be extracted from seaweeds, which can be used as natural food coloring agent due to substitute hazards in artificial (synthetic) food coloring. Chlorophyll, carotenoid, and phycobiliproteins are major photosynthetic pigments presence in microalgae. Extraction of high quality natural food coloring and efficient impact of these coloring on chemical, microbial and sensory quality of gel dessert were evaluated. The main objectives of the present study Chlorophyll and carotenoids were extracted from *Ulva lactuca* and *Sargussum wightti* using acetone, methanol and water as solvents while and pycobiliprotein was obtained from *Gracilaria verrucosa* grinding with ice cold potassium phosphate buffer. The stability, sensory, microbial and nutritional quality was measured after application of natural colors to jell dessert. The chlorophyll, carotenoid and crude phycoerythin yielded 45 %, 31 % and 33 % respectively. These pigments have a shelf life more than six months in 5 % citric acid at ambient temperatures. The color attributes of the jelly dessert prepared using natural colors retain more than thirty days at room temperature 30 % loss whereas artificial colors were retained in similar amount.

Agar jelly prepared using natural food colors had significantly higher concentrations of calcium (120 mg/l) and Potassium (550 mg/l) when compared to jelly prepared using artificial colors. Natural food colors in jelly resulted in high Sodium content (1200 mg/l) and high magnesium content (580 mg/l) when compared to jelly prepared using artificial colors. The protein content (10.2-12 %), carbohydrate (10.8-12.3 %) and fat contents (1.16-1.9 %) in the jelly dessert prepared using natural food coloring. Natural food colors were found to be in higher rangers of nutrition indicating that these dies can be used as food supplement. Microbial and fungal counts in jelly desserts were found within the consumable levels during one month period and indicating overall acceptability and shelf life of the jelly prepared using seaweed natural pigments extract was high when compared to jelly prepared using synthetic pigments.

Keywords: pigments, natural colors, seaweeds, carotenoids, phycoerythrin

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#### Introduction

Dyes and colorants from natural sources are gaining importance mainly due to health and environmental issues. Algae contain a wide range of photosynthetic pigments. These major classes of photosynthetic pigments are chlorophylls, carotenoids (carotenes and xanthophylis) and phycobilins. Phycocyanin and phycoerythrin. These pigments belong to major class of phycobilins photosynthetic pigments (Sudhakar *et al.* 2014). Seaweeds are microalgae found abundantly in coastal waters of Sri Lanka. *Ulvalactua*, *Gracilaria verrucosa* are green and red algae, which contain chlorophyll and carotenoids while *Gracilaria verrucosa* contain R-

phycocrythin and phycobliprotein. There can be exploited for pigment extraction and can be utilized as natural colorant. These are water soluble and very heat sensitive pigments which are phycocolloidalgae. These pigments have high nutritional value and are safe for usage as food colorants. The present study deals with phycoerythin, chlorophyll and carotenoid extraction from red and green algae. The studies also focus on purification, preservation and application of jelly desserts.

#### **Materials and Methods**

The Gracilaria verricosa, (red seaweed), Ulva lactuca (green seaweed) and Sargussumwightti were collected from northwestern and southwest coastal belt of Sri Lanka and transported to the laboratory, in insulated boxes. The seaweeds were washed several times until remove salt, sand and epiphytes. The carotenoid and chlorophyll pigments were extracted from Ulva lactuca and process and purified according to Muntean (2007) in 30 g of fresh biomass were destroy by organic solvents such as ethanol, methanol, acetone and water. Then the samples were stirred with magnetic stirrer for three hours. The one set of samples were sonication before taken filtrate. Phycobiliproteins was extracted from 50 g of fresh bio mass of Gracilaria verrucosa by grinding in a table mixer with ice cold potassium phosphate buffer (0.1M) at pH - 7.0 according to the method of Sadhakar et al. (2014). The phycoerythin was then separated from phycobiliprotein extract and purified in DAAE cellulose. The carotenoid, Chlorophyll and phycobiliprotein were subjected to scan in a UV - visible spectrophotometer by reading absorbance at range of 440 - 662 mn and quantified using equation of Lichtentaler and Wellburn (1985). For the estimation of phycocyanin, allophycocyanin and phycoerythin were scanned in UV-visible spectrophotometer by the absorbance range from 562-652 and quantified according to equation of Benett and Bogord (1973). Green (chlorophyll and carotenoids) and pink (phycobiliproteins) natural colors different contents (0.1.0.5 and 1.6 mg) were dissolved in 200ml the agar jelly dessert and stored in 0<sup>o</sup>C refrigerator over one month period in order to check the stability of pigments. Shelf life of jelly dessert was determined by measuring of changes of color attributes and overall acceptability during one month period (Peryam et al. 1952) compared with artificial colors. The total bacterial counts (APC, SLS, 1991) and total fungal counts (AFC, SLS, 1991) were measured within weekly intervals during one month period. The nutritional composition macro, micro elements were evaluated and compared with artificial color incorporated agar dessert. The experiment results were analyzed by using statistical package SPSS 22.

#### **Results and Discussion**

The results observed from the analysis revealed that jelly incorporated with artificial colors have best acceptable colour even after four weeks with the mean value 7 while natural pigment samples had in the mean value range 6-6.2. However, the results revealed that there was no significance difference between mean values of both type of pigments. The results of sensory evaluation of colour attributes shows that jelly in corporate artificial colors scored bright

colours than naturally extracted colors from seaweeds during the storage. This may be due to natural pigments are poor in stability than artificial pigments.

As comparable to the artificial colours the retaing period of natural colours were around 30 days in refrigerator without preservatives. The sugar, citric acid and sodium benzoate are accepted as preservative for phycobiliprotein chlorophyll and carotenoid could retain the colour for longer period. However Sudhakar *et.al.* (2014) reported that shelf life of phycobiliprotein in water and soda without preservatives could not retain the colour even for shorter period of three days.

**Yield of natural pigments**: The results revealed that the yield of R-phycoerythrin obtain was 0.067 mg/g in crude extract. In fresh sample of *Gracilaria verrucosa* reported higher amount of (phycoerythrin) Pe-0.067mg/g and (phycocyanin) Pc - 0.38 mg/g in Fresh Weights. The Chlorophyll a extracted using 90% ethanol ranged from 6.3mg/g to 24.5mg/g with minimum in red seaweed and maximum in *Ulva lactuca*. The carotenoids extracted from 80% acetone ranged from 8.3mg/g (*Ulva lactuca*) to 32mg/g (*S. wightti*).

The artificial food color incorporated jelly had the lowest Na content1200 mg/kg when compared to jelly dessert in natural colorant. The natural colors incorporated agar jelly has highest Magnesium (Mg) content than the artificial color products were in the  $580\pm$  mg/l. The level of Magnesium (Mg) content in natural colored jelly and artificial colored jelly were not significantly difference (p < 0.05). In comparison to the natural colored jelly, artificial colored jelly exhibited lower potassium (K) content. This may be due to agar and *Gracilaria verrucosa* were abundant with potassium (K) and available considerable amount of K in jellies. All the jelly product have detected very low manganese (Mn). The differences in the manganese (Mn) content of seaweed based jelly may be traced to the possible differences in the raw material used.

For the protein content in Agar jelly were found red color incorporated jelly have the highest level. Natural green color incorporated jelly recorded second highest protein value  $4.42\pm0.25\%$ . Artificial color green reported significantly lowest (p>0.05) content of protein  $3.09 \pm 0.78\%$ . The brown natural color jelly has highest ( $3.67 \pm 1.2\%$ ) fat content while the artificial color incorporated red have lower fat contents ( $1.16 \pm 0.23\%$ ). Natural brown colored jelly records the high ash content indicating their high mineral content. All the natural colored jelly types have carbohydrate content range from 10.8 - 12.3%.

**Shelf life studies of jelly:** The seaweed based jellysample exhibited highest shelf life during the one month period. The overall acceptability was gradually decreased in all the samples with storage period. The decrease in acceptability started after three weeks. Statistical analysis revealed that treatments and storage effect on all the samples weren't significant. For the commercial jelly labeling that it is expired after two weeks.

#### Conclusion

The present study revealed that water and ethanol extracted pigment from *Gracilaria verrucosa*, *Ulva lactuca* and *Sargussum wightti* can be used as an alternative source for natural food colorant for jelly. R-phycoerthrin chlorophyll & carotenoids stability on jelly showed favorable outcome from this study. These pigments have nutritious and bioactive compounds than artificial pigments would affected on other nutritional benefits. Even though low stability of these major natural colorant they could be maintain more than three months without discoloration using in citric acid 5%.

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# Fatty Acids Profile of the Freshwater Prawn (*Macrobrachium rosenbergii*) Collected from Pollonnaruwa Reservoirs

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#### Abstract

Freshwater prawn is a popular delicacy sold at high market price. Thefreshwater prawn, Macrobrachium rosenbergii is commercially important in Sri Lanka as a primary inland culture species. It can tolerate a wide range of environmental temperature and wide ranges of water quality conditions as well as having a high tolerance for diseases compared with marine prawns. The flesh of the freshwater prawn is rich in nutrients, including: amino acids, fatty acids and essential trace minerals. In the present study the lipid content of muscle tissue, and its fatty acid profile, of freshwater prawns M. rosenbergii were analyzed as Fatty Acid Methyl Esters (FAME) by Gas Chromatography. There is a considerable level of lipids in the prawn muscle  $(0.99 \pm 0.04 \text{ mg/g})$ , and with a well balance fatty acid profile. Among the freshwater prawns collected from Polonnaruwa reservoirs (viz., Parakrama Samudraya, Kawudulla, Minneriya, Maduru Oya) the highest fatty acid class was the monounsaturated fatty acids, omega-9 (25.42 %), followed by 17.4 8% of omega-3 polyunsaturated fatty acids (PUFA), and then 9.65 % of omega-6 PUFA. According to the individual fatty acids, the oleic acid (18:1n-9) and palmitic acid (16:0) were in highest amount  $25.01 \pm$ 1.26 % and  $23.50 \pm 1.72$  % respectively. The omega-3 PUFA, which were found in the lipid fraction of freshwater prawn were: α-Linolenic acid (ALA, 18:3n-3), Eicosapentaenoic acid (EPA, 20:5n-3) and Docosahexaenoic acid (DHA, 22:6n-3), with EPA and ALA being more abundant in the flesh of the freshwater prawns. In general, freshwater prawn M. rosenbergii has a healthy and nutritious fatty acid profile, and could play an important role in the maintenance of good health of human being.

Key word: prawn, lipids, fatty acids, omega-3

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#### Introduction:

The main purpose of aquaculture has been to increase the production of natural and wild candidature species for human consumption to reduce the health risk. In Sri Lanka, prawns are considering as a one of the major groups of crustaceans. The shrimp farming industry has suffered serious losses due to outbreak of viral diseases. Recently, freshwater shrimps have been recognized as an alternative and eco-friendly, sustainable system for prawn production. Mainly freshwater prawn species found in the reservoirs throughout the country and although make high priced product and have high market demand in both domestic and export markets (Rangappa *et al.* 2012). Lipids are believed to be one of the key nutrition factors which are important for supply energy through metabolism in the human body. It important in maintaining physiological and structural integrity of cellular and sub- cellular membrane and lipid also act as a carriers of fat soluble nutrients such as fat soluble vitamins like A,D,E and K. (Mahalingam*et al.* 2009)

Fish consumption, fish oil, lipids and the coronary heart diseases are the most related findings and gave the evidence for control the health risk of the human being. Most of the peoples' concern about the nutritional benefits from consuming fish and fishery products through obtains protein, omega-3 beneficial polyunsaturated fatty acids (PUFA), vitamins and other trace minerals. Omega-3 fatty acids are one of essential fatty acids found in the fatty acid profile. In the human body, these essential fatty acids can't synthesizes, and need to obtain in the diet. (Bhavan *et al.* 2010). These fatty acids provide the health benefits due to their capability of affect several processes in the body, such as cardiovascular, neurological and immune function.

Omega-3 fatty acids are highly concentrated in the brain and are important for memory and performance and the behavioral functions. If we do not get the enough omega fatty acids, the infants are at the risk neurological and vision problems. And the other hand the pregnant women are affected by poor memory, heart problem, dry skin, depression, poor circulation etc due to lack of sufficient dietary essential fatty acids. So that, the balance of the mega-6/omega-3 ratio and omega-6/omega-9 ratio in our diet is very much important. (Samuel*et al.* 1998)

In the present study, an attempt has been made to evaluate the fatty acid composition of the muscle tissue of the freshwater prawn, *Macrobrachium rosenbergii* found in the Polonnaruwa reservoirs. Determination fatty acid composition in freshwater prawns provides the information about the essential fatty acids such as omega 3, omega 6, DHA, EPA etc. The profiling of fatty acids of fresh water prawns will help in understanding the nutritional quality of the prawns.

#### **Materials and Methods**

The freshwater prawn samples were collected from Polannaruwa reservoirs such as Parakrama Samudraya, Kawudulla, Minneriya and Maduru Oya. The sample size was 8 from one each reservoir of roughly 65 g. The prawns were labeled under the weight and length. The muscle samples of prawns were analyzed for their fat content and fatty acid profile as composite samples. All the samples were analyzed in duplicates. Total lipids in muscle tissue samples were extracted using the method described by Bligh and Dyer, 1959. Using the gravimetric method, the fat content of the each composite sample was determined as a percentage value. According to the fat content of the each composite sample, the Bligh and Dyer extract was used for the Fatty Acid Methyl Ester (FAME) generation. Capillary Gas Chromatograph (GC) (GC-2014 Shimadzu, Kyoto, Japan) was used to determine the fatty acid profiles.

The gas chromatograph was equipped with fused silica DB wax capillary column (105 m\* 0.25  $\mu$ m) and flame ionization detector (FID). Helium was used as the carrier gas at 14 psi. The initial temperature of the column was set at 160 °C and finally increased to 240 °C at a rate of 3 °C min<sup>-1</sup>. The detector temperature was set at 270 °C, while the temperature at the injection port was maintained at 240 °C. Retention times of FAME standards were used to identify chromatographic peaks. Fish Qualmix sample (89-5550) was run as a quality control sample throughout the experiment.

#### **Results and Discussion**

The composition of the fatty acid profile mainly depends on the feeding habits and the surrounding environment condition of the lakes such as salinity condition, pH and temperature of the water. The lipid content of the flesh varies with the sex and the season. According to the literature survey, the crustacean hepatopancreas is a major lipid storage organ in their body. In the case of female crustacean ovaries also contain higher levels of lipid than other organs and this also suggests that, lipids are most important for maturation of crustacean ovaries and egg production. It has highly affected on the reproduction, egg survival and embryonic development. In this study, we did not categorize the shrimps according to their sex. We selected the random sample of freshwater prawns in the Polonnaruwa reservoir (n = 32) and analyzed their fatty acid profile. There were no statistical difference observed with the four reservoirs tested.

Values for fatty acid profile in the flesh of freshwater prawns are given in the table 1. In general saturated fatty acids showed in a little amount, but the palmitic acid (16:00) recorded in higher amount ( $23.50 \pm 1.72$  %). Eicosapentaenoic acid, EPA (20:5n-3) increase up to 14.97 %.

Type of Fatty Acid		Average percentage		
	Oil %		$0.99\pm0.04$	
1	Myristic acid	14:00	$1.49\pm0.17$	
2	Pentadecanoic acid	15:00	$0.95\pm0.35$	
3	Palmitic acid	16:00	$23.5\pm1.72$	
4	Palmitoleic acid	16:01	$4.1\pm0.67$	
5	Stearic acid	18:00	$12.1\pm0.31$	
6	Oleic acid	18:1 (n-9)	$25.0\pm1.26$	
7	Vaccenic acid	18:1 (n-7)	$4.4\pm0.60$	
8	Linoleic acid	18:2 (n-6)	$8.21\pm0.85$	
9	Linolenic acid	18:3 (n-3)	$2.51\pm0.49$	
10	Octadecatetraenoic acid	18:4 (n-4)	$1.09\pm0.16$	
11	11-eicosenoic acid	20:1 (n-9)	ND	
12	Arachidonic acid	20:4 (n-6)	$0.36\pm0.07$	
13	Eicosapentaenoic acid	20:5 (n-3)	$14.97 \pm 1.93$	
14	Erucic acid	22:1 (n-9)	ND	
15	Docosatetraenoic acid	22:4 (n-6)	ND	
16	Docosapentaenoic acid	22:5 (n-6)	$0.21\pm0.06$	
17	Docosahexaenoic acid	22:6 (n-3)	$1.08\pm0.07$	

Table 1. Fatty acid profile of freshwater prawns M. rosenbergii

However. the Docosahexaenoic acid (DHA), (22: 6n-3) is absent in the flesh or at very low amounts compared with EPA. Omega-6: Omega 3 ratio is 1:2 and omega6: Omega 9 ratio is 1:3 in the flesh of the freshwater prawns. PUFA of both n-3 and n-6 types are very important in biomembranes particularly in the vascular and nervous systems. n-3 fatty acids act as a suppressant to the biosynthetic pathway of prostaglandins. The present study also shows the importance of the freshwater prawns, their fatty acid profile and the importance of n-3, n-6 and n-9 PUFA in their lipids. Finally, we concluded that the freshwater prawn flesh, rich in omega -9, omega-3 and omega-6 fatty acids, which are essential to reduce the human health risk as well as the good alternative for fish consumption.

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# Determination of Total Volatile Base Nitrogen (TVB-N) in Fish and Fishery Products; Validation of the Kjeldahl Distillation Method

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#### Abstract

The objective of this study was to validate the steam distillation method to determine Total Volatile Base Nitrogen (TVB-N) content in fish and fishery products. The method was based on the EU/EC 1995/149 protocol with a few changes. About 10 g of sample was homogenized with 50 ml of 7.5% TCA and filtered. Then 25 ml of filtrate was distilled for 4 min with 30 ml of 10% NaOH and the distillate was collected in 25 mL of 4% boric acid solution and titrated with 0.025N H<sub>2</sub>SO<sub>4</sub>. The following parameters were used to validate the method; specificity, precision, accuracy, linearity and range, limit of detection (LOD), limit of quantification (LOQ), recovery and uncertainty using certified quality control material (canned fish sample, QC25118-FAPAS, UK) and other fish samples. The LOD, LOQ (LOD x 5) and range were0.20, 1.00 and 1.00-682.50 mg/100 g fish respectively. The precision RSD<sub>r</sub> and recovery were 0.83% and 100.65 % (n = 6). Measurement uncertainty, expressed as relative expanded uncertainty (coverage factor, k = 2) was calculated based on EURACHEM/CITAC guide CG 4, 2000 and the value was 2.4 %. Based on the results it can be concluded that the Kjeldahl steam distillation method is suitable for determination of the TVB-N content of the fish and fishery products.

Keywords: Freshness indicator; TVB-N; method validation

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#### Introduction

In the routine laboratory analysis of TVB-N content, there is a high demand for a method, which generates accurate results efficiently and in an easy way to operate. At present, several analytical methods such as steam distillation, colorimetric, photometry, high performance liquid chromatography, gas chromatography, capillary electrophoresis, semiconducting metal oxides sensors, selective electrodes as well as flow injection/gas dilution (FIGD) with spectrophotometric or potentiometric detection are engaged to determine the index of TVB-N content in fish (Jinadasa, 2011). Among these methods, steam distillation is more popular for TVB-N determination due to safety for analysis of samples that contain a high amount of TVB-N content, like cured fish. The principle of the steam distillation method is the extraction of TVB in fish muscle using alkaline solution and titration with acid. Acid consumption is measured by the total base distilled over. These bases are a mixture of ammonia, dimethylamine and trimethylamine.

Method validation is a process that acquires the essential information to assess the ability of the method to perform its intended task and also give reliable results. Further, it helps to determine the results that can be obtained and the limitation of the method. It is a first level of quality

assurance. The main task of method validation is the measurement of method validation characteristics of each specific method using internal quality control procedures, participation in suitable proficiency schemes and accreditation of the laboratory according to the international standards such as ISO/IEC 17025 (Jinadasa, 2011). Single laboratory validation is mainly restricted to the repeatability precision while inter-laboratory validation focuses on reproducibility precision. The extent of the validation procedure mainly depends on the method, precision and linearity like parameters.

Estimation of measurement uncertainty in analytical methods is a major requirement for a laboratory accreditation process. It measures the difference between an individual result and the true value through identifying and quantifying the uncertainty components. EURACHEM provides the guide to estimate the measurement uncertainty in analytical methods (Jinadasa, 2011). The aim of this study was to evaluate the validation parameters and to investigate the suitability of the steam distillation method to determine TVB-N content in fish and fishery products.

#### **Materials and Methods**

All chemicals and reagents used were of analytical reagent grade (Sigma Chemicals, Switzerland). Distilled water was used throughout this investigation. Certified quality control material (QC25118-FAPAS, UK) and marine fish (yellow fin tuna) samples spiked with 0.05 g of ammonium sulfate,  $(NH_4)_2SO_4$  were used to determine the trueness of the steam distillation procedure and 6 replicates of 10g of certified reference material, unknown and TVB-N was determined based on an adaptation of the current official European steam distillation method (EU/EC, 1995, Malle and Poumeyrol, 1989). The method is based on the extraction of TVB using an alkaline solution and the titration of the recovered ammonia as follows: fish were homogenized with a laboratoryblender for 1 min and 10 g of fish was weighed into a beaker. Then 50 ml of 7.5 % trichloroacetic acid (TCA) was added and the extract was homogenized for a further 2 min. After that, the mixture was filtered using Whatman no 2 filter paper to obtain a clear solution ready for analysis. Then, 25 mL of fish extract was placed in the distillation flask in a VELP mark apparatus (model UDK-6, Milan, Italy). Then 30 ml of 10 % NaOH solution was added, the apparatus immediately sealed and the steam distillate collected in a flask containing 25 mL of 4 % boric acid and a few drops of mixedindicator (methyl red /methylene blue 2:1). The steam distillation procedure was continued for 5 min and the distillate had been collected. The obtained basic solution was titrated against  $0.025 \text{ N H}_2\text{SO}_4$  to the endpoint indicated by a green to pink colour change. The TVB-N content was determined after blank correction that had been determined by the steam distillation with 25 mL of distilled water sample.

The effect of trichloroacetic acid (TCA) concentration, distillation time, NaOH volume and concentration was assessed in the determination of repeatability (n = 6) using the sample spiked with 0.05 g of four hours oven dried (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>.Parameters were measured using the average value and relative standard deviation (RSDr) calculated using Excel (2014) and the Kruskal-

Wallis test was used to find out the significant difference between each data set. The measurement uncertainty was done according to the general principles of the EURACHEM/CITAC guide. Expanded uncertainty of this experimental procedure was estimated by calculating uncertainty associated with recovery, precision, repeatability, tolerance, resolution, calibration and temperature variation.

#### **Results and Discussion**

The repeatability precision (RSD<sub>r</sub>) for recovery was 0.83 %. Accepted assign value and a range of TVB-N content in certified quality control material was 67.7 and 58 - 75 mg/100g respectively. The average TVB-N value for a reference material after following this method was 68.14 mg/100g and that was 100.65 % of the recovery. The average TVB-N value of yellow fin tuna samples were 31 mg/100 g fish and the recovery of the spiked samples were 99.2 %. Presence of calculated average TVB-N content of reference material within the accepted range of reference material confirms trueness of the conducted procedure. Detection limit range of TVB-N in steam distillation method was 0.20 and the limit of calculation was given as a 5 times of LOD (1 mg/100 g fish). The working range was 1.00 - 682.50 mg/TVB-N 100 g of fish. The mean recovery percentage given by 5 % and 7.5 % TCA concentrations was higher than 10% TCA concentration. Kruskal-Wallis test results indicate that mean recovery percentage is given by 10 % TCA concentration and was significantly lower than those given by 5% and 7.5 % TCA concentrations (p < 0.05).

The highest amount recovery percentage was provided by 5% TCA concentration while 10 % TCA provided the lowest amount of recovery percentage. At 5 %, 7.5 % and 10 % TCA concentration average recovery percentages are 102.68, 101.47 and 98.20 respectively. The best TCA concentration was 7.5 % due to moderately made effects on bonding of ammonium ions in  $(NH_4)_2SO_4$  used in this experiment as well as use of 7.5 % being safer than 5% TCA concentration to the experiment. Effective shortest distillation time was four minutes. Expanded uncertainty of this steam distillation method is 2.4 %. According to this expanded uncertainty value, the steam distillation method can be suggested as the best method to determine TVB-N content in fish samples. Based on validation parameters, it can be concluded that the steam distillation method provides satisfactory results for determination of TVB-N content in fish and fishery products. Analysis of certified reference materials showed satisfactory trueness and precision over a long period of time confirming the overall stability of the method. Also, 7.5 % is the best TCA concentration and four (04) minutes distillation time is shortest distillation time for effective distillation in this method.

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# Development of a fish base biscuit using Orinoco Sailfin catfish (*Pterygoplichthys multiradiatus*)

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# Abstract

Inland fishery industry plays a major role of human nutrition and livelihoods in rural communities. Orinoco Sailfin Catfish (OSC) is an invasive alien species colonized inland water bodies has become a problematic fish. Although, it can be use as a food fish, the direct introduction to local consumers is arduous since it is popular as an aquarium fish. Because the abundance of the biscuit consumption by Sri Lankans, it is a good carrier to give the OSC as a food source. In this study, OSC flour incorporated about 19 % to a biscuit recipe and compared these with biscuits without fish flour. The sensory attributes between two types of biscuits were not significantly different. The moisture, ash, crude protein, and total fat contents in fish based biscuit and non-fish based biscuit were  $02.28 \pm 0.06\%$ ,  $03.69 \pm 0.13\%$ ,  $29.04 \pm 0.00\%$ 0.36 %,  $13.61 \pm 0.26$  %,  $02.38 \pm 0.026$  %,  $03.81 \pm 0.02$  %,  $10.71 \pm 0.06$  %, and  $12.71 \pm 0.01$  % indicating higher protein content in fish based biscuit. The SF, MUFA, and PUFA contents of OSC flour based biscuit and non-fish based biscuit were 26.35 %, 36.28 %, 37.18 %, 26.11%, 35.90 % and 37.81 % in total fat content. The S/U, omega6/omega3 ratios of OSC flour based biscuit and non-fish based biscuit were 0.36, 13.58, 0.35 and 14.82. The lower ratio of omega6: omega3 and 0.16 % of Eicosapentaenoic acid provide better nutritional benefits for the OSC incorporated biscuit. The pH, moisture content, water activity and free fatty acid value of the final product was within safety limits and their variations for a three week period were not significantly different. The peroxide value and Presumptive Coliforms were not detected and aerobic plate count, yeast and mold were below the maximum allowable limits within this period. The cost of 100 g of product was 40.48 LKR.

### Keywords: Alien fish , fish biscuit

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### Introduction

Orinoco Sailfin Catfish is an invasive alien species colonized inland water bodies has become a problematic fish because of higher growth rate, invasion of the native fish environment, economic losses to the fishermen and loss of biodiversity (Wijethunga and Epa, 2008). Although, its major portion of daily fish catch, the direct introduction to local consumers is arduous since it is famous as an aquarium fish.

# **Materials and Methods**

**Sample collection:** The freshly caught *Pterygoplichthys multiradiatus* from the tanks in Polonnaruwa and Ampara areas were transported to NARA in the chilled condition.

**Product preparation:** The 100 g of biscuit was prepared according to a formulated recipe as 17.90 g of fish flour, 8.06 g of green gram flour, 17.90 g of wheat flour, 25.06 g of sugar powder, 9.00 g of skim milk powder, 0.65 g of baking powder were mixed together. Then 1.79 g of salt and 0.22 g of soya lecithin were mixed with 18.8 g of vegetable fat spread. Then the 00.13 g of potassium sorbate was dissolved in 7 ml of water. Then all of them were mixed together, kneaded for 30 min and moulded. The raw biscuit was baked at 180 °C for 15 min. After cooling to room temperature, the biscuits were packed in nylon and LDPE polymeric bags. Control biscuit was developed without fish flour using the same recipe and replacing fish flour with wheat flour. This is for identification, whether any effect of incorporation of fish flour to the biscuit in sensory attributes or nutritional properties.

**Sensory analysis:** Sensory analysis was done using 30 members of untrained panel and the 5 point hedonic scale. The sensory attributes checked were appearance, aroma, texture, taste and overall acceptability.

**Proximate analysis:** The moisture, ash, crude protein and total fat contents in fish based biscuit and non-fish based biscuit wereanalyzed. The fatty acid profile was determined using gas chromatography.

**Shelf life analysis:** Moisture content, water activity, peroxide value and free fatty acid value were checked for a 3 week period and the variation of each parameter was also analyzed in one way ANOVA. Presumptive coliform, aerobic plate count, yeast and mold counts were analyzed for this period.

**Statistical analysis:**Sensory evaluation was done according to the five point hedonic scale and results were analyzed using Minitab-Kruskal Wallis test.

# **Results and Discussion**

# Sensory analysis

Sensory Attribute	H <sub>cal</sub> value
Appearance	1.14
Aroma	1.22
Texture	0.46
Taste	2.32
Overall acceptability	2.25

Table 1. H values resulted from the Kruskal Wallis test for sensory attributes.

For all sensory attributes, there were no significant difference between fish based biscuit and non-fish based biscuit under 0.05 levels of significance (Chi-square<sup>2</sup> value;  $3.84 > H_{cal}$ ). Incorporation of OSC flour to the biscuit has not contributed an unpleasant sensory attributes.

# **Results of proximate analysis**

Having this compositional information in a table would be helpful. The moisture, ash, crude protein and total fat contents in fish based biscuit and non-fish based biscuit were  $02.28\pm0.06\%$ ,  $03.69\pm0.13\%$ ,  $29.04\pm0.36\%$ ,  $13.61\pm0.26\%$ ,  $02.38\pm0.02\%$ ,  $03.81\pm0.01\%$ ,  $10.71\pm0.06\%$  and  $12.71\pm0.01\%$  respectively, indicating considerably higher protein content and a some higher fat content in fish based biscuit. The SF, MUFA and PUFA contents of OSC flour based biscuit and non-fish based biscuit were 26.35%, 36.28%, 37.18%, 26.11%, 35.90% and 37.81% in total fat content. The S/U, omega6/omega3 ratios of OSC flour based biscuit and non-fish based biscuit were 0.36, 13.58, 0.35 and 14.82. The lower ratio of omega6: omega3 and 0.16% of Eicosapentaenoic acid provide better health and nutritional benefits. Eicosapentaenoic acid provide better health and reduce the risk of cardiovascular diseases and the rheumatoid arthritis (Erdman J *et.al* .2011).

# **Results of shelf life analysis**

Parameter	P-value
Moisture content	0.299
Water activity	0.648
Free fatty acids	0.319

**Table 2.** P-value results for shelf life determination parameters

Peroxide value was not detected and free fatty acid value, moisture content and water activity were within the safety limits for a 3 week period and their variations were not significant under 0.05 levels of significance (P>0.05). Therefore the chemical deterioration rate of the biscuit was not significantly different from the control. The presumptive coliform was not detected and aerobic plate count, yeast and mold count were below the maximum allowable limit for this period and the shelf life analysis should be done further.

# **Results of cost analysis**

The cost of 100g of biscuit was 40.48LKR.

# Conclusion

OSC fish flour can be used successfully for the preparation of fish base biscuit.

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# Heavy metals in Tilapia (*Oreochromis sp*) from Padaviya and Huruluwewa reservoirs in Sri Lanka

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# Abstract

Incidence of chronic Kidney Disease of unknown etiology (CKDu) has significantly increased in the North Central Province (NCP) of Sri Lanka. Tilapia (Oreochromis sp) is one of the most common fish consumedin CKDu affected regions and is one of the main protein source of their regular diet. The consumption of freshwater fish contaminated with heavy metals isconsidered as a possible causative factor for the onset of CKDu. Scientific evidence of the heavy metal concentration in Tilapia need to be investigated in detail, as the CKDuis now becoming a national health issue in Sri Lanka. The aim of thisstudy was to determine the heavy metal concentration in fresh Tilapia collected from Padaviya and Huruluwewa reservoirs in the North Central Province. Scaled, degutted, washed Tilapia were freeze dried, microwave digested and samples analyzed for heavy metals by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Dietary essential metals, Fe (16 – 11 mg/kg), Zn (13 – 16 mg/kg), Mn (2.3 mg/kg -1.0 mg/kg) concentrations were higher in raw Tilapia from both Padaviya and Huruluwewa reservoirscompared with other metals elements Cr, Co, Ni, Cu, As, Mo, Ag, Cd, Hg and Pb studied. Toxic heavy metals, Pb, Hg, Cd and As concentrations in Tilapia from Padaviya reservoir were 152 µg/kg, 42 µg/kg, 11 µg/kg and 6.6 µg/kg, respectively, compared with 111 µg/kg, 86 µg/kg, 8.8 µg/kg and 0.66 µg/kg of the above elements from Tilapia from the Huruluwewa reservoir. Mn, Co and Cd concentrations were significantly (P < 0.05) higher in Tilapia caught from Padaviya compared to Huruluwewa. All the above values are significantly lower than the FAO recommended limits for fish. Results conclude that Tilapia from Padaviya and Huruluwewa reservoirs do not possestoxic levels ofheavy metals. However, periodical studies are further needed.

Keywords: chronic kidney disease, heavy metals, inductively coupled plasma mass spectrometry

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### Introduction

Fish may contain heavy metals in hgh concentrations when the aquatic environment is contaminated. Metals can enter the body via the food chain and causes evere damage to humans when the concentration reaches a toxicological thresholds. Lead (Pb), cadmium (Cd), arsenic (As) and mercury (Hg) are considered as non-essential since such elements are not involved with any functionalities of the human body but can cause harmful effects (Andre *et al.* 2005). Cobalt (Co), copper (Cu), manganese (Mn), molybdenum, iron (Fe) and zinc (Zn) are essential nutrients for humans but becometoxic if ingested in large quantities (Silva and Shimizu, 2004).

Tilapia (*Oreochromis* sp)is one of the important fish in the inland fish production of Sri Lanka and account for 58.4 % of the reservoir fishery catches (MOFAR, 2014). Bioaccumulation of heavy metals in Tilapia (*Oreochromis* sp) which is the uptake and sequestration of contaminants by an organisms from their ambient environment has become a great concern

worldwide as freshwater resources are becoming increasingly polluted (Suhaimi *et al.* 2006). The NCP contributed approximately 37 % of the total inland fish production (NARA, 2009).

Recently, Chronic Kidney Disease of unknown etiology (CKDu) has been reported extensively in the NCP of Sri Lanka especially in the Anuradhapura district. Consumption of Tilapia that is contaminated with heavy metals (especially Cd) was considered as a significant factor in the aetiology of the CKDu, the incidence of which reached a peak in Anuradhapura in last few years and most cases were from the Padaviya, Medawachchiya and Kebithigollewa divisional areas (Bandara *et al.* 2010; Jinadasa *et al.* 2013). This focus of this study was to investigate the heavy metal concentration in Tilapia in the Padaviya and Huruluwewa reservoirs and compare these levels with the FAO standards.

### Materials and methods

Tilapia samples (whole fish N = 28) with same growth similar size (Total length  $218 \pm 4.9$  mm, Standard length  $189 \pm 7.4$  mm) and similar weight ( $203 \pm 8.0$  g) were collected from the Padaviya and Huruluwew areservoirs. Tilapia samples were scaled, degutted, sliced using a plastic dissecting tool and washed with deionized water to remove extraneous matters. Samples were homogenized to obtain a mince. 10 g of each mince was kept in sterile vials containers, labeled and died in a in freeze dryer (Alpha i-2 LD Plus, Germany) for 48 hours, and digested using accelerated microwave system (Mars 6, CEM, Matthews, USA). The digested samples were analyzed using inductively coupled plasma mass spectrophotometer (Thermo Scientific iCAPQc, Bremen, Germany) against aqueous standards. Discriptive analyses were carried out with MS Excel 2007 and SPSS 13.0.

# Results

Thirteen heavy metals; Fe, Zn, Mn, Cr, Co, Ni, Cu, As, Mo, Ag, Cd, Hg and Pb were detected. Dietary essential metals, Fe (16 – 11 mg/kg), Zn (13 – 16 mg/kg), Mn (2.3-1.0 mg/kg) concentrations were higher in raw Tilapia caught from both reservoirs compared with other metals elements. Toxic heavy metals, Pb, Hg, Cd and As concentrations in Tilapia from Padaviya reservoir were 152  $\mu$ g/kg, 42  $\mu$ g/kg, 11  $\mu$ g/kg and 6.6  $\mu$ g/kg, respectively, compared with 111  $\mu$ g/kg, 86  $\mu$ g/kg, 8.8  $\mu$ g/kg and 0.66  $\mu$ g/kg of the above elements from Tilapia from the Huruluwewa . The order of metal element accumulation in Tilapia in Padaviya reservoir was Fe>Zn>Mn>Cu>Cr>Ni>Pb>Co>Mo>Hg>Ag>Cd>As while Huruluweva reservoir was Zn>Fe>Mn>Ni>Cu>Cr>>Pb>Hg>Co>Mo>Ag>As>Cd.

	Concentration (µg/kg)		
	Padaviya	Huruluwewa	P value
Cr	$454 \pm 58$	$430\pm195$	0.917
Mn	$2281\pm201$	$955 \pm 20$	0.022
Fe	$16467\pm1756$	$11401\pm746$	0.117
Со	10 1± 9	$58 \pm 5.5$	0.05
Ni	330±90	$654 \pm 255$	0.353
Cu	657±47	$566 \pm 32$	0.251
Zn	$13674\pm3180$	$16415\pm464$	0.483
As	12.8±0.7	$8.8 \pm 0.7$	0.096
Mo	$74 \pm 4$	$42.4 \pm 20.3$	0.268
Cd	$17.5 \pm 2.5$	$0.7\pm0.6$	0.024
Hg	$42 \pm 7$	$86 \pm 3.0$	0.283
Pb	$152 \pm 28$	$110\pm 8$	0.296

Table 1. Heavy metal concentration of Tilapia in Padaviya and Huruluweva reservoirs.

Mean concentrations of HM  $\pm$  SE. n = 2 (P < 0.05)

# Discussion

Each selected sampling site has been received different types of pollutants from different sources of pollution. When selecting the sampling sites for this study following criteria were considered; size of the reservoir, degree of anthropogenic activities related to the reservoir and reported CKDu patients in the area and fish consumption degree of that areas. Both reservoirs were large scale reservoirs, which covers lager area for the agricultural practices by irrigating. Anthropogenic activities of both areas were the same in general. But specially, degree of kidney disease patients reported was different in both catchment areas. According to Dr. Asanga Ranasinghe, Director of the Provincial Renal Disease Prevention Unit of Anuradhapura General Hospital, around 17,000 people who have been affected with CKDu were reported in the North Central province by the end of 2013 and the province's monthly death rate average as of the end of 2013 due to renal failure was 19. Especially in Padaviya area 2653 patients were recorded which high risk is and in Huruluwewa reservoir area recorded numbers of patients were 274 which is low risk.

Cu, Fe and Zn are essential elements and are regulated by physiological mechanisms in most organisms. However, they show toxic effects when organisms are exposed to levels higher than normally required (Biney *et al.* 1994). In this study, Fe concentration in Padaviya reservoir raw fish is between 14.7-18.2 mg/kg and Fe concentration in Huruluwewa reservoir fish is between 10.6-12.2 mg/kg.But there is no significant difference between Fe concentration in both reservoirs (P > 0.05).

Non-essential heavy metals such as Pb, Hg, As and Cd cab be accumulated in fish tissues and is harmful to human health even in trace level. The accumulation of Pb in the edible muscle of Tilapia fish collected from Padaviya and Huruluwewa reservoirs ranged from 124  $\mu$ g/k to 180

 $\mu$ g/kg and from 102  $\mu$ g/kg to 119  $\mu$ g/kg, respectively. The accumulation of Pb was not significantly different (P > 0.00) between the two reservoirs.

# Conclusion

Most toxic heavy metal concentrations in the Tilapia were in the order of Pb>Hg>Cd>As in the Padaviya reservoir and Pb> Hg>As>Cd in the Huruluwewa. These levels are below the FAO standards. Based on the heavy metal concentrations, the consumption of Tilapia from these reservoirs do not pose a threat to human health.

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Proceedings of the National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2016

# Aquatic Environment Conservation & Management

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# A study on temporal and spatial distribution of sea turtle nesting on the southwest coast of Sri Lanka

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# Abstract

The south and southeast coastlines, with vast areas of sea-grass beds and coral reefs, provide important nesting and foraging grounds for sea turtles. Turtle conservation and management involves a complex and wide ranging set of tasks. Management and conservation of sea turtles cannot be effective without the availability of reliable statistics. The study area extends 25.8 km over two administrative Districts, Colombo and Galle. The initial objectives of this survey were to quantify the number of species, distribution and abundance of sea turtles, the seasonality and geographic range of nesting along the study area. The estimated total annual number of nesting in the study area was 1752 of which 68.6 % and 30.3 % were made by Green Turtle and Olive Ridley respectively. The highest number of monthly nesting frequencies of Green Turtle was observed during the period from February to April. The highest number of monthly nesting frequencies of Olive Ridley turtle was observed during the period from November to March. The highest nesting density of 298 nests km<sup>-1</sup>year<sup>-1</sup> and nesting diversity was reported in Kosgoda beach. Ahungalla ranked next at 105 nests km<sup>-1</sup>year<sup>-1</sup>. This was followed by Induruwa at 94 nest km<sup>-1</sup>yr<sup>-1</sup>. As the nesting density and nesting diversity are very high in Kosgoda beach, it should be declared as a protected nesting ground. For the beaches of Induruwa, Kosgoda and Ahungalla, introduction and implementation of *in-situ* nest protection programmes are recommended.

Keywords: sea turtle, temporal, spatial, diversity

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# Introduction

Of the seven living sea turtle species in the world, five are reported to nest along the coastal belt of Sri Lanka - the Green Turtle (*Chelonia mydas*), Olive Ridley (*Lepidochelis olivacea*), Hawksbill (*Eretmochelys imbricata*), Loggerhead (*Caretta caretta*) and Leatherback (*Dermochelys coriacea*) (Deraniyagala, 1953). The south and southeast coastlines with vast areas of sea grass beds and coral reefs provide important nesting and foraging grounds to sea turtles (Deraniyagala,1939; Amarasooriya, 2000)

The collection of marine turtle eggs from the rookeries is for consumption and sale to sea turtle hatcheries. Egg collection, destruction of nesting and foraging grounds of sea turtles, incidental by-catch in fisheries and certain activities such as rearing tanks were crowded during the turtle nesting seasons at turtle hatcheries have been identified as major threats to marine turtles in Sri Lanka. Conservation of sea turtles in Sri Lanka has gained considerable momentum in the past four decades.

# Materials and methods

The nesting beach survey consisted of two main parts; a frame survey and a comprehensive nesting beach survey. The frame survey was conducted based on the available literature and by personal communications with individuals from the local coastal community. A total of 53 beach sites were visited to collect the basic information. Information such as the nature of the beaches, species nested, nesting seasonality, number of nesting per month and the other relevant information were collected by interviewing the villagers in the coastal areas and through direct investigations made during day and night. The beaches where the annual number of nesting was over 10 were selected for the comprehensive survey. The study area extended 25.8 km over two administrative districts, Colombo and Galle. The initial objectives of this survey were to quantify the number of species, distribution and abundance of sea turtles, the seasonality and geographic range of nesting along the study area. The information were collected by volunteer data collectors and through direct observations by NARA research staff.



# **Results and Discussion**

Fig.1. Pattern of monthly nesting frequency of Green turtle during the study period in the study area

The estimated total annual number of nestings in the study area was 1752. Out of them 68.6% and 30.3% were by green turtle and olive ridley turtle, respectively. Only few observations were found from hawksbill turtle, logger head turtle and leatherback turtle. Similar observations have been reported in southern Sri Lanka, as 62%, 20%, 11%, 5% and 2% were made by green turtle, olive ridley turtle, hawksbill turtle, loggerhead turtle and leatherback turtle turtle respectively (Amarasooriya,1997). The data indicate that the green turtle was the most predominant species nesting here in 2014.

The above data suggest that turtle nesting on the west and south west coast of Sri Lanka is seasonal. The highest number of monthly nesting frequencies of green turtles was observed during the period February to April. The highest number of monthly nesting frequencies of olive ridley turtles was observed during the period November to March. These are the non-monsoon periods and calm seasons for the southwest coast in Sri Lanka. It is evident that

southwest monsoon may be having a severe effect on nesting behaviour of the sea turtles. The highest nesting density 298 nests km<sup>-1</sup>year<sup>-1</sup> and nesting diversity were reported in Kosgoda beach. Ahungalla ranked next at 105 nests km<sup>-1</sup>year<sup>-1</sup>. This was followed by Induruwa at 94 nests km<sup>-1</sup>yr<sup>-1</sup>

Major nesting	Length of the stretch	No. of nestin	ırtle	dley	bill	nead	·bac	Nesting density
Beaches	( <b>km</b> )	g	Green tı	Olive Ri	Hawks	Loggerl	Leather	(nest km <sup>-</sup> <sup>1</sup> ,year <sup>-1)</sup>
Mount	1.44	31	9	20	2	0	0	21.5
Benthota	2.30	49	2	40	0	0	0	21.3
Warahena	0.90	26	6	20	0	0	0	28.9
Induruwa	4.10	384	280	10	0	0	2	93.7
Mahapalana	1.30	72	60	10	0	1	1	55.4
Duwemodara	1.20	99	85	14	0	0	0	82.5
Kosgoda	2.30	685	570	10	3	4	1	297.8
Ahungalla	1.50	157	90	65	2	0	0	104.7
Balapitiya	2.00	46	30	16	0	0	0	23
Ambalangod	1.200	32	2	30	0	0	0	26.7
Kahawa	5.20	94	48	45	1	0	0	18.1
Habaraduwa	0.80	44	14	30	0	0	0	55
Koggala	1.60	33	2	30	0	0	1	20.6
Total	25.84	1752	119	52	8	5	5	

Table 1. Values of nesting densities and nesting diversity at the surveyed beaches

# Conclusion

As the nesting density and nesting diversity were very high in Kosgoda beach, it should be declared as a protected nesting ground. For the beaches of Induruwa, Kosgoda and Ahungalla, introduction and implementation of in-situ nest protection programmes are recommended.

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# Phytoplankton diversity and distribution in relation to the water quality of Batticaloa lagoon, Sri Lanka

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# Abstract

Phytoplankton diversity and abundance changes as a function of physicochemical parameters in aquatic ecosystem; hence these may serve as indicators of water quality. The objective of the study was to determine the diversity and distribution of phytoplankton in relation to the water quality of the Batticaloa lagoon. Sampling was carried out on a monthly basis from April to July 2015. Ten sampling points were selected along the eastern part of lagoon based on the different characteristics. Temperature, pH, Turbidity, Electrical Conductivity, Dissolved Oxygen (DO), Ammoniacal nitrogen (NH<sub>4</sub><sup>+</sup>-N), Nitrate (NO<sub>3</sub><sup>-</sup>-N), Nitrite (NO<sub>2</sub><sup>-</sup>- N), Phosphate (PO<sub>4</sub><sup>3-</sup>), and Chlorophyll-a content in the lagoon waters were measured. The phytoplankton samples were collected from each location by filtering 50 litres of surface water by using a 55  $\mu$ m mesh size plankton net. All individual phytoplankton taxa were identified to the nearest taxonomic group using standard identification keys and analyzed for their abundance and diversity.

The mean values and standard deviation of nitrate, nitrite, phosphate and ammoniacal nitrogen concentrations from surface waters were 0.016 mg/l  $\pm$  0.066, 0.006 mg/l  $\pm$  0.005, 0.07 mg/l  $\pm$  0.112 and 0.07 mg/l  $\pm$  0.045 respectively. The mean pH value was 8.28  $\pm$  0.211 and mean water temperature recorded was 31.74 °C  $\pm$  0.93. Mean turbidity was as 3.25 NTU  $\pm$  1.96. The four main classes of phytoplankton identified in Batticaloa lagoon were Bacillariophyceae (81 %), Dinophyceae (11 %), Chlorophyceae (5 %) and Cyanophyceae (3 %). The results revealed that the water quality parameters were within the Sri Lankan limits for fish and aquatic life. The diversity and abundance of the phytoplankton in the Batticoloa lagoon were affected by some of key water quality parameters.

Keywords: Batticaloa Lagoon, Plankton, Diversity and Abundance, Water Quality

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### Introduction

Aquatic health is a critical issue in Sri Lanka, especially when considering its implications to humanity in terms of water borne diseases. Many groups of organisms have been proposed as indicators of environmental quality (Harris and Vinobaba, 2012). Phytoplankton diversity and abundance varies with changes of physicochemical parameters in aquatic ecosystem. Therefore, phytoplankton are good indicators of water quality in aquatic ecosystems. Phytoplankton are also key organisms in marine aquatic ecosystems. They form the base of the marine food chain, serving as food to primary consumers. About 90% of the total production in marine ecosystems is contributed by phytoplankton that in turn supports commercial fisheries. The influence of various factors on the seasonal growth and abundance of phytoplankton differs significantly,

with physical (such as temperature and light intensity) and chemical factors (Dissolved Oxygen, pH, salinity, eelectrical cconductivity and nutrient level) as primary limiting factors. The objective of the study was to determine the diversity and distribution of phytoplankton in relation to the water quality (Physical, Chemical and Biological) of the Batticaloa lagoon.

# **Materials and Methods**

Sampling was carried out monthly from April to July 2015. Ten sampling points were selected along the eastern part of Batticaloa lagoon based on the different characteristics of the lagoon Fig. 1 indicates the area and the sampling points selected for the study. Temperature, pH, Turbidity, Electrical Conductivity, Dissolved Oxygen (DO), Ammoniacal nitrogen (NH<sub>4</sub><sup>+</sup>-N), Nitrate (NO<sub>3</sub><sup>-</sup>-N), Nitrite (NO<sub>2</sub><sup>-</sup>-N), Phosphate and Chlorophyll-a content in lagoon waters were measured in accordance with Standard Methods for the Examination of Water and Wastewater 20<sup>th</sup> Edition published by American Public Health Association (APHA, 1998). The phytoplankton samples were collected from each location in 100 ml labeled plastic containers. Surface water was filtered (50 l) through a 55 µm mesh size plankton net. Retained material were immediately preserved with 4% formalin and fixed with Lugol's iodine solution for quantitative and qualitative analysis. Preserved samples were transported to the laboratory. Each quantitative sample was concentrated to 10 ml. A representative 1mL sample from each concentrated sample was added to a Sedgewick Rafter counting chamber and all individual phytoplankton taxa present were counted under a light microscope (x10). They were identified to the nearest taxonomic group using standard identification keys and analyzed for their abundance and diversity. Phytoplankton diversity was calculated by using the Shannon-Wiener Diversity Index (Davies et al. 2009).



Fig.1: Location of sampling points in Batticaloa Lagoon

Statistical analysis was performed using MINITAB 15 statistical software. Relationships between water quality parameters and phytoplankton diversity indices were developed with Pearson's Correlation Test. Variability of above factors among the ten sampling locations were compared using One-way ANOVA test.

# **Results and Discussion**

Results of surface water samples indicated that, the mean values and standard deviation of nitrate, nitrite, phosphate and ammoniacal nitrogen (NH<sub>4</sub><sup>+</sup>-N) concentrations in study sites were 0.016 mg/l  $\pm$  0.066, 0.006 mg/l  $\pm$  0.005, 0.07 mg/l  $\pm$  0.112 and 0.07 mg/l  $\pm$  0.045 respectively. The mean value of pH was 8.28  $\pm$  0.211 and mean water temperature recorded was 31.74 °C  $\pm$  0.93. Mean turbidity was 3.25 NTU  $\pm$  1.96. The four main classes of phytoplankton identified in Batticaloa lagoon were Bacillariophyceae (81%), Dinophyceae (11%), Chlorophyceae (5%) and Cyanophyceae (3%). Fig. 2 shows the relative abundances of these different classes of phytoplankton among the sampling locations.



Fig.2. Relative abundance of the different classes of phytoplankton in the lagoon

Low phytoplankton growth was recorded at BT10 during June due to low temperature, salinity, poor nutrient levels and grazing pressure by zooplankton and other animals. Due to the existence of high turbidity at BT1, photosyntheitic phytoplankton were low, whereas diatoms and Cyanophyceae were found to be in abundance. There was apparent effect of pH on the phytoplankton. However, when turbidity increases, hydrogen ions concentration may towards the alkalinity and increase in the level of dissolved salts, which promote the coagulation of fine particulate matter (Phillips, 1972). Salinity may have an inverse relationship with plankton growth (Marcarelli *et al.*, 2006). Greater species diversities were found at low than at high

salinities. Cyanophyceae might adapt to a change in salinity, although they grow slower at higher salinities. Diatoms had a high frequency of occurrence at low salinities. *Nitzschia* spp. was found at all observed salinities. Chlorophyceae and Cynophyceae abundance decreased with increasing salinities. Chlorophycee were found in low quantity at location BT8. Diatom (*Navicula spp.*) and Chlorophyceae (*Peridinium spp.*) were more abundant in higher salinity sites. Eutrophication at the BT8 and BT9 locations may have contributed. Using the Shannon Diversity index, phytoplankton communities at, BT1 and BT6 were identified as moderately polluted areas and all other locations were light polluted areas. *Nitzschia* was found to be a good indicator of water pollution. *Coscinodiscus spp.* was observed in each location as a tolerant species. The water quality conditions such as increased nutrient concentrations at BT1 and BT6 increased the risk of Cyanophyceae species blooms.

# Conclusion

In the present study, some of the physicochemical properties of Batticaloa lagoon strongly correlated in determining phytoplankton diversity and abundance. Salinity and temperature played a major role in the regulation of the planktonic communities. There was an inverse relationship with the salinity and the phytoplankton density. It appears that the availability of nutrients and adaptation of plankton to salinity changes were possible factors responsible for fluctuations in the plankton populations. This study concludes that the diversity and abundance of the phytoplankton in the Batticoloa lagoon fluctuate with some of the key water quality parameters.

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# Measurements of time-averaged intensity of seawater motion with plaster balls at Polhena reef, Sri Lanka

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# Abstract

Water motion is a critical environmental parameter especially for sessile marine fauna and flora. It is difficult to measure seawater motion with a propeller type of current meter in shallow coastal reefs. Therefore, we initiated a method to measure time-averaged intensity of water motion with plaster balls by placing them in the water column below the low tide level. Balls were made with plaster of Paris. A laboratory experiment was conducted on the relationship between of seawater flow and dissolution rate of plaster balls. This laboratory experiment revealed that 3.72 mg of the dry weight of the plaster balls were dissolved in seawater at a flow rate of 0.048 ms<sup>-1</sup>. Using this relation, we calculated the average seawater motion at two reef locations ("off-shore" at the middle of the reef platform and "near-shore" at the edge of the reef platform) at Polhena reef by converting the loss of dry weight of plaster balls to the flaw rate of seawater. Though there was no any significant difference of mean time averaged intensity of seawater motion ( $0.0233 \pm 0.0004$  SE) ms<sup>-1</sup> than at the near-shore locations ( $0.0222 \pm 0.0008$ ) ms<sup>-1</sup> (Two sample t-test; T = 1.20, df = 4, P = 0.297, P > 0.05). An understanding of water motion is essential to understand ecological adaptations of sessile marine fauna and flora. This method can be applied to obtain measurements of seawater motion even in slowly moving situations as it is simple and convenient.

Keywords:seawater motion, wave speed, plaster balls, coral reef, Polhena

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#### Introduction

Water motion is a critical parameter in marine environments, determining the distribution of sessile fauna and flora.Rate of water motion in the environment affects growth rate and distribution of marine organisms such as corals, phytoplankton and seaweeds (Thompson and Glenn, 1994). Measurement of seawater motion is challenging, because it is difficult to measure wave speed with a propeller type of current meter in shallow coastal reefs. There are sophisticated equipment (e.g. Electro-magnetic current meters) to detect wave speed, but they are very expensive, difficult to transport and use in shallow waters. Several methods for measuring time-averaged intensities of water motion have been devised. These include the increase in rust weight on iron plates in proportion to intensity of water motion (Matsudaira et al. 1967), dry weight loss of plaster balls (Muss 1968) and dry weight loss of plaster clods attached to plastic cards (Doty, 1971) those which placed on the sea bottom. There were difficulties in using rust accumulation as rate depends on oxygen content of the seawater (Komatsu and Kawai, 1992). In addition, all other methods by Muus (1968) and Doty (1971) were to estimate intensities of water motion only at the sea bottom not in the water column. The aims of this study were to, 1) develop a method to measure time-averaged intensity of water motion with plaster balls by setting them in the water column below the low tide level and 2)

compare time-averaged water motion at two reef locations ("off-shore" at the middle of the reef platform and "near-shore" at the edge of the reef platform towards the shore) at Polhena reef.

# Materials and methods

**Site selection:** The current study was conducted on Polhena reef situated in the southern coastal region of Sri Lanka and two reef locations were selected as "off-shore" at the middle of the reef platform and "near-shore" at the edge of the reef platform towards the shore.

**Preparation of plaster balls**: Plaster of Paris was mixed with water and poured into plastic balls (mould). They were allowed to solidify. Plaster balls were dried in an oven in  $105^{\circ}$ C to a constant weight and the initial values were recorded.

**Laboratory experiment:** A laboratory set-up was used to calculate the weight loss of plaster balls exposed to a known speed of seawater motion. A plaster balls with known weights were placed in a container in a practical set-up and seawater with known speed ( $0.0482 \text{ ms}^{-1}$ ) was allowed to move through the container for 60 seconds and it was repeated for another 2 plaster balls separately. Finally, the loss of averaged dry weight ( $0.0037 \text{ gs}^{-1}$ ) of those plaster balls were calculated. That value was use to calculate the seawater motion in real marine environment, considering the average weight loss of plaster balls installed in-situ.

**Field installation of plaster balls:**Six plaster balls were fixed in the reef at each location. Two nylon ropes were attached to each ball. One rope was attached to the reef, while a buoy was attached to the other rope keeping the plaster ball suspended in the water column. They were allowed to dissolve for 6 hours. They were collected and carefully transported to the laboratory. Weight loss of plaster balls were measured after drying those balls to a constant weight using a drying oven (nearly 24 hours). Calculations were done to obtain time-averaged seawater motions at two locations of the reef. The field studies were conducted on November 23, 2015.

**Our assumptions:**1) There is unique dissolution over the entire surface of plaster balls, 2) There is unique dissolution rate over the given time and mass losses of balls are directly proportional to flow rate, 3) The shape of the plaster ball (ball shape) does not affect for dissolution rate and 4) There were no any water quality changes (salinity, turbidity, pH.etc) during the study period.

# Results

Laboratory experiment revealed that the mean weight loss of plaster balls was 3.72 mgs<sup>-1</sup> with 0.0482 ms<sup>-1</sup> seawater speed. Time-averaged seawater motion was calculated by dissolution of plaster balls which were placed at off-shore and near-shore locations of Polhena reef by using above data. There was higher time-averaged intensity of seawater motion (0.0233  $\pm$  0.0004 SE) ms<sup>-1</sup> at off-shore location than at near-shore locations (0.0222  $\pm$  0.0008) ms<sup>-1</sup>. However the difference was not significant (Two sample t-test; T = 1.20, DF = 4, P = 0.297, P > 0.05).

# Discussion

The mean time-averaged water motion at Polhena reef was 0.0227 ms<sup>-1</sup>. There was comparatively higher time-averaged water motion at off-shore location (0.0233) than the near-shore location (0.0222). Differences in water motion may contribute to the distribution pattern of benthic organisms at this reef. High speed of waves can break the branching corals thus promoting other growth types such as encrusting corals. Senarathna *et al.* (2013) found that encrusting *Montipora* species dominated at off-shore locations, while the branching Pocilloporids were more abundant at near-shore locations. That may be because higher velocity may result in breakages of branching corals at off-shore locations, thus encrusting *Montipora* species may abundant at that location. Therefore water motion is an important parameter to be concerned in ecological studies in coral reefs.

	Mean dissolu	ition rate of plaster bal	1	Mean seawater motion (ms <sup>-1</sup> )		
Time (s)		(mgs <sup>-1</sup> )	Mean seawa			
	Off-shore	Near-sho	re Off-shore	Near-shore		
60 *60*6	1.796	1.716	0.0233	0.0222		
Mean (+/-) SE of back and forth water motion (ms <sup>-1</sup> )	0.024 0.0235 0.0225 0.0225 0.0215 0.0215 0.0211 0.0205 0.022	Off-shore location	Near-shore location			

Table 1. Calculation of time-averaged seawater motion at two reef locations at Polhena reef.

**Fig 1:** Time averaged intensity of water motion (ms<sup>-1</sup>) at off-shore and near-shore locations of Polhena reef

There were research limitations and improvement of this study in future. Numbers of replicates have to increase with the extended time periods to monitor the dissolution of plaster ball throughout a day (24 hours) and compare with water quality parameters. Studies have to focus onwet weight than dry weight as it is convenient. A laboratory experiment has to examine whether the dissolution rate change with the reduction of the size of plaster ball, and it will be easy to conduct this experiment when using the wet weight. A more robust ball holding unit has to be developed rather than using two ropes to keep the ball in water column.

# Conclusion

Use of plaster balls to determine seawater motions at shallower reef is a cheap and convenient method. This study found that the mean time-averaged intensity of seawater motion at Polhena reef was 0.0227 ms<sup>-1</sup> and it was changed from place to place. Off-shore locations exhibited comparatively higher water motions than the near-shore locations. Water motions might impact on the type of existing sessile fauna at different locations of the reef.

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# Investigating the impact of salinity level on growth and lipid accumulation in*Chlorella vulgaris* as a feedstock for biodiesel production

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# Abstract

High biomass and lipid production are the two most important desirable characteristics of a microalgae species in order to consider it as a suitable feedstock for intensive biodiesel production. It is reported that changes in environmental factors such as, light, salinity and nutrient availability can affect these characteristics of microalgae. Therefore, the research aim was to study the effect of salinity on the growth and the lipid content of the microalgae, *Chlorella vulgaris* because of its potential utilization as feedstock for biofuels. *Chlorella vulgaris* was grown in eight different salinity levels; 35, 30, 25, 20, 15 10, 5 and 0 ppt for 21-day growth period in an outdoor culture system. At the end of the growth cycle, cells were harvested by flocculation and dry weight and the percentage lipid content were estimated.

*Chlorella vulgaris* was able to tolerate all the salinity levels, but showed significantly different growth and lipid accumulation rates at different salinities. The highest dry biomass weights (0.77, 0.78, 0.83 and 084 g/l) were observed when cells were cultured at lower salinities (15, 10, 5 and 0 ppt respectively). The highest salinity (35 ppt) saw the lowest dry biomass weight (0.24 g/L). *Chlorella vulgaris* also showed decreased lipid contents when the salinity was increased. Percentage lipid content was significantly higher (14.6 %) at 5 and 0 ppt salinity levels, and this was about three times higher than lipid accumulation at the highest salinity (35 ppt). The present study concluded that the lower salinity levels of 5 and 0 ppt are the optimum levels for culturing *Chlorella vulgaris* for biodiesel production, as these salinity levels reported the significantly highest lipid yield of 0.12 g/l.

Keywords: dry weight, lipid yield, Chlorella vulgaris, salinity

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# Introduction

Fuel production from phyto-biomass is increasingly important these days due to problems with global warming, pollutants emission and increases in the cost of petroleum fuels. Further, it is understood that the present petroleum reserves are to be depleted in less than 50 years at the present rate of consumption (Huang*et al.* 2010). Therefore, in recent years biodiesel has received considerable attention as a biodegradable and renewable source of energy. Production of biodiesel from microalgae is a newly emerging field because of their high oil content and rapid biomass production. They are one of the fastest growing photosynthesizing organisms and can complete an entire growing cycle every few days. Further, microalgae are capable of utilizing a wide variety of water sources, such as fresh water, marine water, brackish water and waste water (Huang *et al.* 2010). Therefore, microalgae have strong potential as a biofuel feedstock that will not compete with production of food, fodder and other products derived from crops for food production.

Some species of microalgae already possess high oil concentrations and these can be manipulated to produce more oil. According to previous studies, the lipid content in some microalgae could be increased by changing the nutrient concentration, temperature,  $CO_2$  aeration, salinity and light intensity (Gu*et al.* 2012). Accordingly, the main objective of the present study was to determine the effect of salinity on the cultivation of a robust microalgae species, *Chlorella vulgaris*, in order to determine the best conditions to maximize the lipid yield for biodiesel production.

# **Materials and Methods**

For determination of optimum salinity level, *Chlorella vulgaris* was cultured in eight different salinity levels; 35, 30, 25, 20,15 10, 5 and 0 ppt in an outdoor culture system using Guillard and Ryther's modified F/2 media (Guillard, 1975) as the nutrient media for 21 days growth period. The cultures were aerated with mechanical aerators. All the glassware and media were sterilized prior to inoculation. All the experiments were carried out in triplicates. The cultures were harvested during the stationary phase of the growth cycle by chemical flocculation method using NaOH as the flocculent agent. The cells were washed three times with distilled water and dried in an oven for 6 hours at 105 °C for dry weight estimation. The lipid contents of the dried algal samples were then determined using a Soxlet apparatus. The statistical analysis was done by using Minitab 14 version. One-way Analysis of Variance (one-way ANOVA) was performed at 95 % level of probability in order to test the significance differences of lipid content and growth performances under different treatments. When the test reported  $p \le 0.05$ , a Turkey post-hoc test was performed for pair wise comparisons.

### **Results and discussion**

*Chlorella vulgaris* was able to tolerate all salinity levels, but showed significantly different growth and lipid accumulation rates at different salinities. The effects of salinity on dry weight and lipid content of *Chlorella vulgaris* are shown in Fig. 1 and 2. Results revealed that, dry biomass weight in the cultures with different salinity levels were significantly different ( $p \le 0.05$ ). The significantly highest dry biomass weight of 0.77, 0.78, 0.83 and 0.84 g/l was observed when cells cultured at lower salinities of 15, 10, 5 and 0 ppt respectively. The highest salinity (35 ppt) gave the significantly lowest dry biomass weight of 0.24 g/l. Rao*et al.* (2007) showed reduced growth in some microalgal species at higher salinities due to decreases in photosynthetic rate. Some previous studies also reported that many freshwater species are able to withstand higher salinity ranges (Ruangsomboon, 2014).



Fig. 1: Dry weight of Chlorella vulgaris under different salinity levels



Fig.2: Lipid percentage of Chlorella vulgaris under different salinity levels



Fig.3: Lipid yield of Chlorella

There were also significant differences in the percentage lipid content in different treatments of salinity levels (Fig. 1).*Chlorella vulgaris* showed remarkably decreasing lipid content when increasing the salinity. Percentage lipid content was significantly higher with 14.6 % lipid accumulation at 5 and 0 ppt salinity levels, and these were about three times as high as lipid accumulation at the highest salinity (35 ppt). Finally, the overall lipid yield (dry weight x percentage lipid content) was significantly higher in 5 and 0 ppt salinity levels with 0.12 g/l lipid yield (Fig. 3).

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# Fisheries Socio-economics and Marketing

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# Daily routing activities of the fisherwomen in the North-Western Province of Sri Lanka

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# Abstract

This paper explored daily routing of fisherwomen in north western province of Sri Lanka and found that throughout the day they have engaged in many paid and non-paid activities for the wellbeing of their families. It was revealed that 98 present of fisherwomen did not engage in full time job but support their families through productive activities by spending 19 hours and 45 minutes per day .Family supported activities were preparing meals, cleaning and gardening, washing cloths and social activities while leisure, sleeping and having meals were non-productive activities that women have performed .Among un-paid productive activities there were 66 present of fisherwomen whom supported for their husbands who engaged in active fishing through sorting out of fish and repairing fishing gear that spending 3 hours per day.

Keywords: fisherwomen, daily routing, paid work, none paid work, North Western Province

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# Introduction

Although the involvement of women in the fisheries has been recognised globally (Williams, 2008) more remains to be done to recognise and understand women's work in these sectors (Weeratunge *et al.*2010). The lack of gender disaggregated data of fishers globally has hindered the recognition of the role and "invisible" work of women in the fisheries and fisheries production sector (Choo *et al.* 2008). Nevertheless, the situation is same in Sri Lanka. Lack of data and information on economic and social activities of fisherwomen and time of a day they spend daily on those activities is hindered the planning of productively utilization of their spare time on household economic development activities. Therefore, this study planed with the objective of identifying the daily routing of fisherwomen and their contribution for the household economic and social development in North western province of Sri Lanka.

# **Materials and Methods**

Australian Bureau of Statistics (2010) and New Zealand statistic department (2014) were divided household activities into two categories such as productive and non-productive based on the 'third party criterion', which states that an activity is productive if the person can delegate it to a third party (and other person can still derive benefit). Accordingly, for an example, preparing a meal is productive while eating it is not productive. Productive activities

again can be further divided into paid and unpaid. Some of the productive activities do not yield direct financial benefit which are called un-paid activities. Based on the above conceptualization a questionnaire survey was conducted to gather primary data during the time period of January to December in 2014. The sample frame was the North-western province and a sample of 197 fisherwomen was drawn by using random sampling technique. In detail, 86 and 111 samples were represented for Chilaw and Puttalam districts respectively. Descriptive statistics and parametric statistics were used to analyse the data.

# **Results and Discussion**

The majority of the fisherwomen (98%) in north-western province did not engage in full time income generated activities but of them 58% were directly contributing for their household income generation through paid-productive activities. Dried fish production and processing, producing coir based products, cultivating vegetables in home gardens, animal husbandry, selling wet fish and maintaining retail shops were the main self-employment activities while working as paid casual labourers in sorting out of fish at the beach or landing centre were fishing related paid activities that women involved. Throughout the day they have engaged in many productive and non-productive activities for the wellbeing of their families. These activities performed by fisherwomen were grouped into principal functions and average time spent on each activity is shown in Table 1.

Description	Hours per day	Percentage of women
Un -paid productive activities		
Preparing meal	3	100 %
Look after infants	12	18 %
Caring children	4	64 %
Caring adults	3	22 %
Cleaning and gardening	3	100 %
Washing cloth	1	100 %
Social activities	1	100 %
Fishing related activities	3	66 %
Paid productive activities		
Self -employments	6	16 %
Government and private sector employments	8	2 %
Fishing related activities	4.75	47 %
Non -productive activity		
Leisure activities and associate with friends and relatives	2.75	100 %

Table 1. Activities performed and time spend by fisherwomen of the day

Sleeping	7.5	100 %
Having meal	1.5	100 %
Religious activities	0.5	87 %
Watching TV	1.6	92 %

N.B. Fish processing done in fish catching high days only.

It is clear that preparing meals, cleaning and gardening, washing cloths and social activities are unpaid activities that performed by all fisher women and have collectively spent 8 hours by each woman per day. On the other hand a woman had spent 11hours and 45 minutes on non-productive activities such as leisure and associate with friends, sleeping and having meals at home per day. All together all fisher women in the province have spent 19 hours and 45 minutes for the above mentioned productive and non-productive activities while the rest of the time or 4 hours and 15 minutes for other activities per day. Among un-paid productive activities there were 66% of fisherwomen whom supported for their husbands who engaged in active fishing through sorting out of fish and repairing gear. They have spent 3 hours for those activities such asfish selling and dried fish production and processing and have spent 4 hours and 45 minutes per day.

# Conclusion

This paper explored daily routing of fisherwomen in north-western province of Sri Lanka. The research found that a number of productive and non- productive activities were performed by the fisherwomen spending 19 hours and 45 minutes out of 24 hours of the day. Although they had spent8 hours in productive activities they were un-paid. There were 66 percent of fisherwomen that performed fishing related un-paid productive activities and had spent 3 hours per day. Results demonstrated that contribution of fisherwomen was inevitable to smooth functioning and wellbeing of their family.

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# An analysis of net income of different craft and gear combinations in the Puttalam lagoon in Sri Lanka.

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# Abstract

This paper reviews and compares the net income per trip by craft and gear combinations in the Puttalam lagoon in Sri Lanka. A semi-structured questionnaire survey was conducted among the sample drawn from fiber reinforces plastic boats (OFRP), motorized traditional boats (MTRB) and non-motorized traditional boats (NTRB) operated for crab and shrimp fishery in the Puttalam lagoon from January to December in 2015. A total number of craft sampled were 165 of which 65, 52 and 48 numbers of craft representing OFRP, MTRB, and NTRB. The data analysis performed using SPSS and EXCEL packages. To compare net income and to examine significance of income between and among different craft/gear combinations descriptive statistics were used. While Analysis of Variance (ANOVA) was used find the significant differences of the income of the craft type. The results indicated that craft/shrimp net combination for OFRP, MTRB and NTRB earned higher net income compared to craft/crab net combination for same craft. As a result of law harvest of the higher prices species of the crabs. However, ANOVA test proved that the inter craft category net income differences not significant. Therefore, findings of this research suggest promoting non-motorized craft/gear combinations for fishing in the Puttalam lagoon.

Keywords: Puttalam lagoon, craft/gear combination, net income

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### Introduction

Lagoons provide and an array of ecosystem services of which some them are vital for the livelihood of surrounding communities. Among them fishing is the foremost and significant economic activity across all lagoons and estuaries in Sri Lanka. Puttalam Lagoon is one of the largest brackish water bodies of Sri Lanka, extending over 32,750 ha, which supports 5926 fishers for their livelihood (IUCN, 2012). Generally, it was pointed out by many scholars that there are many knowledge gaps with respect to socio-economic aspects of lagoons (Silva *et al.* 2013), which is no exception for the Puttalam lagoon. Fishing in the lagoon is carry out by using fiber reinforced plastic boats (OFRP), motorized traditional boats (MTRB) and non-motorized traditional boats (NTRB). A large variety of fishing gear types are in use for fishing in the Puttalam lagoon and among them crab net and shrimp net are common for all types of craft. This paper reviews and compares net income of different craft and gear combinations for crab and shrimp fishery in the Puttalam lagoon.

# **Material and Methods**

There were about 2145 fishing crafts operated in the Puttalam lagoon consists of 778 OFRP, 162 MTRB and 1204 NTRB craft (IUCN, 2012). Hundred and sixty five fishing families were randomly selected; 65, 52 and 48 numbers of craft representing OFRP, MTRB, and NTRB respectively. Data were collected representing all fisheries Inspector Divisions around the lagoon, administering a semi-structured questionnaire, from January to December 2015. ANOVA and Cross tabulation techniques were used to find mean variance of the income by craft and gear combinations.

# Results

More than 90 % of the lagoon fishers engage only fishing activities for their occupation and more than 50 % of the fishing families comprise 4-5 family members. Considered to the education level of the fishers, 40 % and 53 % of the fishers attended school below grade 5 and 6- O/L gradually. Since 65 % of the lagoon fishers have more than 15 years of experience, fishing in the lagoon is highly competitive. Hence, fishers try to practice different fishing techniques using size of fishing gear, which is changed by themselves. The main fishing gear used by craft were crab nets and shrimp nets. These two fishing gear were alternatively operated by fishing craft depending on season and projected catch rates. The unit of analysis was based on same craft with different fishing gear combinations. Table 1 indicates the operational aspects of selected craft/gear combinations.

 Table 1. Net income, average fuel consumption and average catch per trip by different craft/gear combinations

Craft/gear	r combination	Mean net Income of the fishing unit per trip (after reduce the fuel cost)	Average Fuel consumed (l)	Average catch per trip (kg)
NTRB	Crab net	1027	0	3.6
	Shrimp net	1157	0	2.2
MTRB	Crab net	954	12.2	5.6
	Shrimp net	1493	12.7	5.2
OFRP	Crab net	2542	14.8	7.7
	Shrimp net	2710	13.3	6.8

The results show higher net income for shrimp net/ craft combination than crab net/craft combination for the respective types of craft. However, there were no significant difference in catch rates for crab net and shrimp net. Quantity harvest of the high valued crabs (mud crab) is low compared to the shrimp catch. However average day catch of the law valued crab is higher. The difference in craft wise net income is not explained by fuel cost as it was more or less similar for MTRB and OFRP craft. The variation in catch rates resulted in differences in net income for MTRB and OFRP craft. The highest net income per craft /gear combination observed for OFRP craft and followed by MTRB and NTRB craft. In terms of variable input

costs NTRB shows highest cost effective income due to zero fuel cost. Therefore, an ANOVA test was run to find out to reveal significant differences in income for craft/gear combinations. Table 2 shows results of tests of between subjects- effects. The above result shows that there is no significant effect (P > 0.05) of craft, gears, and craft/gear combinations for the income of the fishing unit.

# Conclusion

Fishing unit with motorized craft in the Puttalam lagoon for crab net and shrimp net fishery were earned higher net income compared to non-motorized traditional craft. However, it was proved by ANOVA test that there are no significant differences of net income of NTRB, MTRB and OFRB craft for respective gear combinations. The exogenous costs (fuel) for motorized craft make negative externalities for both economy and environment. Hence, in respect to Puttalam lagoon it is recommended to promote non-motorized craft for fishing than motorized craft.

Source	Type III Sum of Squares	df	Mean Square	F	Significance.
Corrected Model	39510200.420 <sup>a</sup>	5	7902040.08	1.217	0.309
Intercept	213704179.368	1	213704179.36	32.916	0.000
Fishbo	34342768.561	2	17171384.28	2.645	0.077
fishgr	1535262.652	1	1535262.65	0.236	0.628
Fishbo * fishgr	736255.068	2	368127.53	0.057	0.945
Error	506413781.723	78	6492484.38		
Total	755147850.000	84			
Corrected Total	545923982.143	83			

Table 2. Tests of Between-Subjects Effects ( Dependent Variable: Net Income\_

a. R Squared = .072 (Adjusted R Squared = .013)

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