Preliminary Assessment of Marine phytoplankton Distribution and Fishing in Sri Lanka

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Abstract

Phytoplanktons are the primary producers in marine food webs. The concentration of the chlorophyll-*a* (Chl-*a*) shows their abundance among the habitat, estimated by using remote sensing data. Marine fish harvest mainly depends on Chl-*a* and sea surface temperature (SST) due to food web connectivity. Eight fishing zones of Sri Lanka studied for the average values of Chl-*a* and SST in 12/24 nmi (nautical miles) shoreline bands in each fishing zone subjected linear regression analysis. Southeast zone in 24 nmi showed the highest average Chl-*a* (2.54 mg/m^3), followed by south (2.14 mg/m^3) and north (1.69 mg/m^3), while the lowest averages found in the northeast (0.36 mg/m^3) zone of Sri Lanka. Although results of linear regression suggest preliminary insights for a weak relationship between the fish-catch and Chl-*a* and SST in Sri Lanka. Southwest zone produces high unit fish-catch of 18.42 Mt/km^2, while the lowest on North (3.90 Mt/km^2).

Keywords: chlorophyll-a, fishing zone, fish-catch, SST

Introduction

Sri Lanka is an island located in the Indian Ocean, having a total land area of 65,610 km^2 approximately (Wanninayake, 2017). Due to the geographical location of Sri Lanka and situated within the tropics between 5°55' to 9° 51' North latitude and between 79° 41' to 81° 53' East longitude (DoM, 2016) the climate of the island dominated by the southwest and northeast monsoons which are regional scale wind regimes in the Indian subcontinent. The island nature with the shelf sea, fishing has been the principal livelihood of the coastal communities (Edirisinghe*et al.*, 2018). Phytoplanktons are one of the critical marine species that influence ocean primary productivity for nearly 95% (Morin *et al.*, 1999). Light and nutrients are the critical parameters act upon maintaining the essential ecosystem function sustaining marine productivity (Lyngsgaard *et al.*, 2017). This study mainly focuses on changes in fish-catch due to food web connectivity of marine phytoplankton (i.e. primary producers remotely sensed by using chlorophyll-a (Chl-*a*) content) and sea surface temperature (SST). Shelf sea is the shallow water present above the continental shelf. Although the shelf sea occupies only approximately 10% of the world ocean, neritic phytoplankton contributes about a quarter of global primary production that underpins marine food webs and regional fisheries (Fehling *et al.*, 2012). Changes in SST, phytoplankton (i.e. primary producers consist Chl-*a*), pollution levels and other environmental factors profoundly influence the temporal and spatial distribution of phytoplankton functional groups and even species level. This study is an attempt to explore the possible influence of Chl-*a* and SST concerning the marine fish-catch in Sri Lanka.

Methods

Marine fish-catch in Sri Lanka collected from the secondary data sources on a monthly and zone basis for the year 2017 is from the Statistics Unit of Ministry of Fisheries and Aquatic Resource Development. Monthly fish-catch further categorised into eight zones (Maldeniya, 2013) to study interconnection with fish-catch, Chl-a and SST.Satellite imageries from Ocean Color Web (https://oceancolor.gsfc.nasa.gov/) used to extract the Chl-a and SST data. Particular MODIS satellite use Aqua sensor to find the validated data of Chl-a concentrations and SST at a resolution of 4 km. Random points of 5,000 and 10,000 generated for 12 and 24 nautical miles (nmi) which are territorial sea and continental zone of shoreline bands to cover the Indian Ocean area from the boundary of Sri Lanka, respectively (Tantrigoda, 2010) (Figure 1).

Moreover, 12 and 24 nmi zones are of economic importance in terms of marine fish-catch in Sri Lanka. The satellite imageries of 12 months for the year 2017 were acquired to extract the Chl-$a$and SST independently. The area for individual zones extracted for 12 and 24 nmi by using the spatial analysis tool ArcMap, for further analysis.

Pixel extraction tool in NASA SeaDAS ver7.5.3 utilised to extract the data from predefined random generated points by feeding the latitude and longitude. After obtaining the values of Chl-a and SST for random points, the spatial analysis performed by using the ArcGISver10.2 to execute geostatistical analysis and data visualisation of the data. The average (Avg.) values of Chl-a and SST in each fishing zones and 12/24 nmi shoreline bands computed for further statistical analysis. Computed averages used to fit against the fish-catch by using the Minitab ver18 statistical package. Finally, inferential statistical techniques such as correlation and linear regression analysis performed and results interpreted.

Results and discussions

During the data processing, we found that the year 2017 around Sri Lankan shoreline, annual average SST was 28.15 °C, and the average Chl-a was 1.35 mg/m^3 in the 24 nmi belt and for 12 nmi figures were 28.27 °C and 1.02 mg/m^3 respectively. The response obtained from each of the fishing zones concerning 12 and 24 nmi for maximum and minimum values shown in table 1. Southwest zone produced high fish-catch concerning the area (18.42 Mt/km^2) (see figure 2).

Table 1: Summary of minimum and maximum values of Chl-a and SST in fishing zones of Sri Lanka for the 12 and 24 nmi shorelines

Zone	**SST (°C)**		**Chl-*a* concentration (mg/m^3)**	
	Maximum	Minimum	Maximum	Minimum
12 nmi	28.56, East	28.05, Southeast	1.85, Southeast	0.30, Northeast
24 nmi	28.36, Northwest	27.87, Southeast	2.54, Southeast	0.36, Northeast

The Chl-a distribution showed a weak positive linear correlation with the fish-catch, ($r = +0.179$ and $r = +0.248$ for 12 and 24 nmi, respectively) which emphasises when the phytoplankton concentration is high, the probability of fish caught was also high. The SST showed a weak negative linear correlation with the fish-catch, ($r = -0.252$ and $r = -0.246$, respectively) might be due to the sensitiveness of phytoplankton for the SST eventually decreased the fish-catch in the respective zones. The relationship between the Chl-a and SST revealed that they have a negative and weak linear correlation among them. Whenever the SST increase in the ocean leads to a decrease in surface Chl-a content (Figure 3), agrees with previous findings regarding the fish-catch and SST. Although not significant, results of linear regression suggest a weak relationship between the fish-catch and Chl-a and SST in Sri Lanka. This preliminary study is crucial to understand the distribution of phytoplankton and its contribution to the marine fish-catch in Sri Lanka. Table 2 presents the preliminary results of the summary of the average values of Chl-a/SST in the fishing zone and shoreline band, separately. Preliminary results suggest possible dynamics between Chl-a and SST.

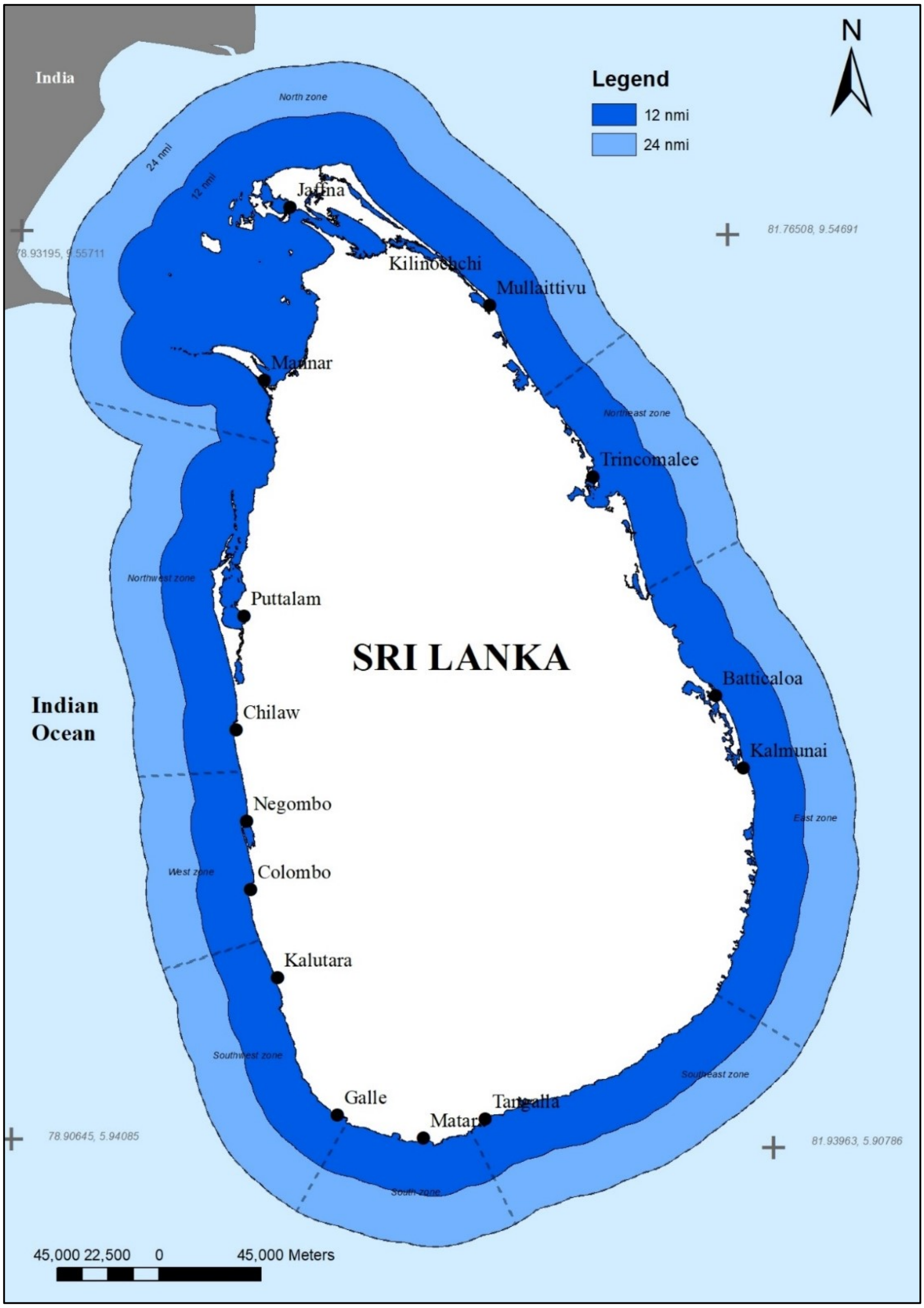

Figure 1: Study Area (Kilinochchi fishing district represent the fish-catch from the Poonakari Lagoon and the Karaichchi Pradesha Sabha)

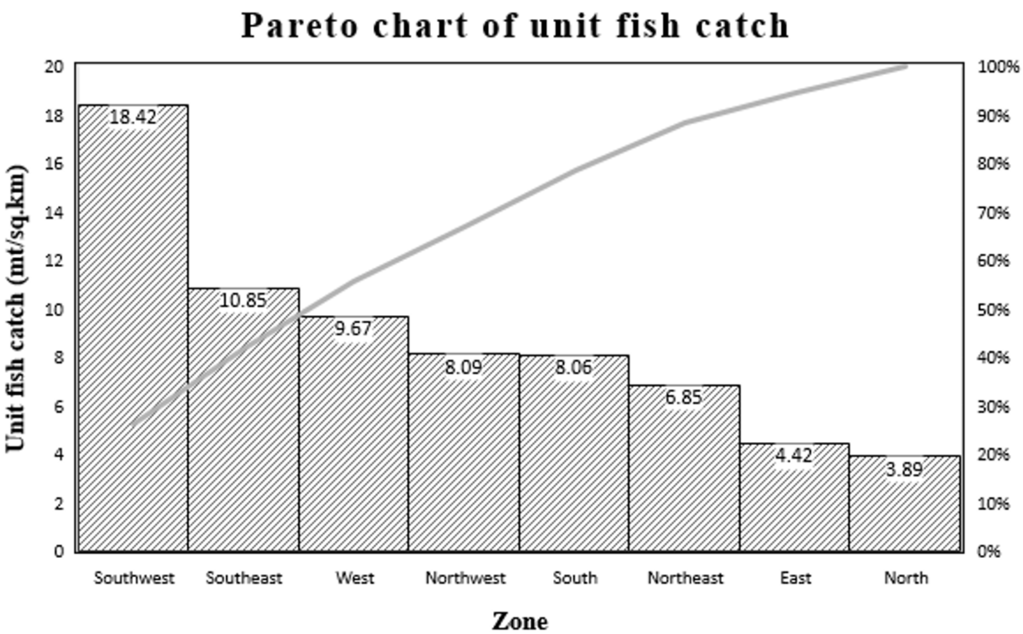

Figure 2: Unit fish-catch in marine fishing zones (in 2017)

In the economic aspect of the ocean, fish-catch is an important phenomenon that is happening. This study mainly focused on the relationship between marine fish-catch with the Chl-*a* and SST distribution in Sri Lanka coastal waters up to 24 nmi. Chl-*a* has interpreted as the phytoplanktons because it is a significant component in it.

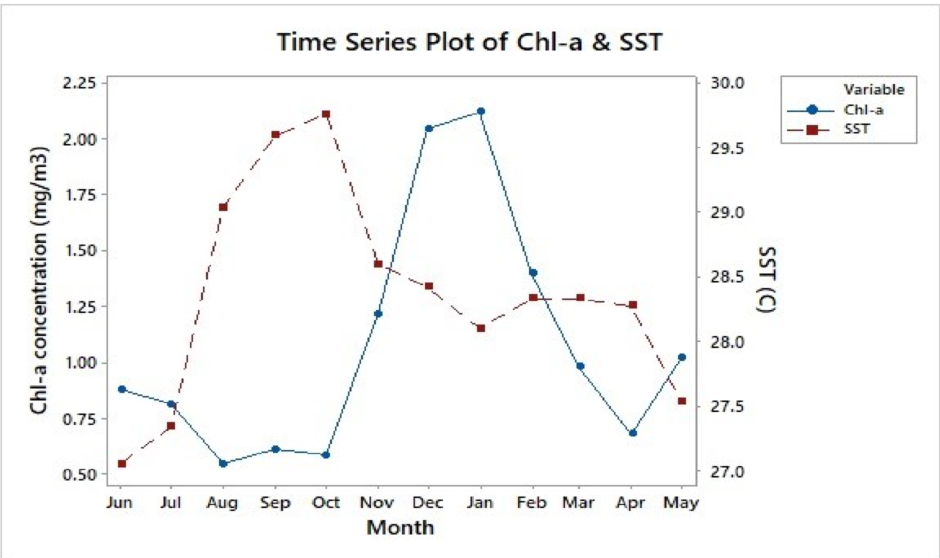

Figure 3: Changes in monthly averages of SST and Chl-*a* around Sri Lankan coastline at 24 nmi

Table 2: Summary of Chl-a and SST averages in fishing zones of Sri Lanka for the 12 and 24 nmi shorelines

Zone	Area (km^2)	Fish-catch (Mt)	Unit fish-catch (Mt/km^2)	12 nmi			24 nmi		
				Number of random points	Avg. SST (°C)	Avg. Chl-*a* (mg/m^3)	Number of random points	Avg. SST (°C)	Avg. Chl-*a* (mg/m^3)
East	10041.90	44380	4.42	758	28.56	0.36	1598	28.33	0.39
North	21332.10	83155	3.89	1865	28.34	1.46	3384	28.17	1.69
North east	4877.27	33410	6.85	401	28.42	0.30	791	28.13	0.36
North west	8131.75	65800	8.09	658	28.30	1.09	1298	28.36	1.52
South	3571.02	28800	8.06	241	28.10	1.59	588	27.95	2.14
South east	6269.48	68050	10.85	446	28.05	1.85	977	27.87	2.54
South west	4896.18	90190	18.42	339	28.17	0.69	767	28.07	0.89
West	3688.61	35655	9.67	292	28.26	0.84	597	28.33	1.27
Total/ Avg.	**62808.31**	**449440**	**8.78**	**5000**	**28.27**	**1.02**	**10000**	**28.15**	**1.35**

Conclusions

This study attempted to find the relationship between marine zonal fish-catch and Chl-*a*/SST distribution in the Indian Ocean waters owned by Sri Lanka. In this study, we focused on the 12 and 24 nmi since they are of economic importance in terms of marine fish-catch in Sri Lanka. At the 24 nmi boundary, the 2017 annual average SST found to be 28.15°C, and the average Chl-*a* was 1.35mg/m^3. For the 12 nmi, annual average SST found to be 28.27°C, and the average Chl-*a* was 1.02 mg/m^3. The Chl-*a* distribution showed a weak positive correlation with the Chl-*a*, emphasise when the phytoplankton concentration is high, the probability of fish caught was also high. The SST showed a weak negative correlation with the fish-catch, maybe due to the sensitiveness of phytoplankton for the SST eventually decreased the fish-catch in the respective zones. The relationship between the Chl-*a* and SST revealed that they have a negative and weak correlation among them. Whenever the SST increase in the ocean leads to a decrease in surface Chl-*a* content, in that case, we proved above mention results regarding the fish-catch and SST. This preliminary study is crucial to understand the distribution of phytoplankton which affect the marine fish-catch in Sri Lanka.

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