Vidyodaya J. of Sci, (1999) Vol 8 161-171

A preliminary studies on fish production in relation ot primary production of the western coastal waters in sri lanka

R R M K P Ranatunga
Department of Zoology, University of Sri Jayewardenepura, Nugegoda, Sri Lanka.

Received on 99.03.03
Accepted on 99.06.18

Abstract

The present study deals with an account of the results of an investigation on plankton primary production using Oxygen technique in the coastal waters of the western coast in Sri Lanka. Magnitude of primary production and its monthly variations were studied. Factors governing the primary production such as; transparency of water, temperature, phytoplankton density, and dissolved nutrient concentration, their variation in time have discussed and an attempt has been made to relate these parameters with primary production. Mean photosynthetic rate measured over the continental shelf of west coast was 0.944 g Cm^{-2} d^{-1}. This would amount to an annual gross production of 344.0 g C m^{-2}.Depth integrated total primary production from the continental shelf of west coast for an area of 1050 km^2 was 361830 tones. The present fish yield from the same area is around 2000 tones (200 tones in terms of Carbon), which is only 0.06 percent the Carbon produced by primary production. Compare to intensely exploited waters where, 0.2-0.3 percent of the primary production is harvest as fish, potential harvest from the western shelf waters would be 31/2 to 5 1/2 times the present yield.

Key words: Primary production, fish production, west coastal waters of Sri Lanka.

1. Introduction

The synthesis of organic matter of higher potential chemical energy from the inorganic substances is referred to as *primary production*. The plankton algae are the prime synthesizers of the marine habitats (Tait, 1981). Total amount of Carbon fixed by autotrophic production is termed *Gross Primary Production* (GPP), and some of the organic matter manufactured are broken down to inorganic state by plants during their respiration, reminder is referred to as *Net Primary Production* (NPP). Much of this NPP

become new plant tissues and balance assimilates through the trophic levels. Therefore, the animal population of the sea depends directly or indirectly on the primary production of the area (Raymont, 1980).

Sri Lanka has 1760 Km. long coastline, continental shelf which is 6 percent the Exclusive Economic Zone (EEZ), is very narrow, rarely extending 40 km and averaging around 25 km in width has total area of 30200 km^2. Coastal fishery resource (excluding Aquaculture) contributed to about 65 percent of the marine fish production in 1997.

A systematic study encompassing primary production and plankton density of the coastal waters around Sri Lanka hitherto has not been carried out. Therefore the main objectives of the present study were to study the magnitude of the primary productivity, plankton density, their relationship to dissolved nutrient concentrations, water transparency and temperature of the west coastal waters of Sri Lanka, and to relate these parameters to fish production of the area.

As the size of different animal populations in the sea depends ultimately on the size of the primary production, its estimates provide at least partial answers to the questions raised by fisheries scientists; where and When we can find the living resources?, How large are these resources?, What is the maximum sustainable yield we can obtain?. In addition estimates of the ratio of the present yield to that of potential yield would provide good base data to scope for further exploitation.

2. Materials and methods

Present study was carried out in the continetal shelf waters off Moratuwa, Moratu-modara and Mount-lavinia in the west coastal waters of Sri Lanka. Study was stretched over a period of nine months from September 1997. Samplings were carried out fortnightly. For the major location (off Moratuwa) three stations (A,B and C) were selected, at a distance of 3km, 3/12 km and 4 km from the shore.

For the minor two locations (off Moratu- Modara and Mount-Lavinia) shallow waters adjacent to shore at a distance of 100-150 m were selected. locationsSampling and stations are shown in figure 1.

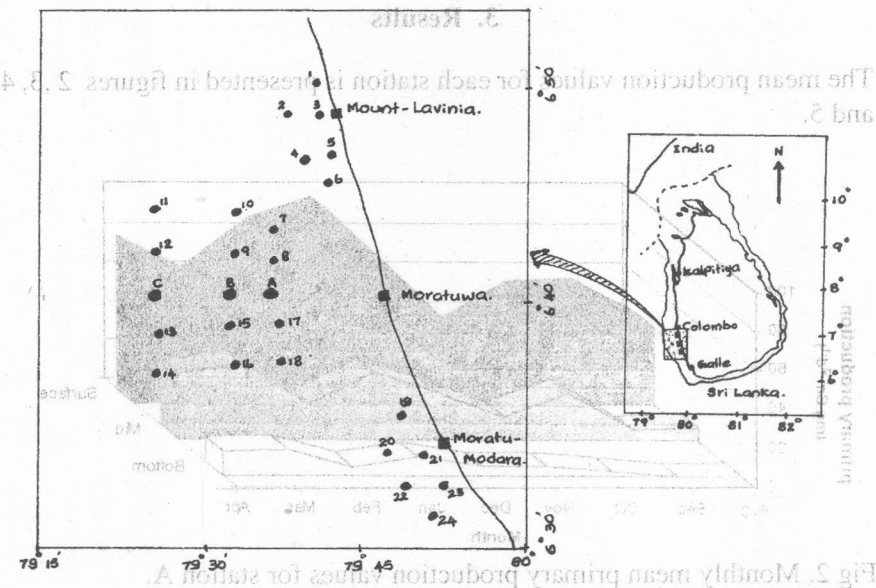


Fig 1. Map of the study area showing sampling stations

At each station water samples were collected from surface and at depths 10 m and 20 m for the determination of temperature, Dissolved nutrient salts (nitrate and phosphate), plankton and plankton primary production. Temperature measurements were taken along with the water samples. For the sub-surface temperature readings a *reversing thermometer* was used. At each station transparency of water was measured using a secchi disk. Euphotic limit (depth in which 1 percent of the surface light penetrates) was considered as 2.5 times the secchi depth. Dissolved Oxygen concentration was measured using Winkler's procedure and dissolved nutrient concentrations were measured using standard methods (Stirling,1985). Plankton samples were collected from the upper and lower 5 meters of the euphotic column using a 50 μ closing type plankton net. Photosynthetic rate was measured using "Light and Dark bottle" method (Strickland and Parsons, 1972). Bottles were set at surface, mid and bottom to represent euphotic column, and incubated for 6-10 hours. Primary production values measured in mg Cm^{-3} d^{-1} were integrated to obtain column production, and values in g Cm^{-2} d^{-1} were used to compute overall productivity of the area.

3. Results

The mean production values for each station is presented in figures 2 ,3, 4 and 5.

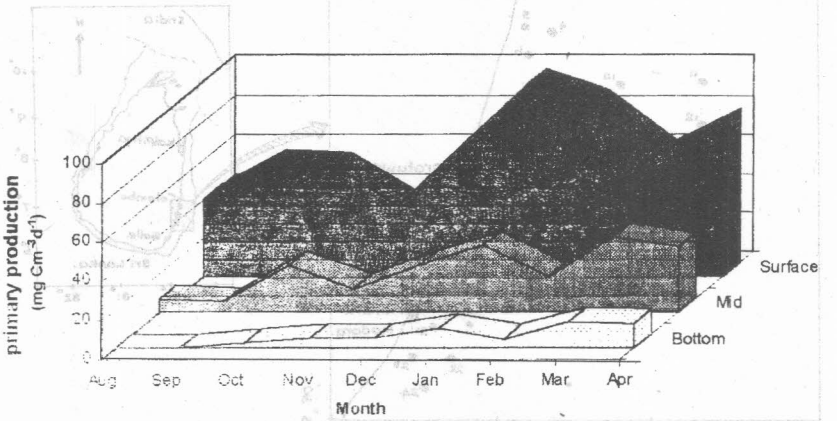


Fig 2. Monthly mean primary production values for station A.

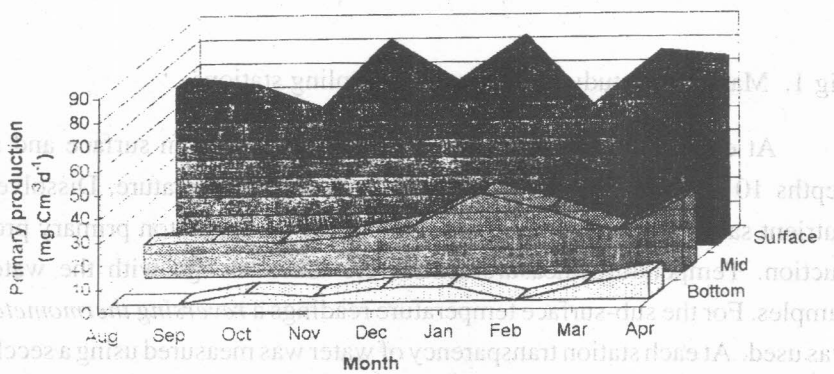


Fig 3. Monthly mean primary production values for station B.

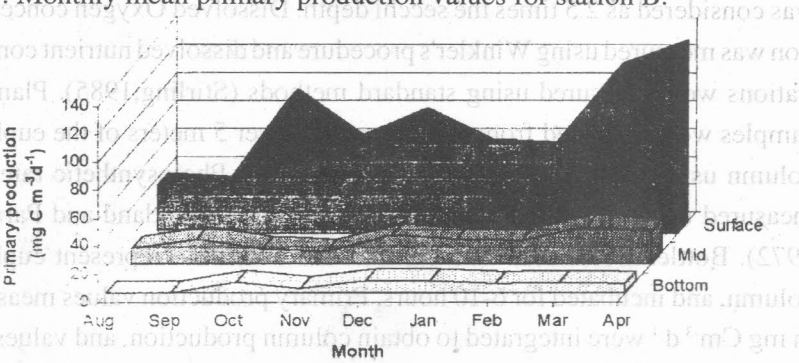


Fig 4. Monthly mean primary production values for station C.

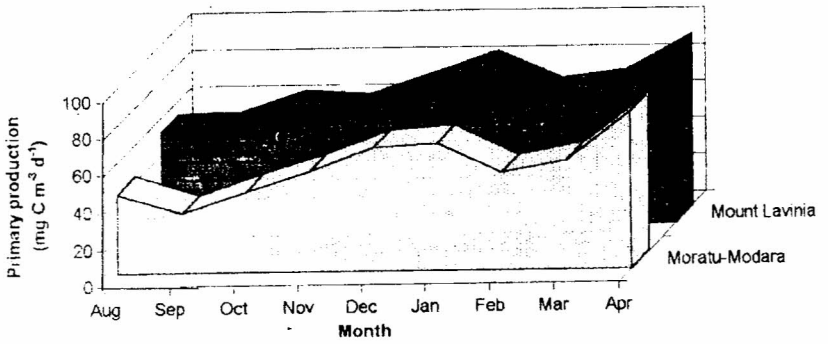


Fig 5. Monthly mean primary production values for mount -Lavinia and Moratu-Modara (surface only)

During the study, monthly organic production values for surface ranged between 32.32-129.4mgCm^{-3} d^{-1}, values for mid waters ranged between 5.38-38.42mg Cm^{-3} d^{-1} and for bottom, values were ranged between 2.75-13.75 mg Cm^{-3} d^{-1}. Surface 10 m water column was responsible for 72 percent of the organic production and 10-20 m column accounted for 20.6 percent. Production below the 20 m depth accounted for 7.4 percent of the total organic production of the area. Data reveals that the distribution of organic production values among the stations and locations do not show significant variation in space. As seen from the figure 6, Depth integrated organic production averaged for all the observations of the euphotic column in the continental shelf waters of part of west coast studied was 0.944 mg Cm^{-2}d^{-1}. This would amount to an annual gross production of 344.6 gCm^{-2}y^{-1}

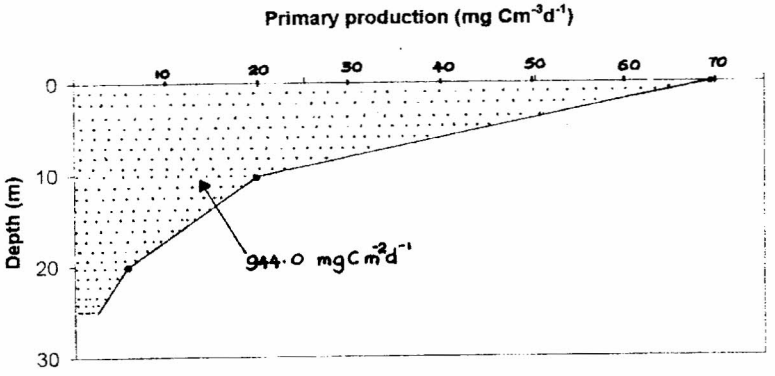


Fig 6. Changes in primary production with depth

Based on value 344.6g Cm^{-2} y^{-1}, GPP of the west coast studied for an area of 1050 Km^2 where there is active fishing would amount to 361830 tones of Carbon production annually. Taking this mean value 344.6 g C m^{-2} y^{-1},and extrapolating the data to the continental shelf, 14 Km average width around

Sri Lanka's 1760 Km long coastline for an area of 30200 Km^2, assuming that no variation in space it would produce about 10,400,000 tones of carbon per year .

Organic production in relation to fish production

According to the present study, total annual carbon fixation of the continental shelf of part of west coast studied was 361830 tones. Fish production statistics available at the Department of Fisheries and Aquatic Resources revealed that the total fish landings from the fish landing centers located within the study area was around 2000 tones in 1997, which is equal to 200 tones in terms of Carbon (assuming that only 10% the fish flesh is Carbon). Which is only 0.06 percent the total Carbon fixed by photosynthesis.

Considering mean photosynthetic rate of west coast of Sri lanka, If extrapolate data to estimate potential yield of the entire continental shelf for an area of 30200 Km^2, which has annual gross primary production around 10,400,000 tones of Carbon. As the total annual fish production from the continental shelf is around 1,60,000 tones (16000 tones of Carbon), which is 0.15 percent the Carbon fixed by photosynthesis.

Measurements of temperature revealed that it decrease with depth from surface to bottom.Lowest temperature value observed for surface waters was 29.0 °C in January and highest value was 31.8 °C in April.

According to the regression analysis, primary production and temperature do not show any positive correlation (figure 7).

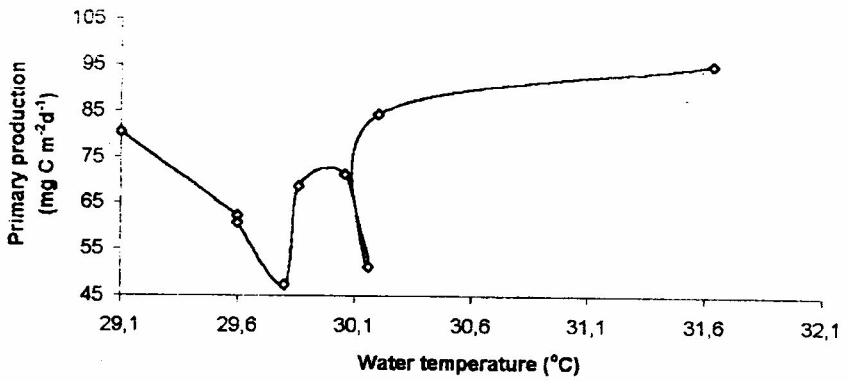


Fig. 7: Relationship between primary production and temperature.

Investigations on transparency of water revealed that it increased seaward from station A though C and some times it reach the bottom. Lowest value recorded was 22.75 m and highest value was 38.5 m.Considering all the data for study period mean depth of the euphotic column could be given as 32.13m for the continental shelf waters of the west coast of Sri Lanka. According to figure 8, data cannot be fit into a straight line, hence cannot see any linear relationship between primary production and transparency of water.

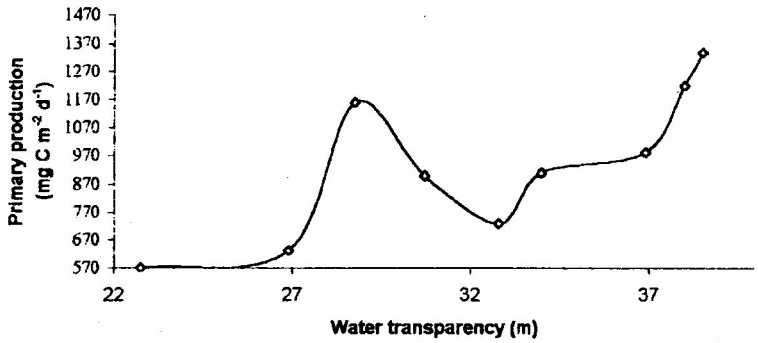


Figure 8 : Relationship between primary production and water transparency

The distribution of concentration of dissolved nitrate and phosphate of the surface, mid and bottom waters of major location showed that concentration increased from surface to bottom. Nitrate concentration ranged between 12.5-45 $\mu g\ l^{-1}$, and Phosphate concentration ranged between 0.12-0.44$\mu g\ l^{-1}$.

The phytoplankton community was dominated mainly by two orders of algae,Bacillariophyceae (Diatom)and Dynophyceae (Dinoflagellates). Diatoms were represented mainly by centric diatom such as; *Chaetoceros* sp., C. *diadema, Rhizosolenia alata,R.stolterfothi, Coscinidiscus* sp., *Skeletonema* sp., *Asterionella* sp., *Biddulphia* sp.,*Ditylum* sp., and two species of pennate diatoms *Thalassionema* sp. and *Nitzschia* sp.Dinoflagellates were dominated by five species of Ceratium; *Ceratium macroceros,C.tripos, C.longipess, C.fusus, C.furca and Peridinium* sp.

Investigations on phytoplankton density from the surface and bottm 5 m water columns revealed that number of plankton cells for surface were greater than that of bottom.

The zooplankton community contained with Radiolaria, Foraminifera, Chaetognatha (*Sagitta* sp), Cladocera, Ostracods, Calanoid and Cyclopoid copepodes, Mysid, Tunicate (*Oikopleura* sp),Nauplii stages of crustaceans and larval stages of Fish and Polychaets. Remarkable uniformity in the monthly fluctuations of the zooplankton as well as its main constituents was observed over the coastal stretch investigated.

4. Discussion

In general rate of photosynthesis increases with temperature up to a maximum and then diminishes. But present study did not show any significant correlation between temperature and primary production. This may be due to the fact that the temperature is not a limiting factor for tropical seas as it is freely available (Nair and Pillai,1983).

Photosynthesis is confined to the illuminated surface zone of the sea. Intensity of the solar radiation and water transparency are the two factors influencing the depth of the euphotic zone. From the study it is observed seaward increase in water transparency, it may be due to diminished particle content and low turbulence of seawater with increasing depth. We cannot see positive correlation between depth of the euphotic column and primary production, because solar radiation never a limiting factor for tropical Indian sea.

Dissolved nitrate concentration of the coastal waters ranged between 1.25- 4.55$\mu g l^{-1}$. Pillai, (1968) observed that nitrate concentrations ranged between 5.5-12.8$\mu g\ l^{-1}$ for off Bombay coast. Concentration of phosphate ranged between 0.12-0.44 $\mu g l^{-1}$ for west coastal waters and for off Bombay coast it fluctuated between 0.15-0.42$\mu g l^{-1}$ (Pillai, 1968) which is very similar to our waters.

Phytoplankton and zooplankton composition observed for west coastal waters of Sri Lanka were very much similar to those of the north Kanara coast of India (Ramamurthy, 1962) and the observations of the Pillai, (1968) for the off Bombay coastal waters.

Monthly primary production values for surface, mid and bottom waters ranged between 31.32- 129.4 mg $Cm^{-3} d^{-1}$,5.38-38.42mg $Cm^{-3} d^{-1}$ and 2.75-13.75mg $Cm^{-3} d^{-1}$ respectively. By the use of ^{14}C technique Qasim *et al,* (1973) observed that the productivity for surface waters of the Gulf of Mannar towards the coast ranged between 250-300 mg $Cm^{-3} d^{-1}$.Nair et al, (1973) observed that the surface productivity varied from 1.12-65.11mg $Cm^{-3}d^{-1}$ in the shelf regions of the Indian seas. It has been concluded that production values of 10-100 mg $Cm^{-3}d^{-1}$ are common for shelf waters (Nair,1973).

Study revealed that photosynthetic rate did not show significant variation in space for locations studied. Photosynthetic rates derived from satellite- based chlorophyll concentrations also show that daily integrated plankton Carbon fixation for continental shelf of Sri Lanka was uniform (Micheal et al,1997) Therefore it is safe to consider mean photosynthetic rate observed for west coast to estimate overall productivity of the continental shelf of Sri Lanka.

Depth integrated daily production value for west coastal waters was 0.944g $Cm^{-2}d^{-1}$, though this rate is fairly high it is not unusual for tropical shelf waters. Values of over 1.0 g Cm^{-2} d^{-1} were commonly met with shallow coastal waters (Nair et al, 1973). Within the 50 m depth limit Nair *et al,*(1973) have observed mean production value of 1.19 g Cm^{-2} d^{-1}.

Table I, compares the organic production values obtained from different research works (values in g C m^{-2} y^{-1});

Table 1. Organic production values obtained from different research works (g $Cm^{-2}y^{-1}$).

English channel	60-98	Harvey, (1954)
Gulf of mannar (within 10 m)	745	Prasad and Nair, (1963)
West coast of India (within 50 m)	434	-do-
Continental shelf of all Indian seas	310	Prasad et al, (1970)
Cochin Backwaters	281	Qasim et al, (1968)
West coast of Sri Lanka (continental shelf)	344.6	Present study

Primary productivity and potential fish yield

It has been observed by Nielson and Jensen, (1957) that the commercial fish catch from intensely exploited waters were about 0.4 percent of the organic matter produced by phytoplankton. We do not need to exploit our marine resources intensely. As Prasad and Nair,(1963) concluded, correctly I think, exploitation of fish resources 0.2-0.3 percent of the Carbon fixed by photosynthesis would be more realistic. Considering this, as the primary production to fish yield ratio is 0.06 percent the potential fish harvest from the part of west coast studied would be around 3 1/2- 5 1/2 times the actual catch (2000 tones), which would be between 7000 and 11,000 tones.

As the estimated plankton primary productivity to fish yield ratio was 0.15 percent, the potential harvest from the entire continental shelf waters of Sri Lanka would be around 1.3 to 2 times the present yield (1,60,000 metric tones). Maximum sustainable yield of 0.2 percent of the carbon fixed by photosynthesis would be more realistic in conserva-

tional point of view, which would amount to minimum potential harvest of about 2,13,000 tones of fish. To become socially preferable 0.3 percent would be more realistic, which would amount to an annual optimum yield of 3,20,000 tones. This means that between 53,000 and 1,60,000 tones of potential fish harvest is left untapped from the continental shelf waters of Sri Lanka.

5. Acknowledgement

I would like to express my deepest gratitude to my supervisor, Profeessor J. Jinadasa, Head Department of Zoology, University of Sri Jayewardenepura, for his guidance, encouragement and for revising the manuscript.

6. References

Micheal, J.B.and Folkowski, P.G. (1997). Photosynthetic rates derived from satellite-based chlorophyll concentration, *Limnol. Oceanogr.*,42(1), 1-20

Nair *et al*, (1973). Primary production and potential fishery resources in the seas around India, *Proc. of the symposium on living resources of the seas around India*, Central marine Fisheries research Institute, Cochin, pp 184-197.

Nair,P.V.R.and PIllai, V.K. (1983). Productivity of the Indian seas, *J.Mar.Biol. Ass., India*, 25 (1&2),pp 41-50.

Nielson, S. and Jensen, E.A. (1957) .Primary oceanic production, *Galathea Rep.*, 1:49- 136.

Pillai, V.K.(1968).Observations on the plankton off Bombay coast with remarks on the hydrographic conditions and fishery, *J.Mar.Biol. Ass. India*, 10 (2): 237-244.

Prasad, R.R. and Nair, P.V.R. (1963). Studies on organic production- Gulf of Mannar,*J.Mar.Biol.Ass.India*, 1:1-26.

Qasim et al., (1968). The estimation of plant pigments of Cochin Backwaters, *Proc. Indian Acad. Sc.*,69(2):51-94.

Ramamurthy, S. (1962) Studies on the plankton of the north Kanare coast in relation to the pelagic fishery, *J.Mar. Biol. Ass. India*, 7 (1) 127-149.

Raymont,J.E.D.(1980).Plankton and productivity in the seas, Pergamon press, Oxford.

Stirling,H.P. (1985). Water analysis for Aquaculturist, Academic press, London

Strickland,J.D.H. and Parsons, T.R.(1968).A practical handbook of seawater analysis, Fisheries research board, Canada.