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Dr. M. Sakthivel, President,
Aquaculture Foundation of India
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MARINE MICROALGAE

C.P. Gopinathan
Central Marine Fisheries Research Institute, Cochin, Kerala

ABSTRACT

The microscopic plant components of the sea, excluding the macroscopic seaweeds, form the microalgae or phytoplankton. They are the primary producers synthesizing the basic food for all the larval forms in a marine ecosystem. They belong to the Class Algae, which besides chlorophyll possess other characteristic pigments. The important components of microalgae are: Diatoms (Bacillariophyceae), Dinoflagellates (Dinophyceae), Blue-green algae (Cyanophyceae), Phytoflagellates (Chlorophyceae, Haptophyceae, Cryptophyceae) and Nanoplankters (*Chlorella, Nannochloropsis*). Besides, two other subclasses - Silicoflagellates and Coccolithophores also belong to the microalgae since they are autotrophic organisms. Culture of microalgae is an essential component in any type of hatchery system. Blooms of toxic phytoplankton causes severe harmful effects to the aquatic system and sometimes causes mass mortality of fishes in coastal waters. Based on the productivity of an ecosystem, potential harvestable resources can be estimated. Recent estimates based on phytoplankton production indicated that vast exploitable resources are available from the Indian seas.

INTRODUCTION

The importance of microalgae lies in the fact that they are photosynthesizing organisms and serve as first link in the food chain. In the seawater, the diatoms and dinoflagellates are the more obvious representatives of the phytoplankton, in terms of both size and availability when water samples are examined under microscope. Depending on the size grading of micro-algae organisms, they are grouped under: Macroplankton (>1 mm), Microplankton (<1 mm), Nanoplankton (5-50μ), Ultraplankton (<5μ) and Picoplankton (>1μ).

Most microalgae are unicellular. The longer colonial forms possess individual cells that are usually of uniform structure and appearance. Some planktonic green and blue-green algae are of filamentous type and in some diatoms and dinoflagellates, chain of loosely associated cells may be formed. Unicellular organisms are identified by recognizing certain characteristics and ease of identification will clearly be limited by cell size and the degree of magnification obtainable.

ORGANISMS

Diatoms

Diatoms constitute the major part of the microalgae of the sea. They serve as a vital first link in the food chain, either directly or indirectly of almost every animal in the sea. It is probably true to say that at sometime in their life history, all fish, molluscs and crustaceans are diatom feeders.

Diatom cells are unique, having a rigid silica impregnated cell wall (frustule) consisting of two soap-box. This siliceous box encloses a lining of cytoplasm, vacuoles and central nucleus. Chloroplast colours are usually yellow-brown in planktonic species and dark brown in benthic forms. The shape of diatom cells can be complex and are important in determining genera and species.

Diatoms are broadly divided into 2 major divisions: the Centrales or Centrica and the Pennales or Penatae (Plate I and II) depending on the structure and sculpture on their cell walls. Both vegetative and sexual reproduction occur in diatoms.

Dinoflagellates

Dinoflagellates are animal-like diversified group of organisms, which move around in water with the help of their cilia or flagellae. The cells bear paired flagella which arises in close proximity, usually with one flagella trailing behind the cell and lying in a groove (sulcus) and the ribbon-like transverse flagellum also lying in a groove (singular/gindle). The gindle lies between the epicone and hypo cone (Plate III).

Most of the dinoflagellates are harmful to other phytoplankters and aquatic organisms, since they produce some toxins, which act as poison to others. The discolouration of the water, either red, pink or brown due to the blooming of dinoflagellates is termed as Red Tide or red water phenomena and this causes harmful effects to the fishery.

Blue green algae

The members of this class are distinguished from all other algae in the absence of an organized nucleus, lacking nuclear membrane and chromatogranules, instead a central body is present.
Besides chlorophylls, the chloroplast contain a blue-green pigment known as phycocyanin. Planktonic blue green algae are either unicellular, colonial or filamentous in structure. In the inshore environments blooming of one filamentous form, *Trichodesmum* sp. is a common phenomenon, causing discolouration of water and sometime harmful effects to the aquatic organisms. There is no sexual reproduction in blue-green algae (Plate IV).

Silicoflagellates

Silicoflagellates are several star shaped organisms, characterized by the possession of a skeleton taking the form of frame-work of siliceous rods, arranged in diverse ways and with intervening spaces of definite shape (Plate IV). Outside the skeleton is a delicate layer of cytoplasm containing a number of bright yellow to brownish yellow discoid chromatophore. No sexual reproduction in this class.

Coccolithophore

Cocolithophore are by-flagellates, most of them enveloped in a colony covered by calcium carbonate. The characteristics of the coccolithophore are that on the surface these, there are deposition of large number of circular bodies or cavities (coccoliths) (Plate IV). Here also the flagellates reproduce by vegetative cell division.

Nannoplankters

Nannoplankters form the 'hidden flora' of the sea and playing a significant role in the productivity of the waters. They form the basic food of almost all the zooplankton and larval stages of fishes, crustaceans and molluscs. Members of Chlorophyceae, Xanthophyceae, Chloromonadinea, Cryptophyceae and Heptophyceae belong to this group (Plate IV).

TOXIC ALGAL BLOOMS

Incidence of microalgal blooms, either harmful or harmless, discolouration of coastal waters, either red, pink, brown and green has been a regular feature along the Indian coasts, especially in the west coast. The 'red tide' is generally intermingled with changes in chemical properties of coastal waters. Introduction of nutrients during the summer monsoon through river run off and coastal upwelling are major factors influencing the algal blooms. Most cases of blooms have been harmless to the aquatic fauna since they will try to avoid the area. However, in recent years a few cases of fish mortality have been reported in the west coast due to algal blooms. Thus the problem of harmful algal blooms along the Indian coast is more serious than apparent and needs urgent attention to check further escalation due to eutrophication.

MICRO-ALGAE CULTURE

As is well known, the success of any hatchery operation, either prawns, oysters, fishes or sea cucumbers, entirely depend on the availability of suitable live feed viz. the microalgae. In the natural environment, the larvae feed on any minute plant components, which are readily available to them. But in a hatchery, the forms which are acceptable to the larvae for their growth and further development have to be identified and isolated. In the early critical stages of the rearing larvae of finfishes and shellfishes, the phytoflagellates (*Isochrysis, Palova, Dicrateria, Chromulina* and *Tetraselmis*) and other nannoplankters (*Chlorella, Nannochloropsis*) form the basic food. But in the postlarval stages of crustaceans and post juvenile stages of bivalves, the diatoms (*Chaetoceros, Skeletonema & Thalassiosira*) form the primary food. Hence the culture of microalgae and the various steps such as isolation, culture media preparation, maintenance of the pure culture as stock, mass culture in the indoor and outdoor facilities, harvesting of the pure culture without any contamination and preservation for thriving the unfavourable conditions, are essential pre-requisite for the rearing operations of economically important cultivable organisms in a hatchery system (Gopinathan, 1996).

PRIMARY PRODUCTION

The primary production can be defined as the amount of organic material, which by the activity of organisms in unit time is synthesized in a unit value of water and extending from the sea surface to the bottom of the euphotic zone. The primary productivity is confined entirely to that brought about by phytoplankton. The growth and distribution are controlled by many factors which may be physical, chemical biological (like grazing and reproductive) and seasonal.

PLATE I

DIOTOMS - CENTRALES

Figures 1 - 19

1. *Skeletonema costatum*
2. *Stephanophyxix palmeriana*
3. *Thallassiosira subtilis*
4. *Thallassiosira subtilis* Girdle view
5. *Coscinodiscus excentricus*
6. *Coscinodiscus excentricus* - Girdle view
7. *Planktoniella sol*
8. *Rhizosolenia styliformis*
9. *Rhizosolenia robusta*
10. *Bacteriastrum hyalinum*
11. *Cheatoceros eibenii*
12. *Eucampia cornuta*
13. *Triceratium reticulatum*
14. *Biddulphia mobiiliensis*
15. *Ditylum brightwelli*
16. *Hemidiscus hardmannianus*
17. *Biddulphia sinensis*
18. *Cerataulina bergonii*
19. *Isthmia enervis*

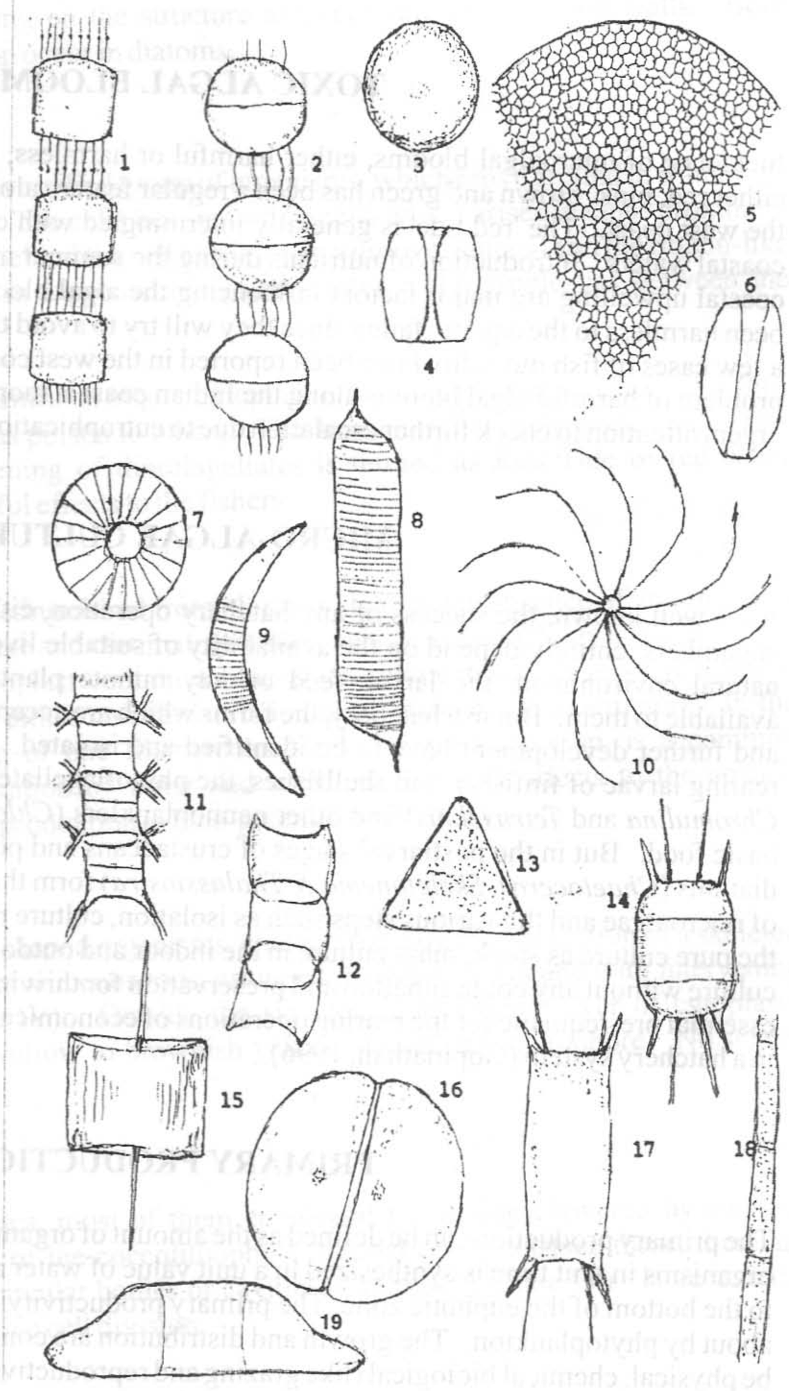


PLATE II

DIOTOMS - PENNALES

Figures 1 - 28

1. *Grammatophora undulata*
2. *Striatella delicatula*
3. *Licmophora abbreviata*
4. *Thalassiosira nitzschioides*
5. *Climacosphenia moniligera*
6. *Fragilaria oceanica*
7. *Rhaphoneis amphiceros*
8. *Synedra formosa*
9. *Thallasiothrix frauenfeldii*
10. *Asterionella japonica*
11. *Mastogloia exilis*
12. *Cocconeis littoralis*
13. *Amphiprora gigantiea*
14. *Amphora liniolata*
15. *Navicula henneydii*
16. *Pleurosigma normanii*
17. *Gyrosigma balticum*
18. *Tropidoneis aspera*
19. *Cymbella marina*
20. *Bacillaria paradoxa*
21. *Nitzschia closterium*
22. *Amphiprora ostrearia*
23. *Nitzschia longissima*
24. *Nitzschia striata*
25. *Surirella eximia*
26. *Nitzschia panduriformis*
27. *Surirella fluminensis*
28. *Campylodiscus iyengarii*

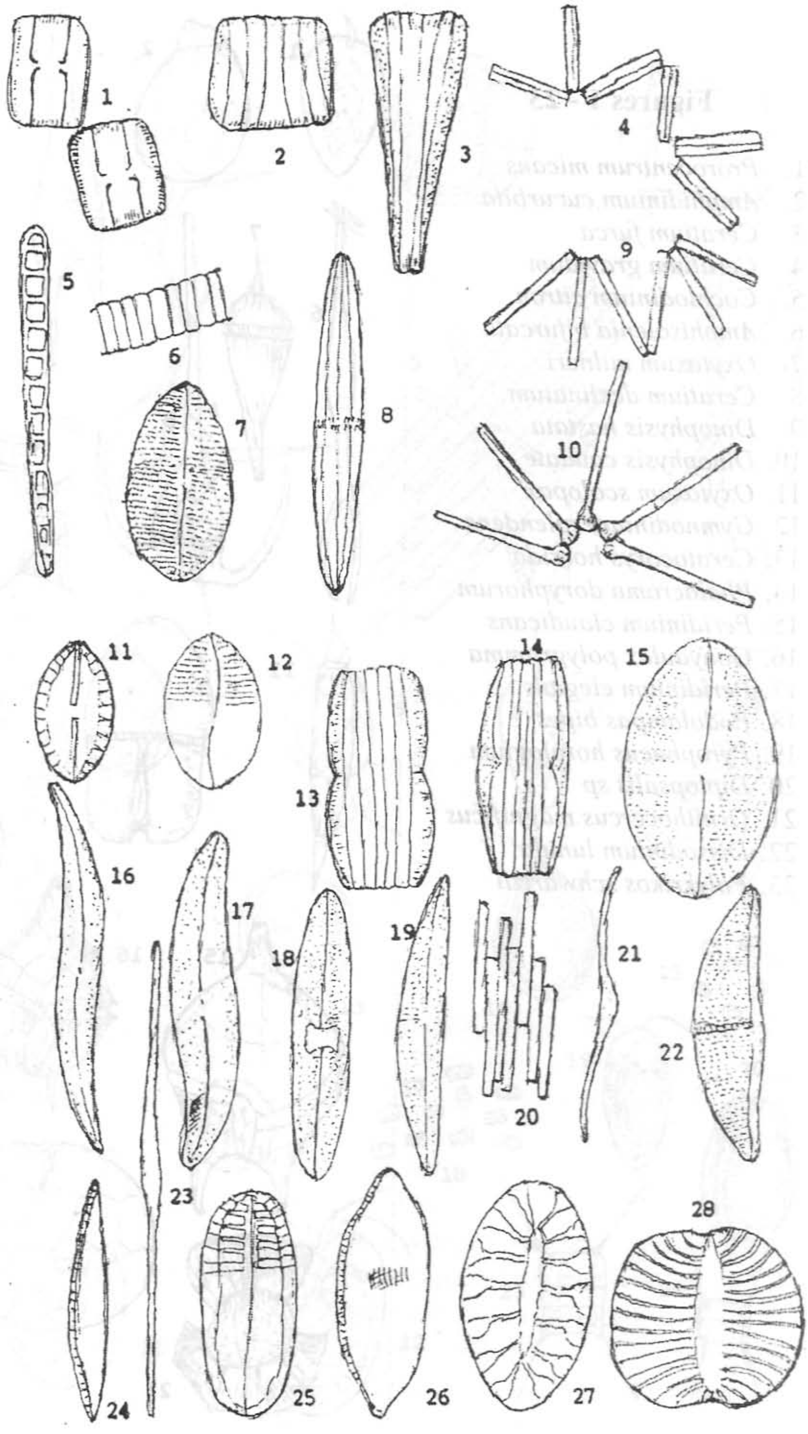


PLATE IV
SILICOFLAGELLATES, COCCOLITHOPHORE
BLUE - GREEN ALGAE & NANNOPLANKTON

Figures 1 - 24

1. *Dictyocha* sp.
2. *Coccolithus* sp.
3. Blue green algal cell
4. *Distephanus* sp
5. *Trichodesmium theibautii*
6. *Trichodesmium erythreaum*

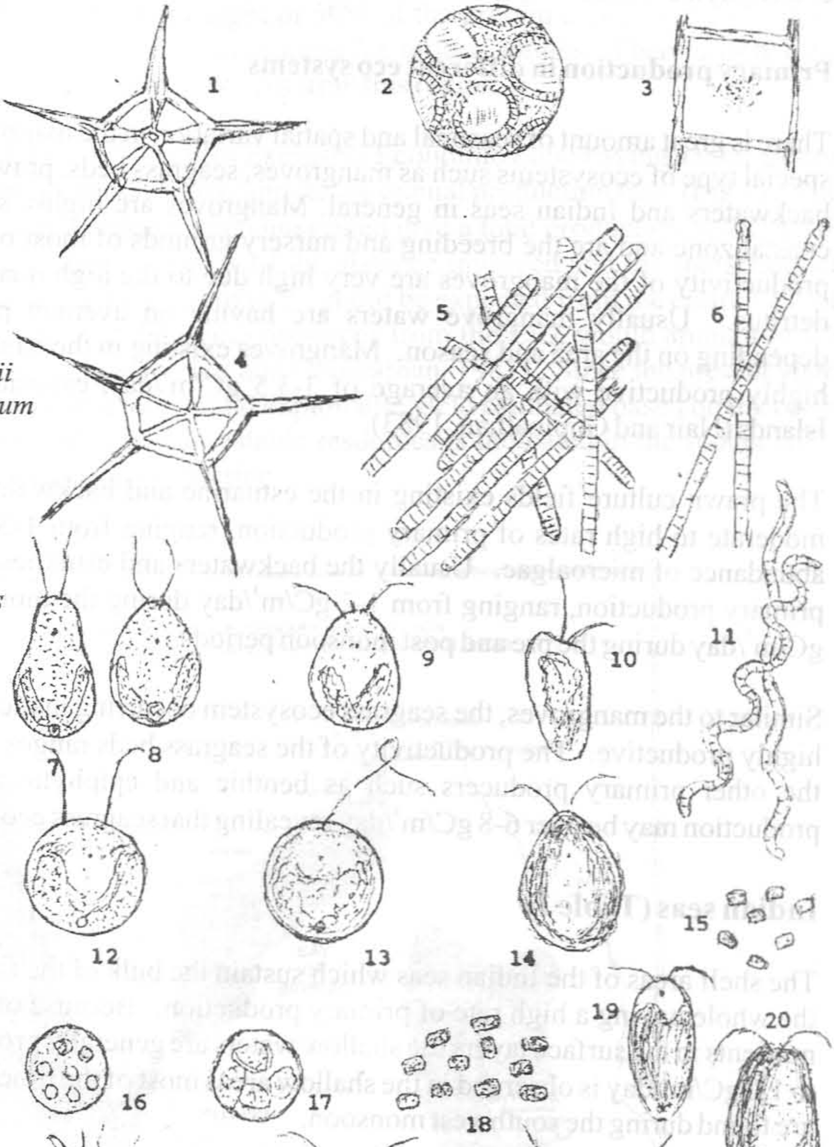
7-8. *Isochrysis galbana*

9. *Pavlova* sp
10. *Cryptochrysis fulva*
11. *Spirulina* sp
12. *Dicrateria inornata*
13. *chromulina freibargensis*
14. *Dunaliella* sp
15. *Nannochloropsis salina*
16. *Chlorella marina*
17. *Chlorella salina*
18. *Synechocystis salina*

19-20. *Dunaliella salina*

21. *Tetraselmis gracilis*
22. *Tetraselmis chuii*

23-24. *Cheatoceros calcitrans*



The word 'production' is synonymously used for standing crop as well as primary production, which is basically a measure of the photosynthetic activity of the microalgae. Various methods, both direct and indirect are employed for estimating the productivity of an area. Of the direct methods, that are used in the measurement of primary production, the light and dark bottle oxygen technique (Gaarder and Gran, 1927), ^{14}C technique (Steeman Nielsen, 1952) and chlorophyll estimations (Strickland & Parsons, 1972) are the most popular.

Primary production in different eco systems

There is great amount of seasonal and spatial variation in the magnitude of primary production in special type of ecosystems such as mangroves, seagrass beds, prawn culture fields, estuaries and backwaters and Indian seas in general. Mangroves are highly specialized ecosystems in the coastal zone and are the breeding and nursery grounds of most of the aquatic organisms. The productivity of the mangroves are very high due to the high quantity of litter fall and organic detritus. Usually mangrove waters are having an average production of 2-3 gC/m^3/day depending on the area and season. Mangroves existing in the island ecosystems are found to be highly productive with an average of 3-3.5 gC/m^3/day, especially in the Andaman-Nicobar Islands (Nair and Gopinathan, 1983).

The prawn culture fields existing in the estuarine and backwater regions of Kerala indicated moderate to high rates of primary production, ranging from 1-3 gC/m^3/day depending on the abundance of microalgae. Usually the backwaters and estuaries will have a moderate rates of primary production, ranging from 1-2 gC/m^3/day during the monsoon season and less than 1.5 gC/m^3/day during the pre and post monsoon periods.

Similar to the mangroves, the seagrass ecosystem occurring in the coastal area is also found to be highly productive. The productivity of the seagrass beds ranges from 3-4 gC/m^3/day and when the other primary producers such as benthic and epiphytic algae are included, the daily production may be over 6-8 gC/m^3/day revealing that seagrass ecosystem is highly productive.

Indian seas (Table 1)

The shelf areas of the Indian seas which sustain the bulk of the fish production at present are on the whole having a high rate of primary production. Because of the constant replenishment of nutrients in the surface layers the shallow waters are generally productive. An average rate of 0.5 to 1.0 gC/m^3/day is observed in the shallow areas most of the time. Rates exceeding 2 gC/m^3/day are found during the southwest monsoon.

In the eastern Arabian sea, towards the coast of India, the average rate within 50m depth is about 1.2 gC/m^3/day and for the outer shelf region, the rate is 0.5 gC/m^3/day. The net production (taken as 60% of the gross) from the shelf area on the west coast of India, upto 50m depth has been computed as 30 x 10^6 tonnes of carbon. Between 50 and 100 mm, the net production is only 17 x 10^6 tonnes C. Thus for the whole continental shelf area on the west coast, the annual net production is computed at 47 million tonnes of carbon. The rates of primary production for the east coast are 0.65 $gC/m^3/day$ on the shelf and 0.20 $gC/m^3/day$ outside the shelf and the annual estimate of net production is 17 x 10^6 tonnes of carbon, totalling 64 million tonnes of carbon from the entire coastal area within 100 m depth of the Indian seas (Nair and Pillai, 1983).

In recent years, various projections of potential yield have been made from the estimates of primary production. The optimum yield from organic production generally varies from 0.3-0.4% (in terms of carbon - 10% of the wet weight or 50% of the protein content), the potential exploitable resources for the whole Indian coast is about 3.5 million tonnes. There is only little scope for further exploitation of the fishery resources from this region.

However, in view of the declaration of 200 miles Exclusive Economic Zone having a total area of 2.02 million sq. km, it would be worthwhile to compute the annual production rate (Fig.1). The different gradients for the shelf and outside when integrated give a total production of 283 x 10^6 tonnes of carbon (Gopinathan, 1981). In view of the distance involved and the sparseness of distribution, a minimum possible exploitation of 0.2% could be expected from the entire EEZ of India. Therefore the exploited yield of the living resources from the EEZ would amount to 5.5 million tonnes, both pelagic and demersal (Nair and Gopinathan, 1981). Since the present yield from the Indian seas is only 2.7million tonnes and exploitable yield estimated based on the catch statistics is 3.92 million tonnes, still vast harvestable resources is indicated in the Indian EEZ, based on the estimates of phytoplankton production

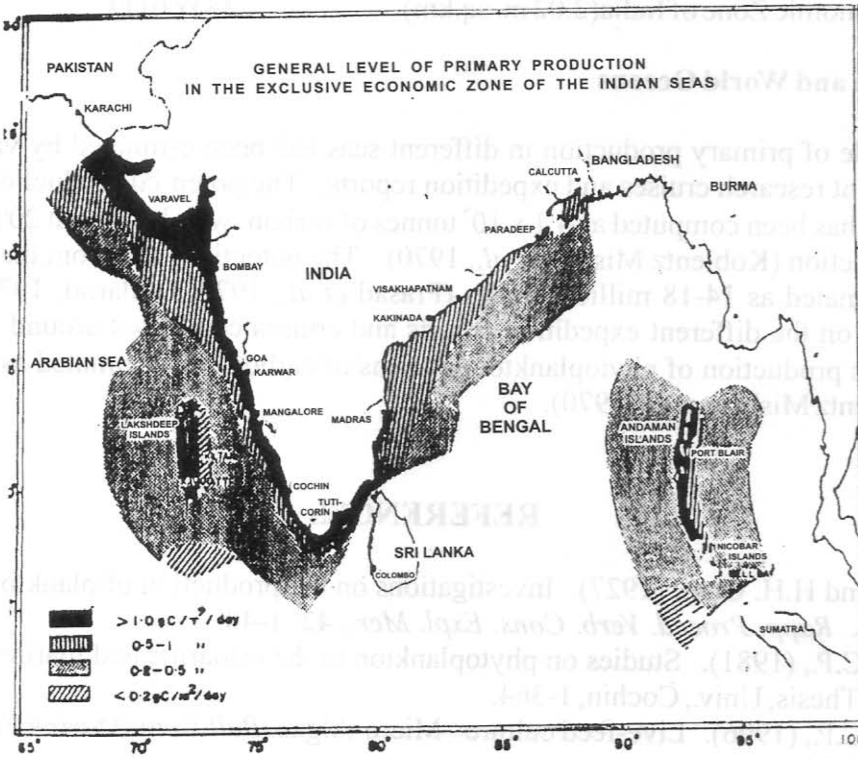


Fig.1

TABLE 1. General level of primary production in various ecosystems

Estuaries, backwaters & prawn culture fields	--	1-3 gC/m^3/day
Mangroves, seaweed & seagrass ecosystems	--	3-5 gC/m^3/day
Inshore and coastal areas	--	1-2 gC/m^3/day
West coast of India upto 50 m	--	1.2 gC/m^3/day
West coast of India upto 100 m	--	0.53 gC/m^2 day
East coast of India upto 50 m	--	0.68 gC/m^2 day
East coast of India upto 100 m	--	0.20 gC/m^2 day
Annual Gross Production		
West coast upto 50 m	--	$30x10^6$t.C
West coast upto 100 m	--	$17x10^6$t.C
East coast of India upto 50 m	--	$10x10^6$t.C
East coast of India upto 100 m	--	$7x10^6$t.C
Indian seas upto 100 m	--	$64x10^6$t.C
Exclusive Economic Zone of India(2.02 m. sq.km)	--	$283x10^6$t.C

Indian Ocean and World Oceans

The magnitude of primary production in different seas has been estimated by various authors during different research cruises and expedition reports. The potential production of the entire Indian Ocean has been computed as 4.1×10^9 tonnes of carbon, which is about 20% of the world oceanic production (Koblentz Mishke *et al.*, 1970). The potential yield from the Indian Ocean has been estimated as 14-18 million tonnes (Prasad *et al.*, 1970, Gullarnd, 1970, Nair *et al.*, 1971). Based on the different expedition reports and cruises conducted around the world, the world oceanic production of phytoplankton in terms of carbon was estimated as $2.5\text{-}3.0 \times 10^{10}$ tonnes (Koblentz Mishke *et al.*, 1970).

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