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Productivity of Specialized Environments

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The term productivity here refers to "primary production" or the photosynthetic production of organic carbon in which carbon dioxide is the only source of carbon. This definition easily distinguishes primary production from chemosynthetic uptake of carbon dioxide by microbial flora, where no photosynthesis is involved. Specialized environments are in many ways unique ecosystems and rather specific to a particular region —for example the backwaters of Kerala, consisting of a system of monsoonal lagoons and estuaries—form such a specialized environment, the equivalent of which is not found anywhere in the world. The specialized environments are unlike the generalized marine ecosystems in which the changes could easily be predicted (Qasim, 1972a).

The author's present interest in the study of productivity of specialized environments began in 1965, and he, during his stay at the Biological Oceanography Division, National Institute of Oceanography, formed a small team of scientists and began studying the backwater around Cochin. Subsequently, in 1968, the study was extended to the atolls of the Laccadives. These studies were continued till 1970. In this communication, the productivity of the following three environments has been summarized:

(1) Cochin Backwater
(2) Atoll
(3) Seagrass bed

Cochin Backwater.

Two main factors influence the hydrography of Cochin Backwater: (1) the short-term changes induced by the tides (Qasim and Gopinathan, 1969) and (2) the seasonal changes brought about by the monsoon cycle (Sankaranarayanan and Qasim, 1969a). Marked changes in the hydrography of the coastal waters around Cochin during the monsoon months affect not only the environmental features of the backwaters but the associated fauna and flora including fish and prawns of the nearshore region get equally affected (Sankaranarayanan and Qasim, 1969b). Sedimentation of suspended material in the backwater is maximum during the pre-monsoon and post-monsoon months. Most of the silted material gets resuspended during the monsoon months and with the strong ebb currents gets transported into the sea (Gopinathan and Qasim, 1971).

Because of the high turbidity prevailing in the estuary, the light penetration gets considerably reduced. The euphotic zone varies from 2 to 6 metres during the year, with the attenuation coefficient (k) ranging from 0.60 to 3.00 (Qasim, Bhattathiri and Abidi, 1968). During the monsoon months, marked changes occur in temperature, salinity, dissolved oxygen, pH and alkalinity. The nutrient concentrations attain very high values during these months. The backwater remains sea water dominated for about 6 months, and then, with the commencement of rains, it becomes fresh water dominated (Qasim, 1972b). Chlorinity in the backwater ranges from 0-20‰. In a recent communication the relationship between chlorinity, salinity and electrical conductivity of sea water has been discussed with reference to the results obtained from the backwater (Gopinathan and Qasim, 1970).

Estimates of primary production were made using the ^{14}C method concurrently with the light-dark-bottle oxygen method. *In situ* experiments were conducted throughout the year by using a float from which bottles were suspended at various depths of the euphotic zone. These were predetermined using a submarine photometer. Since the backwater is a polluted estuary, the presence of suspended inert material and large populations of bacteria affect the measurements of ^{14}C uptake. SCOR (1969) emphasized the need for collecting experimental data on the extent to which these two factors affect the productivity results. Thus the simulated effects of inert material and the different concentrations of bacteria on the ^{14}C uptake in light and dark bottles were studied in detail (Qasim, Bhattathiri and Devassy, 1972a ; Unesco, 1973).

Gross production in the backwater ranged from 270-295 gC/m^2/year (average = 280 gC/m^2), while the net production based on days only was 180-200 gC/m^2/year (average = 195 gC/m^2). The average net production based on day and night (24 hr) was approximately 124 gC/m^2/year (Qasim, Wallershaus, Bhattathiri and Abidi, 1969). The seasonal cycle of chlorophyll *a* in the estuary was found to be non-synchronous with that of the primary production. The presence of dead chlorophylls coming from detrital material and stirred-up sediments affects the measurement of plant pigments (Qasim and Reddy, 1967).

From the ecological observations it was deduced that three factors largely govern the primary production of backwater. These are light, salinity and nutrients (Qasim, Wallershaus, Bhattathiri and Abidi, 1969).

To determine the extent to which each of these factors influences the growth of phytoplankton, the following experimental procedure was adopted: Several species of diatoms and flagellates were isolated and cultured in enriched sea water. They were exposed to different light conditions and their rates of photosynthesis were measured by ^{14}C assimilation. The effect of intensity and quality of light was studied in 11 different organisms. The saturation point (I_k) in most of the organisms ranged from 11 to 15 kilolux. When the organisms were exposed to a particular range of the visible spectrum, no wavelength dependence of photosynthesis in saturating light was observed. All regions of the visible spectrum were found to be effective as long as there was enough light-energy to stimulate photosynthesis (Qasim, Bhattathiri and Devassy, 1972b).

The organisms when exposed to varying salinities, from 5–35 ‰, were found to have their maximum photosynthesis at low salinities In the Cochin Backwater, where salinity variations are large, maximum abundance of phytoplankton occurred at low salinities. Such a dependence of phytoplankton on low salinity seems an adaptation to utilize the enrichment of water to a maximum degree, for the enrichment along the south-west coast of India is associated with large dilutions during the monsoon months (Qasim, Bhattathiri and Devassy, 1972c).

Like salinity, the nutrient requirements of different phytoplankton are quite variable and that high concentrations of phosphate or nitrate alone do not give rise to a substantial increase in primary production. This was experimentally demonstrated by studying the growth rate of nutrient-depleted cells of *Biddulphia sinensis* and *Ceratium furca*. The growth, rates of both these organisms, as a function of phosphate and nitrate, followed the hyperbolic function of Michaelis-Menten. The capacity of eachorganism to utilize phosphate and nitrate, when available either singly or in combination, was determined from the values of half saturation constant (K_s). In the backwater, high concentrations of nutrients seem to favour the abundance of diatoms and at low concentrations, dinoflagellates become predominant (Qasim, Bhattathiri and Devassy, 1973).

The annual cycle of primary production and phytoplankton succession, when examined in the context of a simple model, were found to be related to the increased flushing of the estuary caused by the monsoon (Wyatt and Qasim, 1972).

Theoretical models on fish populations using the informations on growth and mortality rates formed a separate study (for details see Krishnan Kutty and Qasim, 1968; Krishnan Kutty and Qasim, 1969).

Seasonal changes in zooplankton biomass of the Cochin Backwater had little correlation with the cycle of primary production. The estimated annual consumption of primary production by the zooplankton herbivores was approximately 25% of the total production. The rate of consumption was greater during the premonsoon season (46%) than in the other seasons (Qasim, Wellershaus, Bhattathiri and Abidi, 1969). The unconsumed basic food gives rise to several alternate pathways in the food chain either directly or through detritus (Qasim, 1970a). The shallow euphotic zone increases the fall-out of basic food material which keeps sinking to the bottom as detritus. The settled detritus is consumed by the benthic animal communities (Qasim, 1971).

Continuous collections of detritus settling to the bottom were made throughout the year. The total quantity of detritus ranged from 67 to 1013 g/m²/day during the year. Detritus is derived from dead material of plants and animals. It also includes a substrate of inorganic matter fiine silt and stand) around which organic matter adheres and forms aggregates. The caloric content of detritus ranged from 250–400 cal/g dry wt. Penaeid prawn *(Metapenaeus dobsoni)* when fed on detritus pellets in the laboratory continued to live indefinitely (Qasim and Sankaranarayanan, 1972).

Atoll

The work related to productivity was mainly carried out on one of the atolls of the Laccadive Archipelago—the Kavaratti Atoll. This atoll is located along Lat. 10°33′N and Long. 72°36′E. In April 1968, a massive bloom of *Trichodesmium* was observed in the Laccadive Sea (Qasim, 1970b). The following year (1969), a similar bloom was reported almost during the same period (Qasim, 1972c). The sea during the bloom was found to be nitrogen impoverished and had a sparse population of other phytoplankton and zooplankton.

In November, the transparency of water near Kavaratti Atoll was fairly high. The attenuation coefficient of light at depths 0–60 m ranged from 0.066 to 0.118 and the Seechi disc reading was 23 m. Phytoplankton production in waters surrounding the atoll (adjacent sea and lagoon), as determined by the ^{14}C assimilation during April, November and December was from 0.43 to 2.49 mg $C/m^3/hr$ and chlorophyll *a* values were from 0.04 to 0.21 mg/m^3 (Qasim, Bhattathiri and Reddy, 1972).

Estimates of gross production and community respiration of the atoll were made from diurnal changes in oxygen at two stations in the lagoon which were parallel to the direction of the currents and were up and down stream. The values of dissolved oxygen were corrected for the diffusion across the air-sea interface. Gross production of the atoll community was found to be 12.92 $gC/m^2/day$ and the respiration 4.77 $gC/m^2/day$. Production of the reef was determined from the changes in oxygen during its transport over the reef (Qasim, Bhattathiri and Reddy, 1972). Experiments conducted on the oxygen changes of several species of plants and corals confirmed that their rates of photosynthesis for 12 hours were greater than their rates of respiration for 24 hours. From these estimates it was concluded that the atoll communities produce more organic matter in 12 hours than what they consume in 24 hours.

Zooplankton biomass in waters of Kavaratti was found to be highly variable, which indicates that these alone cannot meet the energy demand of the reef. The presence of large quantities of organic aggregates near the reef and in the lagoon indicates that possibly the reef plays a recycling role. The particulate matter which the reef produces serves as a source of energy for zooplankton on which the corals feed. The rate of production of particulate matter was about 20% of its gross production or 95% of coral respiration (Qasim and Sankaranarayanan, 1970).

Seagrass Bed

The seagrass bed studied is found in the lagoon on Kavaratti. It largely consists of turtle grass (*Thalassia* sp.) and manatee grass (*Cymodocea* sp.). The bed is a luxuriant community growing in oceanic conditions.

Primary production of the grass bed was studied from the diurnal changes in dissolved oxygen over the bed and by conducting experiments on isolated plants and measuring their rates of oxygen production and consumption. Gross production of the seagrass community was equivalent to 11.97 $gC/m^2/day$ and its respiration was 6.16 $gC/m^2/day$ (Qasim and Bhattathiri, 1971). A comparison of the estimates made for the seagrass bed on Kavaratti with those of the other seagrass communities showed that the seagrass community on Kavaratti is the most productive community. It offers shelter to a very large number of animals and serves as food either directly or through detritus to many animals.

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