CHAPTER V
DISCUSSION

The culture pond and connected field and canal system studied are mostly the extension of the estuarine and backwater systems, and are therefore subjected to wide variation in the environmental condition. In these culture systems which are dynamic ones, and in which the monsoon rains trigger changes from the marine conditions prevailing the during the premonsoon season to the freshwater condition during the monsoon period and with a gradual but progressive recovery of saline condition during postmonsoon months. It has been established that abiotic factors, particularly chemical characteristics of the environment exert profound influence on the growth and survival of aquatic organisms such as algae. Hence, in the present study, attention has been focused to elucidate the nature and extend of the physical-chemical environmental features, and their bearing on the primary productivity in the three selected tropical ecosystems, viz., a perennial prawn culture pond, canals among the coconut grove and a seasonal prawn - cum - paddy field at Cochin during 1986 and 1987.

Since the nutrients are the main sources for primary producers, special emphasis has been given to study the availability of nutrients both qualitatively and quantitatively in the culture ponds. Further enrichments were also conducted to analysis and understand the significant of the nutrients in the primary productivity.
Detailed description of environmental features and nutrient distribution in the Cochin backwater have been reported earlier. (Ramamirthan and Jayaraman, 1963; George and Krishnakartha, 1963; Desai and Krishnankutty, 1967; Qasim, 1969; Wellershaus, 1971; Qasim and Wyatt, 1972; Shynamma and Balakrishnan, 1973; Mohammed Salih, 1974; Balakrishnan and Shynamma, 1976; Lashmanan et al., 1982, 1987).

William, 1960; Zein - Eldin and Griffith, 1969; Vankataramaiah et al. 1974; Sreekumar Nair and Krishnakutty, 1975; Suseelan, 1978; Sankaranarayanan et al. 1982; Gopinathan et al. 1982; Nair et al. 1988, have stressed the importance of salinity and temperature in the survival and growth of prawns. The present observation clearly indicate that high salinity prevailed in the ecosystems during the premonsoon. Low salinity values recorded in the monsoon season was mainly due to the monsoon rains and the ensured in flow of water. The recovery of salinity was observed during the postmonsoon season in all the culture ponds during both the years. Towards the end of postmonsoon season, the salinity range observed in the ponds was in accordance with the required optima for the growth of prawns.

According to Suseelan (1978), the minimum survival level of oxygen content for *Penaeus indicus* range between 1.49 ml/l and 3.80 ml/l among early juveniles and subadults. The dissolved oxygen content of water in all the ponds was mostly above 30% saturation level. However, relatively lower saturation values (3 ml/l) during postmonsoon period of 1987 in the CIBA pond and
COCO field were also observed when the ponds were of freshwater dominated.

In brackishwater aquaculture a regular exchange between tidal water and pond water is highly essential to maintain optimum temperature requirement by the organisms. The preferred temperature range of the medium for prawn culture was observed to be 28 - 32°C (Suseelan, 1978). Water temperature in all the ponds ranged between 27 - 34°C during different months of 1986 and 1987. Due to the prevalent nature of the habitats which is tropical variation in the temperature of water was observed to be narrow. However, the observed range was found to be within the optimum level for the growth of prawns.

During the present investigation, the observed range of pH was 7 and 8 indicating the alkaline nature of the environment. However, low pH value (7.0) recorded in the month of October in the ponds could be backtraced to the large scale influx and leaching activity during the monsoon months.

The oxidation reduction potential (Eh) exhibited a ranged of 130 to 270 MeV with an increasing trend from premonsoon season to the postmonsoon season. The observed values in the water did not evince a reducing condition as observed in the mud by Sankaranarayanan et al. (1982). Eh values were observed to be in the range of 47 to +06 in the prawn culture systems around Cochin earlier (Sugunan and Pillai, 1984).

Distribution of nutrients in the prawn culture ponds has
been studied earlier (Sankaranarayanan et al., 1982; Gopinathan et al., 1982; Nair et al., 1988). During the present study, concentration of nutrients in different ponds was investigated. In the CIBA pond, the ammonia content was found to be higher during the premonsoon season with a gradual increasing trend subsequently. The observed tendency can be attributed to the fact that local matter and metabolites from the organisms get accumulated. If fluctuates highly and irregularly during the other seasons. Similar observation of high ammonia concentration in premonsoon season and fluctuation in other seasons were observed in the COCO field also. In the POKKALI field also the ammonia concentration was high during the premonsoon season.

Inorganic phosphate in the water showed a relatively high values (2 μg at/l) in most of the months. Highest values were recorded during monsoon season in all the ponds. However high values of inorganic phosphate were recorded in the postmonsoon season also in the COCO field. George and Krishnakartha (1963) and Qasim and Wyatt (1972) reported June and July as period of higher possible concentration in this estuary. The phosphates level showed a general increase during the SW monsoon period in the prawn culture fields (Sankaranarayanan et al., 1982). Results obtained during the present study agree with these results. High values of phosphate in water could be attributed to the common use of fertilizers in the situated fields adjusted to the culture ponds, and leaching activity during the monsoon months.
Gopinathan et al. (1974, 1984) observed the silicate values were found to be high during June - August in Cochin Backwaters. However, it was observed during the present study that there was no such high concentration of silicate confined to monsoon season but it was irregular throughout the year in the prawn culture ponds. The dissolved silicon showed wide range of values between 4 to 43 µg at/l in all the culture pond during different months. The chief source of silicate is from the sediment and soil of the ponds and presumed to be brought down by runoff. However the available silicats values ranged within the optimal level for phytoplankters.

Gopinathan et al. (1982) recorded the nitrite content of the water, in general was very low (1 µg at/l) in the prawn culture fields. Nitrite values in the CIBA pond varied between 1 and 5 µg at/l throughout years. Relatively high values were recorded during the monsoon period and low values recorded in the postmonsoon season. In the COCO field nitrite values ranged 1 µg at/l during the premonsoon seasons. High values were also recorded in the period monsoon. Distribution of nitrite in water in the postmonsoon was found to be irregular. In the FOKKALI field nitrite concentration ranged 1 µg at/l during the period of observation. The distribution of nitrite suggest that the riverine inputs are more and a regenerative source exists within the culture system. Low values in the postmonsoon season were due to depletion of nitrites by phytoplankters.

Nitrate concentration ranged widely in the ecosystems
during the period of study. In the CIBA pond, the values ranged between 4 - 12 µg at/l during the premonsoon season and a higher ranged of 5 to 26.8 µg at/l during the monsoon and a higher ranged of 5 to 26.8 µg at/l during the monsoon and relatively a lower ranged of 2 to 7 µg at/l during the postmonsoon. In the COCO field, the range in the concentration of nitrate was between 2.76 and 23.98 µg at/l with high concentration during monsoon period. In the POKKALI field higher range of 8 to 20 µg at/l of nitrate concentration was observed. The features are very similar to those observed for the nitrite distribution in the culture ponds. These results agree with those observed in the prawn culture field by Gopinathan et al. (1982) and Sankaranarayanan et al. (1982).

Primary production in the Cochin Backwater Area has been studied in general earlier (Qasim et al., 1969; Gopinathan, 1972, Qasim, 1973, 1979; Devassy and Bhattathiri, 1974; Joseph and Kunjikrishnan Pillai, 1975; Kumaran and Rao, 1975; Nair et al., 1975; Gopinathan et al., 1984), and extensive investigation on this aspect in the adjasent prawn culture fields are limited (Gopinathan et al., 1982; Gopalakrishnan et al., 1986). Even in these studied, and comprehensive attempt on the phytoplankton production in the different types of prawn culture systems are lacking. Hence, in the present investigation, an attempt has been made to determine the different productivity indices, and the relationship of different variables responsible for the phytoplankton production by statistical analysis.

Gopinathan et al. (1984) have observed two seasonal peaks of primary production, a primary one during monsoon season
and a secondary peak during the postmonsoon period in the Cochin Bakwater. In the present study it was observed that the annual cycle of gross and net primary productivity showed two peaks during 1986 and 1987. Maximum primary productivity was recorded during April (Premonsoon season) and the secondary peak was observed during the postmonsoon period (September) in both CIBA pond and COCO field. In the POKKALI field maximum rate of primary production it was recorded in April. High rate of productivity has been recorded with the influx of inshore water into the culture ponds was relatively high. It was also observed that the low rate of productivity was due to low rate of replenishment by water or by the influx of freshwater. The present study substantiates the earlier observation that the culture ponds located at Narakkal in between Cochin and Azhikode bar mouth is relatively high productive ecosystem, (George et al., 1968; George, 1974; Pillai and George, 1974; Gopinathan et al., 1982). The advantage of the presence of two opening to the sea within a short distance through which there is a regular incursion of salinewater and also periodical enrichment from the run off from Periyar river and seasonality could be the causative factor for high rate of production. However, the higher values noticed during the premonsoon season in both COCO field and POKKALI field during 1987 presumably due to very lower level of water (< 0.5m) and more light penetration and temperature as observed in the culture ponds. The observed seasonal peaks of primary productivity in culture ponds agree with the observation made by Gopinathan et al. (1984) in the Cochin culture.
Since chlorophyll 'a' is one of the major indices of the standing crop of phytoplankton, the estimation of this pigment along with that of primary productivity is expected to give a general idea of variation in the magnitude of production. (Gopinathan et al., 1984). During this period of study, concentration of chlorophyll 'a' always exceeded that of other pigments. Being a major constituents, distribution of chlorophyll 'a' alone was computed and compared with that other productivity indices.

Maximum concentration of chlorophyll 'a' values was recorded during the premonsoon season of the years in all the ponds. High chlorophyll concentration were usually observed with bloom of single species such as Nitzschia closterium and Skeletonema costatum during the premonsoon season (up to 45 mg chl/m$^3$). In general, the concentration of chlorophyll 'a' was found to be high throughout the year in all the culture ponds (7 mg chl/m$^3$). Periodical development of bloom such as diatoms during premonsoon season, blue-green during monsoon and dinoflagellates in the postmonsoon, coupled with the abundance of nanoplanckters contributed to relatively high concentration of chlorophyll 'a' throughout seasons.

The results of enumeration of phytoplankton cells revealed that abundance of diatoms during the premonsoon season in all the ponds. Relatively low cell counts was recorded in the monsoon season. However, in the postmonsoon period, sporadic occurrence of dinoflagellates and blue-green algae were observed in CIBA pond on account of the favourable condition such as low
salinity, high nutrient concentration and moderate temperature. Abundance of diatoms during the premonsoon season in the indicative of the establishment of true marine environmental condition in the culture system. Qualitative and quantitative estimation of phytoplankters revealed that they were abundant in the POKKALI field, followed by CIBA pond and COCO field.

Statistical analyses of the data was attempted to elucidate the correlations and interdependence of abiotic and biotic factors observed during the study. The hydrological factors and nutrients were reckoned as the independent variables and primary productivity indices as the dependent variables. The correlation coefficient between the independent variable and production indices were computed, and the variables which were found to be not significant deleted to determine standard regression coefficient for productivity indices viz., primary productivity chlorophyll 'a' and numerical analysis of phytoplankters.

In the CIBA pond, during 1986, ammonia, silicate and nitrate gave significant multiple correlation coefficient. These variables gave coefficient of determination of 0.38. About 38% of the variation in primary productivity was explained by all these parameters. During 1987, phosphate, silicate and nitrate gave significant values and about 66% of the variation in primary productivity was explained by these factors.

In the COCO field during 1986, salinity, dissolved oxygen, temperature nitrite and nitrate showed significant
multiple correlation. About 73% of the variation in primary productivity was explained. During 1987, temperature redox potential, silicate and nitrite gave a coefficient of determination of 0.800. These variables together contributed to 80% of the variation in primary productivity.

In the POKKALI field, salinity, dissolved oxygen, ammonia, phosphate, and silicate gave a multiple correlation coefficient of 0.95. These variables together contributed to 95% of the variation in primary productivity during the premonsoon of 1986 and 1987.

Fluctuation in the concentration of chlorophyll 'a' was positively correlated to the distribution of phosphate and nitrate during 1986. These variables gave a coefficient of determination of 0.46. During 1987, salinity, redox potential, ammonia, phosphate and nitrate together explained about 57% of the variation in chlorophyll 'a' production in the CIBA pond. During 1986, in the COCO field, ammonia, silicate and nitrate showed significant multiple correlation coefficient. These variables gave a coefficient of determination of 0.70.

Values of Cell counts in the CIBA pond was found to be not significant which implies that it is not dependent on the contributing variables. However, in 1987, in the COCO field, dissolved oxygen, ammonia, silicate, nitrite and nitrate together was responsible for 62% of the variation in cell counts.

From the standard regression coefficient it can be seen that the "contributing variables" evinced difference during
different periods of the two years. Difference between culture ponds, was also evident from the data. The multiple regression analysis proved that these culture ponds were independent, and the contributing parameters also evinced variation. As opined by Gopinathan et al. (1984), the dynamic nature of these ecosystems coupled with its topographical features are responsible for such seasonal and spatial variation of the "variables".

The significance of nutrients based on data on primary productivity and chlorophyll 'a' concentration was also attempted in this study. Ketchum et al. (1958) had put forward that the ratio of N.P: G.P. was indicative of the actual physiological states of phytoplankton population, which occur due to nutrients availability or deficiency. At times of nutrients deficiency the ratio would approach zero. In the present study the ratio was found to be within the range of 0.58 and 0.99 (Table - 25). These values agree with the abrivation of Qasim et al. (1969) for the Cochin backwater where N.P : G.P. ratio was found to be within the range of 0.55 and 0.75 and with that of the observed range of 0.40 to 0.90 by Vijayalakshmi, 1986 for the Vellar estuary. The observed values, during this present study signify that the available nutrients are rich in concentration in all the culture ponds.

Assimilation number (the ratio of carbon fixed/chlorophyll 'a') were calculated based on data of primary productivity and concentration of chlorophyll 'a' (mg C/mg Chl 'a'). A nutrient relationship could be understood from the annual numerical value of assimilation number. Curl and Small (1965)
suggested that assimilation ratio of 0-3 indicate nutrient depletion; ratio of 3-5 boderline nutrient deficiency and 5-12 indicate nutrient rich water. Radhakrishana et al. (1978) observed that the assimilation number in the north eastern Arabian Sea varied from 24 at the deepest station to 208 at the inshore station. At the offshore stations, the assimilation number averaged to 22 (range 11-34). In the present observation the annual numerical number between 8-136 in ponds in different seasons lend support to the fact that the culture system is rich in nutrient concentration. It is also observed that fluctuation in productivity rate was not only dependent on chlorophyll 'a' concentration but also due to other accessory pigments.

An attempt was made to assess the possible ratios among the estimated chlorophyll pigments and its biological significance. In the present study chlorophyll 'a' concentration always exceeded that of chlorophyll 'b', 'g' and carotenoids. However, in certain circumstances chlorophyll b/a ratio was found to be high during the concurrence of the development of bloom and the monsoonal rain (Table - 30). The blue-green algae Lyngbya aeruginosa bloomed in November 1987. The observed values of chlorophyll b/a which was 1.04 was indicated as monthly mean value of 0.69 in Table - 30 during November in the CIBA pond. In COCO field, the unidentified blue-green algal bloom was also accounted and presented as 0.86 (monthly mean value) during November. In the CIBA pond the observed ratio of 0.68 for the bloom Microcystis aeruginosa during December was presented the monthly mean value of 0.42 in Table - 30. In another instance, the ratio of chlorophyll
'a'/'a' was found to be pronounced concomitant development of dinoflagellates in the CIBA pond during October 1987 (Table - 31). The observed ratio of 0.82 of the bloom *Peridinium pallidum* was presented as the monthly mean value of 0.44 in Table - 31. The obtained ratio of Carotinoids/chlorophyll 'a' 0.49 in October also coincide with the bloom of dinoflagellates (Table - 32).

Studies on nutrient limitation shown that for marine coastal waters nitrogen is usually the most limiting nutrient for potential phytoplankton biomass formation (Burland *et al*., 1980, Nixon and Pilson, 1963; Caruco *et al*., 1987). For brackish waters, phosphorus may play an important role, especially if freshwater inflow is high, as, for example, is the case in Trondheim fjord (Sakshaug and Myklestad, 1973), the inner part of Marseille Bay (Burland *et al*., 1980), Bothnian Bay, located at the northern part of the brackish Baltic Sea (Alasaarela, 1979), and Chesapeake Bay during winter (D'Elia *et al*., 1986).

An attempt was made during the present study to test which nutrient may limit potential biomass accumulation in the culture ponds. Statistical analysis (ANOVA technique) was conducted to examine the influence of nutrients, individually and in combination. Production was measured by means of chlorophyll 'a'.

In vitro experiment during monsoon season showed that phosphate and trace metals individually gave significant values. The calculated F ratio is significant at 5% level. The high rate of utilization of phosphate by blue-green algae during monsoon
season contributed to this significance. It supports the view that an increase in phytoplankton biomass through the growth of blue-green algae was due to the addition of phosphate to the samples (Graneli, 1979, 1984).

During in situ experiment carried out in the post monsoon period, all the nutrients including trace metals gave high significant results. The calculated 'F' value is highly significant at 1% level of significance. During premonsoon season also all the nutrients gave highly significant results at 1%.

Significance of treatment with nutrients during postmonsoon were presumably due to the concentration of nutrients relatively lesser than that of the premonsoon condition. Generally, an input of nutrients enhanced the concentration of the chlorophyll 'a' to same extent, and response of phytoplankton to nutrients lead to growth are production. Similar results of obtained during the premonsoon season. Hence, it is concluded that enrichment of the culture ecosystems during the periods of active farming practise such as premonsoon and postmonsoon seasons would ensure enhanced production rate.

AN EVALUATION OF POTENTIAL YIELD AND CONCLUSION

Knowing the primary production and the quantitative transfer between trophic levels, the potential production of fish/prawn in an area - both first stage carnivores (Zooplankton feeders) and predators can be estimated.
Slobodkin (1961) indicated a value of ecological efficiency at about 10%. Shaefer (1965) considering the effect of ecological efficiencies ranging from 10 to 20% noted an order of magnitude of increase in the production of fish at the fifth trophical level. In general, the trophic levels included are- autotrophs and saprophages at the first trophic level, herbivorous organisms at the second trophic level, omnivorous organisms at the third trophic level, primary carnivores at the fourth level, secondary carnivores at the fifth level and tertiary carnivores at the sixth level (Petipa et al., 1970).

Ryther (1969) considered the number of trophic levels in three communities which may be described as of oceanic, continental shelf and upwelled. In these communities ecological efficiencies at each trophic level were assumed to be highest when governed largely by phytoplankton/herbivore associations and lowest for communities in these which were secondary and tertiary carnivores. Consequently a 10, 15 and 20% efficiency was assigned to be oceanic, coastal and upwelling food chains respectively. From this Ryther estimated the potential fish production of 36,000,340 and 0.5 mg C/m³/hr. for the upwelling, shelf and oceanic areas respectively.

Several attempts have been made to relate productivity parameters with that of potential yield or optimum sustainable yield (Subramanyam, 1959; Prasad and Nair, 1963; Nair et al., 1969; Prasad et al., 1978; 1970; Qasim et al., 1976). It has been postulated by Steeman Nielsen and Jensen (1957) that landings of commercial fish catch in intensely exploited water is about 0.4%
of the organic matter produced by the phytoplankton. However Nair and Pillai (1983) observed that a maximum sustainable yield of 0.2% would be a more realistic estimate for the EEZ of INDIA which would amount to just about 5 million tonnes of fish.

An attempt has been made to compute the potential fishery yield from primary production from the CIBA pond and that of COCO field and POKKALI field at Narakkal. Total primary production during the present study in the CIBA pond amounted to 5000 g C/m$^3$/year (5 kg. C/m$^3$/yr) in each year.

Since prawns are carnivores and they have been cultured in a closed system the energy conversion could be as high as 30% if not more. So it is postulated that a minimum yield of 20% is possible to be harvested at the third trophic level where the crustaceans occur in a closed system.

Total primary production during this study (biomass) = 5 kg/m$^3$/yr.

Taking 30% ecological efficiency at the second trophic level for 0.6 ha (6000 m$^2$) pond = \( \frac{30 \times 5 \times 6000}{100} \)

20% ecological efficiency at the third trophic level = \( \frac{20 \times 9000}{100} \)

.. sustainable yield would be 1800 kg/0.6 ha./yr. (3000 kg/ha./yr.)

It is possible to obtain a yield of 3000 kg. of prawn or fishes at the third trophic level from one ha. pond. Therefore the possibility of getting a quantum of harvest amounting 1800 kg. for 0.6 ha. pond is expected.
However in intensly stocked closed ecosystem as the CIBA pond exploited seasonaly a 0.4% yield in terms of carbon produced appear to be more reasonable. This would amount to 2000 kg. of prawns or fishes at this trophic level. Hence the possibility of getting a harvest of 1200 kg. for 0.6 ha. of the pond is within the possible limits.

In otherwords, since the culture practice is such that prawn larvae are stocked at a rate of 50,000/ha. and with a normal survival rate of 40% would result in a harvestable production of 200 kg. per crop (ie. 20000x10 g based on an average weight of each prawn). Maximum three harvests of 600 kg. is the average yield at present. Hence stocking can be made to utilize the available primary producers in full in the culture pond and increase production.

In this context it can therefore be concluded that it may be possible to increase the fish and prawn production by scientific planning and management of the existing prawn culture systems for which this document would form a scientific base.