JOURNAL

OF

INLAND FISHERIES

Volume 3 December 1986

Published by

THE MINISTRY OF FISHERIES

SRI LANKA

JOURNAL OF INLAND FISHERIES
SRI LANKA

The Journal of Inland Fisheries will be published once a year by the Inland Fisheries Division of the Ministry of Fisheries, Sri Lanka. The month of publication is December

The Journal is intended to cover the entire range of inland fisheries and aquaculture. The papers will relate mainly, but not exclusively, to Sri Lanka.

Papers for publication and all connected correspondence should be addressed to the Director of Inland Fisheries, Ministry of Fisheries, P. O. Box 1707, Maligawatte Secretariat, Colombo 10, Sri Lanka. Remittances should be drawn in favour of Secretary, Ministry of Fisheries. Price per copy is Rs. 50/- (local) and US $ 10/- (Overseas—inclusive of postage).

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J. Inland Fish., Vol. 3, December, 1986, pp. 3—14

APPLICATION OF 'YIELD PER RECRUIT' AND 'SURPLUS YIELD' MODELS TO THE GREY MULLET FISHERY OF NEGOMBO LAGOON, SRI LANKA

M. J. S. Wijeyaratne[1] and H. H. Costa[1]

Introduction:

The maximum sustainable yield (MSY) has been widely used to determine the biological status of exploitation of fishery rasources. The yield per recruit model of Beverton and Holt (1957) has been widely used in the determination of variation of yield per recruit of a fish stock with fishing effort while surplus yield model of Schaefer (1954) is used to estimate the MSY and the maximum sustainable fishing effort of a fishery. In the management of small scale fisheries, in addition to the biological status of the fish stock, socio-economic conditions are also been considered and the concept of maximum social yield (MScY) has been suggested recently to determine the optimum rate of exploitation (Panayotou, 1982). However, estimation of MScY needs the determination of MSY.

In Negombo lagoon (7°10'N and 79°50'E), grey mullets are the most important group of fish contributing for about 38% of the total fin fish catch (Wijeyaratne, 1984). Nine species of grey mullets have been recorded to exist in this lagoon (Costa and Fernando, 1981). They are *Liza dussumieri* (*L. subviridis*), *L. macrolepis*, *L. strongylocephalus* (*Valamugil cunnesius*), *L. tade*, *L. vaigiensis*, *L. parsia*, *L. oligolepis*, *Mugil cephalus and Valamugil buchanani*.

In this analysis, Beverton and Holt's (1957) "yield per recruit" model and Schaefer's (1954) "surplus yield" model were used to determine the maximum sustainable yield of grey mullets and the optimum fishing effort needed to obtain that amount of yield in Negombo lagoon.

Materials and Methods:

The grey mullet catch of Negombo lagoon was sampled weekly at fish landing sites at Katunayake, Pitipana and Negombo from January, 1980 to December, 1982. The species of grey mullets were identified and the numbers present in each 2 cm length group were recorded. The total weight of each grey mullet species as well as that of all fish species landed were measured. The types of gear used and the amount of time spent in fishing were also recorded. Using these catch data, instantaneous mortality coefficients and catchability coefficients for each gear were calculated by the methods described by Pauly (1980) and Gulland (1969). The yield per recruit (Y/R) of six species of grey mullets, namely *Liza dussumieri, L. macrolepis, L. tade, Mugil cephalus, Valamugil buchanani and V. cunnesius* at different levels of instantaneous fishing mortalities was calculated by Beverton and Holt's (1957) yield model. The fishing efforts of each gear which are needed to obtain maximum Y/R of each grey mullet species were then determined. Maximum sustainable yields of grey mullets for different types of gear were calculated also by the 'surplus yield' model of Schaefer (1954) using the procedure described by Pauly (1980).

Results and Discussion:

Seven species of grey mullets were identified in the commercial catches of the lagoon during this study. These are *Liza dussumieri, L. macrolepis, L. tade, L. vaigiensis, Mugil cephalus, Valamugil buchanani*

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oand *V. cunnesius*. In additin to these, Costa and Fernando (1981) have identified two more species, *L. parsia* and *L. oligolepis*. All these species except *L. vaigiensis*, *V. buchanani* and *V. cunnesius* have been observed from the brush parks of the lagoon by De Silva and Silva (1979). Most of these species have been observed in the estuaries of India. In Hoogly, Thakur (1970) has observed five species of grey mullets namely, *Mugil cephalus*, *M. corsula*, *M. cunnesius* (*V. cunnesius*), *M. parsia* and *L. tade* while in Mahanadi, in addition to the above species *L. macrolepis* (*M. troscheli*) has also been found. In brackishwater environments of West Bengal, Pakrasi *et al.* (1966) have observed four species of grey mullets of which *L. tade* and *M. parsia* were the most important.

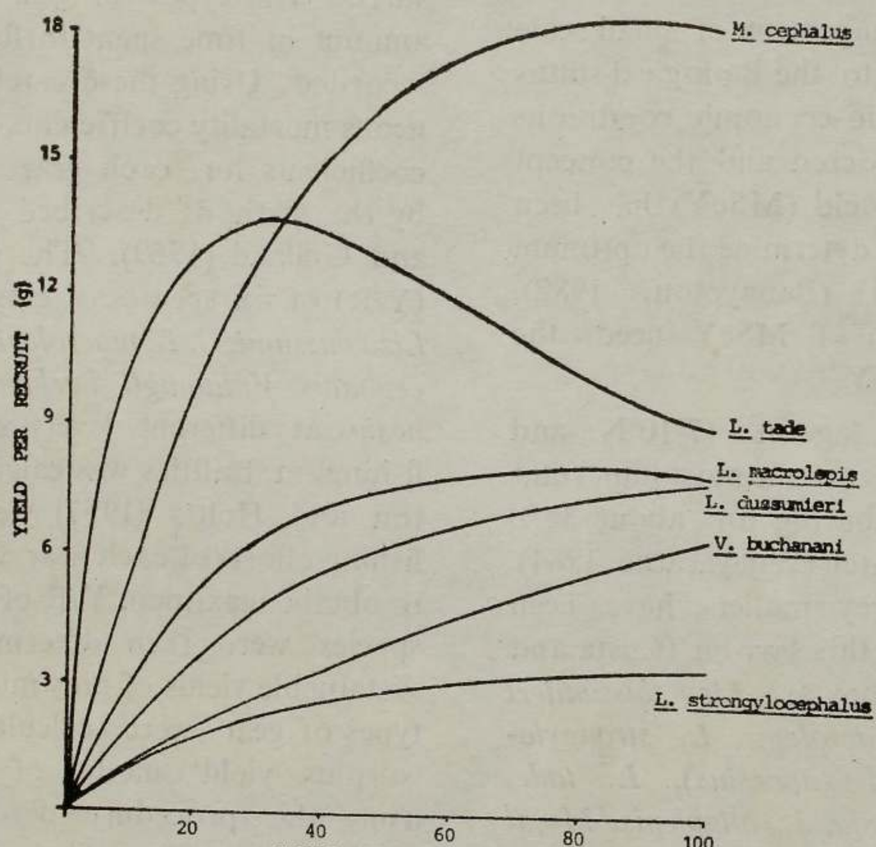

Fig. 3: The change of yield per recruit of different species of grey mullets with the fishing intensity of brush parks.

TABLE 1

Catch and effort statistics of grey mullet fishery in Negombo lagoon

Type of gear	Total weight of grey mullets landed (kg/year)	Grey mullet catch as a % of total grey mullet catch of all gears	Grey mullet catch as a % of total fish catch of all gears	Fishing effort		Grey mullet catch per unit effort kg/manhour
				manhours per year	manhours per day	
Brush parks	11206	48.80	52.01	23565	75.5	0.4829
Encircling nets	4060	16.76	21.84	58575	187.7	0.0717
Gill nets	1604	6.88	24.85	12359	39.6	0.1275
Cast nets	4117	17.78	43.49	27889	89.4	0.1505
Modified set nets	2106	9.44	70.08	6370	20.4	0.3373
Other gears	77	0.35	3.36			

Catch and effort statistics for grey mullets in Negombo lagoon are summarized in Table 1. Total catch of grey mullets of the entire lagoon was about 23,000 kg/year (5.67 kg/ha/year) while the total catch of all fin fish species was about 63,000 kg/year (14.74 kg/ha/year). About half of the catch of grey mullets came from the brush parks. The contributions from cast nets and encircling nets were about 18% and 17% respectively while those of modified set nets and gill nets were less than 10%. However, of the total fin fish catch of modified set nets, more than 70% were the grey mullets. Similarly, about 50% of the total catch of brush parks comprised of grey mullets. In encircling nets and gill nets, the percentage occurrence of grey mullets was less than 25% of the total fin fish catch (Table 1). When the catch of grey mullets per unit effort is considered brush parks were the most efficient type of gear for grey mullet with a catch per unit effort of 0.48 kg/man hour. The value for encircling ets was the lowest with 0.07 kg/man hour.

TABLE 2

Total Catch and Relative Importance of Grey Mullets in Negombo Lagoon.

Species	Total catch (kg)	Relative importance (%)
Liza dussumieri	8470	37.25
L. macrolepis	2125	9.10
L. tade	5981	25.19
L. vaigiensis	136	0.58
Mugil cephalus	1398	6.12
Valamugil buchanani	1920	8.56
V. cunnesius	3107	13.07
Other grey mullets	32	0.13

The total catch and the relative importance of different species of grey mullets in Negombo lagoon are given in Table 2. The catch of *L. dussumieri* was the highest immediately followed by *L. tade*. These two species together contributed to more than 60% of the total grey mullet catch of the lagoon. *V. cunnesius* was the next most important grey mullet species in the commercial catch contributing to 13% of the total grey mullet catch. The catch of *M. cephalus* was very low being only 6% of the total mullet weight landed. This species composition may reflects the abundance and recruitment rates of different grey mullet species present in the lagoon. In Hoogly estuary, India, *M. parsia* and *L. tade* were found to be the most abundant while in Mahanadi estuary, *V. cunnesius M. cephalus* and *M. parsia* predominated (Thakur, 1970). Grey mullets, which contributed for about 38% of the total fish catch, formed the most important group of fishes in the commercial landings of Negombo lagoon. This figure is above that recorded for Mahanadi estuary where 30% of the total fish catch is constituted by grey mullets (Thakur, 1970).

TABLE 3

Catchability coefficients and optimum fishing efforts of different types of gear used in Negombo lagoon.

Species	Catchability coefficients					Optimum fishing efforts (manhours/day)				
	Brush parks	Encircling nets	Gill nets	Cast nets	Modified set nets	Brush parks	Encircling nets	Gill nets	Cast nets	Modified set nets
Liza dussumieri	0.0037	0.0042	0.0120	0.0026	0.0256	127	112	39	181	18
L. macrolepis	0.0045	0.0031	0.0060	0.0008	0.0198	78	113	58	438	18
L. tade	0.0111	0.0026	0.0075	0.0064	0.0269	30	127	44	52	13
Mugil cephalus	0.0032	0.0017	0.0034	0.0002	0.0107	91	171	85	14500	27
Valamugil buchanani	0.0011	0.0034	0.0091	0.0007	0.0204	391	126	47	614	21
V. cunnesius	0.0083	0.0050	0.0168	0.0189	0.0260	125	208	62	55	40

The catchability coefficient of a particular species was found to vary greatly with the type of gear. The lowest catchability coefficients for all gear other than brush parks were observed for *M. cephalus* while the lowest for that gear was obtained for *V. buchanani* (Table 3). The highest catchability coefficients for brush parks and modified set nets were observed for *L. tade* while those for other types of gear were obtained for *V. cunnesius*.

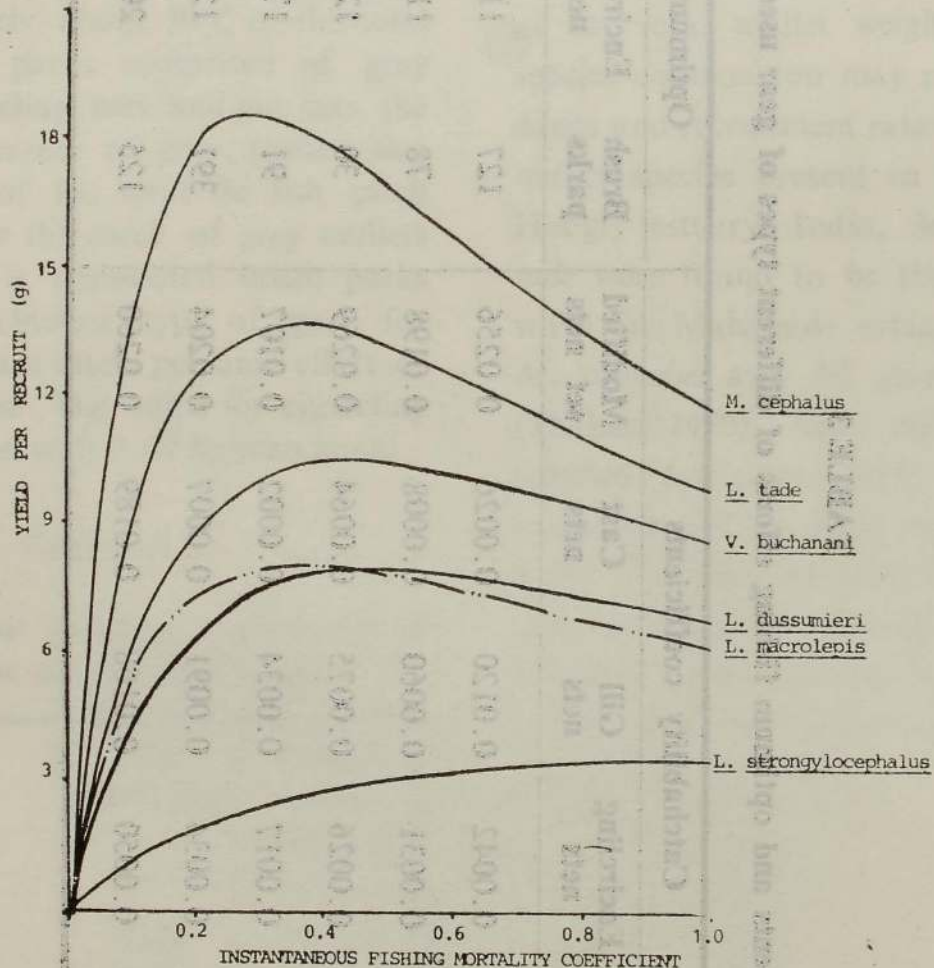

Fig 1 : The change of yield per recruit of the different species of grey mullets with instantaneous fishing mortality coefficient.

TABLE 4

Instantaneous fishing mortality coefficients and the parameters used in Beverton and Holt's yield equation.

F — Instantaneous fishing mortality coefficient
Optimum F — Calculated optimum value of instantaneous fishing mortality coefficient.
M — Instantaneous natural mortality coefficient.
t_o — Age when the length would theoretically be zero (years)
t_r — Age at recruitment (years)
t_c — Age at first capture (years)
k — Coefficient of growth
w_∞ — Asymptotic weight (g)

Species	F	Opitimum F	M	t_o	t_r	t_c	k	w_∞
Liza dussumieri	0.4595	0.47	0.7024	—0.1126	0.1170	0.7287	0.1526	1753
L. macrolepis	0.1230	0.35	0.5628	—0.5975	—0.3080	0.4534	0.0969	3139
L. tade	0.5488	0.33	0.5109	—0.1949	—0.0335	0.5832	0.1734	1276
Mugil cephalus	0.1845	0.29	0.5082	—0.3623	—0.1232	0.4993	0.0943	6698
Valamugil buchanani	0.3191	0.43	0.6541	—0.3238	—0.1043	0.4803	0.1582	1891
V. cunnesius	0.9408	1.04	1.0408	—0.2651	—0.0601	0.5245	0.3365	264

The change of Y/R with instantaneous fishing mortalities (F) are shown in Fig. 1. The parameters used in these calculations are given in Table 4. Y/R increases with F until it reaches a maximum value and then decreases. The optimum level of F, at which maximum Y/R is obtained are also given in Table 4. The minimum and maximum values of these were observed for *M. cephalus* and *V. cunnesius* respectively. It is also seen that the optimum level of F for *L. dussumieri, L. macrolepis, V. cunnesius, M. cephalus* and *V. buchanani* are higher than the existing level (Table 4). This indicates that by increasing the fishing mortality, Y/R of these species could be increased. Fig. 1 shows that Y/R at a particular value of F varies with the species. The highest and the lowest values for Y/R at a given value of F were observed for *M. cephalus* and *V. cunnesius* respectively. The change of Y/R with fishing efforts of different types of gear is shown in Figs. 2—6. The optimum fishing efforts of different types of gear for each grey mullet species at which the highest Y/R is obtained are given in Table 3.

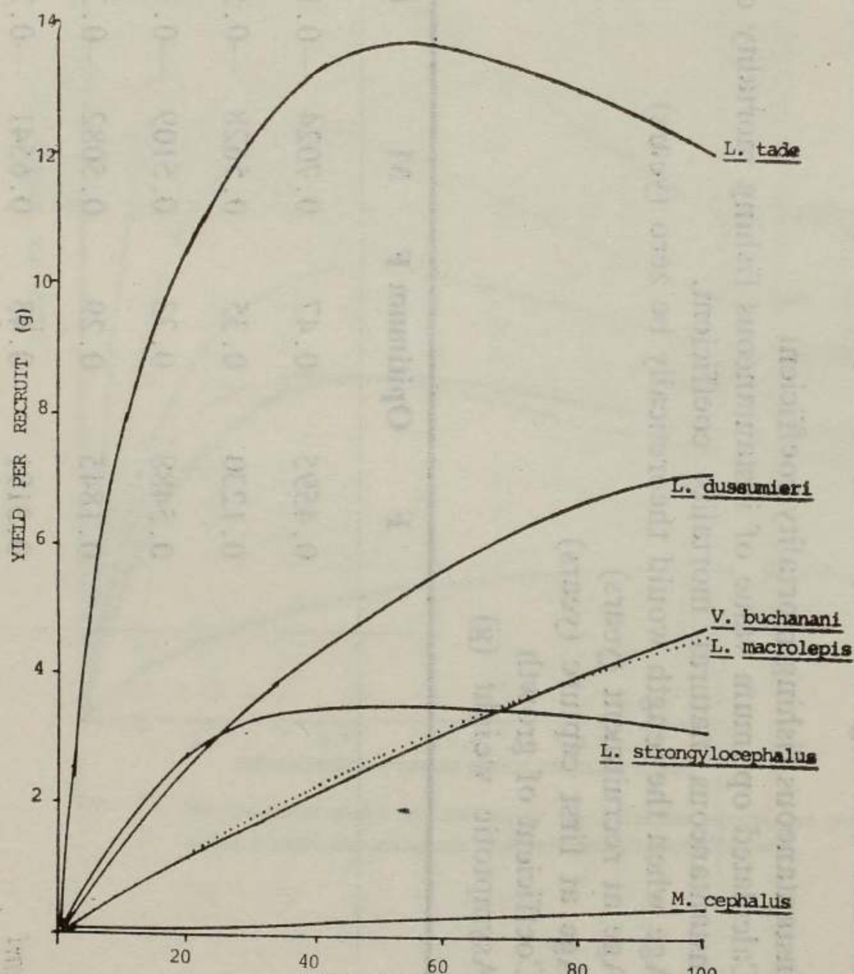

Fig. 2 : The change of yield per recruit of different species of grey mullets with the fishing intensity of cast nets.

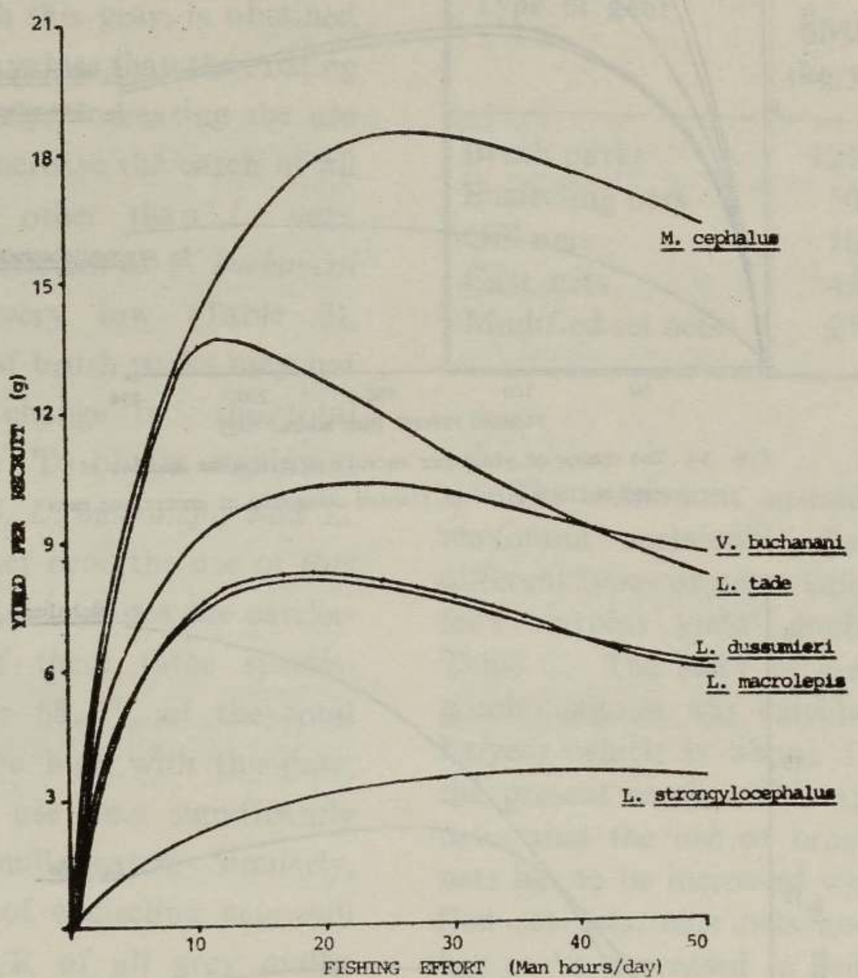

Fig. 4 : The change of yield per recruit of different species of grey mullets with the fishing intensity of modified set nets.

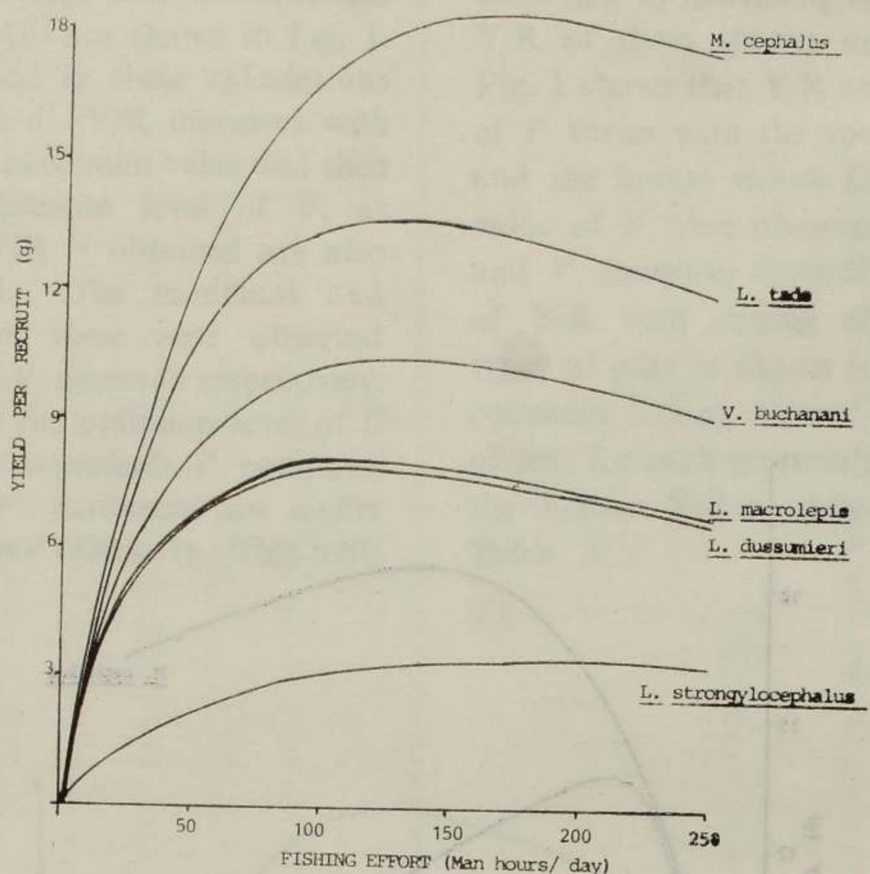

Fig. 5 : The change of yield per recruit of different species of grey mullets with the fishing intensity of encircling nets.

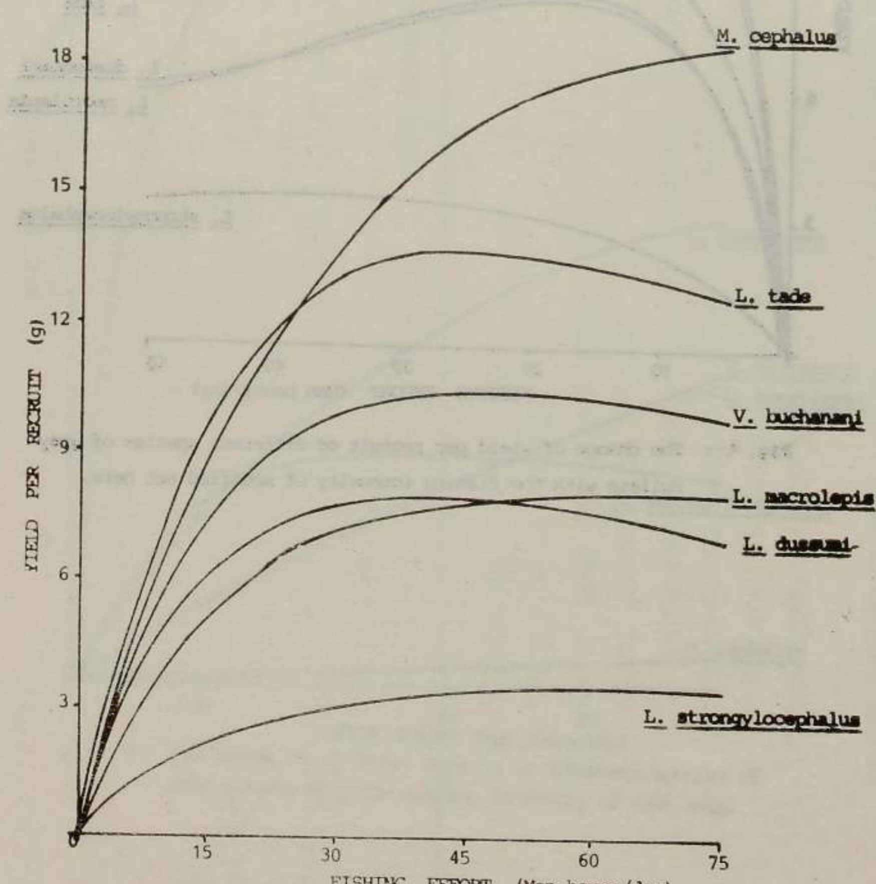

Fig. 6 : The change of yield per recruit of different species of grey mullets with the fishing intensity of gill nets.

Since catchability coefficients of cast nets for *L. macrolepis*, *L. dussumieri*, *M. cephalus* and *V. buchanani* are very low (Table 3), bringing a change in the use of this gear may not significantly affect their catch. However, a decrease in the use of cast nets may increase the catch of *L. tade* and *V. cunnesius* because maximum Y/R of these species whose catchability coefficients are higher with this gear, is obtained at lesser fishing effort values than the existing level (Fig. 2). Similarly, increasing the use of brush parks will increase the catch of all grey mullet species other than *L. tade*. Since catchability coefficient of *V. buchanani* for this gear is very low (Table 3), a change in the use of brush parks may not show a significant change in the total catch of this species. To obtain maximum Y/R of *L. dussumieri*, *L. macrolepis* and *L. tade* from modified set nets, the use of this gear has to be decreased. Since the catchability coefficients of these three species, which contribute for 68.5% of the total grey mullet catch, are high with this gear, this decrease of the use may significantly affect the total grey mullet catch. Similarly, decrease in the use of encircling nets will also increase the Y/R of all grey mullet species other than *V. cunnesius* which comprises only 13% of the total grey mullet catch. The increase in the use of gill nets will increase the Y/R of all grey mullet species other than *L. dussumieri*. Therefore the analysis using Beverton and Holt's model shows that a decrease in the use of cast nets, encircling nets and modified set nets and an increase in the use of brush parks and gill nets will increase the yield of grey mullets in Negombo lagoon.

TABLE 5

Maximum sustainable yields and optimum fishing efforts of different types of gear for the grey mullets calculated by Schaefer's 'surplus yield' model.

Type of gear	MSY (kg/year)	Optimum effort (Man-hours/day)
Brush parks	12593	109.7
Encircling nets	5096	133.1
Gill nets	1679	42.8
Cast nets	4383	64.2
Modified set nets	2797	15.8

The maximum sustainable yields and maximum sustainable fishing efforts of different types of gear calculated by Schaefer's 'surplus yield' model are given in Table 5. The MSY of grey mullets in Negombo lagoon was calculated to be 27148 kg/year which is about 15% higher than the present catch. This analysis also indicates that the use of brush parks and gill nets has to be increased while that of modified set nets, cast nets and encircling nets has to be decreased in order to obtain the MSY of grey mullets.

When the fishing effort is changed, in multispecies fisheries, the species composition of the catch may also change (Panayotou, 1982). However, since the prices of individual grey mullet species do not greatly vary from each other, the unit market value of the total grey mullet catch may not vary considerably due to the changes of species composition which may result by the changes of fishing efforts of different types of gear.

Acknowledgements :

The financial support provided by Natural Resources, Energy and Science Authority of Sri Lanka (Research grants RGB/80/6 and RGB/81/12) is gratefully acknowledged.

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TOPOGRAPHY AND SUBSTRATUM OF BOLGODA LAKE

P. P. G. S. N. Siriwardena and W. K. T. Perera[1]

Introduction :

Apart from the water qualities basic knowledge of the topography, substratum etc., of Sri Lankan water bodies is essential for the development of Inland Fisheries. Surveys to this end are important since primary productivity and fish yields are highly related to morphology of lakes (Rawsan, 1952; Fryer and Iles, 1972). Sachithanandan and Perera (1970) described the topography and substratum of Jaffna lagoon in the Northern Province, Perera and Sachithanandan (1977) surveyed the topography of Nanthikadal and Nayaru lagoons in the Northeast coast, Perera and Siriwardena (1982) studied the topography, substratum and vegetation of Puttalam lagoon in the North-western province while Jayasinghe (1979) gave an account on the morophometry of the lowermost 8 km region of the Panadura estuary. Morphometric data for the Colombo lake has been given by Mendis (1964).

This paper describes the topography and substratum of the Bolgoda Lake system.

Location :

The Bolgoda lake opens into the sea via the Panadura estuary which is situated in the southwest coast of Sri Lanka. The region investigated for this study lies between 6° 41'N and 6° 48'N latitudes and 79° 53'E and 79° 58'E longitudes. The lake system consists of two main basins, namely the North lake and the South Lake and these two basins are inter-connected by a canal, the Bolgoda Ganga. The lake system is fed by Panape ela which discharges via Kepu ela into the South lake, Maha oya which flows into Bolgoda Ganga via Rambana ela and Wereha ganga which discharges into the North Lake (Fig. 1).

Sand Bar :

In Sri Lanka, sand bar formations at openings of lagoons and rivers into the sea along the southwest coast is a well known feature (Wickramasooriya 1969). Complete cut off of the sea opening of the Panadura estuary was first recorded in 1945, and this was considered as an adverse effect of completion of the Bolgoda flood protection bund and the Kepu ela lock gate (Thurairaj 1967). The groynes of heavy rock material constructed at the mouth is effective in preventing the complete closure of the mouth by altering the wave pattern but still a sand bar is formed at the north bank of the river mouth varying temporally in its length and direction (Jayasinghe 1979). A detailed description of the sand bar formation of Panadura estuary including its growth and direction has been provided by Jayasinghe (1979). During this study, observations were made monthly to check whether the sand bar formed effected complete closure. Observations revealed that the sea mouth kept open throughout the study though most of the time it was narrow.

Sand bar formation has a definite influence on the physical and chemical characteristics of the water body since it alters the normal water movement, restricts tidal flow and reduces the tidal amplitude.

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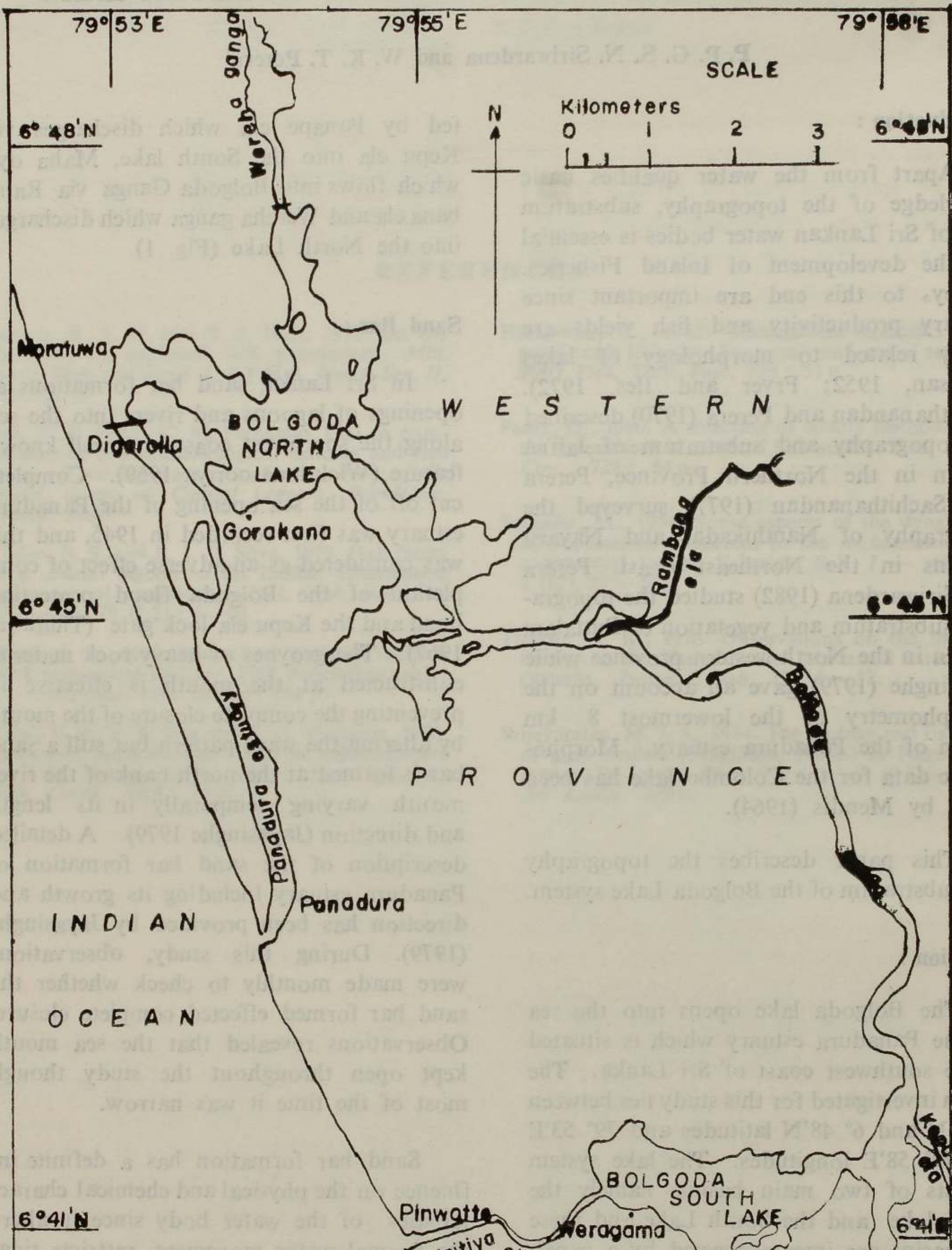


Fig. 1 Location of Bolgoda Lake System.

Position and soundings :

Positions of soundings were determined by the method followed by Sachithanandan and Pereia (1970) i.e., by taking bearings of three or more established land marks with a hand bearing compass which could read upto 30 minutes accuracy. Fig. 2 and 3 show the depths below the lowest tide levels recorded during the study.

Extents of the regions investigated :

Bolgoda North lake has an area of 412.192 hectares shallower than one meter; 248.066 hectares between 1 and 2 meters isobaths and 22.15 hectares deeper than two meters. Bolgoda South lake has 81.1 hectares shallower than 1 meter; 270.903 hectares between 1 meter and 2 meter isobaths and 20.909 hectares deeper than 2 meters. Bolgoda ganga covers an area of 192.23 hectares generally deeper than 2 meters with hardly any area shallower than one meter as the banks are steep.

Tide levels :

Tide levels were measured at three stations of the Bolgoda lake system, namely, Digarolla bridge, Gorakana and Weragama. At Digarolla bridge and Weragama, tide levels were determined round the clock at half hour intervals, on random days, from 12 January, 1985, to 5 November, 1985. At Gorakana, tide levels were obtained for 12 hours daily at half hour intervals and once a week round the clock at same intervals from 2nd April, 1984 to 2nd November, 1985.

The highest amplitudes of 61 cm, 73 cm and 53 cm were recorded at Digarolla bridge, Gorakana and Weragama respectively. The highest variation in a day was 21 cm on 5th November, 1985 and the lowest of 6 cm on 31st March, 1985 at Digarolla; at Gorakana the highest variation in a day was 29.5 cm on 24th September, 1985 and the lowest of 4.0 cm on 9th September, 1985 and at Weragama the highest variation in a day was 13 cm on 23 February, 1985 and lowest was 1.0 cm on 1st November, 1985.

The average daily variation was found to be 12.63 cm from 33 observations at Digarolla; 11.9 cm from 109 observations at Gorakana; and 6.2 cm from 22 observations at Weragama.

Topography and substratum :

The substratum cannot be compared with that of Puttalam, Nanthikadal, Nayaru or Jaffna. The percentage of clay and silt is considerably high in the Bolgoda lake system. Shell particles were hardly observed. The north lake has a more or less uniform bottom and the south lake has a gentle gradient. Both soft mud with clay and medium mud with clay were found to be present at all depth levels. Mud with sand was found very close to the shore. (Fig. 4 and 5).

Discussion :

Complete closure of the lake opening into the sea at Pinwatta prevents sea water intrusion into the south lake via Talpitiya canal and as expected the average daily variation in tide level was found to be very low. Infeed from the catchment area into the south lake and flow from the lake into the Bolgoda ganga were the main causes for the water level variation in South Lake. Digarolla, as it was the tide observation point nearest the sea via Panadura estuary, recorded the highest daily average in tidal variation. Causes of fluctuation were the natural outflow of water collected in North

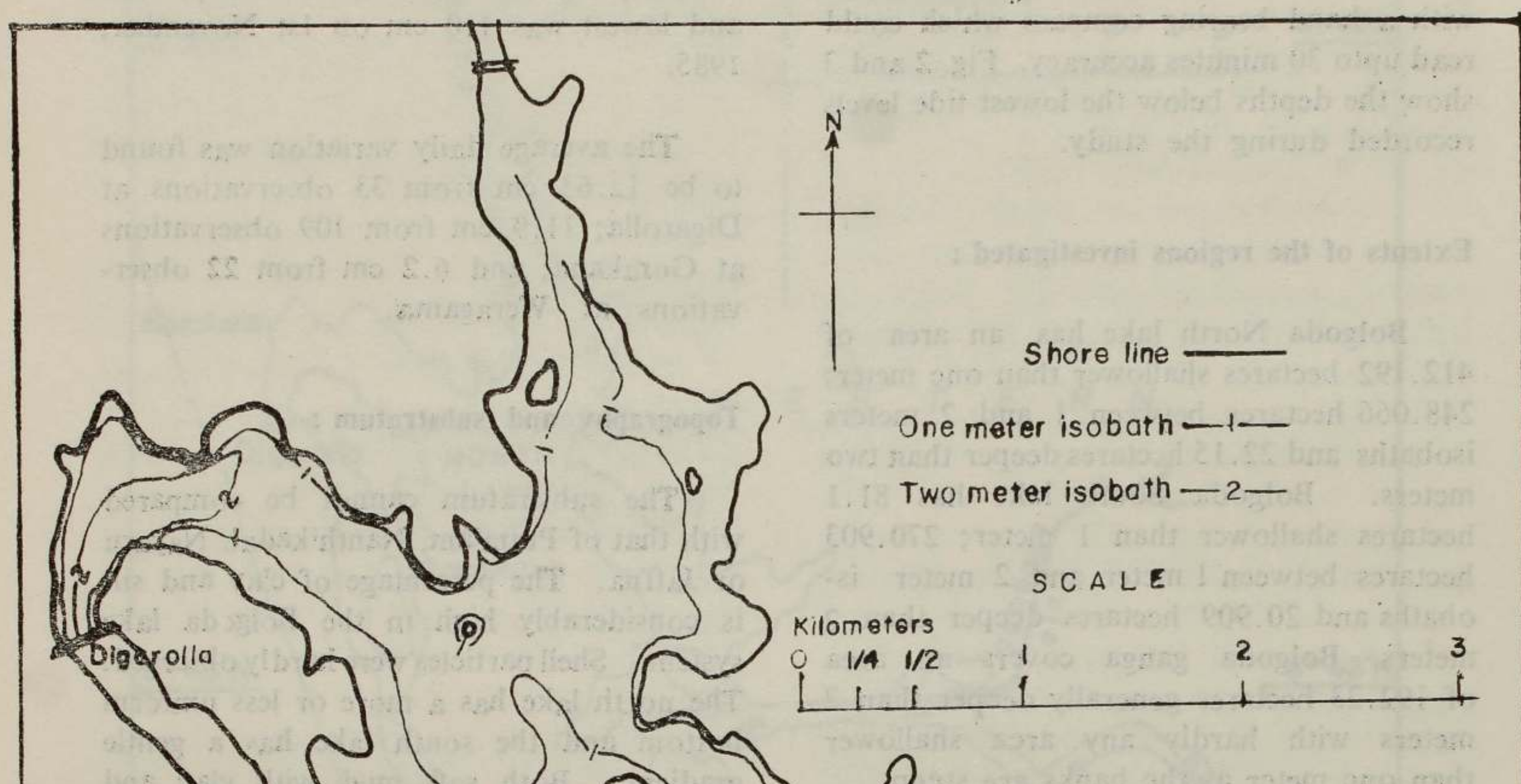
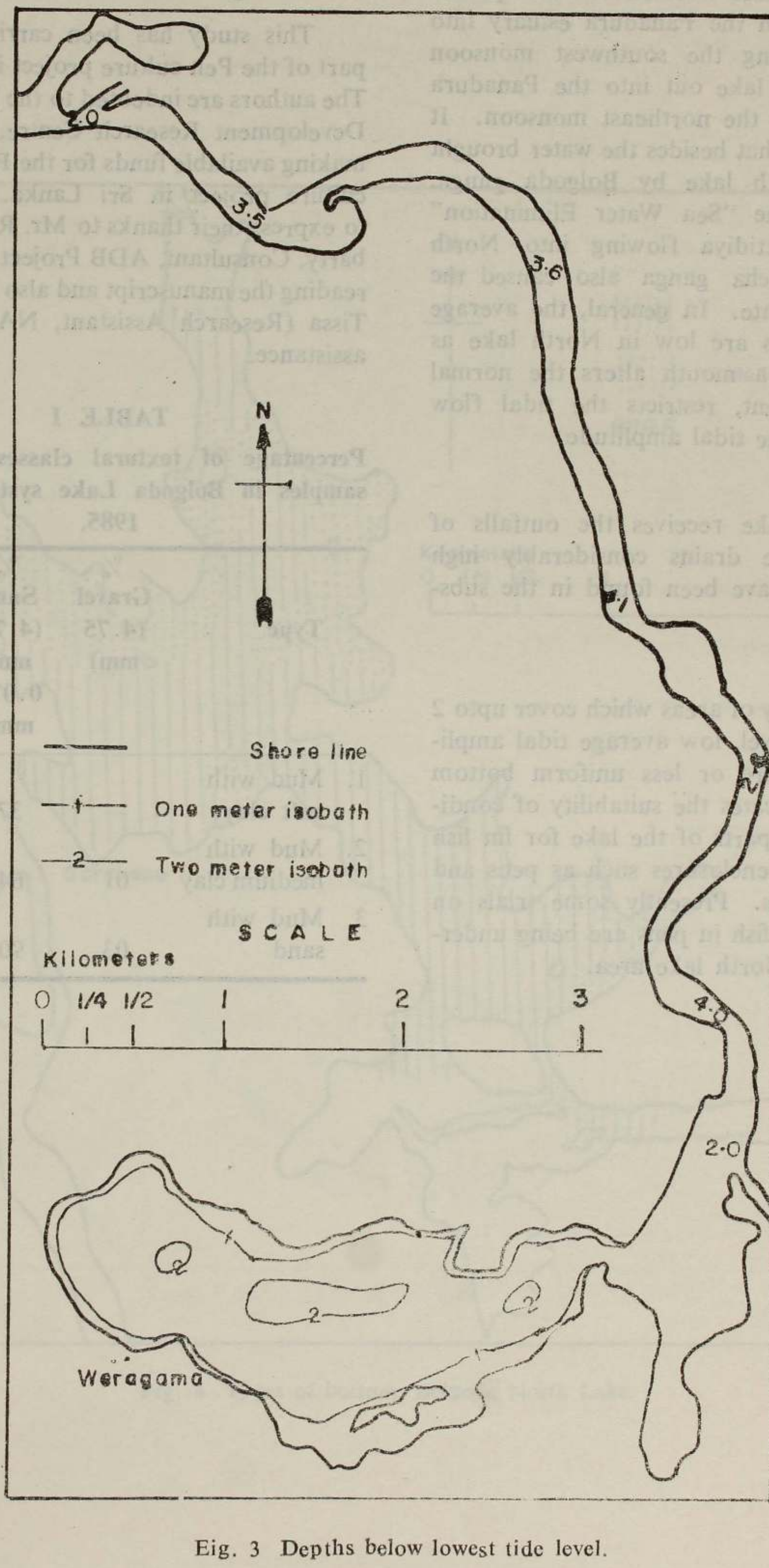


Fig 2 Depths below lowest tide level.



Eig. 3 Depths below lowest tide level.

lake in to sea and wind-effect which pushes the water from the Panadura estuary into the lake during the southwest monsoon and from the lake out into the Panadura estuary during the northeast monsoon. It was observed that besides the water brought into the North lake by Bolgoda ganga, water from the "Sea Water Elimination" scheme at Attidiya flowing into North lake via Wereha ganga also caused the level to fluctuate. In general, the average tidal variations are low in North lake as the narrow sea mouth alters the normal water movement, restricts the tidal flow and reduces the tidal amplitude.

As the lake receives the outfalls of several surface drains considerably high levels of silt have been found in the substratum.

Availability of areas which cover upto 2 meter depth level, low average tidal amplitudes, and more or less uniform bottom with mud indicates the suitability of conditions in some parts of the lake for fin fish culture in net enclosures such as pens and fixed net cages. Presently some trials on culture of milkfish in pens are being undertaken in the North lake area.

Acknowledgement :

This study has been carried out as a part of the Pen culture project in Sri Lanka. The authors are indebted to the International Development Research Centre, Canada for making available funds for the Pen and Cage culture project in Sri Lanka. They wish to express their thanks to Mr. R. D. Chakrabarty, Consultant, ADB Project for critically reading the manuscript and also Mr. R. P. K. Tissa (Research Assistant, NARA) for his assistance.

TABLE I

Percentage of textural classes of Bottom samples in Bolgoda Lake system October, 1985.

Type	% Gravel (4.75 mm)	% Sand (4.75 mm 0.074 mm)	% Clay and silt (0.074 mm)
1. Mud with soft clay	—	37	63
2. Mud with medium clay	01	64	35
3. Mud with sand	03	90	07

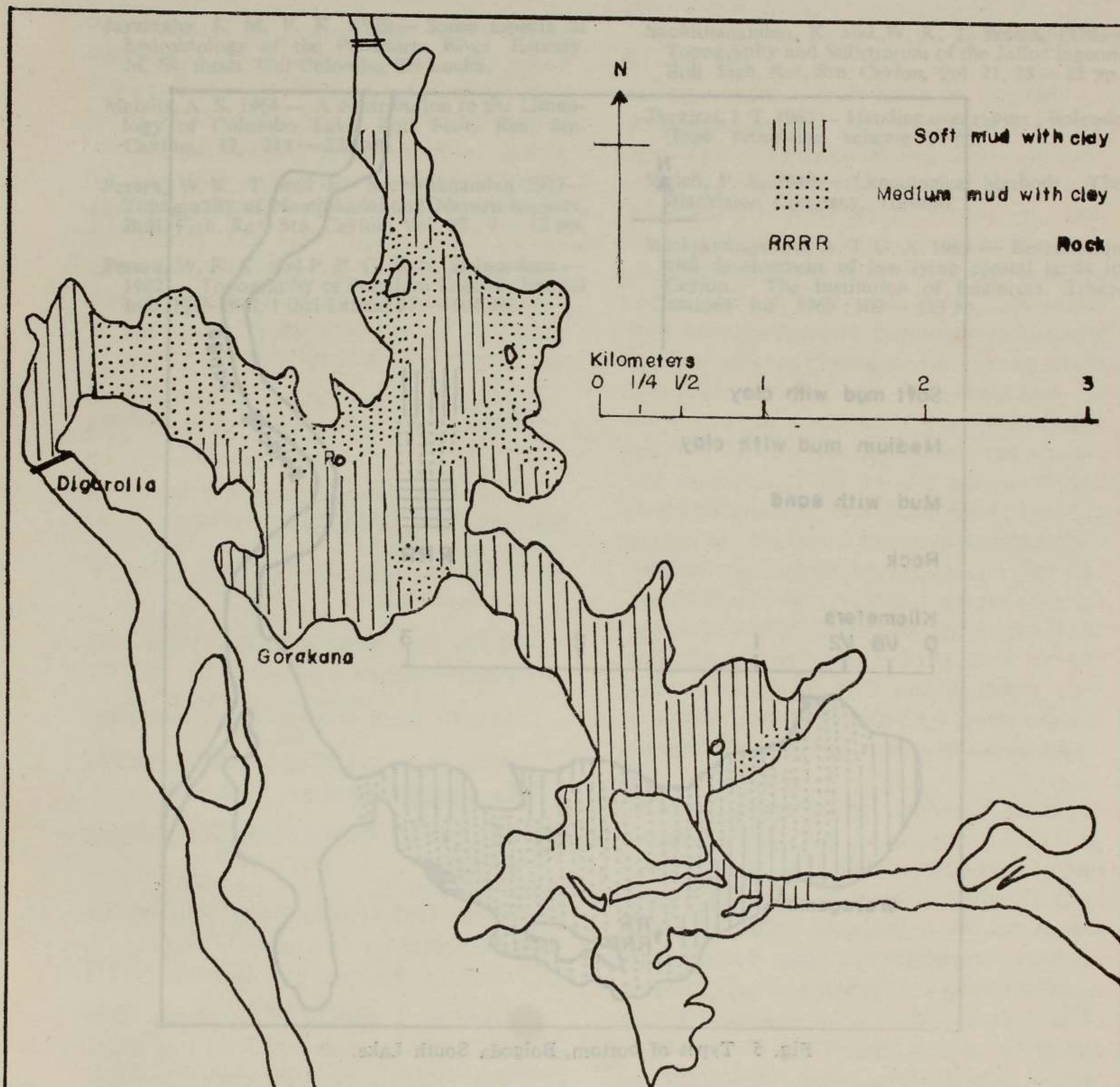


Fig. 4 Types of bottom, Bolgoda North Lake.

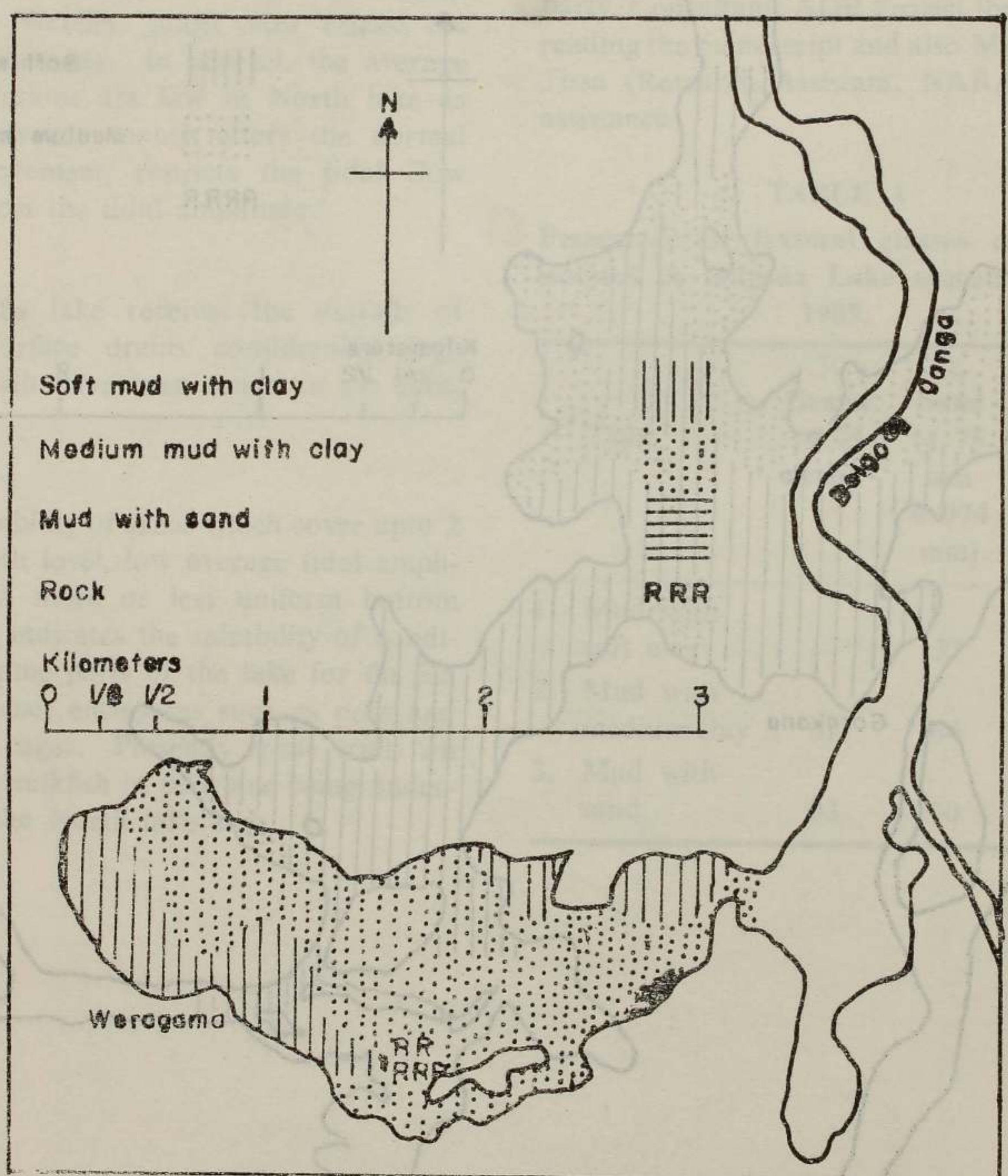


Fig. 5 Types of bottom, Bolgoda South Lake.

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J. Inland Fish, Vol. 3 December, 1986., pp. 24—30

POTENTIAL ROLE OF INLAND FISHERIES IN BIOLOGICAL CONTROL OF MALARIA

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Introduction :

Malaria is considered a major public health problem in the tropical countries affecting about 250 million people annually. Controlling of this disease involved interruption of the life cycle by controlling the vector using chemical and biological methods and controlling the parasite in man by chemotherapy. However, the gradual development of resistance in the vector as well as the parasite to various drugs has resulted in resurgence of this disease. Initially insecticides were widely used in controlling malaria mosquitoes and the W.H.O. strongly supported the use of DDT. Though the use of this chemical and other chlorinated hydrocarbons as agents for control of insects and other pests gained momentum around the mid twentieth century, by the 70's their ill effects on human system became apparent due to their persistant properties. It has been reported that fish ponds have been contaminated by malathion after mosquito eradication spraying, in some countries.

It is therefore, environmentally compatible to use biological methods for controlling mosquitoes. Although this method is of comparatively recent origin it is now recognized as a potential tool for check of insect population without having any harmful effects on human system. Culture of larvivorous fish, control of aquatic weeds and fisheries development in water bodies have a considerable impact in controlling this disease. Shallow derelict ponds, mining pools, clay pits, gem pits, swamps, marshes, village tanks and in fact, all inland water bodies provide abode and shelter to mosquitoes, snails and a host of micro and macro-biota which are vectors of parasites of diseases such as malaria, schistosomiasis and filaria. Inland fisheries development of the water bodies will improve the environment thus leaving lesser chance for the growth of mosquito larvae. Raising of larvivorous fish species and stocking them in various water bodies will play an effective role in the control of malaria.

Species of fish suitable for malaria control :—

The main characteristics of larvitvorous fish have been identified as :—

— Small, so that it can move about in shallow waters;

— Hardy and flourish in both deep and shallow waters;

— Able to stand transport and handling;

— Difficult to catch and able to escape its natural enemies;

— Absolutely worthless and insignificant as food;

— A top-feeder and carnivorous in its own diet;

(Covell, 1927)

There are a number of exotic and indigenous species of fish which at one stage or other feed on mosquito larvae. Most of the cultured fish are also larvivorous in their young stages. Invariably, these

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species when cultured in water bodies contribute to control of malaria. Three introduced species *Carassius auratus*, *Lebistes spp.* and *Gambusia affinis* feed on mosquito larvae. Among the indigenous fish which feed on mosquito larvae are *Notopterus*, *Oxygaster*, *Chela laubuca*, *Rasbora*, *Danio*, *Puntius*, *Wallago*, *Aplocheilus*, *Oryzias*, *Channa*, *Etroplus*, *Anabas*, *Mugil*, *Ambassis* and *Therapon*.

Hora and Mukerji (1953) have classified the larvicidal fish according to their mosquitocidal activity.

— Typical surface feeders (*Aplocheilus*, *Gambusia*) which are the most suitable mosquito fish;

— Those which are surface feeders but are less efficient owing to mode of life, *Oryzias*, *Lebistes spp*;

— Sub-surface feeders: *Amblypharyngodon*, *Danio*, *Rasbora* which are larvicidal to a considerable extent;

— Column feeders: *Puntius*, *Anabas*, *Therapon jarbua* which feed on mosquito larvae when a chance permits;

— Large size food fishes such as *Labeo*, *Catla*, *Mugil*, etc. whose fry are helpful in the reduction of larvae;

— Predatory food fishes, *Wallago*, *Channa*, *Notopterus*, *Mystus*, where fry may swallow larvae but both young and adults are very destructive to other fishes including larvicidal fish.

The exotic species *Gambusia affinis* and *Lebistes reticulatus* (Family Poecsilidae) and indigenous forms *Aplocheilus*, *Oryzias* (Family Cyprinodontidae) constitute the most important and useful mosquitocidal species in India (Jhingran, 1974).

Food fish culture and malaria control :

In Sri Lanka there are several types of water bodies where mosquito breeding could occur. Gem pits in gem mining areas form stagnant water bodies. These pits are mostly irregular in shape and the depth varies. They are usually not connected to any streams. Mosquito larvae may find these as suitable habitats for them to grow. Subsequent growth of water plants such as *Salvinia*, *Eichhornia*, *Pistia*, etc. provide shade for the larvae. Pottery pits too are irregular in shape and usually deep. By suitable modifications and little management measures these water bodies can be converted into fish ponds as seen in many villages in India. Fish culture in these water bodies will not only produce fish for consumption but also helps in direct control of malaria. Most of the fish feed on mosquito larvae in their young stages. Removal of aquatic weeds during fish culture operations and also consumption of aquatic weeds by the cultured fish will reduce the sheltering space for mosquito larvae. In Galle, Passara and Wennappuwa areas some of the lime and clay pits have been utilized for raising freshwater food fish.

Treated sewage too is used in many countries for raising food fish. Sewage generally consists of liquid wastes discharged from all domestic and industrial sources. Indian major carps have been successfully cultured in treated sewage (Jhingran 1974, Sreenivasan and Muthuswamy, 1980). *Channa*, *Anabas*, *Hateropneustes* and *Clarias* are highly suitable for culture in ponds. This method is adopted in Asia, Far East, Middle East and in Germany. These fish species are important in controlling mosquito larvae in the sewage in addition to their major role of serving as food.

Air breathing predatory fish such as murrels thrive well in swamps and weedy marshes where mosquito breeding could occur. They also live in slightly brackish-waters. *Clarias batrachus* inhabits rivers, swamps and ponds. Fry feed on insect larvae. *Heteropneustes* and *Anabas* too are cultured in these waters.

Construction of reservoirs invariably increase the incidence of malaria and other mosquito borne infections. Because of the stagnation of waters and creation of seapage pools, etc. mosquitoes find a favourable environment for multiplication. Stocking of fish species in the reservoirs has an indirect positive effect in controlling malaria.

Village tanks are used by the people in remote areas for bathing and washing, etc. These tanks often get infested with weeds. Stagnant waters infested with weeds support the growth of mosquito larvae, thus causing public health hazards. In Sri Lanka, there are at least 100,000 ha of seasonal/village tanks. Due to high fertility of water, these can be effectively used for fish culture. Small scale management measures are adopted in these water bodies. Weeds are often removed manually and mechanically. Young fish very often feed insect larvae including mosquito larvae. Control of weeds in fish culture indirectly removes the sheltering areas of the larvae.

Pisciculture and weed control in relation to malaria :

Weed control is an essential function in fish culture. Weedy ponds and tanks are the ideal breeding places for mosquitoes. Weeds can be biologically controlled by fish. The effective species are *T. rendalli*, *Puntius pulchelus*, *Osphronemus gourami*, *Tilapia zillii*, etc. and the best fish is Grass carp (*Ctenopharygodon idella*). In rural areas derelict ponds, reservoirs and canals choked with vegetation are a common sight. The dense aquatic submerged vegetation affects recreational activities like swimming, bathing, rowing and fishing becomes difficult. Vegetation growth, death and decay are continuous processes and with the passage of time ecology changes and the water becomes stagnant. The water flow in the canals become slow. Many of these water bodies provide environment for mosquito breeding. *Gambusia*, *Lebistes* and *Panchax* seldom approach the masses of plants covering the surface of the water and such vegetation provides protection for mosquito eggs laid therein and also gives safe refuge to larvae. Waters having a clean surface and containing a small stock of *Lebistes* or similar fish are generally free of mosquito larvae, hence effective measures of mosquito control would involve removal of vegetation, when the water bodies are stocked with herbivorous food fish (Chakrabarty, Per. Com. 1985).

In various parts of the world the Grass carp has proved very effective in controlling aquatic weeds like *Potamogeton*, *Eleocharis*, *Hydrilla*, etc. It is a voracious eater and an efficient converter of macro vegetation into fish flesh. In a single day it can consume plants equivalent to about 70% of its own body weight. It has been reported that about 30 Grass carp per/ha. can check the excessive growth of weeds and with about 100 grass carp per/ha. the aquatic weeds can be totally eradicated. In India, it has been observed that when stocked at 300 — 375 fish weighing 79 — 173 kg./ha. the fish cleared a pond choked with Hydrilla within one month. It also feeds on *Wolffia*, *Lemna* and *Spirodella*. Advance fingerlings, juveniles and adults of Grass carp relish and effectively control *Azolla* and *Salvinia*. Thick infestations of submerged weeds such as *Hydrilla*, *Najas* and *Ceratophyllum* can be controlled by Grass carp. *Ottelia*, *Vallisneria*, *Utricularia*, *Trapa*, *Myriophyllum* and *Spirogyra* are also consumed by this fish. However, it does not feed entirely on *Eichhornia*, *Nymphoides* and *Nymphaea*. Thus, it seems to be a very promising fish for the control of submerged aquatic weeds in fishery waters. Grass carp checks the growth of weeds, gives additional fish production and can be cultured in back yards. If cultured in irrigation canals it can control growth of weeds (CIFE, 1979).

For effective mosquito control with successful fish culture, mosquito infested areas should be stocked with a combination of herbivorous and larvicidal fish.

The Inland Fisheries Division is currently carrying out mass breeding and propagation of Grass carp and Tilapia. This Division is thus playing a key role in the control of malaria and other mosquito borne diseases with the least upsetting of the ecological balance or creating adverse side effects that occur when chemicals are used.

Introduction of larvicidal fish :

Most of the fish in their young stages feed on insect larvae. Hence, the presence of young fish in waters would reduce the incidence of mosquitoes. However, large scale efficient control and eradication requires the use of special larvicidal fish species. In Sri Lanka two indigenous species, *Aplo cheilus spp* (*Panchax*) and *Lebistes reticulatus* (Guppy) are ideal larvicidal fish which do not affect other fish species. Presence of these fish will ensure control of mosquitoes. These species are commonly found in all waters, they are hardy too, and can be easily cultured in small ponds, cement cubicles or plastic pools (Sreenivasan, Per. Com. 1985).

(1) **Gambusia affinis** — Mosquito fish :

Gambusia, a native of Southern U.S.A. is naturalized in countries and recorded from South East Asia, India, etc. The fish are small in size and inhabit swamps, streams and creeks, ditches, etc. They are hardy and easily adaptable to all types of waters and are easily transported. The young are agile, strong and capable of escaping danger (Chakrabarty Per. Com. 1984). The fish is found to live without any discomfort in highly polluted sewage waters with low dissolved oxygen and high ammonia. It is a good larvicide and is extensively used in the control of mosquito larvae.

However, some scientists are of the opinion that it is not a desirable fish in large waters when other economic species also exist. It destroys a large number of mosquito larvae, but is also known to eat the eggs of other species of fish. Sreenivasan, (1984) has reported that *Gambusia* are egg predators and prevent the multiplication of economic fishes like the Mirror carp in lakes and ponds.

It has been found to be useful for mosquito control in Yugoslavia but, results of the introduction in other countries reportedly vary as success, disapperance after several months, no eradication effect on mosquitoes, etc. It is reported that under laboratory conditions the fish consume 260 mosquito larvae in 24 hrs. (Menon, *et.al*, 1959).

2. Poecilla reticulata — **(Lebistes reticula) :**

A native of parts of the West Indies, Venezuela and Northern Brazil, *Lebistes* has been widely distributed throughout the world for mosquito control. It is also reported to kill mosquitoes when not hungry and later eject them dead. The fish reportedly consume 80 mosquito larvae in 24 hours.

3. Aplocheilus :

Fishes of the genus *Aplocheilus* (*Panchax*) distributed in freshwaters and brackishwaters of Asia and the Indo-Australian Archepelago are small in size and are known as mosquito destroyers. *Aplocheilus* occurs in almost all types of altitudes such as hill country streams, reservoirs, rivers, tanks, wells, paddy fields, swamps, and backwaters. It is a hardy fish thriving even in foul waters containing sulphuretted hydrogen and red sulphur bacteria (Menon *et.al.* 1959). In view of its hardiness and adaptability to different environmental conditions it can be transported easily over a long distance. It is mainly an insectivore. It is therefore useful for larvicidal work and found to consume 270 mosquito larvae in 24 hrs.

The estuarine top minnow (*Orizias melastigma*), green top minnow (*A. dayi*) and lesser top minnow (*A. blochi*) which are surface feeding have been described as occurring in Sri Lanka, in freshwater and brackismwaters of coastal plains. These small fishes locally known as Handa Thiththaya, Irinale Handaya and Udda are useful mosquito larvivores.

For mosquito control, larvivorous fish should be introduced into a water body preferably after clearing any dense surface vegetation and removing predatory fish so as to allow the larvicidal fish to propagate themselves. The breeding of mosquitoes according to Jhingran (1974), is confined to a narrow strip of water about 22.5 cm wide adjoining the bank. The most suitable stocking ratio of *Aplocheilus* (*Panchax*) for effective mosquito control has been found to be 3 fish (2 adults to 1 young per 929 cm^2 of the breeding area of mosquitoes. When more than one species of fish are stocked the ratio of adults to young in case of each species may be mueh less than the above.

Use of village tanks for breeding and rearing of larvicidal fish :

Sri Lanka's water resources are characterised by the presence of large number of village tanks. Water from these tanks are used for irrigation, washing, drinking and livestock raising purposes while they are ideal for raising food fish.

Culture of larvicidal fish in confined areas such as net cages and pens constructed within the tanks may be undertaken by village level organizations. The pens made with bamboo poles and mosquito netting can be used as enclosures for raising the fish. No artificial feeding is required as there are plenty of organisms in the water for them to feed on. The enclosures should be stocked with *Aplocheilus*, *Gambusia* and *Lebistes* spp. The fish breeds in the enclosures. The young ones can be allowed to grow and transferred to various water bodies for mosquito control.

Culture of larvicide fish may also be undertaken in cages. The fish are transferred to cages from pens, from where subsequently they are stocked in various water bodies infested with mosquitoes. Since fish like *Gambusia* are live bearers (viviparous) they can breed even in cages unlike other fishes (Sreenivasan, Pers. Com. 1985).

The management of the pens and cages should be undertaken by the village level organizations under the supervision of Anti-malaria Campaign Extension Officers. The aquaculturists of the Ministry of Fisheries could provide technical assistance in construction and installation of pens and cages etc.

It is recommended that several pilot projects in different areas of the country be carried out. The advantages of this method is that the cost of construction is less, management is convenient and no feeding is required.

Maintenance of public health fish nurseries :

Earthen or cement ponds in villages or urban areas may be used for larvicidal fish such as *Gambusia*. Public health fish ponds may be stocked with larvicidal fish collected from swamps and marshes. In Madras, the Municipal Corporation has used these ponds to raise *Gambusia* for subsequent stocking in wells, etc. (Sreenivasan Pers. Com. 1985). Management of public health fish nurseries may be undertaken by the local organizations such as Gramadaya Mandela and Municipal/Town Councils under the supervision of Anti-malaria Extension Officers. The Inland Fisheries Division could provide necessary technical assistance.

Training of extension workers :

The biological control of mosquitoes depends on the availability of personnel with sufficient knowledge and experience in fish culture, weed control as well as malaria control. Therefore, training programmes should be organized for the extension workers involved in fishery development, agriculture and irrigation work.

Discussion and conclusion :

Development of fisheries in various types of water bodies have direct or indirect effects in controlling malaria. Fish culture in various water bodies will assist in the elimination of mosquito larvae and making their breeding habitats unsuitable for their growth.

Insufficient production of fry and fingerlings of fish due to lack of sufficient pond space in the Fish Breeding and Experimental Stations has been recognized as the major constraint in stocking water bodies. The Ministry has now taken steps to expand pond area and is also considering alternative systems for rearing of fingerlings. Introduction of larvicidal fish which are hardy and tolerant to a wide range of environmental conditions should be undertaken on a large scale. Selection of species play an important role in effective biological control of mosquitoes. Control of weeds in various water bodies can be undertaken using herbivorous fish species supplied by the Ministry of Fisheries or by manual or mechanical removal. Stocking water bodies with herbivorous and larvivorous fish species provide best results in the biological control of malaria.

Training and education programmes for the extension workers are considered an essential step in the successful implementation of malaria control programmes. Discarded shells and tins filled with water and unclean water logged drains are also ideal habitats for breeding of mosquitoes. Therefore, proper disposal of refuse and keeping the drains and water logged areas clean, are some important measures that should be undertaken by the people. Educational programmes for the rural and urban communities on malaria eradication may also be organized.

Co-ordinated efforts of anti-malaria campaign extension workers, fishery extension workers, village level organizations and rural and urban communities can be considered essential for the successful implementation of malaria control programmes through biological methods.

Acknowledgement :

The author wishes to express his gratitude to Mr. A. Sreenivasan, Inland Fisheries Advisor, and to Mr. R. D. Chakrabarty, Consultant, ADB for their valuable suggestions. Sincere thanks are also due to Miss. Manel Sumanasekera for carefully typing the manuscript.

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J. Inland Fish., Vol. 3 December, 1986, pp. 31—37

LARVAL REARING TRIALS WITH M. rosenbergii (GIANT FRESH WATER PRAWN)

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Introduction:

With the advent of interest in aquaculture in Sri Lanka *Macrobrachuim rosenbergii* (Giant Fresh Water Prawn) has become an important species, not only because of its rich taste and high price but also on account of culturable qualities that makes it a suitable candidate for extensive and intensive culture both in fresh and brackishwaters.

The Brackishwater Fisheries station at Pambala Sri Lanka originally built for rearing of *chanos* fry and plagued with acidity problems is gradually being transformed into a *Macrobrachium* hatchery.

This paper records some trials done at this station utilising the available minimum facilities and improvised techniques for rearing larvae of *M. rosenbergii.*

Materials and Methods :

General :

Source of larvae :

Wild spawners of *M. rosenbergii* were collected to obtain larvae for the initial operations. Then a brood-stock was raised from the post larvae obtained. In some later trials both types of larvae (from pond reared spawners and wild spawners) were used when the previous trial was repeated, in order to compare the results in these two types.

Source of water :

Sea water was transported in polythene bags, (usually used for transport of fish fingerlings) from about 10 km. from the station. Hence sea water for water exchange requirements in larval rearing tanks was a limiting factor. Fresh water and low saline brackishwater were freely available, which were used to mix with sea water in order to make 10—13 p.p.t. brackishwater, Prepared brackishwater was filtered through a simple sand filter, (Samarasinghe, 1983) prior to use.

Larval rearing tanks :

Eight numbers of 260 L, rectangular concrete aquarium tanks were used for larval rearing. The transparent glass of the tank was covered by dark paper, in order to reduce light penetration into the tank.

Aeration system :

Electrically operated portable aerators were used for hatching of artemia cysts and larval rearing. As the number of aerators were limited, one aerator was used for two larval rearing tanks. Hence the pressure and volume of air, produced in the tank, by the aeartor was not sufficient to agitate and circulate water properly.

Aeration and agitation of water were almost equal in all the trials, except for the last one (trial No. 6).

Bottom cleaning of tanks :

This was done once a day between 07.30 hrs. and 08.30 hrs. by siphoning, with a 10 mm rubber tube.

1. Brackishwater Fisheries Station, Pambala, Kakkapalliya, Sri Lanka.

Water renewal :

Water renewal in individual tanks was accomplished by siphoning out the required volume of water and filling with new water up to the initial water level of the tank.

Feed :

Artemia :

Artemia cysts were hatched in 25 L clay pots. Each clay pot was aerated with one or two portable aerators. Cysts were hatched for over 40 hrs. and the hatching rate was around 80%.

Egg custard :

The whole egg (hen's) was beaten and cooked in boiling water for 3 — 4 minutes and made into a custard. The custard was broken into small particles according to the size (age) of the larvae.

Feeding :

For trials 1 and 2, only artemia nauplii were given, twice a day at 08.30 hrs. and at 17.00 hrs. For trial 3 — 6 egg custard was provided 4 times a day at 07.00 hrs., 0.900 hrs., 10.00 hrs. and 14.30 hrs. For these trials artemia was fed only once a day between 15.00 hrs. and 17.00 hrs.

Stocking of larvae and maintenance of salinity :

A spawner with brown eggs was placed in an aquarium tank with 3 — 4 p.p.t. brackishwater and provided aeration. Then salinity was gradually increased to 13. p.p.t. in 2 days. When all the eggs were hatched the female was removed and the larvae were fed daily with adequate artemia nauplii until the 7th day (after hatching). If the estimated number of larvae were over 34,500 in the tank (over 150 larvae/L) these were thinned out on the 2nd day after hatching.

The trials really started on the 7th day after hatching.

On 7th day, larvae were individually counted and stocked in experimental rearing tanks. Water level in these tanks was maintained around 50 cm, to give a volume of water of 230 L. Salinity in all trials was maintained as given below : —

7th. to 15th. day	—	13 p.p.t.
15th. to 25th. day	—	12 p.p.t.
25th. to 35th. day	—	11 p.p.t.
35th to metamorphosis (over 95% PL)	—	10 p.p.t.

When the amount of post larvae in the tank was over 95%, salinity was gradually reduced to 2 p.p.t. within 1½ days.

Harvesting of Post larvae :

The post larvae were harvested, using a scoop net made with mosquito netting. These were then hand counted and transfered to nursery ponds, containing fresh water (table—I).

Trial No. 1 :

Three treatments (in duplicates) were tested during the trial. The larvae were obtained from a wild spawner (wt. 140 g).

Treatment — A :

(*i*) Feeding regime —
Only artemia nauplii were fed throughout the rearing period at the following rates.

7th to 14th day — (2nd week) — artemia nauplii from 0.5 g of cysts for 1000 larvae.

14th to 21st day — (3rd week) —
artemia nauplii from 1.0 g of cysts for 1000 larvae.

21st to 30th day —
artemia nauplii from 2.0 g of cysts for 1000 larvae.

After 30 days —
artemia nauplii from 2.5 g of cysts for 1000 larvae.

(*ii*) Density of larvae —
75/L (at stocking on 7th day)

(*iii*) Water exchange rate —
50% by volume daily.

Treatment — B :

(*i*) Feeding regime —
same as in treatment A.

(*ii*) Density of larvae —
50/L

(*iii*) Water exchange rate —
same as in treatment A.

Treatment — C :

(*i*) Feeding regime —
Same as in treatment A.

(*ii*) Density of larvae —
25/L

(*iii*) Water exchange rate —
same as in treatment A.

Trial No. 2 :

Three treatments (treatment D, E, & F) were tested in duplicates during this trial. This was started after the 1st. trial was completed. The larvae were obtained from a wild spawner (wt. - 100 g.)

Treatment — D :

(*i*) Feeding regime —
same as in trial No. 1

(*ii*) Density of larvae —
30/L (at stocking on 7th day)

(*iii*) Water exchange rate —
50% by volume once in 2 days.

Treatment — E :

(*i*) Feeding regime —
same as in trial No. 1

(*ii*) Density of larvae —
25/L

(*iii*) Water exchange rate —
same as in treatment D

Treatment — F :

(*i*) Feeding regime —
same as in trial No. 1

(*ii*) Density of larvae —
20/L

(*iii*) Water exchange rate —
same as in treatment D.

Trial No. 3 :

This trial was carried out after the trial No. 2 was completed. Three treatments were tested in duplicate during the trial period. The larvae were obtained from a wild spawner (wt = 100 g) for this trial.

Treatment G :

(*i*) Feeding regime —
Egg custard (size of the particles varied according to the size of larvae) was given 4 times a day as described earlier. Artemia nauplii were fed at the following rates.

7th — 14th day (2nd week) —
nauplii from 0.5 g of cysts for 1000 larvae.

14th — 21st day (3rd week) —
nauplii from 0.75 g of cysts for 1000 larvae.

21st — 30th day —
nauplii from 1.0 g of cysts for 1000 larvae.

After 30th day —
nauplii from 0.75 g of cysts for 1000 larvae.

(*ii*) Density of larvae —
25/L (at stocking on 7th day)

(*iii*) Water exchange rate —
50% by volume once in two days.

Treatment H :

(*i*) Feeding regime —
same as in treatment G.

(*ii*) Density of larvae —
25/L

(*iii*) water exchange rate —
Until 21st day 50% by volume once in 4 days. After 21st day 50% by volume once in two days.

Treatment I :

(*i*) Feeding regime —
same as in Treatment G.

(*ii*) Density of larvae —
25/L

(*iii*) Water exchange rate —
50% by volume once in 4 days through out the rearing period.

Trial No. 4 :

Only two treatments were tested during this trial in triplicates. The larvae were obtained from a wild spawner (wt = 110 g)

Treatments J :

(*i*) Feeding regime —
same as in trial No. 3

(*ii*) Density of larvae —
22/L

(*iii*) Water exchange rate —
same as in treatment H in trial No. 03.

Treatment K :

(*i*) Feeding regime —
same as in trial No. 03.

(*ii*) Density of larvae —
22/L

(*iii*) Water exchange rate —
Until 21st day 35% by volume once in four days. After 21st day 35% by volume once in two days.

Trial No. 05 :

The same treatments (J and K) were retested with larvae obtained from a pond reared spawner (wt. = 65 g). in triplicate. In the discussion these are refered to as Treatment J' and Treatment K'.

Trial No. 06 :

In this trial, aeration in the tank was increased by using two aerators for one rearing tank. In this system agitation of water in rearing tanks was much better than in earlier trials. Under this condition treatment K was tested again in duplicates with the larvae obtained from a pond reared spawner (wt = 60 g). This is indicated as Treatment K".

Observations and Results:

Performance of Post larvae in different trials are given in table I.

Trial No. 01 :

High mortality occured in both treatments A and B from 15th to 30th day. In treatment A, mortality started on 15th day and in treatment B high mortality was observed ofter 20th day. After 20th day the estimated average number of larvae in treatments A and B were 1500 and 2000 respectively. Few numbers of Post larvae were seen for the first time in these treatments on the 32nd day.

Even though high mortality was not observed after the 30th day, few dead larvae were found at the bottom every day when cleaning was carried out. In treatment C high mortality was not observed as in treatments A & B. But after the 25th day few dead larvae were found. Cannibalism was observed in all the treatments, especially after the 20th day. Some larvae were observed carrying (feeding on) dead larvae even though there was enough artemia nauplii in the tanks.

Trial No. 02 :

The pattern of mortality and canibalistic action seen in treatments D and E was similar to that observed in C. In treatment F mortality was considerably low. Few post larvae were seen on the 25th day in treatments E and F. In treatment D metamorphosis started only after the 30th day.

Trial No. 03 :

Unlike in previous trials cannibalistic action was observed rarely in these treatments.

Few dead larvae were found between the 20th and 24th day in all the treatments of this trial. After the 25th day dead larvae were found seldom when cleaning was carried out. Metamorphosis started after 29th day in these treatments.

Trial No. 04 :

Cannibalism was rarely observed in both treatments of this trial. A few dead larvae were noted for the first time on the 20th day. Metamorphosis started on the 29th day and the 31st day respectively in 'Treatment J' and 'Treatment K'.

Trial No. 05 :

As in 'Trial No. 04' the same pattern of mortality, growth and metamorphosis were observed during this trial.

Trial No. 06 :

Cannibalism was not observed at all during this trial. But a few dead larvae were encountered on 19th day when cleaning was done and mortality was seen to continue until 23rd day. Metamorphosis started on the 25th day in this trial.

TABLE 1

Performance of Post Larvae in Different Trials.

Trial No.	Treatment	Av. No. of P.L obtained	Av. percent survival to post larvae %	Duration for Metamorphosis (over 95% P.L) (*days*)	P.L/L	Average Temperature C
No. 1	A	933	5.4	53	4 06	25.6
	B	1490	12.96	50	6.48	
	C	3795	66	47	16.50	
No. 2	D	3730	54	46	16.21	26.7
	E	3756	65.3	41	16.33	
	F	3220	70	40	14.0	
No. 3	G	4112	71.5	40	17.88	27.0
	H	4030	70	43	17.52	
	I	3820	66.43	50	16.61	
No. 4	J	4137	81.76	41	17.99	27.5
	K	4054	80.12	45	17.63	
No. 5	J¹	4050	80.04	43	17.61	27.2
	K¹	4000	79.05	46	17.39	
No. 6	K"	4650	90.1	40	19.83	27.5

Discussion :

Larval densities tried in treatments A and B (75/L and 50/L) appear too high for the system of rearing used. But even in a rearing system like this. 75/L density can be safely used until 14th day, (mortality started after 15th day in treatment A). Thereafter thining out is necessary, similarly 50/L, density can be safely used until 19th day. These high densities 75/L and 50/L have also affected the duration of the rearing period. For treatments A and B the rearing periods were 53 days and 50 days respectively, while it was 45 days for treatment C (25/L density). In treatment C survival rate of post larvae is also very high in comparison with the other two treatments. (table 01). During the trial it was found that daily water exchange in the rearing tanks, was not practicable with existing facilities at the station.

The observations and results of Trial No. 1 were helpful in designing Trial No. 2. When density of larvae was reduced (from 30/L to 20/L) the survival rate increased (54% to 70%). The culture period also decreased with the density. The water temperature also affected the rearing period. (Compare data of Treatment C and Treatment E). Even though the water exchange rate was reduced by 50% in Trial No. 2 (Compared to Trial No. 1) it has not significantly affected the survival rate (compare data of Treatment C and Treatment E). During these two trials it was observed that the larvae preferred to take food particles bigger in size than artemia nauplii, especially after the 20th day due to their voracious feeding habits. Therefore, the regime (containing egg custard) in Trial Nos. 3 — 6 reduced the cannibalism and, increased the survival rate, considerably. It also reduced the feed cost nearly by 50% by reducing the amount of artemia, given to larvae.

Water exchange rate in Treatment H was reduced, without affecting the survival rate, significantly. But the rearing period slightly increased, (compare the-results of Treatment G and Treatment H). The duration of the rearing cycle of Treatment I is comparatively high as water exchange rate is too low. Survival rate increased when the density was reduced from 25/L to 22/L. (See results of Trial No. 4) In Treatment K of Trial No. 4, water exchange rate has been further reduced in comparison to Treatment J. It did not significantly affect the survival rate. But the rearing period of the Treatment K has been increased by 4 days (see results of Trial No. 04). If the water exchange rate is reduced more than the rate tried for Treatment K, it could have significantly affected the survival rate as well as the duration of the rearing cycle. The survival rates in Treatment J' and Treatment K' (the same treatments used in Trial No. 4, but repeated with the larvae from a pond reared spawner) are slightly lower than in Treatment J and Treatment K, though the difference is not significant. The rearing period were also little longer in Trial No. 5.

The system of rearing used in Trial Nos. 4, and 5 is suitable for the existing set-up of the hatchery at the Brackishwater Fisheries Station, Pambala. But results of the Trial No. 6, indicate that if the aeration system can be improved, the survival rate and the number of post larvae obtained per liter can also be further increased. The duration of the rearing period also decreased considerably with improved aeration system. (Compare the results of Treatment K and Treatment K") There is scope to increase the density of larvae and hence increase the number of P.L/L, with improved aeration and water exchange systems.

Conclusion :

The following conclusions were made in the course of the trials.

1. Cannibalism of the larvae could be minimized and their survival increased by reducing the initial larval density, use of suitable feeding regime and improving the aeration system.

2. Improved aeration system and efficient water exchange system, result in obtaining better survival rate, higher number of Post larvae/L and reduction in the duration of rearing.

Acknowledgement :

The author wishes to thank Mr. K. S. B. Tennakoon, Deputy Director (ADP) and Mr. R.A. D. B. Samaranayake, Asst. Director (IF) for the guidance and encouragement given in this work. Mr. R. D. Chakkrabarthy Fish Farming Expert is acknowledged for valuable comments made during the preparation of this paper. The staff of the Brackishwater Fisheries Station Pambala is gratefully acknowledged for the corporation given in carrying out this work.

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J. Inland Fish., Vol 3. December, 1986. pp. 38—48

PRODUCTION OF PENAEID SHRIMP POST LARVAE IN A MAKE SHIFT HATCHERY AT THE COASTAL AQUACULTURE STATION—PITIPANA

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Introduction :

Penaeid shrimp culture in Sri Lanka has drawn attention of local and foreign investors over the past few years. To encourage investors in Shrimp farming the government has provided credit, subsidies as well as export incentives. These and the availability of land suitable for construction of shrimp ponds, international demand for shrimp and their high prices, diminishing natural stocks and high fuel costs for their capture have influenced many investors to have a closer look at shrimp culture possibilities in Sri Lanka.

For shrimp culture the availability of quality seed throughout the year could be assured best by mass production of fry from a hatchery. Such shrimp fry production facilities are being successfully operated in most of the South East Asian countries. Realising the importance of hatchery production of shrimp seed for coastal aquaculture the Inland Fisheries division of the Ministry of Fisheries initiated work in rearing penaeid shrimps using some of the existing facilities at their Coastal aquaculture Station at Pitipana with partial support from the Bay of Bengal Programme of the FAO. The decision to operate a small — scale shrimp hatchery was taken with the following objectives in mind.

(*i*) Test the technical feasibility of producing shrimp seed under local conditions.

(*ii*) Gain competence by Aquaculturists of the Ministry in the operation of a shrimp seed production facility.

(*iii*) Demonstrate the operation of a small-scale shrimp larvae production unit.

(*iv*) Generate enthusiasm among people interested in shrimp culture.

Materials and Methods :

For installation of the hatchery, a part of the existing laboratory building of the Coastal Aquaculture Station (Fig. I) was renovated (Fig. II) and provided with necessary physical facilitie.. (appendices I and II). The air supply consisted of 50 mm diameter PVC pipes placed at a height of 2.5 meters to enable sufficient air to be drawn for aerating all the tanks. Filter nets of various grades (60,100,200) microns were stitched and fitted to the frames made of PVC pipes. Fabricated sand filters, two in numbers, were used one placed in the sea water storage tank and the other in that used for spent spawners. Sea water for the hatchery was obtained by operating a 2" pump at the sea shore, about two kilometers away from the hatchery and the water transported by a bowser.

Collection of Spawners :

As there were few trawlers operating to catch shrimp in the Negombo area (sea area near the Aquaculture Station) the shrimp spawners were collected from

1. Brackishwater Fisheries Station, Pitipana, Negombo, Sri Lanka.

Chilaw about 58 kilometers north of Pitipana. Spawners collected were from among shrimps captured in usual commercial operation of shrimp trawlers. These spawners were transported to the hatchery in plastic buckets containing battery operated aerators or in oxygenated polythene bags containing about 20 liters of sea water. Each bucket or polythene bag contained only one spawner. On reaching the hatchery the shrimps were released into plastic buckets of 30 liter capacity containing filtered sea water and provided with continuous aeration.

Spawning Tanks :

Circular plastic lined pools or rectangular aquarium type tanks each of 250—300 liter capacity were used as spawning tanks. About an hour before transfer of spawners to the spawning tank, di-sodium salt of EDTA (Ethylene diamine tetra acetic acid) was added at 0.1 gram per 100 liter of water and vigorous aeration ensured. Only one spawner was released into a spawning tank and this was done in the evening. Each spawning tank containing a spawner was covered with black cloth to shield it from light and left undisturbed but with mild aeration. The following morning the shrimp that had spawned were shifted from the spawning tanks to the maintainance tank and the yellow creamy substance that usually adhered to the side of the spawning tank just above the water level was removed by using cotton swabs or a scoop net. Samples of eggs were counted to determine the number of eggs obtained per spawner. The eggs were allowed to hatch in the spawning tank. The resulting nauplii were transfered to larval rearing tanks at densities varying from 50,000 to 100,000/m3.

Larval Rearing :

The operational procedures for larval rearing resembled those that are followed at the Narrakkal prawn culture laboratory in India (Mohamed; 1985). The steps are given in appendix 3.

Plankton culture :

Culture of mixed phytoplankton was maintained in one ton capacity fibre glass tanks kept out door. The nutrients added, together with their concentrations used are given in table, 1. The plankton was scheduled to be harvested, batchwise, on the third day after addition of nutrients.

Larval Food :

The ingredients and their proportions in the diets formulated are given in Table II. The ingredients were finely powdered and thoroughly mixed and soaked in 40 ml of water for every kilogram feed base. The dough thus formed were passed through a hand operated meat mincer. The noodles issuing were cut into small pieces and sun-dried. These dried pellets were ground until the powder could pass through a 100 micron sieve. For feeding the later mysis and post-larvae, powder that passed through 200 micron sieve was used.

Results :

The number of post — larvae produced per batch of spawners and corresponding survival percentages from nauplius to the PL5 stage is given in Table III. The hatchery was able to produce post-larvae of four species of penaeid shrimps namely *P. monodon P. indicus*, *P. merguensis* and *P. semisulcatus*. The highest survival percentage recorded from nauplius to PL5 stage is 66.6%. The average survival recorded for *P. indicus* was higher than that for other species.

Discussion :

The overall survival achieved was low. The survival of larvae in a hatchery is dependent on many factors.

Relatively clean unpolluted sea water is essential for the hatchery operations. Absence of sand and gravel filtration system for storage tanks could have had adverse effects on the rate of survival. The proper design is to have water from the storage tank fed by gravity to the various tanks in the hatchery. A reservoir would help in the hatchery operations because bacterial content and their variety are reduced in water that is stored over a longer period. The water storage tanks should be 10% of total tank capacity of the hatchery (Kungavankij, 1984). The addition of EDTA (Ethylene diamine tetra acetic acid) to sea water used for spawning is to enhance its quality and prevent catastrophic mortalities.

Quality of the shrimp spawner affect survival of larvae. Good spawners produce high quality eggs resulting in high survival rates. To prevent stress and physical damage spawners have to be handled gently. When relying on commercial shrimp catchers for collection of spawners it is important to educate the fishermen in identification of the desired shrimp and correct handling of the same.

Most of the hatchery runs were performed using spawners of *P. indicus* and *P. merguensis* because of their relatively easy availability.

A hatchery should preferably have two sources for spawner supply, the wild and the pond raised brood stock (Primavera, 1984). Availability of wild spawners particularly of *P. monodon* is inconsistant. The use of pond reared brood stock would partly solve the availability of spawners.

Timely supply of the needed food organisms in sufficient quantity is one of the key factors ensuring success in shrimp hatchery operations. A hatchery should be complemented with a small room for growing algal starter. Circular larval rearing tanks are better than rectangular tanks because the former ensure the uniform distribution of feed particles.

Shrimp larvae can survive well by feeding on mixed culture developed in fibre glass tanks by use of fertiliser. However, sometimes the diatoms fail to bloom which may happen specially during the rainy periods. Under such conditions alternate feeds like bread yeast, finely powdered soya bean cake, powdered fat free rice bran and egg yolk could give fair amount of success. For the mysis and the early post larvae stages brine shrimp nauplii have been the accepted feed for a long time. The latest among the prepared feeds used are the micro encapsulated feeds. These are possible supplementary feeds but should not be used as total substitute for natural food. Addition of supplementary feed helps cut down the cost of procurement of expensive *Artemia sp.*

Some hatchery runs resulted in zero survival mainly due to the occurence of diseases and in few instances due to the scarcity of sea water as a result of the breakdown of the pump. To ensure trouble free service, the pump to be used for drawing sea water has to be the Marine type.

Maintainence of proper hygenic conditions is vital in a hatchery. Frequent disinfection of the tanks and pipes and other equipments will ensure the prevention of disease out-break. If attempts were made to diagnose the disease at the onset and to treat with proper antibiotics at least some of the runs may have been saved.

Compared to the initial stages survival percentages improved towards the latter part of the hatchery operations. Developing and maintaining plankton cultures, feeding and monitoring basic environment parameters and identifying and treating diseases require technical experience. It requires time to gain competence in the efficient operation and management of a hatchery. However, a technician with right training and attitude would be able to manage a hatchery.

Typically marine prawn hatcheries have had to rely on the capture of spawners from the wild for hatchery operations. This requires that hatcheries be sited in proximity of fishing grounds with an abundance of the appropriate prawn species and necessitates the use of fishing vessels for the capture of spawners. The seasonality of breeding among wild stock and the vagaries of weather and sea conditions often prevent hatchery operations from continuing at full capacity throughout the year with wild spawners. New development in the technology of induced breeding of marine prawns are however removing this constraint on successful year round hatchery operations. Employing the newly developed maturation technology for breeding in captivity, taking advantage of recent developments in the areas of disease control, food production and water quality management and application of good organizational and management practices should lead to increased production in hatchery operations. As the demand for shrimp fry is ever increasing development of commercial shrimp hatcheries present an excellent investment opportunity.

Acknowledgement :

The authors are thankful to Mr. K. H. Mohamed for the consultancy in establishing the make shift hatchery and for his guidance in basic techniques on shrimp hatchery. We are also grateful to Bay of Bengal Programme of the FAO for the financial support given for the construction and operation of the hatchery. We also wish to express our thanks to Mr. R. P. Samarasinghe for his contribution to hatchery work during the initial period of hatchery operation. The help rendered by Dr. R. D. Chakrabarty, Consultant ADB Aquaculture Development Project in the preparation of the paper is gratefully acknowledged.

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Table 1

Nutrient medium for mixed plankton culture :—

Urea	12 *gms/ton*
Triple super phosphate	6 *gms*
E. D. T. A.	6 *gms*
Sodium silicate	6 *gms*

Table 2

The feed ingredients for shrimp larvae :

Acetes sp	50%
Soya bean	37.5%
Fish meal	12.0%
Vitamin mineral mix	0.5%

Wheat flour as binder — 20 grams for each 100 grams of feed base.

TABLE 3

Penaeid shrimp post larvae produced at the Coastal Aquaculture Research Station— Pitipana

Duration From— To	Species	No. of spawners	No. of Nauplii stocked (X 10^3)	No. of PL 5 (X 10^3)	Survival (%)
11.10.84—23.10.84	*P. indicus*	1	93	40	43
17.10.84—30.10.84	*P. indicus*	4	440	170	38.6
26.10.84—10.11.84	*P. indicus*	3	316	4.5	1
02.11.84—16.11.84	*P. indicus*	8	970	17	1.75
03.11.84—18.11.84	*P. indicus*	1	60	40	66.6
04.11.84—15.11.84	*P. indicus*	1	60	—	—
28.11.84—17.12.84	*P. indicus*	1	90	20	22.2
04.12.84—30.12.84	*P. indicus*	1	160	40	25
27.12.84—11.01.85	*P. indicus*	1	80	18	22.5
03.11.85—19.01.85	*P. indicus*	5	290	55	18.9
08.01.84—15.01.84	*P. indicus*	2	185	—	—
25.01.85—07.02.85	*P. semisulcatus*	1	60	12	20
26.01.85—15.02.85	*P. semisulcatus*	1	60	—	—
	P. indicus	1	82	2	2
27.01.85—13.02.85	*P. monodon*	1	600	45	7.5
28.01.85—13.02.85	*P. monodon*	1	200	40	6.6
07.02.85—16.02.85	*P. monodon*	1	2000	—	—
17.02.85—26.02.85	*P. semisulcatus*	1	480	—	—
20.02.85—12.03.85	*P. semisulcatus*	1	200	3	1.5
22.02.85—12.03.85	*P. monodon*	1	120	7	5.8

Penaeid shrimp post larvae produced at the Coastal Aquaculture Research Station—Pitipana

Duration From—To	Species	No. of spawners	No. of Nauplii stocked (X 10^3)	No. of PL 5 (X 10^3)	Survival (%)
13.03.85—29.03.85	*P. semisulcatus*	1	80	1	1.25
14.03.85—29.03.85	*P. semisulcatus*	1	160	10	6.25
16.03.85—01.04.85	*P. indicus*	1	100	3.7	3.7
04.04.85—18.04.85	*P. monodon*	1	50	10	20
	P. indicus	1	50	15	30
08.04.85—25.04.85	*P. semisulcatus*	2	203	62.2	30.6
23.04.85—08.05.85	*P. monodon*	1	300	10	3.3
25.04.85—10.05.85	*P. indicus*	2	380	60	15.7
03.05.85—16.05.85	*P. semisulcatus*	4	166	20	12
07.07.85—21.07.85	*P. monodon*	1	50	15	30
12.07.85—15.07.85	*P. monodon*	1	25	—	—
14.07.85—29.07.85	*P. merguensis*	1	210	2.2	1
	P. indicus	1	98	4	4
19.07.85—04.08.85	*P. merguensis*	2	200	53	26.5
	P. indicus	1	80	31	38
02.08.85—	*P. monodon*	1	301.6	—	—
	P. semisulcatus	1	96	—	—
	P. indicus	1	75	—	—
13.10.85—30.10.85	*P. monodon*	3	528	71	13.4
	P. indicus	1	142	70.8	49.2
25.10.85—11.11.85	*P. indicus*	1	134	35.1	26.1
08.11.85—26.04.85	*P. indicus*	1	134	36.5	27
25.11.85—11.12.85	*P. monodon*	1	270	78.4	28

Penaeid shrimp post larvae produced at the Coastal Aquaculture Research Station—Pitipana

Duration From—To	Species	No. of spawners	No. of Nauplii stocked (X 10^3)	No. of PL 5 (X 10^3)	Survival (%)
25.11.85—10.12.85	*P. semisulcatus*	1	62	10	16
01.12.85—19.12.85	*P. indicus*	1	142	15	10.7
06.12.85—20.12.85	*P. indicus*	1	70	—	—
10.12.85—24.12.85	*P. monodon*	1	152	26.2	17

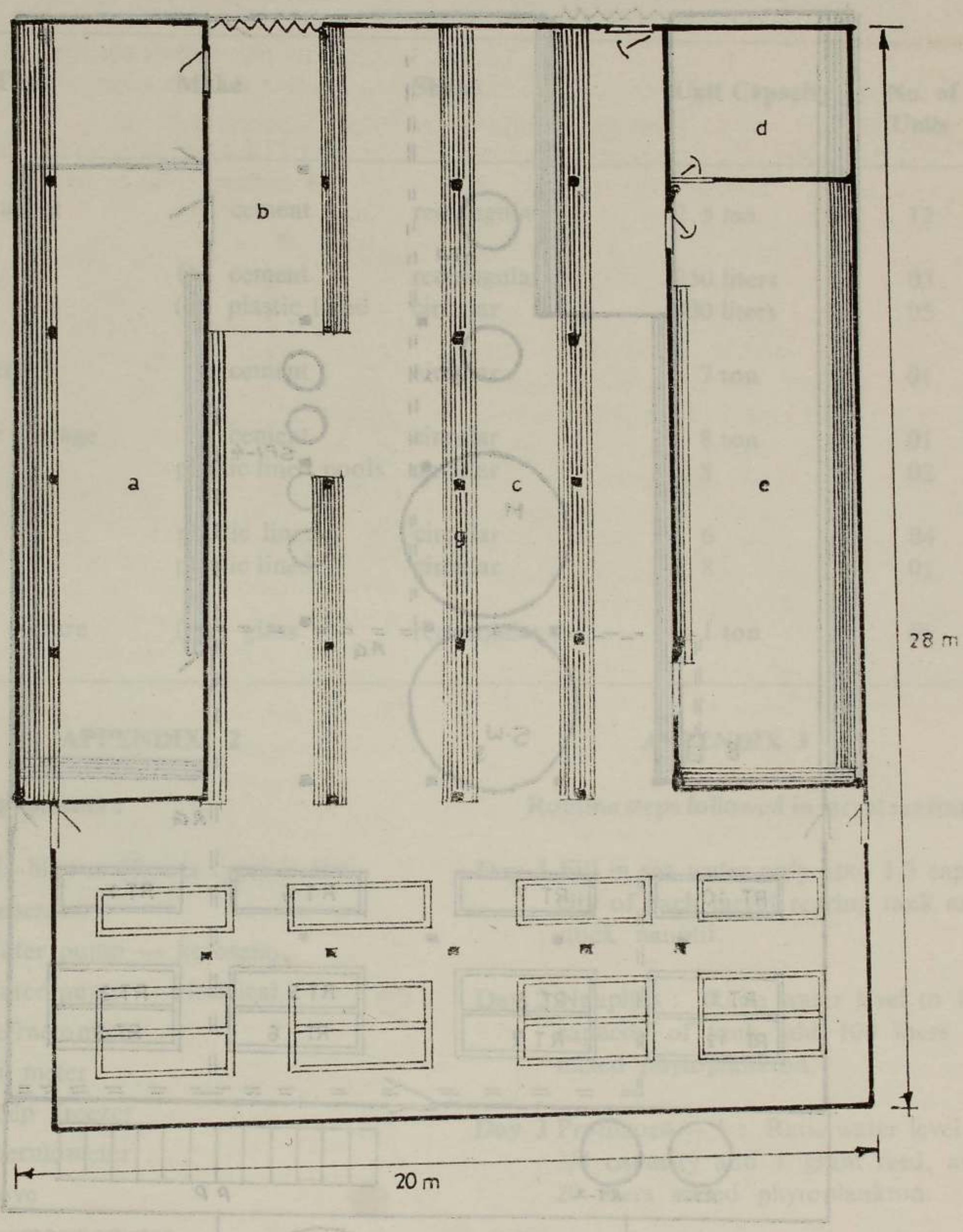

FIG 1 LAY OUT OF THE COASTAL AQUACULTURE STATION PITIPANA BEFORE RENOVATION a GENERAL STORE b GARAGE c HALL d LABORATORY STORE e LABORATORY f CEMENT TANKS g PLATFORMS.

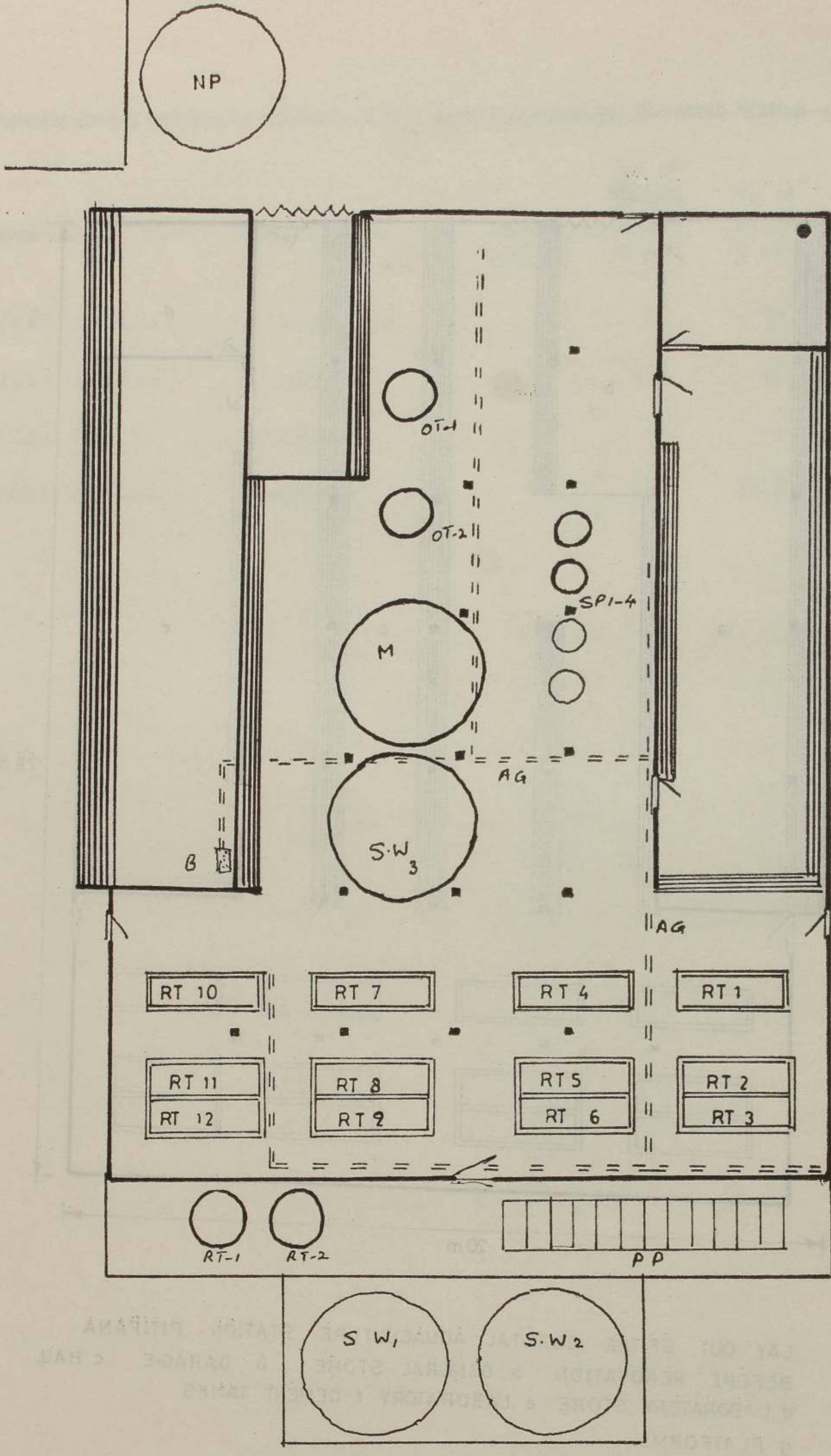

FIG 2 LAY OUT OF COASTAL AQUACULTURE STATION PITIPANA AFTER RENOVATION FOR PRAWN HATCHERY WORK (AG) AIR SUPPLY SYSTEM (B) AIR BLOWER (S.W) SEA WATER STORAGE (NP) NURSERY POOLS (OT) OBSERVATION TANK (RT) REARING TANK (SP) SPAWNING POOL (M) MAINTAINENCE TANK

APPENDIX 1

Tank facilities :

Type of Tank	Make	Shape	Unit Capacity	No. of Units
Larval rearing	cement	rectangular	2.5 *ton*	12
spawning	(1) cement	rectangular	250 liters	03
	(2) plastic lined	circular	300 liters	05
maintainence	cement	circular	7 ton	01
sea water storage	cement	circular	8 ton	01
	plastic lined pools	circular	8	02
nursery	plastic lined	circular	6	04
	plastic lined	circular	8	01
Plankton culture	fibre glass	rectangular	1 ton	06

APPENDIX 2

List of equipments :

1. Air blower (Roots type) 2.5kw
2. Generator
3. Water pump — kerosene
4. Water pump — electrical
5. Refractometer
6. Ph meter
7. Deep freezer
8. Thermometer
9. Stove
10. Haemocytometer
11. Top loading balance
12. Polythene tubings
13. Air stones
14. Filters
15. Glass ware

APPENDIX 3

Routine steps followed in larval rearing :

Day 1 Fill in sea water only upto 1/3 capacity of each larval rearing tank and stock nauplii.

Day 2 Nauplius : Raise water level to 1/2 capacity of tank add 100 liters of mixed phytoplankton.

Day 3 Protozoea — 1 : Raise water level to 3/4 capacity add 1 gram feed, and 20 liters mixed phytoplankton.

Day 4 Protozoea — 2 : Raise water level to full capacity, add 20 liters of plankton.

Day 5 Protozoea — 3 : Remove sediments by siphoning using 60 micron filter net. add 20 liters plankton, add 1 gram of feed every 6 hours.

Day 6 Mysis — 1 : Remove sediments, reduce water level by 1/3 and replenish with new water, add 1 gram of feed every 6 hours.

Day 7 Mysis — 2 : Remove sediments using 200 micron filter net. Renew 1/3 of water add 1 gram of feed every 6 hours. Increase the quantity if necessary, add artemia nauplii obtained from 1 gram of dry artemia cysts per m^3.

Till the appearance of post larvae repeat the procedure of previous day.

At PL5 stage take count and transfer to nursery pools or hapas.

J. Inland Fish., Vol. 3, December, 1986, pp. 49—55

OBSERVATIONS ON POLYCULTURE OF FISH IN SEASONAL TANKS IN RATNAPURA AND MONARAGALA DISTRICTS IN SRI LANKA

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Introduction :

Seasonal tanks as the name suggests are water bodies that dry up annually for a few months. A detailed description on seasonal tanks, their distribution, basic characteristics and fishery potential are given by Thayaparan (1982). Chakrabarty and Samaranayake (1983) reviewed the fish culture activities in these water bodies from 1980 to 1983. Future inland fisheries development in Sri Lanka, to a great extent depends on the utilization of seasonal tanks for fish culture. Seasonal tanks exhibit a unique habitat which had not been methodically exploited in respect of fish production till recently. Hence information that would assist in the formulation of strategies to develop fish culture in them, are limited.

This paper focuses on the results obtained in the 83/84 fish culture cycle in some seasonal tanks in the Ratnapura and Moneragala Districts. Observations made on fish production, survival rates, size of fish at harvest, performances of carp species and their contribution to total fish production species-wise, are dealt with. This information would assist in the practise and spread of fish culture in seasonal tanks, in the coming years.

Materials and Methods :

23 seasonal tanks situated in the Ratnapura and Moneragala districts, totalling an area of 133.4 ha were brought under carp polyculture during 1983/84. Water in these tanks at F. S. L. ranged from 2 — 16 ha. All the tanks dried up during August 1983, and with the monsoonal rains filled up reaching the FS Levels. Stocking of these tanks with carp fingerlings, namely Bighead carp (*Aristichthys nobilis*) Catla (*Catla catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*) Common carp (*Cyprinus carpio*), and Grass carp (*Ctenopharyngodon idella*) was carried out during September — October 1983. Four stocking densities ranging from 2000 — 3500/ha were employed (Table II). Size of the fingerlings stocked were 6 — 8 cm in length. Species combinations used were almost similar with minor variations. The fish species were stocked in the proportions indicated below :—

Bighead carp	— 35%	
Rohu	— 25%	
Grass carp	— 5%	
Mrigal	— 15 — 20%	} 35%
Common carp	— 15 — 20%	

In four of the tanks, namely Tunkama, Mahawewa, Epitagoda and Maduwanwela percentage of Bighead carps stocked was 30% and 5% of catla was added.

Harvesting of fish in these tanks were done during July — August in 1984. In 15 tanks harvesting was completed and only partial harvesting was possible in seven tanks. Harvesting was not carried out in Kehellanda tank, due to high water level

1. Fresh Water Fisheries Station, Uda Walawe, Sri Lanka.

that prevailed throughout the period under consideration. As such data from the 15 tanks that were completely harvested have been made use of.

RESULTS :

Fish production :

A total of 71.3 tonnes of fish were harvested from the 23 tanks (133.4 ha), the average production working out to 534.5 kg/ha. In the 15 tanks, completely harvested fish production ranged from 219.8 kg to 2303.5 kg/ha (Average 891.5 kg/ha). Table 1 denotes the details on fish production.

Recovery :

Total recovery of fish (all species taken together) ranged from 34.78% to 65.0% (Average 43.76%) irrespective of the stocking density adopted. Details on recovery rates of different fish species are given in Table II. Percentage of recovery (considering the total number of each species stocked in these 15 tanks and the total number of each species harvested) for Bighead carp, Rohu, Catla, Common carp, Mrigal and Grass carp were 47.7%, 49.53%, 41.88%, 33.63%, 45.29% and 22.16% respectively.

Contribution of different fish species to fish production :

Contribution of different species to total fish production (percentage) and production per hectare are shown in Table III. The percentage contribution and production per hectare different fish species irrespective of the stocking densities adopted are 38.92% (347.0 kg/ha), 22.67% (201.17 kg/ha), 14.96% (133.44 kg/ha), 11.81% (105.7 kg/ha) and 2.67% (23.84 kg/ha) for Bighead carp and Catla, Rohu, Common carp, Mrigal and Grass carp, respectively.

Although not deliberately stocked *Tilapia* which gained access to these tanks contributed to 8.9% of the production. Catla was stocked in only four tanks and contributed to 7.75% of the production.

Size of the fish at harvest :

Fingerlings stocked in seasonal tanks varied in weight from 0.4 — 0.6 g. Average weight of fish (irrespective of stocking densities) at harvest was 0.71 kg for Bighead carps, 0.65 kg for Rohu, 0.98 kg for Common carp, 0.52 kg for Mrigal and 0.81 kg. for Grass carp (Table II). Average weight of Catla at harvest was 1.63 kg in the four tanks, where it was stocked. Average weight of fish at harvest (irrespective of stocking density as well as species) was 0.69 kg.

Discussion :

Two important factors, which determine fish production in seasonal tanks are their natural productivity, and effective water area. Natural producti vity of these tanks is governed by the nature of the bottom soil (its fertility, physical characteristics *etc.*), catchment area and amount of organic wastes from animal (grazing cattle) and human sources as well as decaying vegetation that find their way into the tank.

Seasonal tanks generally receive water during the North — East monsoon, the filling commencing with the October rains. After February onwards the water level recedes gradually. Some tanks do not reach their full supply levels during certain seasons. The drop in volume and depth of water will depend on several factors like topogaphy of the tank, depth, rainfall intensity, evaporation and the amount and pattern of drawdown for irrigation purposes. Effective water area not only varies from tank to tank but also may vary in the same tank from season to season. Hence it becomes considerably difficult to determine stocking densities in proportion to area of seasonal tanks. Consequently great variations are observed in unit area production and size of the fish at the time of harvest even in tanks where same stocking densities were adopted.

There are some seasonal tanks, which go dry during April — May after being filled in October — December in the previous year. For those tanks, which have a shorter water retention period, it is better to adopt low stocking densities, in order to allow for the fish to grow to marketable size at harvest. In addition it is recommended that these tanks be stocked as early as possible, with the onset of the monsoonal rains, without waiting for complete filling up of the tanks.

Only few numbers of predatory fish such as *Ophiocephalus sp*, *Anabas sp* were found among the fish catches from these tanks. Hence recovery rate cannot be related to predatory fish. Winkler (1983) estimated the mean daily fish consumption of Cormorants in the Parakrama Samudra, a perennial reservoir in Sri Lanka, to be 696 kg. fish by fresh weight per day. The predatory action of birds is very high also in seasonal tanks and this could be the main reason for the low recoveries recorded.

The contribution of zooplankton feeders (Bighead carp and Catla) and Rohu to the total catch is more or less similar to their respective stocking rates. Bottom feeders (Common carp and Mrigal) contributed only 26.7% to the total catch, though in-terms of stocking they accounted for 35%. Grass carp contributed only 2.67% to production despite the stocking rate being 5%. Recovery rate recorded for Grass carp too, is the lowest among the species stocked in these tanks. The poor performances of Grass carp may be due to the lack of suitable submerged aquatic vegetation that can be utilized as food by the fish. Although aquatic plants such as Lotus and Nelumbo are present in some tanks, Grass carp may not be capable of utilizing these.

Although all these tanks were cleared of macrophyte vegetation prior to stocking, in some tanks aquatic macrophytes such as Lotus and Nelumbo emerged 2 — 3 months after getting filled-up. It would be seen from Table III, that in tanks, where macrophyte vegetation such as Lotus and Nelumbo were found in abundance, the contribution of Rohu to the total production was comparatively higher than in tanks, where macrophyte vegetation was scarce. Contribution of zooplankton feeders (Bighead carp and Catla) to the total harvest is comparatively low in tanks, where macrophytes are abundant and vice versa. Contribution of Rohu and zooplankton feeders in tanks where macrophytes are abundant is 33.54% (241.4 kg/ha) and 23.6% (167.3 kg/ha), respectively. In tanks where these macrophytes are scarce, contribution of Rohu and zooplankton feeders were 17.5% (167.1 kg/ha) and 46.2% (452.56 kg/ha), respectively. These differences may be attributed to the following factors.

(1) Rohu is a bottom and column feeder and prefers to feed on plant matter including decaying vegetation (Jhingran and Pullin, 1985). According to them Rohu fingerlings of 100 — 250 mm in length are found to subsist on unicellular and filamentous algae (15 percent), decaying vegetation (55 percent) and zooplanktons (10 percent) and the decaying vegetation component in the food increases in bigger fish. It may be possible that the decaying parts of macrophytes present in these tanks contributed to the better performance of Rohu. Hence it may be recommended that the stocking

rate of Rohu in tanks, where macrophytes are emerging, be increased.

(2) Bighead carp and Catla are predominantly zooplankton feeders. Presence of macrophytes such as Lotus and Nelumbo obstruct sunlight. Also these macrophytes compete for nutrients with phytoplankton. As a result phytoplankton growth and inturn zooplankton growth is slowed down, affecting availability of the preferred food of these species.

Catla catla contributed 6.24% — 8.55% to the total fish catch in four tanks, where it was stocked despite the stocking rate being 5%. Growth attained by Catla at the time of harvest, also varied from 1.09 — 2.33 kg in these tanks. Villagers prefer Catla to Bighead carp. It fetches a higher price being thrice of that for Bighead carp. It would be much useful for fish farmers, as well as for consumers, if attempts are made to stock Catla in place of Bighead carp.

Kumarasiri (in preparation) observed that during the 1984/85 fish culture season in most tanks, where Silver carp was stocked together with Bighead carp and other carp species, the former fared more or less similar to that of Bighead carp. According to him in some tanks Silver carp fared much better than Bighead carp in terms of growth, survival and percent contribution to the total catch. In these instances he has stocked more or less similar numbers of both species (both species together accounting for 40 — 50% of the total stocking).

Kumarasiri (in preparation) observed that *Macrobrachium rosenbergii*, attained an average size of 160 g in two seasonal tanks, where it was stocked, but the recovery rate was around 25%. As *M. rosenbergii* fetches a much higher price compared to carps, more attention should be focussed on this species, which will help to swell the income of the fish farmers. Information on the performance of this species is lacking and studies to determine suitable stocking rates and economics of this species in seasonal tanks would be a worthwhile effort.

Observations of the fish production in seasonal tanks reported in this communication confirm the productivity of these water bodies. With appropriate stocking of the desired species, prevention of loss of fish due to predation and poaching through proper management and timely harvesting selected seasonal tanks can be made to yield profitable fish crops.

Acknowledgements :

Authors' sincere thanks are due to Messrs K. Handysoma, P. Wanniarachchi, Lakshman Chandrasiri and A. Waduge, Fisheries Inspectors attached to Freshwater Fish Breeding and Experimental Station, Udawalawe, for their co-operation during the study.

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TABLE I

Details of fish production from 23 seasonal tanks

	Name of the tank	Area at F.S.L. (ha)	Total harvest (kg)	Production per hectare (kg/ha)	Remarks
1.	Weheragala	9.0	6127.6	680.8	Harvesting completed
2.	Bogaswewa	6.0	4653.3	775.5	
3.	Karametiwewa	2.4	2060.5	858.5	
4.	Angunukclawewa	3.6	1605.0	445.8	
5.	Nikawewa	6.0	4011.5	668.5	
6.	Welapahala	2.5	1964.5	785.8	
7.	Komaligama	3.0	2697.1	899.0	
8.	Epitagcda	3.5	2626.5	750.0	
9.	Tunkama	4.0	9214.9	2303.5	
10.	Mahawewa	6.0	7924.1	1320 6	
11.	Maduwanwela	3.5	4023.8	1149.6	
12.	Benthiswewa	2.0	1040.5	520.3	
13.	Muwanpelessa	3.0	2401.9	800.3	
14.	Angunu 'pelcssa	4.0	879.5	219.8	
15.	Kalawelgala	4.0	4474.3	1118.5	
16.	Kohellanda	8.0	—	—	Harvesting not commenced
17.	Kumaragama	12.0	3296.0	—	Incomplete harvesting
18.	Karivilakanatta	6.0	1835.5	—	
19.	Yakunnawa	12.0	2602.3	—	
20.	Aratugasmedilla	12.0	1590.0	—	
21.	Bendiwewa	16.0	4212.5	—	
22.	Kudanctula	2.4	1500.0	—	
23.	Timbirigas Ara	2.5	571.5	—	
	Total	133.4	71312.8		

TABLE II

Percentage recovery and average size of the fish at harvest for different carp species

Name of the tank	Stocking density	Production kg/ha	Overall recovery (%) (all species combined)	Recovery/Average size of the fish at harvest (in kg.)											
				Bigheadcarp		Catla		Rohu		Common carp		Mrigal		Grass Carp	
				% Re-covery	Avg. size	% Re. covery	Avg. size	% Re-covery	Avg. size	% Re-covery	Avg. size	% Re. covery	Avg. size	% Re-covery	Avg. size
1. Weheragala	2000/ha	680.8	39.3	22.8	0.82	—	—	59.1	0.8	69.59	0.61	19.16	0.37	11.8	1.04
2. Bogaswewa		775.5	52.8	37.14	0.55	—	—	39.6	1.21	56.1	1.12	50.7	0.93	18.4	0.85
3. Karametiwewa		858.5	63.1	52.5	0.28	—	—	67.5	0.71	88.5	1.65	74.16	0.47	8.75	1.00
4. Angunukola-wewa		445.8	55.6	53.49	0.40	—	—	85.0	0.41	0.69	0.6	40.9	0.30	6.1	0.52
5. Nikawewa	2500/ha	785.8	42.4	64.07	0.58	—	—	35.1	0.64	12.8	0.56	43.9	0.76	7.2	0.37
6. Welapahala		668.5	57.6	80.2	0.18	—	—	37.9	0.6	29.1	1.12	66.5	0.50	17.9	2.87
7. Komaligama		899.0	34.7	33.86	0.73	—	—	51.04	1.26	30.8	1.43	16.2	0.65	45.86	1.11
8. Epitagoda	3000/ha	750.0	29.1	67.17	0.79	38.47	1.09	8.3	0.22	7.42	0.52	20.19	0.45	12.28	0.36
9. Tunkama		2303.5	65.0	57.38	1.67	71.8	1.82	93.6	0.56	51.4	0.86	64.66	0.53	15.8	0.65
10. Mahawewa		1320.6	32.9	55.42	1.34	23.55	2.33	22.4	0.89	7.08	2.28	42.7	0.72	32.88	0.70
11. Maduwanwela		1149.0	46.1	30.25	0.63	42.43	1.27	27.66	1.07	53.4	0.79	80.6	0.61	54.9	1.17
12. Benthiswewa		520.3	32.3	31.71	0.36	—	—	40.6	0.43	25.77	1.29	35.08	0.45	3.66	0.73
13. Muwanpelessa	3500/ha	800.3	50.0	53.25	0.39	—	—	65.06	0.45	28.6	0.59	53.39	0.44	28.33	0.57
14. Angunukola-pelessa		219.8	38.4	52.77	0.15	—	—	44.17	0.11	26.52	0.36	35.42	0.15	—	—
15. Kalawelgala		1118.5	58.0	69.8	0.93	—	—	83.05	0.29	44.76	0.99	59.04	0.25	52.28	0.11
Average ...				47.7	0.71	41.88	1.63	49.53	0.65	33.63	0.98	45.29	0.52	22.16	0.81

TABLE III

Contribution of different fish species to the total fish production

Name of the Tank	percent contribution/production per hectare (kg/ha)													
	Bighead carp		Catla		Rohu		Common carp		Mrigal		Grass carp		Tilapia	
	%Cont.	kg/ha	%Cont.	kg/ha	%Cont.	kg/ha	%Cont.	kg/ha	%Cont.	kg/ha	%Cont.	kg/ha	%Cont.	kg/ha
Weharagala*	24.84	169.1	—	—	34.7	236.2	18.85	128.3	3.33	22.7	2.42	16.5	15.83	107.7
Bogaswewa*	23.9	185.6	—	—	24.8	192.4	24.3	188.6	18.35	142.3	3.03	23.5	5.44	42.9
Karametiwewa* ...	12.18	104.8	—	—	34.12	292.9	27.8	238.7	20.7	177.9	1.01	8.7	4.12	35.4
Angunukolawewa* ...	33.95	151.4	—	—	48.44	215.9	0.18	0.8	13.9	62.1	0.72	3.2	2.77	12.4
Nikawewa	49.41	330.3	—	—	20.94	140.0	4.05	27.1	23.35	156.2	0.5	3.3	1.74	11.7
Welapahala	16.8	132.0	—	—	17.82	140.0	15.5	122.2	21.1	166.0	8.19	64.4	20.5	161.2
Komaligama* ...	24.33	218.8	—	—	44.75	402.3	18.47	166.1	5.92	53.3	7.13	64.2	—	—
Epitagoda	64.4	483.4	8.45	63.5	1.9	14.3	3.04	24.35	5.5	41.7	0.74	5.6	15.65	117.5
Tunkama	37.5	864.7	8.55	197.1	17.08	393.5	11.64	268.2	16.78	156.3	0.67	15.6	7.72	408.3
Mahawewa	50.8	671.1	6.24	82.4	11.36	150.2	7.35	97.2	10.56	139.5	2.62	34.7	11.02	145.7
Maduwanwela* ...	15.0	172.5	7.75	89.2	22.7	253.8	24.2	278.3	19.5	224.6	9.19	105.8	2.21	25.4
Benthiswewa* ...	23.34	121.4	—	—	25.3	132.1	28.8	149.9	18.51	96.3	0.77	4.1	3.17	16.5
Muwanpelessa ...	32.31	258.6	—	—	32.61	261.0	15.0	120.2	15.62	125.1	3.54	28.3	0.92	7.4
Angunukolapellessa ...	44.45	97.7	—	—	19.61	43.1	23.13	50.9	12.79	28.1	—	—	—	—
Kalawelgala	50.9	569.5	—	—	18.8	211.2	20.8	233.0	6.96	77.9	0.93	10.4	1.48	0.37

* Macrophyte vegetation (Lotus and Nelumbo) abundant in these tanks

J. Inland Fish., Vol. 3, December, 1986, pp. 56—62

PRIMARY PRODUCTIVITY AND FISH YIELD IN TEN SEASONAL TANKS IN SRI LANKA

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Introduction :

Seasonal tanks as the name suggests are water bodies that dry-up yearly for a few months. Utilization of seasonal village tanks for fish production has been suggested by Mendis (1977). A detailed description on seasonal tanks, their distribution, basic characteristics and fishery potential is given by Thayaparan (1982). The ADCP (FAO) mission which carried out a survey of aquaculture possibilities in Sri Lanka in 1980, concluded that seasonal tanks represented the best possibility for increasing the availability of fish in the inland areas and annual production of 25,000 tons of good quality fish could be obtained through a well managed seasonal tank aquaculture development programme (Refer ADCP mission report). To optimize the efforts for improvement and management of fisheries in these tanks, knowledge of their ecology is a pre-requisite.

Little or no literature exists on physicochemical and biological characteristics of seasonal tanks in Sri Lanka. Observations on primary production and fish production from 10 seasonal tanks in Sri Lanka are presented in this communication. In addition information on physicochemical characteristics of these tanks are also presented.

Materials and Methods :

Ten seasonal tanks situated in the Ratnapura and Moneragala districts were selected for this study. These tanks were selected because of their close proximity to the Udawalawe Fisheries Station. The study was carried out during the 1983/84 fish culture season. Water areas of these tanks at F.S.L. ranged from 2 to 6 ha.

All the tanks dried up during August 1983, and with the onset of monsoonal rains were filled-up with water. Stocking of these tanks with carp fish fingerlings was carried out during September — October. Three stocking densities varying from 2500 — 3500/ha were employed. Species combinations used were almost the same with minor variations. The fish species were stocked in the proportions indicated below :-

Aristichthys nobilis (Bighead carp)	— 35%	
Labeo rohita (Rohu)	— 25%	
Ctenopharyngodon idella (Grass carp)	— 5%	
Cirrhinus mrigala (Mrigal)	— 15 — 20%	} 35%
Cyprinus carpio (Common carp)	— 15 — 20%	

In four of the tanks, namely Tunkama, Mahawewa, Epitagoda and Maduwanwela percentage of bighead carps stocked was 30% and 5% of Catla was added.

Harvesting of fish in these tanks were done during July — August in 1984. During the culture cycle monthly determinations of primary productivity of these tanks were carried out using the light and dark bottle method (Sreenivasan 1964, b). In addition surface dissolved oxygen (by Winkler method), PH (using a PH meter), conductivity (using a conductivity meter),

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and transparency (using a secchi disc) were also determined. Free CO_2, methyl orange alkalinity and total hardness estimations were also made according to standard methods. Chlorophyll 'a' was estimated from spectrophotometer readings at 665 nm after extraction in 90% Acetone.

Results and discussion :

Physico-chemical conditions as recorded are presented in Table I. Primary production and fish production data are given in Table II. Average primary production ranged from 0.75g C/m²/ day (Angunakolapelessa) to 4.25g C/m²/day (Kalawelgala). Fish production per hectare ranged from 219.8 kg (Angunukolapelessa) to 2303.5 kg. (Tunkama). Wide variations can be observed in percent conversion of photosynthesis to fish (refer table II). Maduwanwela tank showed the highest conversion (5.35%) of Photosynthesis to fish, next was the Tunkama tank (4.78%) and the lowest observed was for Nikawewa tank (1.57%).

Sreenivasan (1972) reported on primary productivity of 13 different biotopes in Madras, India ranging from 0.405g C/m²/ day for Yercaud lake and 9.00 gC/m²/day for Ayyankulam, a 1.4 ha pond. High fish productions were reported from Ayyankulam pond (1438 kg/ha/yr), Fort Moat (1607 kg/ha/yr) and Chetpat Swamp (2200 kg/ha/yr). Percentage conversion of photosynthesis to fish in these water bodies were 0.438%, 0.707% and 0.774% respectively. In all these instances 90 — 99% percent of the total fish yield consisted of plankton feeding carps, Tilapia, chanos *etc*. Compared to the percentage of photosynthetic production which has been converted to total fish yield for 13 biotopes in India by Sreenivasan (1972), the seasonal tanks reported herein showed very high conversions ranging from 1.73 to 5.35%. In some seasonal tanks, as shown in Table II, percentage conversion of photosynthesis production to production of zooplankton feeding fishes (Catla and Bighead carp) alone is much higher than the conversion values reported by Sreenivasan (1972).

Observations of Sreenivasan (1980) on primary production (16.87 g O_2/m²/day) and fish production (6900 kg/ha/yr), for Fort Mort Vellore in India during 1971 — 1977 period shows that percentage conversion of Photosynthesis to total fish production is around 3%. According to him the Vellore Fort Mort is heavily polluted by sewerage and high level of organic carbon (mostly sestonic) occur in this ecosystem. Schroeder (1978) and Noriega — Curtis (1979) reported similar high conversions of photosynthesis to fish in manured ponds with no supplementary feeding. Attempts of Noriega — Curtis (1979) to predict fish yields from measured primary production gave values less than 25% of the observed fish yields. Odum (1960) felt that a harvest of 1.2% of primary production as fish would be excellent.

The composition of standing crop of fish may have some bearing on the conversion efficiency (Sreenivasan, 1972). Species composition of the fish harvests in seasonal tanks are included in Table III. It is seen that major portion of the catch is made-up of zooplankton consumers (Bighead carp and Catla), detritus feeders (Mrigal and Common carp) and Rohu, which mainly feeds on decaying vegetation. Except in Maduwanwela (9.19%), Welapaha (8.19%) and Komaligama (7.13%), in all the other tanks, contribution of Grass carp to the catches is very low (less than 3%). Although not stocked *O. mossambicus*, which gained access to some of these tanks contributed significantly to production. *O. mossambicus* in Sri Lankan reservoirs is found to feed on detritus, zooplankton and phytoplankton (Maitipe and De Silva, 1984).

Of the total phytoplankton primary production, 90% is in the nanoplankton range *ie*. capable of passing through a 30 to 40 μm net (Hillbricht — Ilkowska et. al 1972; Schroeder, 1978). Dokulil et. al (1983) reported on similar findings from the Parakrama Samudra reservoir, Sri Lanka. This is available as a natural food for fish only after entering further food chains or conglomerations to increase it's effective size (Schroeder, 1980). Considering these and the feeding habits of fish species cultured in seasonal tanks, only a very small fraction of the fish yield could be accounted for by direct harvesting of autotrophic photosynthetic production. Hence high conversion values of photosynthetic production to fish production observed in this study clearly show that food chains additional to autotrophic production must be involved in fish production is some seasonal tanks. Schroeder (1980) and Noriega-Curtis (1979) attributed high fish yields observed in manure loaded ponds over that estimated on primary productivity determinations, to heterotrophic production of bacteria and protozoa. The detritus or seston provided by the manure appears to supply a base for colonization by micro-organisms essential to the food web (Schoroeder, 1980).

Seasonal tanks mainly retain water for 6 — 10 months. Large quantities of droppings are left behind by cattle, who graze in the catchment area as well as in the tank during the dry season. In the rainy season large amount of plant materials including fallen leaves enter the tank with incoming water. Terrestrial vegetation, which grow within the f. s. l. area of the tank during low water levels, get submerged after rains and increase the organic matter content of the tank. All these together make seasonal tanks rich in organic matter.

It may be possible, that as suggested by various workers (Schroeder, 1980; Noreiga, 1978) heterotrophic production of bacteria and protozoa, which flourish on organic matter, could contribute to high fish yields attained in some seasonal tanks. Nevertheless primary productivity studies indicate the comparative merits of seasonal tanks for raising food fish, particularly involving carp polyculture. Studies on food chains present and the role of bacteria will be of vital importance to understand the dynamics of food web in seasonal tanks.

Acknowledgements :

Thanks are due to Messrs. K. Handisoma, P. Wanniarachi, Lakshman Chandrasiri and A. Waduge, Fisheries Inspectors attached to Fresh Water Fisheries Station, Udawalawe for their co-operation during the study and Mr. R. D. Chakrabarty Advisor, Ministry of Fisheries for critically reviewing the manuscript.

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TABLE I

Physico — Chemical features of seasonal tanks

Name of the tank	Area at f.s.l. (ha)	Surface Dissolved Oxygen (mg/1)	PH	Conductivity (μmho/cm)	Sechi disc-visilibility (cm)	Chlorophyll'a' (μg/l)	Free Co2 (mg/1)	M.O. Alkalinity (CaCo3 mg/1)	Total hardness (CaCo3 mg/1)
1. Tunkama	4.0	2.5—6.4	7.2—8.7	530—750 (618)	40—75 (59)	7.14—145.65 (33.86)	4—18 (11.3)	90—250 (150)	130—220 (144)
2. Mahawewa ...	6.0	3.0—6.4	7.1—7.8	640—950 (770)	33—75 (59)	14.28—21.89 (19.67)	6—20 (12.4)	109—310 (193)	55—120 (112)
3. Epitagoda	3.5	4.2—6.7	7.1—7.9	90—120 (106)	20—40 (35)	12.38—74.25 (35.06)	0—14.8 (6.4)	30—41 (34)	20—31 (24)
4. Maduwanwela ...	3.5	4.2—5.2	7.0—7.7	135—250 (184)	70—110 (93)	5.71—13.32 (9.89)	0—4 (3.0)	48—61 (56)	52—67 (59)
5. Benthiswewa ...	2.0	5.0—8.7	7.3—8.1	210—390 (281)	40—70 (50)	5.24—13.3 (8.4)	3—10 (6.0)	82—92 (87)	50—65 (58)
6. Nikawewa ...	0.6	3.7—10.0	7.2—8.3	155—540 (324)	30—70 (51)	12.38—50.45 (25.47)	4—12 (6.2)	55—75 (62)	40—70 (53)
7. Welapahala ...	2.5	4.1—4.7	6.9—7.4	110—250 (153)	80—110 (93)	8.57—29.98 (15.09)	0—3 (1.7)	52—64 (57)	58—64 (60)
8. Komaligama ...	3.0	4.4—5.8	7.0—7.5	200—240 (212)	80—110 (96)	7.1—12.2 (9.42)	0—3.1 (1.7)	54—70 (62)	50—72 (62)
9. Angunukolapellessa ...	4.0	4.3—10.2	7.1—7.6	80—105 (91)	30—35 (31)	8.09—26.2 (15.23)	8—12 (9.3)	20—38 (28)	30—60 (42)
10. Kalawelgala ...	4.0	4.6—10.3	7.0—8.0	50—92 (76)	30—70 (48)	10.95—87.58 (48.45)	5.1—14.0 (8.4)	45—100 (65)	28—80 (46)

TABLE II

Photosynthetic and fish production in the seasonal tanks

	Tunkama	Mahawewa	Epitagoda	Maduwan-wela	Benthis-wewa	Nikawewa	Welpahala	Komali-gama	Angunuko-lapelessa	Kalawel-gala
(1) Photosynthetic Production										
(a) O_2 g/m²/day (average) ...	8.55	6.44	4.207	3.906	4.246	7.526	3.929	4.052	1.995	11.34
(b) C g/m²/day (1)	3.21	2.49	1.577	1.464	1.592	2.822	1.47	1.519	0.75	4.25
(c) C kg/Water area (2) /Culture period (3)	19260	22410	8279.25	7685	4776	25398	5512.5	6835.5	4500.0	25500
(2) Fish production :										
(a) Total fish yield kg.	9214.9	7924.1	2626.5	4023.8	1040.5	4011.5	1964.5	2697.1	879.5	4474.25
(b) Total fish yield C kg (4) ...	921.49	792.41	262.65	402.38	104.05	401.15	196.45	269.71	87.95	447.43
(c) Yield of zooplankton eating fish (Catla & Bighead carp) kg. ...	4246.95	4521.75	2103.5	916.25	342.85	1982.0	330.0	656.2	391.37	2279.39
(d) Yield of zooplankton eating fish C kg (4)	424.69	452.1	210.35	91.62	34.28	198.20	33.0	65.62	39.14	227.94
(e) Fish yield.kg/ha	2303.5	1320.6	750.0	1149.6	520.25	668.5	785.8	899.03	219.8	1118.5
(3) Percent conversion of :										
(a) Photosynthesis (kg C) to total fish yield (kg C)	4.78	3.53	3.17	5.35	2.17	1.57	3.56	3.94	1.95	1.75
(b) Photosynthesis (kg C) to yield of zooplankton eating fish (kg C) ...	2.20	2.01	2.54	1.19	0.717	0.780	0.598	0.959	0.869	0.893

Following conversion factors and assumptions were used in this work.

(1) 1g O_2 = 0.375g C (Laevastu, 1957).

(2) Average water area was taken as half the area of the f.s.l.

(3) For calculations a culture period consisting of 300 days were considered, although in some tanks it is little less than that.

(4) 1 g C = 10 g of fish wet weight (Rodhe, 1958).

TABLE III

Species composition of the fish harvests in seasonal tanks studied

Name of the tank	Bighead carp/ Catla(%)	Rohu(%)	Common carp/ Mrigal(%)	Grass carp(%)	Tilapia (%)
Tunkama	46.08	17.08	28.42	0.67	7.72
Mahawewa	57.04	11.36	17.91	2.62	11.02
Epitagoda	72.85	1.9	8.59	0.74	15.92
Maduwanwela	22.75	22.7	43.7	9.19	1.66
Benthiswewa	23.34	25.3	47.31	0.77	3.28
Nikawewa	49.41	20.94	27.4	0.5	1.74
Welapahala	16.8	17.82	36.6	8.19	—
Komaligama	24.33	44.75	24.39	7.13	—
Angunukolapelessa	44.45	19.61	35.92	0	—
Kalawelgala	50.9	18.8	27.7	0.92	1.4

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OBSERVATIONS ON STOCKING OF THE INDIAN MAJOR CARP Labeo rohita (Ham) IN THE OPEN WATERS OF KANDALAMA AND UDAWALAWE RESERVOIRS IN SRI LANKA

I. M. D. B. Illukkumbura[1]

Introduction :

Records indicate the initial introduction of the exotic Indian major carps to Sri Lanka in 1948. However, there had not been any noteworthy attempt to breed them or to stock the species in water bodies (Records — Polonnaruwa Fresh Water Fisheries Station).

Efforts at reintroduction of the Indian major carps were made in 1981, 1982, followed by successful propagation of the species.

Significant numbers of fingerlings of Indian major carps are presently being stocked in selected perennial reservoirs in the country. A considerable number of fingerlings of *Labeo rohita* (Rohu) have been stocked in the Kandalama tank and the Udawalawe reservoir. This paper attempts to examine results of stocking of these two perennial water bodies reflected in fish yields in the years 1983, 1984 and 1985. Economic aspects of the programme have also been considered to assess prospects of continuing the same.

MATERIALS AND METHODS :

Kandalama Reservoir :

This is a perennial water body located 10 miles away from the Dambulla Fisheries Station with a surface area of about 800 ha and depth of 28' at F. S. L. Water comes from the Mahaweli diversion scheme, the biggest irrigation scheme in the country.

Udawalawe Reservoir :

A detailed description of the Udawalawe reservoir is given by Chandrasoma *et al* (this volume).

Stocking of fingerlings of L. rohita :

Fingerlings of *L. rohita* of size 5 cm were stocked. Prior to stocking, fingerlings were netted and released back in the ponds in order to get these conditioned for transportation. Feeding was stopped a day prior to transportation. Counted number of fingerlings were transported in double polythene bags containing water and oxygen. (Water volume — 15l ; capacity of the bag 40l). Normally, this was done in the morning hours before noon. 300 — 350 fingerlings were put in one bag. The time taken for transportation to both water-bodies from the respective fisheries station was 20 — 30 minutes. Stockings were done according to availability of fingerlings, after meeting demands of other programmes at the fisheries stations.

Collection of catch statistics :

Statistics of fish catches were collected fortnightly, by Fisheries Inspectors at selected landing sites. Additional supervision by senior staff of the Fisheries Stations was possible as these water bodies were in close proximity to fisheries stations. The Fisheries Extension Society of fishermen engaged in fishing also submitted species-wise catch figures obtained from their members, monthly. The estimates of fish production for a year were estimated on the

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basis of random sampling, the statistical method normally practised. Production figures thus obtained for Rohu (*L. rohita*) in 1984 and 1985 are presented in Table II.

Results :

Stocking :

The number of Rohu fingerlings introduced in the Kandalama Tank and Udawalawe Reservoir from 1983 upto 1985 are given in Table I.

TABLE I

***L. rohita* fingerlings stocked in Kandalama and Udawalawe Reservoirs**

Year	Kandalama Tank	Udawalawe Reservoir
1983 ...	105,000	127,050
1984 ...	100,000	45,500
1985 ...	100,000	285,700
Total ...	305,000	458,250

TABLE II

Fish landings (in kg) for 1984 and 1985, in Kandalama and Udawalawe reservoirs

Year	Kandalama Reservoir			Udawalawe Reservoir		
	L. rohita	Other Spp.	Total	L. rohita	Other Spp.	Total
1984 ...	4,995	30,106	35,161	26,264	559,691	585,955
1985 ...	29,433	56,787	86,787	27,895	426,001	453,896
Total ...	34,428			54,159		

Cost computation :

Cost of production per post larvae (8 — 10 mm size) and the cost of production per fingerling (Av. size 5 cm) were calculated on the basis of data gathered at the Dambulla Fisheries Station. Refer Annex I and Annex II.

Cost per post larvae ... ... *Rs.* 0.064

Cost per fingerling ... ... *Rs.* 0.42

Weight of fish captured per 100 *L. rohita* fingerlings stocked is shown in Table III.

TABLE III

Rohu harvests in different years

Water Body	Fingerlings stocked in 1983, '84 & '85	Weight of fish harvested in 1984 & '85 (kg)	Computed weight of fish obtained per 100 Rohu fingerlings stocked (kg)
Kandalama ...	305,000	34,428	11.29
Udawalawe ...	458,250	54,159	11.82

Financial returns : Computed Financial rate of return is shown in Table IV.

TABLE IV

Financial returns from stocking rohu fingerlings in reservoirs

Water Body	Fish obtained per 100 finger lings stocked (kg)	Cost per fingerling (Rs)	Cost per 100 finger-lings (Rs)	Sale* pro-ceeds from harvest (Rs)	Financial rate of Return
Kandalama ...	11.29	0.42	42.00	112.90	269%
Udawalawe ...	11.82	0.42	42.00	118.20	281%
					Average 275%

*Selling price considered at Rs. 10/- kg. is fast increasing as the species gets more popular with consumers.

Recovery : The percentage of *L. rohita* harvested from fingerlings stocked, is shown in the Table V.

TABLE V

Details on stocking, capture and recovery of Rohu

	Kandalama Reservoir		Udawalawe Reservoir	
	1984	1985	1984	1985
Catches of Rohu	4995 kg	29,433 kg	26,264 kg	27,895 kg
No. of fingerlings stocked by the end of the year	205,000	305,000	172,550	458,250
Average weight of Rohu captured	1.25 kg	2.25 kg	1.25	2.25
Percentage of fish captured in relation to numbers stocked ...	2%	4.3%	12.18%	2.71%

Discussion :

First appearance of Rohu in the fish catches of Udawalawe reservoir was made after six months from the date of first stocking whereas in Kandalama it was 8 months. The average weight attained by the fish of around a kilogram indicates the availability of natural food for proper growth. Rohu attained average weights of over one kilogram within one year in both the water bodies. In the second year fish weighing around 4 kilograms also figured in the catches.

The recovery of Rohu in 1984 and 1985 in Kandalama reservoir as indicated by fish captured was as low as 2% and 4.3% respectively, suggesting that many of the Rohu may have escaped capture or that the fishing effort was inadequate. The recovery rate of Rohu is observed as 12.18% in 1984 in Udawalawe reservoir was the reflection of higher fishing effort. As such recovery of Rohu perhaps does not indicate the actual outcome of stocking.

The weight of fish obtained per 100 Rohu fingerlings stocked in the Kandalama and Udawalawe reservoirs was around 11 kg. The financial rate of recovery for Rohu in Kandalama and Udawalawe reservoirs were 269% and 281% respectively and this is a significant financial recovery. The numbers of Rohu fingerlings stocked in 1985 in both water bodies are also included in the calculations. Usually the fingerlings stocked in 1985 would have appeared in catches after December 1985. The probability of getting marketable Rohu in the fish catches resulting from these fingerlings would be in 1986. Hence the financial rate of return could be considered more than the calculated value.

There are 48 families comprising 192 members engaged in fishing in Kandalama reservoir. 48 bicycle vendors and 2 motor bicycle vendors are engaged in marketing. These families derive benefit through-out the year.

Observations made from fish catches in the two water bodies suggest the possibility of similar economic returns being obtained by stocking *L. rohita* (Rohu) fingerlings in other perennial water bodies.

Production figures from Kandalama reservoir show that *Labeo dussmerii* (indigenous species) production is decling since 1983. One of the reasons could be competition for food with the newly introduced Rohu. Further investigations need to be carried out regarding this. Eventhough the study shows significant financial recovery, a final conclusion may not be drawn because of the following reasons :—

(*a*) Introduction of Rohu started in 1983 and catches for only two years have been considered.

(*b*) Natural food suitable for the growth of Rohu may not have been used by the existing species. After the introduction of Rohu, the species may have fed on these abundant natural food, not used effectively by others and grown fast. This could result in over exploitation of the natural food by the newly introduced Rohu and availability of natural food may decrease in future. Therefore, further investigations and monitoring should be done for some years before conclusions are arrived at.

(*c*) The study was confined to only two water bodies in Sri Lanka. This should extend to several other perennial water bodies in different climatic zones for several years in order to help arrive at final conclusions.

Acknowledgements :

I wish to thank Mr. N. M. Siril Bandara, Fisheries Inspector attached to Freshwater Fisheries Station, Dambulla, for his generous help with the collection of statistics for this study.

Thanks are also due to Mr. J. Chandrasoma, Fish Feed Technologist, Freshwater Fisheries Station, Udawalawe for his kind help with providing me the necessary data of Udawalawe reservoir.

Annex I

Cost estimates for production of Indian major carp Post larvae

Pond area used for the brood stock	2.3 *ha*
Depreciated value of 2.3 ha of pond area ... *Rs.*	230,000.00
Maintenance costs ...	23,000.00
Inputs :	
(*i*) Bleaching powder ...	2,400.00
(*ii*) Cowdung with transport costs	1,500.00
(*iii*) *Feeds :*	
(*a*) Molac	16,665.00
(*b*) Rice bran ...	2,000.00
(*c*) Fish meal ...	4,000.00
(*d*) Germianted paddy	1,995.00
(*e*) Leybes	15,000.00
(*f*) Transportation ...	5,450.00
(*iv*) Chemicals	10,000.00
(*v*) Hormones	19,000.00
(*vi*) Nets	10,000.00
Net cages, hand nets, *etc.*	5,600.00
Field equipment ...	1,000.00
Energy costs :	
Electricity charges ...	12,000.00
Fuel for water pump ...	7,500.00
Depreciated cost of the pump	5,000.00
Telephone	1,000.00
Depreciated cost of buildings	100,000.00
Transportation ...	5,000.00
Management costs :	
Salaries	150,000.00
Subsistance and overtime	2,500.00
Hatchery :	
Hatchery Jars (depreciated cost)	10,000.00
Breeding hapas ...	2,000.00
Transportation ...	1,000.00
Total cost	643,610.00
Post larvae production ...	10 *million*
Cost of production per post larvae	*Rs.* 0.064

Annex II

Cost estimates for production of fish fingerlings

Pond area utilized for fingerling rearing	0.65 *ha*
Depreciated value for 0.65 pond area ...	Rs. 65,000.00
Maintenance Cost	6,500.00
Cost for pond preparation :	
Bleaching powder ...	7,000.00
Transportation	500.00
Fertilizer	1,600.00
Transportation	4,000.00
Feed costs :	
Soya been	33,700.00
Rice bran	1,500.00
Transportation	1,000.00
Chemicals (Dipterex and Kerosene)	5,000.00
Nets	5,000.00
Cages	2,000.00
Buckets and Basins ...	1,000.00
Miscellaneous	6,000.00
Transportation	10,000.00
Buildings (depreciated cost) ...	75,000.00
Salaries	75,000.00
Overtime	5,000.00
Cost of post larvae (7.2 mil)	460,800.00
Total cost	765,600.00
Fingerling production ...	1.8 *million*
Cost of production per fingerling	*Rs.* 0.42

J. Inland Fish., Vol. 3, December, 1986, pp. 69—86

LIMNOLOGY OF AND FISH PRODUCTION IN UDAWALAWE RESERVOIR, SRI LANKA.

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Introduction :

Sri Lanka has no natural lakes, but there are several thousand of shallow irrigation reservoirs scattered in the dry zone of the country. These reservoirs are of extreme importance with respect to irrigation, flood control and hydroelectric power. Increasing attention has been focussed recently on reservoirs as animal protein source for human consumption. Large perennial reservoirs and small sized village tanks are sources for freshwater fisheries development. Presently the bulk of fish production (about 80 to 90%) from inland fisheries is constituted by the yield from large perennial reservoirs. To optimize efforts for improvement management of fisheries in these reservoirs knowledge of reservoir ecology is essential.

Only a few reports are available on limnological studies associated with fish production in Sri Lanka. Limnology and fisheries of the ancient Parakrama Samudra, situated in the north central province of Sri Lanka is well documented (Schiemer, 1983, Fernando and Indrasena, 1969; De Silva and Fernando, 1980). Recently Amarasinghe *etal.* (1983) have described the limnology of a few reservoirs in the Anuradhapura district.

Udawalawe reservoir is the largest reservoir situated in the southern region of the country. It has been constructed by damming the fastest flowing river in Sri Lanka *viz*, river Walawe. The present study was undertaken to gather information about the limnology and fish production of this reservoir.

Description of the reservoir :

The Udawalawe reservoir across the river Walawe (*fig.* 1) was constructed in 1965. This is situated in the dry zone of Sri Lanka (6° 26' N, 80° 50' E). The catchment area of the reservoir is about 455 sq. miles. The river and especially the catchment above the dam is under the influence of north east monsoon. At full supply level the reservoir has a water spread of 3374 ha and a volume of 2.55 x 10^{12} Cu. m. Mean water level at F. S. L. is 78.3 m. A. S. L. The bed level of the river is at 66 m. A. S. L. The dead storage capacity is 1.66 x 10^{11} Cu. m. with a surface area of 508 ha. The full supply level is at + 87.5 m. A. S. L. Since bed level of the river is at + 66 m. A. S. L. there is a dead storage of 6 m. of water.

The water is released through two sluices and irrigates about 18,000 ha of paddy land. In addition to irrigation, water is used for power generation too. There is a spill way constructed to discharge excess water, in addition to the natural surplus at + 87.5 m. This is the deepest of the southern reservoirs in Sri Lanka.

1. Fresh Water Fisheries Station, Udawalawe, Sri Lanka.
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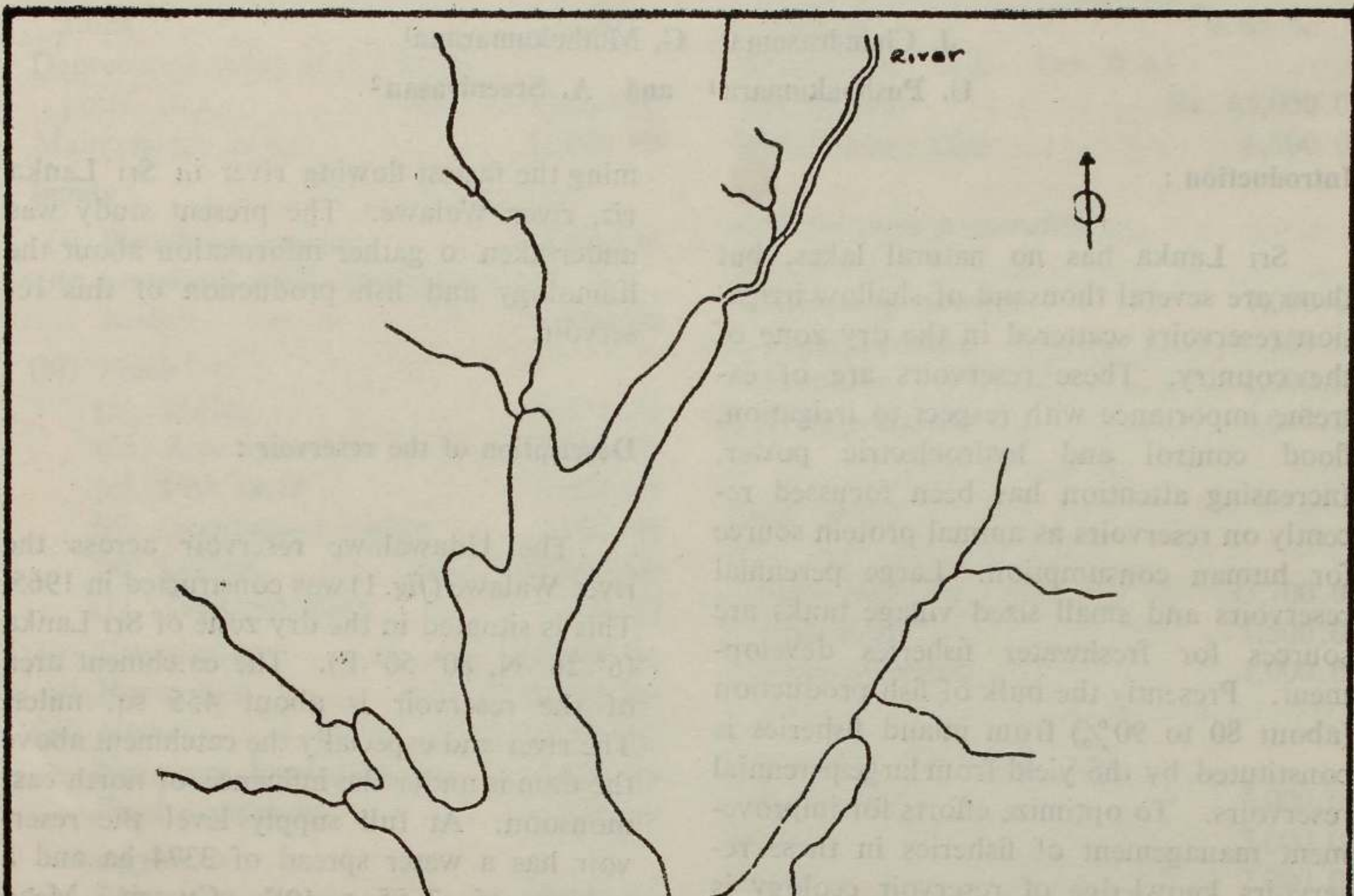

Figure 1. Map of the Udawalawe Reservoir

Materials and Methods :

Locations of the sampling stations are given in *Fig*. 1. The study was carried out from September 1983 to February 1985. Sampling was carried out once a month between 9.00 — 10.00 a.m. Water samples were collected with a 500 ml. ruttner sampler at different depths from surface to the bottom at 2 meter intervals, at two Stations. Temperature was recorded from a thermometer attached to the sampler immediately after the samples were brought-up. Oxygen was determined in the field by un-modified Winkler method after fixing the sample soon after collection. pH and conductivity were determined using a pH meter and a conductivity meter respectively. For Free CO_2, Hardness and Alkalinity samples were analysed according to Standard methods. Primary productivity in the water column was measured by the light and dark bottle method as described by Sreenivasan (1964 b). For qualitative analyses, phytoplankton and zooplankton samples were collected using 100 mesh/cm and 60 mesh/cm nets, respectively. These nets were hauled vertically from a depth of 5 m to the surface.

For quantitative analysis of plankton, water samples were collected on four occasions confined only to Station II. Water samples were collected at different depths from the surface to 5 m depth using a 500 ml Ruttner sampler. At each depth two water samples were collected and sieved through 100 mesh/cm plankton net. Phytoplankton and zooplankton were preserved using Lugol's iodine and 5% formalin respectiverly.

RESULTS :

Temperature :

Thermal profile of Stations I and II is given in *Figs*. 2(a) and (b). Highest water temperature at surface and the bottom were 31.6 °C (Sta. I, May '84) and 28.5 °C (Sta. II, Feb. '85), respectively. The lowest were 28.0 °C (Sta. I, Dec. '84) and 25.0 °C (Sta. I, March '84) for surface and bottom respectively. The lowest and the highest temperature difference between the surface and the bottom were 1.5 °C (Sta. II, Feb. '85) and 5.6 °C (Sta. I, May '84) respectively. Except for December '84 and February '85 temperature differences between the surface and the bottom varied between 3.5 °C to 5.6 °C.

Dissolved oxygen :

Dissolved oxygen profile of the stations I and II is given in *Fig*. 3 and 4 respectively. Surface dissolved oxygen varied from 6.0 mg/l (Sta. II, Feb. '85) to 9.6 mg/l (Sta. I & II, Dec. '83). Significant differences in variations of dissolved oxygen with the depth can be seen for Sta. I and II. In Sta. I, well oxygenated conditions along the entire water column was found almost throughout the study period. The depth-dissolved oxygen curve for the station II indicated that except for the months July '84, Oct. '84 and Dec. '84, on all other occasions well oxygenated conditions were noted at the top 6—8 meters of the water column and below this depth severe oxygen deficits occured.

Free carbondioxide, alkalinity, hardness and pH :

Free carbon dioxide was absent in the surface waters most of the times. Phenolphthalein alkalinity values were very low and maximum values noted were 4.84 ppm (Nov. '84) and 5.3 ppm (Dec. '84) for stations I and II respectively. Highest total Alkalinity values recorded were 105 ppm (Sept. '83) for Sta. I and 104.3 ppm (Sept. '83) for Sta. II. Lowest recorded total Alkalinity values were 53.0 ppm. (Jan. ,84) and 51.1 ppm (March '84) for Sta. I & II

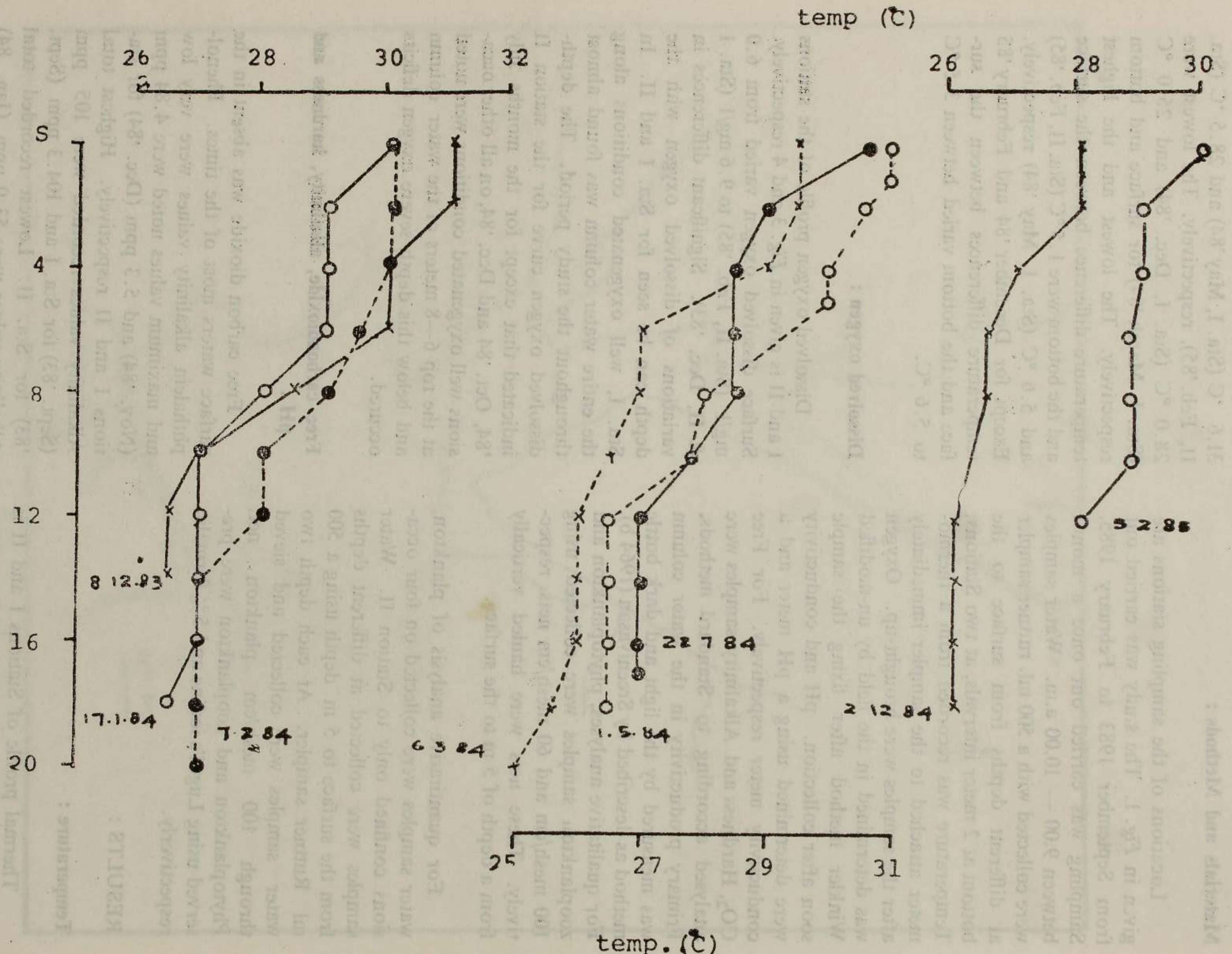

Figure 2(a) Thermal profile of the station I in the Udawalawe reservoir

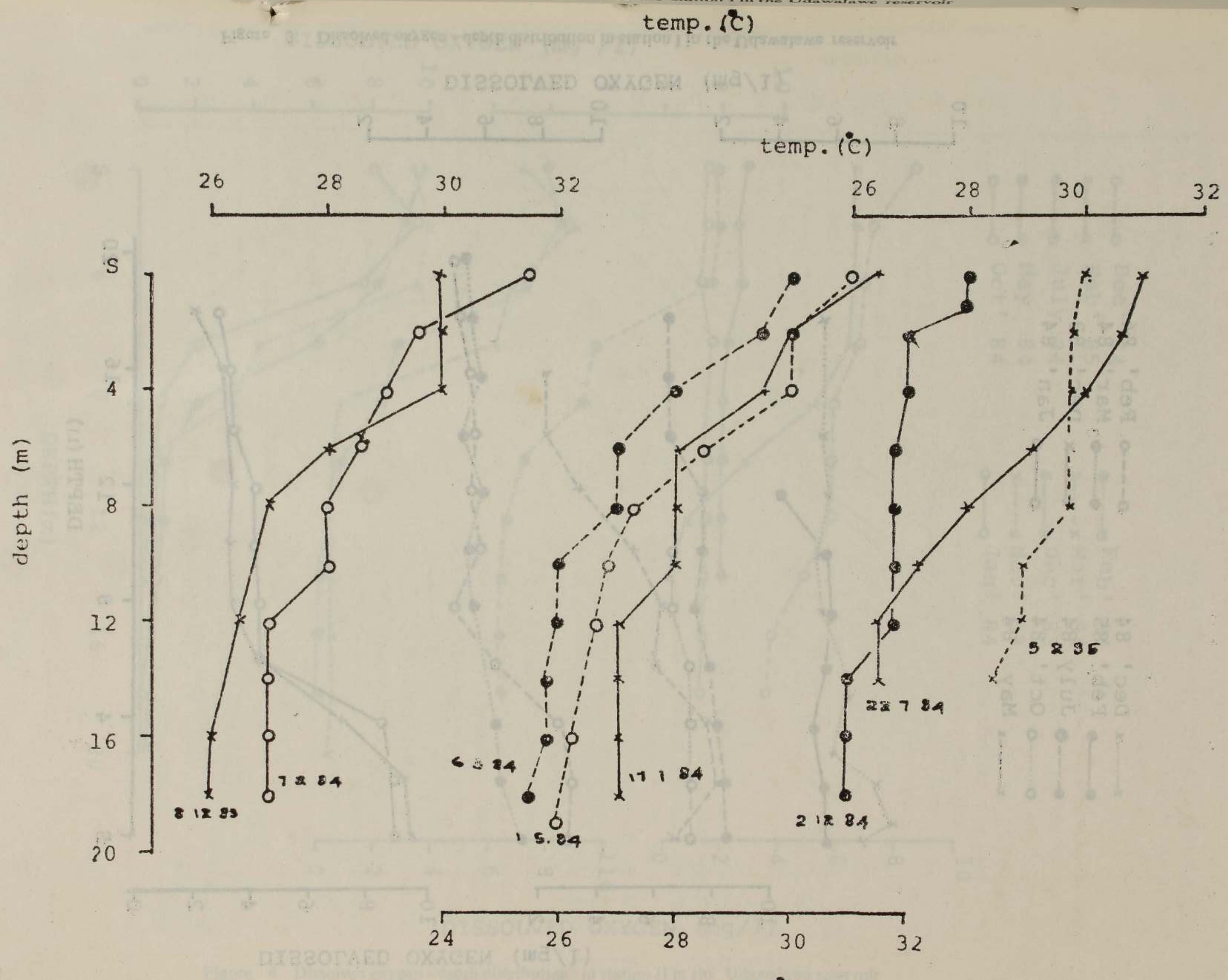

Figure 2(b) Thermal profile of the Station II in the Udawalawe reservoir

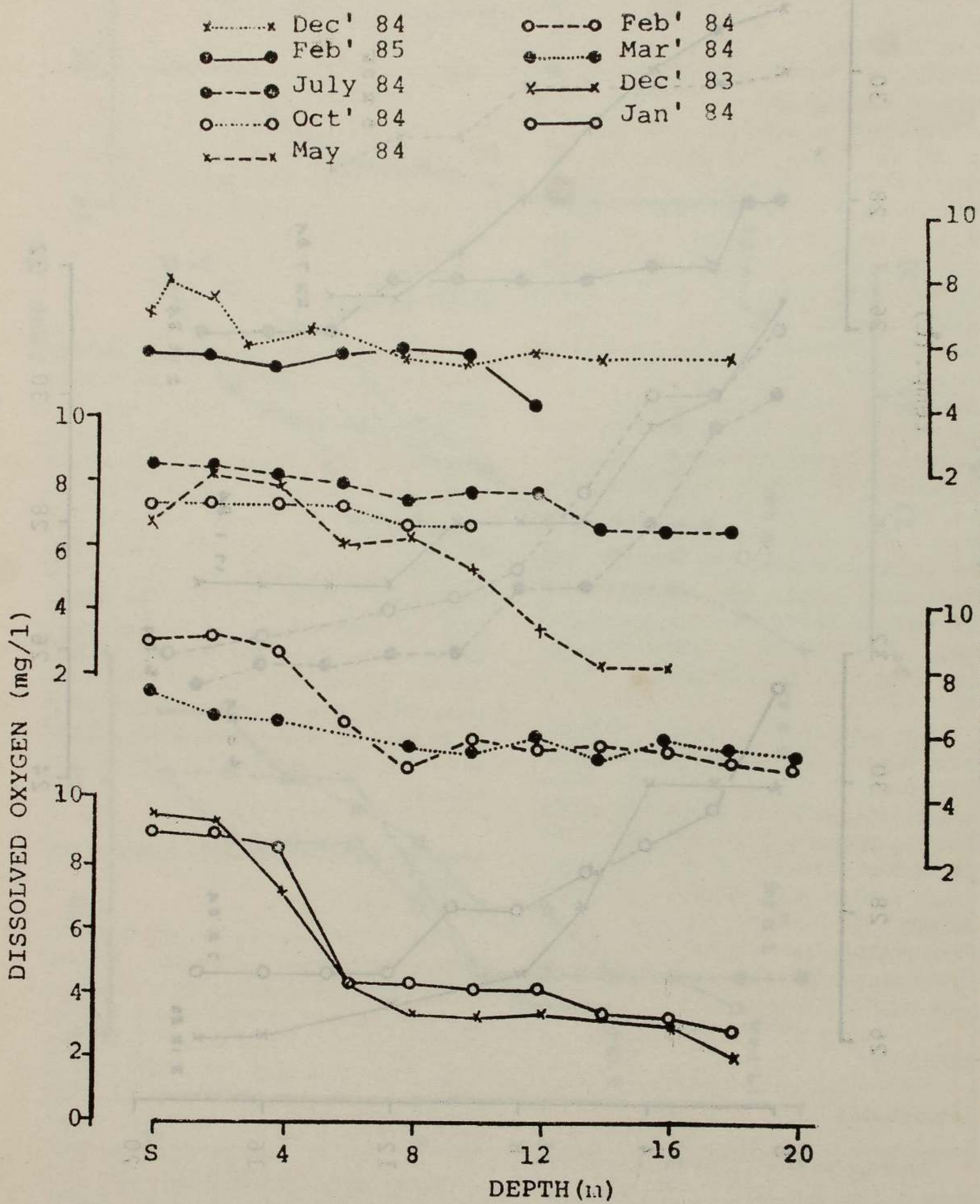

Figure 3. Dissolved oxygen - depth distribution in station I in the Udawalawe reservoir

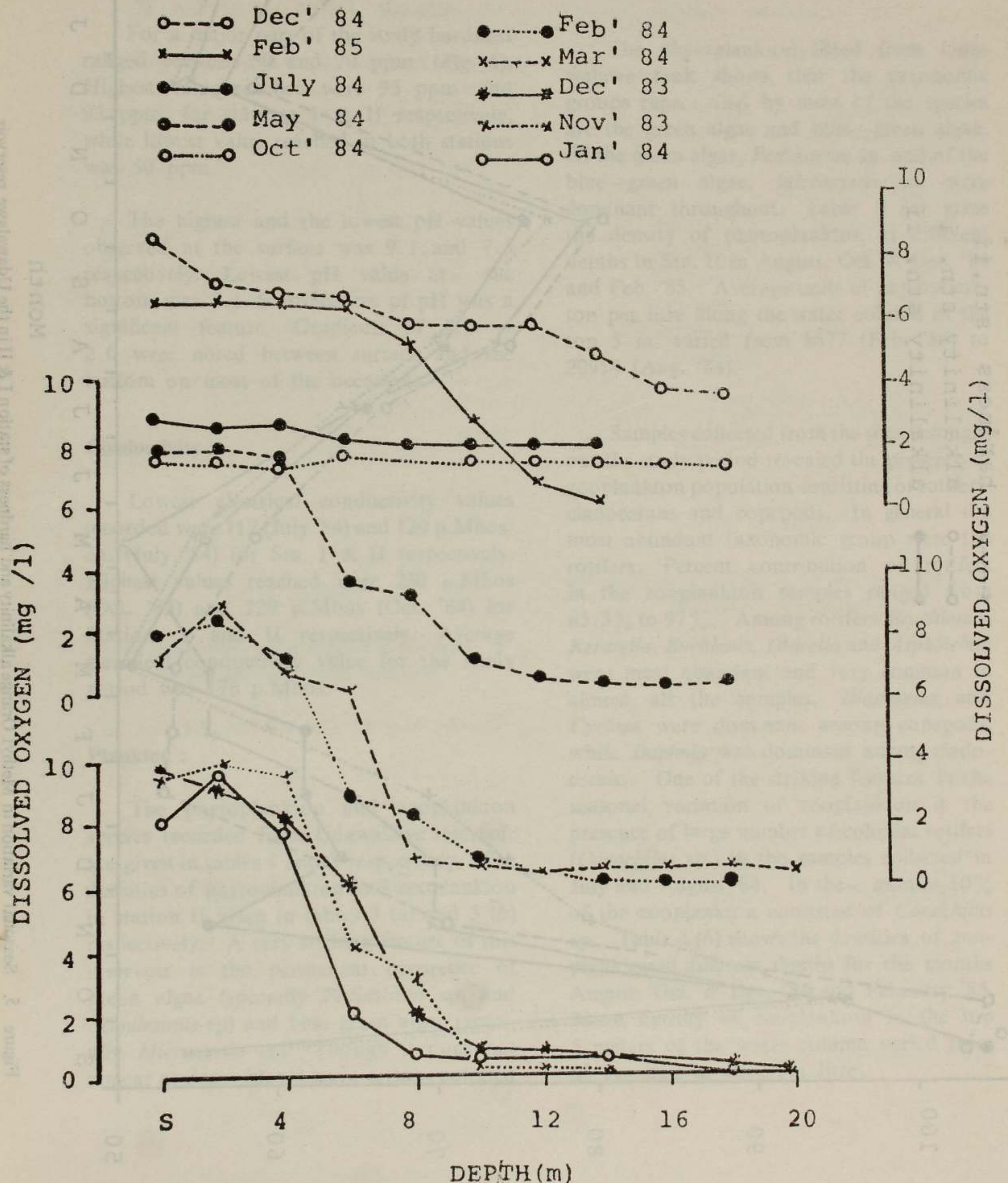

Figure 4 Dissolved oxygen - depth distribution in station II in the Udawalawe reservoir

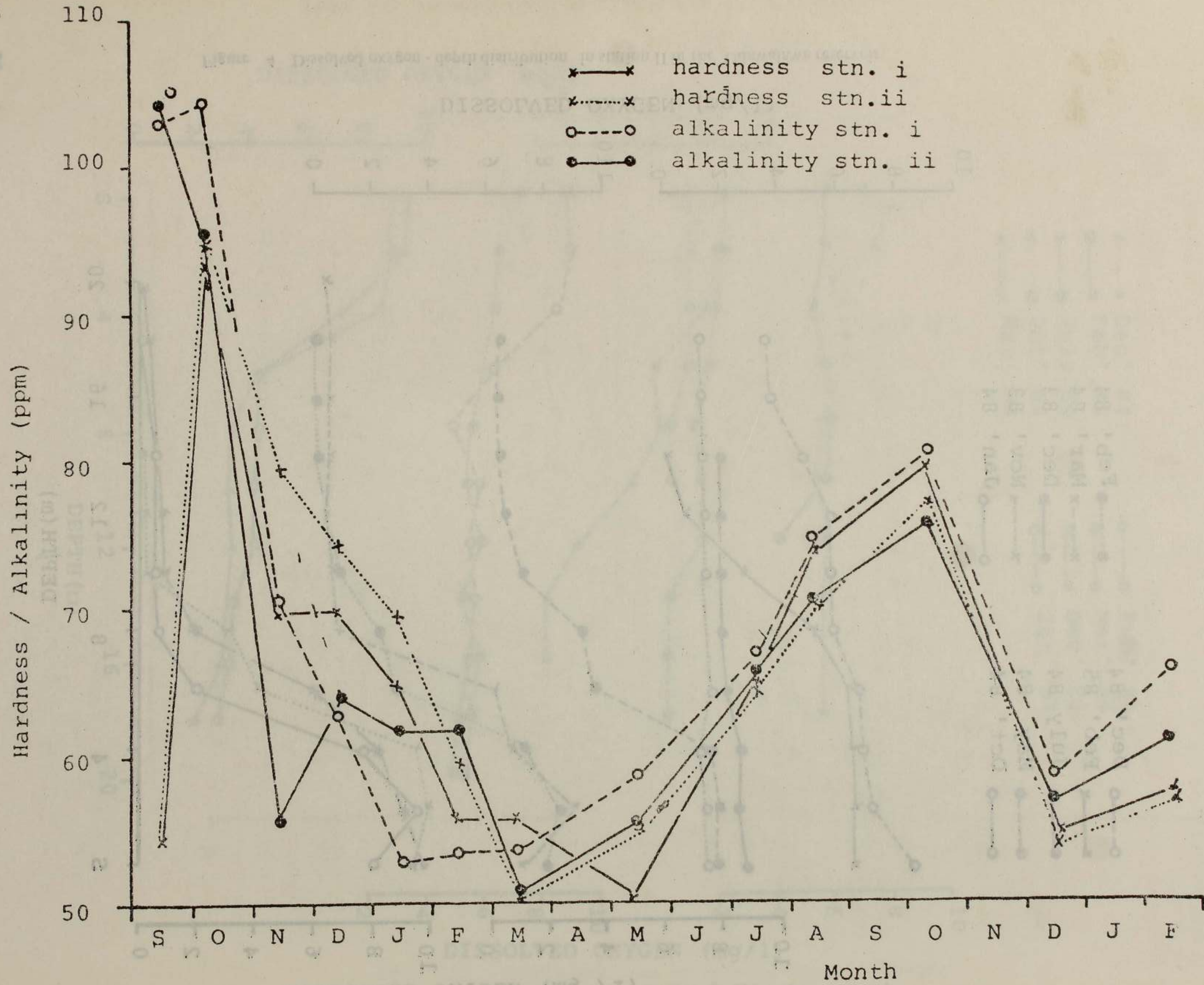

Figure 5. Seasonal variation in Methyl Orange alkalinity and hardness of station I & II in the Udawalawe reservoir

respectively. Two peaks in total alkalinity could be observed in Sept. — Oct. 1983 and Oct. '84 (*Fig.* 5).

For a major part of the study hardness ranged between 50 and 70 ppm (*Fig.* 5). Highest value reached were 95 ppm and 93 ppm. for stations I & II respectively, while lowest value reached in both stations was 50 ppm.

The highest and the lowest pH values observed at the surface was 9.1 and 7.3 respectively. Lowest pH value at the bottom was 7.1. Stratification of pH was a significant feature. Gradients of 1.1 — 2.0 were noted between surface and the bottom on most of the occasions.

Conductivity :

Lowest electrical conductivity values recorded were 112 (July '84) and 120 µ.Mhos/cm (July '84) for Sta. I & II respectively. Highest values reached were 230 µ.Mhos (Oct. '83) and 220 µ.Mhos (Oct. '84) for Stations I and II respectively. Average electrical conductivity value for the study period was 176 µ.Mhos.

Plankton :

The phytoplankton and zooplankton species recorded from Udawalawe reservoir are given in tables 1 and 2 respectively. The densities of phytoplankton and zooplankton in station II given in tables 3 (*a*) and 3 (*b*) respectively. A very striking feature of this reservoir is the permanent occurence of green algae (specially *Pediastrum* sp. and *Scendesmus* sp) and blue green algae (specially *Microcystis* sp). Though it does not appear as dense bloom as in certain polluted waters (Ganapati, 1960; Sreenivasan 1964, 1968, 1969), yet it's presence is recognizable visually throughout the year.

The phytoplankton listed from Udawalawe tank shows that the taxonomic groups represented by most of the species are the green algae and blue—green algae. Of the green algae, *Pediastrum* sp. and of the blue—green algae, *Microcystis* sp. were dominant throughout. Table 3 (*a*) gives the density of photoplankton at different depths in Sta. II in August, Oct. & Dec. '84 and Feb. '85. Average units of phytoplankton per litre along the water column at the top 5 m. varied from 8877 (Feb. '85) to 20954 (Aug. '84).

Samples collected from the sites throughout the study period revealed the presence of zooplankton population consisting of rotifers cladocerans and copepods. In general the most abundant taxonomic group were the rotifers. Percent contribution of rotifers in the zooplankton samples ranged from 65.3% to 97%. Among rotifers *Brachionus*, *Keratella*, *Euchlanis*, *Diurella* and *Asplanchna* were most abundant and very common in almost all the samples. *Diaptomus* and *Cyclops* were dominant among copepods, while *Daphnia* was dominant among cladocerans. One of the striking features in the seasonal variation of zooplankton is the presence of large number of colonial rotifers (*Conochilus* sp.) in the samples collected in July and August '84. In these months 90% of the zooplankton consisted of *Conochilus* sp. Table 3 (*b*) shows the densities of zooplankton at different depths for the months August, Oct. & Dec, '84 and February '85. Mean density of zooplankton in the top 5 meters of the water column varied from 60 per litre to 1032 per litre.

TABLE 1

List of Phytoplankton (Genera) present in the Udawalawe reservoir

CYANOPHYCEAE

Anabaena	*Lyngbyia*
Merismopedia	*Microcystis*
Oscillatoria	

CHLOROPHYCEAE

Anktistrodesmus	*Coelastrum*
Cruciginella	*Richterella*
Scenedesmus	*Selanastrum*
Spirogyra	*Tretraedon*
Treubaria	*Pediastrum*
Ulothrix	*Zygnema*

BACILLARIOPHYCEAE

Frustulia	*Melosira*
Synedra	

TABLE 2

List of Zooplankton (Genera) present in the Udawalawe reservoirs

ROTIFERS

Asplanchna	*Brachionus*
Conochilus	*Euchlanis*
Keratella	*Lecane*
Notholca	*Platyias*
Trichocerca	

CLADOCERANS

Daphnia	*Diaphanosoma*
Macrothrix	*Moina*

COPEPODS

Canthocamptus	*Cyclops*
Diaptomus	

OSTRACODS

Cypris

Nauplii Larvae

TABLE 3 (*a*)

Density of Phytoplankton (Units/l) in different depths in Station II

Depth	Aug.'84	Oct.'84	Dec.'84	Feb.'85
Surface	18199	20058	8900	8120
1 *m*	22856	23022	9880	14218
2 *m*	22000	24850	9624	9658
3 *m*	24160	22184	9800	9100
4 *m*	19856	16470	6920	8710
5 *m*	18658	11426	6875	3460
Mean density	20954	19668	8666	8877

TABLE 3 (*b*)

Density of Zooplankton (number/l) in different depths in Station II

Depths	Aug.'84	Oct.'84	Dec.'84	Feb.'85
Surface	450	800	128	44
1 *m*	252	800	60	28
2 *m*	320	1500	30	72
3 *m*	240	880	96	106
4 *m*	224	1400	72	58
5 *m*	67	816	68	56
Mean density	259	1032	75	60

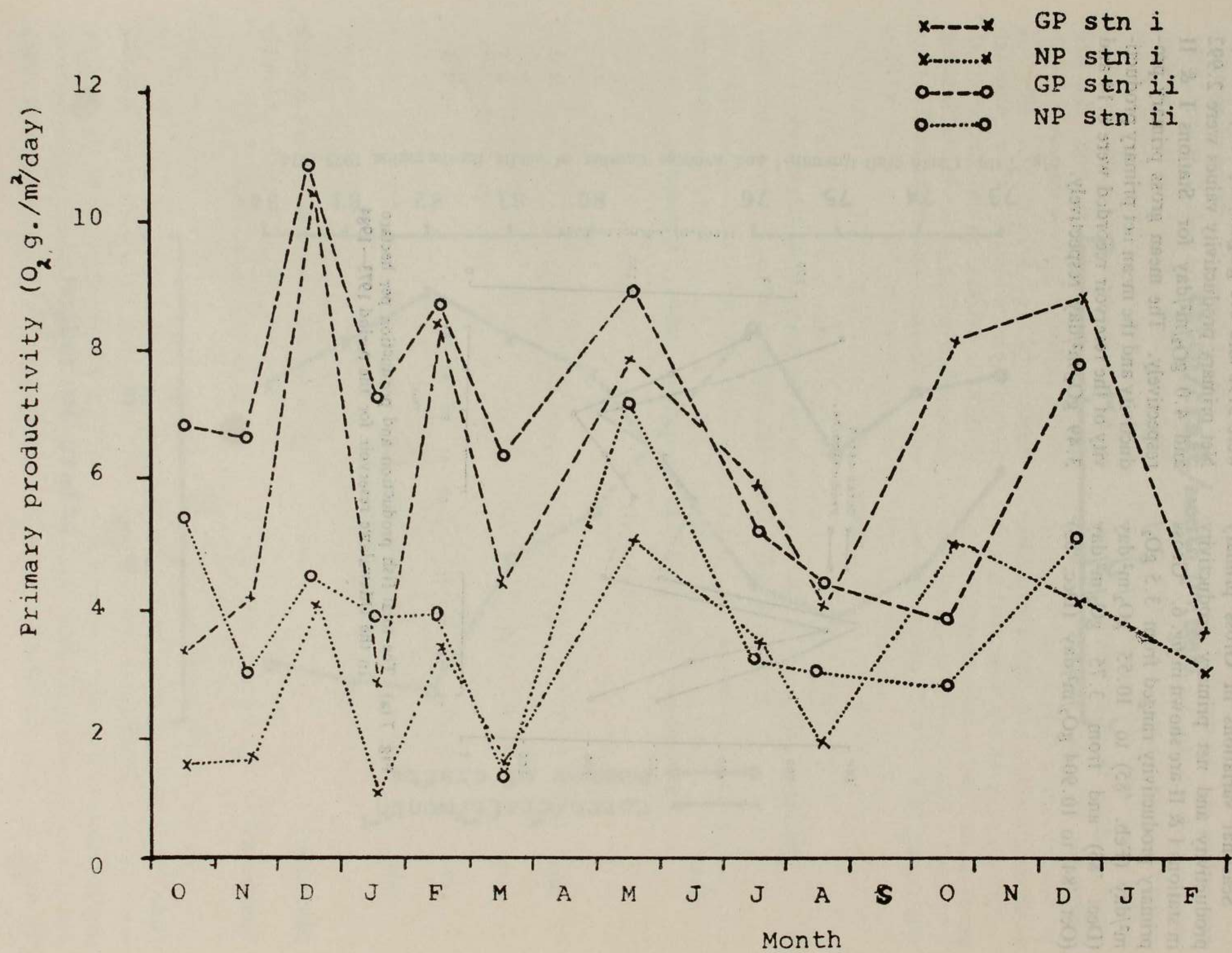

Figure 6. Seasonal variation in gross primary productivity and net primary productivity of Station I & II in the Udawalawe reservoir

Primary productivity :

Seasonal variations in Gross primary productivity and net primary productivity in stations I & II are shown in *fig*. 6. Gross primary productivity ranged from 3.5 gO_2/m^2/day (Feb. '85) to 10.55 gO_2/m^2/day (Dec. '83) and from 3.75 gO_2/m^2/day (Oct. '84) to 10.904 gO_2/m^2/day (Dec. '83) in Stations I & II respectively. Average gross productivity values for stations I & II were 5.96 and 6.3 gO_2/m^2/day respectively. Net primary productivity values were 2.992 and 4.0 gO_2/m^2/day for Stations I & II respectively. The mean gross primary productivity and the mean net primary productivity of the reservoir recorded were 6.14 and 3.49 gO_2/m^2/day respectively.

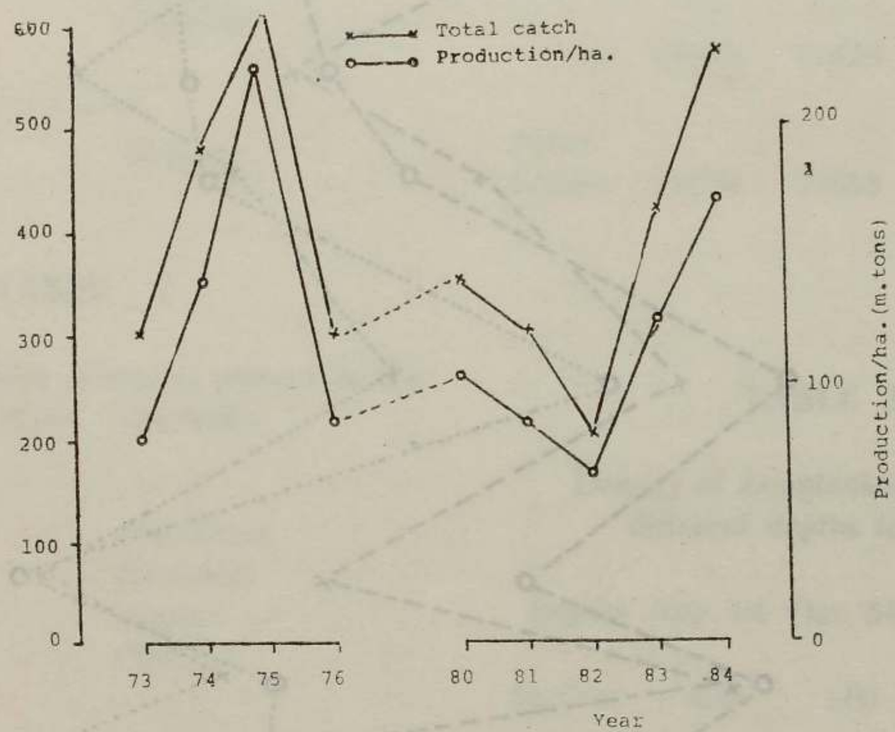

Fig. 7 (a) The total fish production and production per hectare in the Udawalawe reservoir for the period 1973—1984

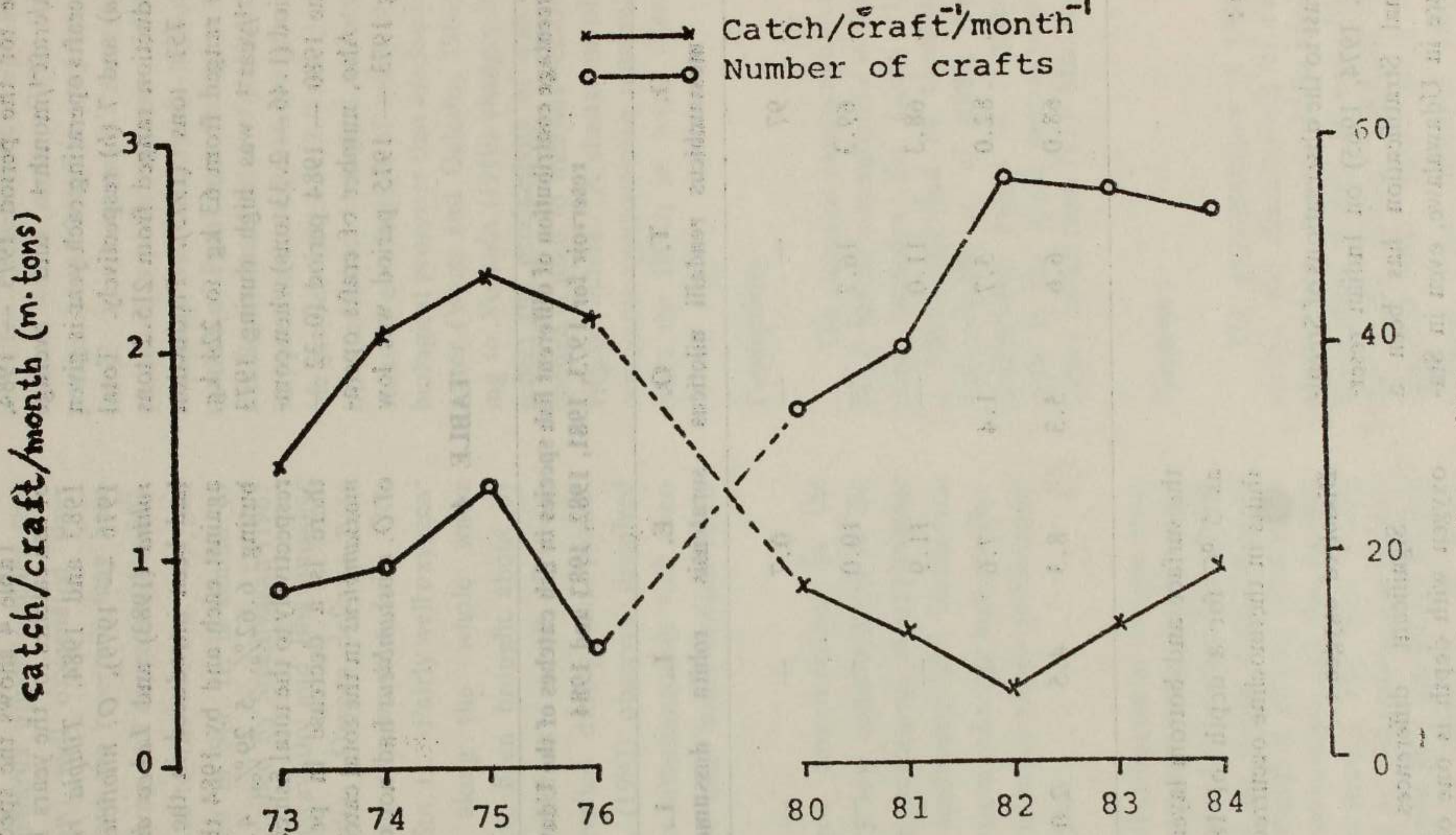

Fig. 7 (b) Catch/craft-1/month-1 and average uumber of crafts for the period 1973-1974

Fish production :

The total fish production and production per hectare for the period 1973 — 1984, and catch/craft^{-1}/month^{-1} and average number of crafts operating each year is given in *figs*. 7 (*a*) and 7 (*b*) respectively. Total annual production ranged from 215.2 tons (1982) to 757 tons (1975). Production per hectare ranged from 63 kg to 224 kg. Catch/craft^{-1}/year^{-1} was high during 1973 — 1976 period (1.46 — 2.33 tons) when compared to the 1980 — 1984 period (0.32 — 0.91 tons). Also, number of crafts operating during 1973 — 1975 period was low (15 — 27) when compared with that for 1980 — 1984. (34 — 53).

Table 4 shows the species composition of fish catches for the years 1973, 1981, 1982, 1983 and 1984. *Tilapia rendalli* (between 1976 — 1979), *O. niloticus* (1982), *Labeo rohita* (1983) and *Labeo dussumeiri* (1983) had been introduced in the years indicated against each and by 1984 they were contributing 6.62%, 5.29%, 4.53% and 2% respectively to the total fish catch. Although there is a decrease in percentage of *O. mossambicus* in the total catch, total landings of *O. mossambicus* had not declined.

TABLE 4

Percentage contribution of different fish species in fish catches of the Udawalawe reservoir for 1973, 1981, 1982, 1983 and 1984

Year	O. mossambicus	T. rendalli	O. niloticus	E. suratensis	L. rohita	L. dussumeiri	Other sp.
1973 ...	97	—	—	0.7	—	—	2.2
1981 ...	69.3	16.7	—	10.0	—	—	4.0
1982 ...	68.3	11.0	—	11.9	—	—	8.8
1983 ...	82.0	5.7	1.4	7.6	—	—	3.3
1984 ...	68.0	6.6	5.3	8.3	4.5	2.0	5.3

Discussion :

Temperature :

In contrast to the observations of Sreenivasan (1975, 1974, 1965) on Indian reservoirs, thermal Stratification has been a regular feature in Udawalawe, even in Station I which was nearer the inflow point of the river. At times the difference between the surface and bottom layers was as much as 5 °C for a depth of 18 m. Monthly shifts in thermocline occurred.

Dissolved oxygen :

Significant differences in dissolved oxygen with depth is one of the most interesting features found in this reservoir. In Station I, fairly well oxygenated conditions prevailed along the whole water column from surface to the bottom, almost throughout the study period. Since Station I is situated more towards upper reaches (towards the inflow) well oxygenated river waters flowing into the reservoir may have aided in maintaining well oxygenated conditions from surface to the bottom. Oxygen depletions noticed in Sta. II, is similar to the situation described by Sreenivasan (1965 & 1974) for Amaravathy and Bhavanisagar reservoirs in India. Oxygen defecits were not visible during the months July, Oct. and Dec. '84 in Sta. II. Fairly well oxygenated conditions along the whole water column may have been brought about by the mixing of water as a result of strong winds that prevailed during this period. Uhlmann *et al.* (1982) observed dissolved oxygen gradients simultaneously with thermal gradients in nine South Indian reservoirs.

High oxygen concentrations in the surface and very low concentration in the hypolimnion are indications of trophogenic activity in the epilimnion and tropholytic activity in the bottom reflecting high metabolism of waters, in other words productivity (Sreenivasan, 1965).

The depth distribution of oxygen coupled with free carbondioxide concentration has a bearing on fish movements (Byrd, 1952) and data on depth distribution of oxygen will be useful in getting some information on fish movements and also to plan out fishing operations. The most widely used fishing gear at Udawalawe are gill nets As this is a passive gear knowledge on fish movements is very important. It is expected that fish are more abundant in the middle and upper reaches of the reservoir.

Free Carbondioxide, Alkalinity, hardness and P^H.:

Free carbondioxide was absent from surface waters most of the time. When present it was found in very low concentrations. This indicates it's removal by phytoplankton in photosynthesis. Methyl orange alkalinity was moderately high comparable to that of Parakrama Samudra (Gunatileke and Senaratna, 1981). Total hardness (50 — 70 ppm.) too is moderately high. Considerable gradients (1.4 — 2.0 units) in pH noted here indicated biological activity. The pH value is a reflection of many chemical and biological processes that are found in natural water (Weiss and Oglesby, 1960). According to Verduin (1960) changes in pH value reflect the productivity of waters, and pH change is used to measure relative productivity of waters. A change in pH of 1 unit represents approximately removal of $2gC/m^3$ from the HCO_3 in water (Verduin 1975).

Conductivity :

The electrical conductivity value (112 — 260 μ Mhos) is comparable to that of Parakrama Samudra, Sri Lanka (130 — 210 μ Mhos) reported by Gunatilaka (1980). Amarasinghe *et. al* (1983) reported that conductivity values in 7 perennial reservoirs in the north central province in Sri Lanka varied from 197 μ Mho to 628 μ Mho.

Plankton :

The phytoplankton of Udawalawe reservoir was characterized by dominance of green algae (mainly *Pediastrum*) and blue-green algae (mainly *Microcystis*) throughout the study period. Dokulil *et.al* (1983) reported that blue — green algae and diatoms were dominant among phytoplankton in Parakrama Samudra, Sri Lanka.

Uhlman *et. al* (1982), recorded a predominance of *Microcystis* in the South Indian reservoirs studied by them. In Udawalawe, sizes of the *Microcystis* colonies varied greatly. Rotifers were the dominant zooplankters. Schiemer (1981) reported that the entire zooplankton in Parakrama Samudra, Sri Lanka consisted of rotifers, but suprisingly unlike in Udawalawe reservoir, not a single *Conochilus* was noted in Parakrama Samudra. Fernando (1980) also noted a striking feature namely the virtual absence of crustacean zooplankton in Sri Lanka reservoirs. Mean density of zooplankton observed in the study ranged from 60 — 1032 per litre. There was a sharp drop in Dec. '84 & Feb. '85 samples, when compared to August & Sept. '84 samples. Duncan (1983) reported of a similar situation in Parakrama Samudra, Sri Lanka. Duncan & Gulati (1981) attributed such changes to high flushing rates (inflow and/or out flow). Changes noted at Udawalawe reservoir too seems to be associated with high flushing rates and dilution (*fig*. 8).

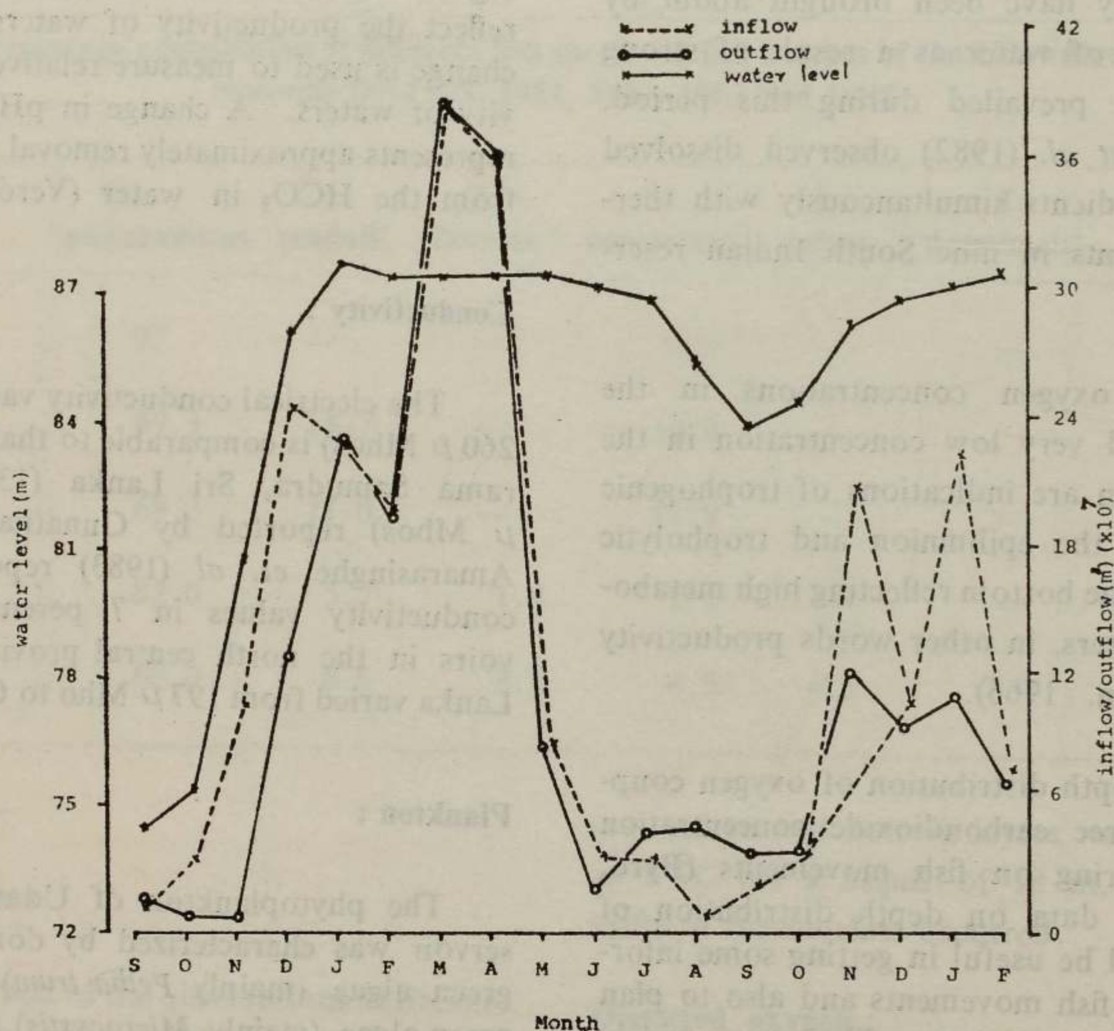

Fig. 8. Seasonal changes in the monthly inflow, and the water level at the main sluice of Udawalawe reservoir from September 1983 to February 1985

Previous accounts (Duncan, 1983; Fernando, 1980) of plankton in Sri Lanka based on northern reservoirs indicated the poverty or absence of crustacean zooplankton. But in Udawalawe reservoir, we find a better distribution of Cladocerans and Copepods and an abundance of rotifers. The swarming of *Conochilus* deserves special mention.

Primary production :

The mean gross primary productivity is 6.14 g. O^2/m^2/day or 23.025 kg C/ha/day which is similar to that recorded in Bhavanisagar, Stanley and Sathnur reservoirs in India (Sreenivasan, 1972) and Parakrama Samudra, Sri Lanka (Dokulil *et. al*, 1983). This may be considered to be a fairly high rate for a water body continuously flushed. This would be equivalent to 8404.13 kg C/ha/ Annum. According to Waldichuk (1958) dry weight of plankton biomass shall be 19098.02 kg/ha/Annum. Average water area for the period 1981 — 1984 was 2560 ha. Considering this as the average water area for the year dry weight of plankton biomass would therefore be 48.89 x 10^6 kg/or 48891 tons per annum. Even if 1% of primary productivity could be converted into fish an annual yield of 488.91 tons of fish could be obtained. Average annual fish production of the reservoir is 411 tons. (based on catch statistics for the periods 1973 — 1976 and 1980 — 1984). This indicates a fairly good management of the fisheries of this reservoir.

Fisheries :

Species composition of fish catches clearly indicated the impact of stocking. *O. mossambicus*, which contributed 81.6% to 97.0% of the fish catches in the 1973 — 1976 period, had decreased to 68% in 1984. Contribution of *T. rendalli*, another cichlid which feeds on macrophytes, varied from 5.7% in 1973 to 16.7% in 1981. Chandrasoma (in press) observed that the contribution of *T. rendalli* to fish catches in most of the reservoirs where it has established itself is around 10%. Percentage contribution of *Etroplus suratensis*, an indigenous cichlid, transplanted into fresh waters from coastal lagoons, to the total fish catch is around 10%. De Silva *et. al* (1984) reported that *E. suratensis*, which feeds on molluscs in a lagoon (it's orginal habitat) feeds on macrophytes in Udawalawe reservoir. According to them dentition of *E. suratensis* is well suited to exploitation of the two food resources namely molluscs and macrophytes. There is a paucity of macrophytes as well as molluscs in the Udawalawe tank (Personal observation). *T. rendalli* and *E. suratensis* mainly depends on terrestrial vegetation, which cover the exposed areas during low water levels, which is of importance after flooding, as food. This paucity of macrophytes probably limits the contribution of *T. rendalli* and *E. surantensis* to the fishery of Udawalawe reservoir.

O niloticus, which was introduced into Udaw.alawe reservoir in 1982, contributed 5.29% to the total catch. Findings of many workers (Dokulil, 1983; Costa & Abeysiri, 1978; Maitipe & de Silva, 1984) indicates that blue—green algae play only a minor role in the diet of *O. mossambicus* and that the species is not capable of utilizing blue—green algae. All these workers found the contribution of detritus to the diet of *O. mossambicus* to be fairly high. This indicates that blue—green algae, a dominant phytoplankton might not directly contribute much to increase the production of *O. mossambicus*, the dominant fish species. Moriarty (1973) and Moriarty & Moriarty (1973) demonstrated that *O. niloticus* can assimilate 70% — 80% of carbon in ingested blue—green algae. It may be worthwhile to pay more attention to *O. niloticus*, which can utilize blue—green algae.

Labeo rohita, which was stocked in Udawalawe reservoir only in June 1983, is contributing about 5% to the total catch. Chandra soma (1983) reported that 127,050 fingerlings of this species were stocked in this reservoir in 1983, and within a period of 6 — 8 months the species attained an average weight of 1 kg. At the end of the year 1984, most of the *L. rohita* caught in Udawalawe had attained weights around 5 kg. *L. dussumeiri*, an indigenous species which was absent in Udawalawe, was stocked in 1983 and it's contribution to the total fish landings in 1984 is 2%.

Although percentage contribution of *O. mossambicus* has declined from 97% (1973) to 68% (1984), total landings of *O. mossambicus* had not decreased (table 4). Total fish production has gone up by about 100 tons as a result of stocking of species which are capable of making use of unutilized ecological niches.

Acknowledgements :

We wish to thank Messrs. N. J. W. Nanayakkara and A. Karunarathna, Aquaculture Assistants and K. Handisoma, Fisheries Inspector attached to Freshwater fish breeding and experimental station, Udawalawe for their generous help with the field work connected with this study.

Thanks are also due to Mr. W. S. A. A. L. Kumarasiri, Officer in-charge, Freshwater fish breeding and experimental station, Udawalawe for providing laboratory facilities.

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J. Inland Fish., Vol. 3, December, 1986, pp. 88—90

STATUS AND PROSPECTS FOR BRACKISHWATER AQUACULTURE IN SRI LANKA

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Introduction :

The brackishwater area in Sri Lanka is estimated at about 120,000 h.a., 80,000 h.a., of these are estuaries and large deep lagoons and the rest comprises shallow lagoons, tidal flats and mangrove swamps. The smaller lagoons especially in the south-western, south and south-eastern regions are mostly closed with sand bar formations. Some have connections with the sea for a short duration during the rainy season. Some of the larger lagoons, which are called estuaries such as Puttalam, Jaffna and Negombo perennialy maintain connection with the sea. Large extent of tidal flats and mangrove areas exist in the Kalpitiya and Mannar regions.

Most of these lagoons and estuaries are inhabited by fin fishes such as *Chanos chanos, Siganus sp., Lates Sp., Lutajuns sp., Epinephalus sp., Mugil sp., Etroplus sp.* etc. Crustaceans such as *Penaeus indicus, P. monodon P. semisulcatus, P. latisulcatus, Metapenaeus dobsoni, M. eleganus, M. monoceros, Macrobacium rosenbergii*, and crabs such as *Scylla serrata* etc. Significant quantities of the sea weed, *Gracillaria sp.* are available in some of the lagoons in Puttalam and Trincomalee districts, Molluscs oysters such as *Crassostrea sp.* and cockles such as *Anadara granosa* are abundant in east and west coasts of Sri Lanka.

Chanos chanos cultivation :

Milk fish fry occur in tidal pools from March to June in the Mannar and Kalpitiya areas. The second season of Chanos chanos is from October to November though the seed avilability is of lesser mangnitude. About 1500 ha of shallow tidal pools could serve as collection ground for milk fish fry. Milk fish fry potential of Mannar and Puttalam is estimated at about 400 million and 200 million fry per year respectively (Ramanathan, 1969).

The Pitipana brackishwater fisheries station was established by the Ceylon Fisheries Corporation in the 1960's for rearing *Chanos chanos* fry to fingerlings for use as baits for Tuna. At present the Pitipana and Pambala brackishwater fisheries stations are used for rearing *Chanos chanos* fry to fingerlings. During the *chanos* (milk fish) fry availability seasons in the year, fry are collected from Kalpitiya and Mannar and transported to Pambala and Pitipana stations for rearing. Then the reared fingerlings are distributed among the milk fish farmers for their ponds and village tanks. At the Pitipana station, milk fish rearing trials were carried out and very favourable results obtained. A production of 1600 kg/ha for 6 months culture which is comparable to that reported from the Philippines was obtained in one trial. Private milk fish farmers of Negombo area obtain productions of about 600 — 1000 kg/ha/year and make profits. Further, milk fish culture trials in pens are being carried out in the Puttalam lagoon and the Bolgoda lake with the assistance of International Development Research Centre Canada.

Prawn Culture :

About 2000 — 3000 metric tons of shrimps are exported, annually. These are

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mainly catches from the wild. At present the Pambala Brackishwater fisheries station is engaged in the production of *Macrobacium rosenbergi* (Fresh water Prawn) post larvae. With the existing hatchery facilities about 50,000 Post-larvae are being produced, monthly. These post-larvae are sold at the rate of 50 cents (0.5 S.L.Rs.) per Post-larvae to shrimp pond farmers and also cultured in village tanks.

The prawn has been observed to attain weights of 200 — 250 gms within six months, in these seasonal tanks, stocked along with cultivable major carp species.

The shrimp Hatchery at the Pitipana, Brackishwater Fisheries Station, was improved with additions of brood stock tanks, larval rearing tanks, phytoplankton tanks, air blowers and other equipments through assistance of the B.O.B.P (Bay of Bengal Project). Production of Post larvae of penaid shrimps (*Penaeus mondon*, *P. indicus*, and *P. semisulcatus*) commenced in October 1984 and the present average production is about 100,000 to 150,000 post larvae per month. The production is mainly dependent on the availability of spawners from the Chilaw and Negombo areas. Post larvae produced from the hatchery are utilized for shrimp culture trials in pens and ponds conducted by the Ministry of Fisheries and NARA (National Aquatic Resources Agency). The balance is sold to private shrimp farmers at the rate of 30 cents per post larvae. Pen culture trials commenced in September 1984, with *P. indicus* post larvae stocked in two pens each of extent of 0.1 ha, in the Negombo lagoon. Six trials were carried out with post larvae captured from the wild and hatchery produced post-larvae, using different stocking densities varying from 20,000 p.l./ha to 60,000 p.l./ha. Productions recorded were 366 kg/ha and 385 kg/ha with stocking densities of 50,000 p.l./ha and 60,000 pl./ha, respectively.

Two more Pen culture trials are being carried out in the Koggala and Puttalam lagoons with *Macrobacium resenbergi* and *p. indicus*, respectively.

Brine shrimps (artemia) occur in the Palavi and Hambantota salterns, Studies carried out on the natural populations of artemia at these salterns indicate that approximately 25 kg/ha/yr may be harvested. At present Brine shrimp collected from these salterns by technical officers of the NARA are utilized by some private shrimp hatcheries.

According to the Export Development Board of Sri Lanka, the quantity of shrimp export in 1984 was 2606.5 metric tons. This mainly consisted of captured shrimps from the wild. Due to heavy exploitation by the fishermen, the natural stocks are being depleted. Hence shrimp culture through private sector investment is being encouraged. According to preliminary estimates of the Inland Fisheries Division of the Ministry of Fisheries, the total land area adjoining lagoons, available for shrimp farming in Sri Lanka is around 15,000 Acres, made up as follows :—

Puttlam ..	... 3000	*Acres*
Hambantota	... 1000	,,
Galle ...	... 500	,,
Batticaloa ...	... 4000	,,
Mannar ...	.. 2000	,,
Jaffna ...	... 1000	,,
Trincomalee ...	... 1500	,,
Mulaitivu ...	... 2000	,,
	15000	*Acres*

Three shrimp hatcheries have been commissioned in Talahena, Thoduwawa and Karukkapone by three firms in Sri Lanka and Post-larvae production from these, ranges from 2 — 8 million per month. One shrimp farm has been set-up in Batticaloa in the east coast of Sri Lanka and the other farms are at Thoduwawa and Karukkapone on the west coast. One farm, which practices the intensive culture technique, has reportedly achieved a production of 16 tons/ha/year and some farms which practice the semi-intensive culture technique, have produced 500 — 1000 kg/ha/crop. At present the total acreage utilized for shrimp farming is around 600 Acres.

A few people have tried crab culture in net cages in the Negombo lagoon. They collect the juveniles from the wild and fattern-ing is done in cages by using artifical feeds. But this activity is limited untill a hatchery is set-up for producing juveniles. Over exploitation of juveniles could be a major threat to the natural population of crabs.

Future prospects :

Chanos chanos fry potential of Sri Lanka, seems to be adequate for stocking 10,000 hectares of brackishwater ponds. The donor agencies, such as IDRC, SEAF-DEC, and ADB offer assistance for the development of milk fish monoculture and polyculture with shrimps in ponds and cages. In recent years, requests have beer received from various countries for export of milk fish seed from Sri Lanka. At present except the Ministry of Fisheries, private operators are not engaged in seed collection. But with the expansion of brackishwater fish farming it would be possible for private people to derive financial benefits by collecting and exporting *chanos chanos* seed.

With the increasing demand for shrimps, fishermen will intensify the catching of wild shrimps and at the same time shrimp farming by shrimp farmers also may increase rapidly. With such intensification of efforts, exports in 1990 could be expected to be around 4000 tons of cultured shrimps and 5000 tons of wild shrimps. Presently another 5 or 6 firms have requested the government for approval for starting shrimp farms in the east and west coasts of Sri Lanka. Finally, all these groups may construct shrimp farms in about 3000 acres of land in the near future.

The Sri Lanka aquaculture development Project funded by the Asian Development Bank will construct a shrimp hatchery to produce 20 million Penaid shrimp post larvae annually, and also construct brackish-water demonstration ponds of an extent of 25 hectares. This project would provide the post-larvae and technology to the small holders in shrimp culture. With the financial support from the ADB, small holders will be given credit facilities through local banks for shrimp farming. 200 hectares of shrimp ponds are to be developed, through small holders, on this basis.

Sri Lanka, with more than 810 ha of salterns offer a great scope for the production of brine shrimp to meet the demand by local shrimp farmers and ornamental fish dealers and also to earn foreign exchange by exporting the surplus.

With the development of fin fish and shrimp culture in brackishwater areas, efforts could also be made to promote Cockle culture, mussel culture, oyster culture and sea-weed culture in Sri Lanka.

Acknowledgement :

I am thankful to Mr. R. D. Chakrabarty (Expert ADB) for encouraging me to wright this paper.

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J. Inland Fish., Vol. 3, December, 1986, pp. 91—95

SUITABILITY OF GUINEA A GRASS (Panicum maxicum) AS A COLLECTING MATERIAL FOR EGGS OF COMMON CARP (Cyprinus carpio) DURING SPAWNING.

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Introduction :

Common carp was the first fish reared in China, in about 460 B.C. (Hsien-wen and Ling, 1964). Earlier, common carp monoculture was the only type of fish culture in Europe (Woynarovich, 1980a). Furthermore, common carp is the main species cultivated in Hungary (Woynarovich, 1980b), Japan (Suzuki, 1979) and is the main species grown in Indonesia and in rizipisciculture (Huet and Tan, 1980).

Common carp and red carp were introduced to Sri Lanka from China in 1948 and in 1976 respectively. Because of their feeding habits, these carps have a unique place in pond fish culture.

According to Indrasena and Ellepola (1965), the survival rate of common carp to the fingerling stage in the Polonnaruwa Nursery is less than 0.5% of the eggs laid. Hence, methods to increase the survival rate during different stages of early life are necessary. Edirisinghe *et al.* (1985), found that Guinea A bundles are better than coconut fronds as egg collectors and hence an experiment was undertaken to determine whether the readily available Guinea A grass leaves are more suitable than commonly used polythene strips as egg collecting material in common carp spawning. Subsequently, the most desirable distance between two Guinea A bundles was found out.

Materials and Methods :

Experiment 1. This experiment was undertaken to determine whether Guinea A grass leaves are more suitable than polythene strips as egg collecting material in common carp spawning.

Guinea A grass bases and polythene bases were prepared by tying bundles of leaves/strips on either side of bamboo sticks leaving a space of 25 cm in between bundles.

Each bundle of Guinea A/Polythene strips consisted of 25 leaves/strips each of 50 cm length. Total area of Guinea A leaves and polythene strips in each bundle were approximately equal.

Experiment 2. This experiment was undertaken to determine whether a distance of 50 cm or 25 cm between two Guinea A grass bundles was more effective.

Guinea A grass bundles prepared as in Experiment 1 were tied to bamboo sticks. In each tank two bamboo sticks had bundles tied at distances of 50 cm and two with bundles tied at distances of 25 cm.

Experiment 3. This experiment was undertaken to find out whether a distance of 25 cm or 12.5 cm between two Guinea A grass bundles was more desirable.

Guinea A grass bundles tied to bamboo sticks at 25 cm and 12.5 cm intervals were placed in the four cement tanks.

Experiments were conducted in four 12.5 m^2 cement tanks. In each tank, four bamboo sticks, each of 3m in length and with the two types of spacing with regard to the grass bundles were randomly placed.

1. Fresh Water Fish Breeding and Experimental Station, Dambulla, Sri Lanka.

Common carp spawners were distributed equally among the four tanks. 6 females and 12 males were introduced in each tank at 1000 hrs. Ground water was let-in continuously, for 24 hours, from the time of introduction of fish and samples of water from each tank were obtained for analysis. Physico-chemical analyses were done by standard methods.

After the spawning, total number of eggs deposited, rates of fertilization and hatchability were determined from random samples of leaves/strips from each treatment and counting the eggs deposited in each.

Complete random block design was used for the statistical analyses.

Results :

Physico-chemical condition of water in the cement tanks are given in Table 1.

Experiment 1. Common carps in three out of the four tanks had spawned. Number of eggs in an unit area, % fertilized eggs and % hatched eggs were significantly higher (P.<.01), with Guinea A leaves than in polythene strips (Table 2).

Experiments 2 & 3. Common carp in all the cement tanks had spawned. Though the number of eggs in an unit area was significantly higher (P.<.05) in Experiment 2 (Table 3), % unfertilized eggs and % unhatched eggs did not show significant differences (P.>.05) in either experiment (Tables 3 & 4).

Discussion :

Physico-chemical conditions of water in the four tanks showed that meterological conditions were suitable for spawning. Common carp needs shallow and clean water with temperature of not less than 16 — 17 °C for spawning (Woynarovich, 1975). Water in the spawning pond should be clear with dissolved oxygen content above 4 mg/l (Hsien-wen and Ling, 1964).

Experiment 1. It was observed that most of the Guinea A leaves were submerged while majority of polythene strips were floating. This would have been the reason for the significantly (P.<.01) higher number of eggs to be deposited and fertilized on Guinea A leaves. Furthermore, common carp might have preferred to spawn more on the Guinea A bundles due to its green colour, and easy attachment of eggs to the rough surface of the grass leaves.

Common carp are provided with bundles of brushwood (Hickling, 1948) or 'Kakabans' (Woynarovich, 1975) to spawn. In Europe, common carp are bred in special ponds with a grassy raised bed in the centre and in China, *Eichhornia*, *Ceratophyllum* and *Myricphyllum spp.* are used as egg collectors, while in Japan artificial egg collectors made of polythene are increasingly being used (Chaudhuri and Tripathi, 1979.)

According to Alikunhi (1960) as reported by Chaudhuri and Tripathi (1979), in India, *Hydrilla* provides the substratum for egg deposition. *Hydrilla* bundles hung on strings have been used in Sri Lanka (Indrasena and Ellepola, 1965), and coconut fronds or polythene strips are being used when *Hydrilla* is not available.

Air bubbles were seen accumulated along the floating polythene strips. This deprived the eggs from being submerged in water and would have affected their embryonic development resulting in the observed significantly low (*P.*<.01) hatchability.

Experiments 2 & 3. Number of eggs deposited in Guinea A leaves indicate that the increase in the number of Guinea A leaves per unit length of the bamboo stick by reduction of the distance between bundles have significantly increased ($P. < .05$) the deposition of eggs (Table 3). However a further reduction in distance between two grass bundles from 25 cm. to 12.5 cm. did not show a significant difference ($P. > .05$) in the number of eggs deposited (Table 4.)

The percentage of unfertilized eggs and percentage of unhatched eggs in these two experiments show that the reduction in distance between grass bundles have no significant effect ($P. > .05$) on the hatchability and fertility rates.

Conclusions :

Results of this study indicate that Guinea A leaf bundles are better than polythene strips as collecting material of common carp eggs and placement of bundles at distances of 25 cm. is more suitable for egg deposition than sepereted over greater distances.

Acknowledgements :

Thanks are due to Mr. A. M. Jayasekera, Director of Inland Fisheries Development, for the encouragement and to Fish Pathologist Kamal Balasuriya, Aquaculturists Sisira Tilakaratna, Mahinda Kulathilake, Research Assistant Saman Bandula and Assistant Aquaculturist Kitsiri Weerasinghe for assisting in the work. Support received from IFS (Sweden) is hereby acknowledged.

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TABLE 1

PHYSICO-CHEMICAL PARAMETERS OF WATER USED FOR SPAWNING COMMON CARP.

Parameter	Unit	Mean	Range
Alkalinity (Total)	mg/l	50.0	40.0 — 60.0
Hardness (Total)	mg/l	145.0	120.0 — 170.0
Dissolved Oxygen	mg/l	6.7	6.4 — 7.8
qPH		7.2	6.9 — 7.4
Temperature (Air)	°C	29.0	28.0 — 30.0
Temperature (Water)	°C	29.5	27.0 — 32.0
K+	mg//l	4.5	4.1 — 5.2
Na+	mg/l	2.2	1.8 — 2.8
Ca^{2+}	mg/l	15.3	12.6 — 17.1
Mg^{2+}	mg/l	2.8	2.4 — 3.3

[a]Geometric Mean
Number of Samples = 16.

TABLE 2

NUMBER OF EGGS DEPOSITED, % UNFERTILIZED EGGS AND % UNHATCHED EGGS PER 12 LEAVES/STRIPS.

	Number of eggs deposited		% Unfertilized eggs		% Unhatched eggs	
	Guinea A	Polythene	Guinea A	Polythene	Guinea A	Polythene
Block 1	2965	701	4.50	10.83	5.51	18.65
	1434	689	6.44	6.76	5.11	25.81
Block 2	1144	431	3.10	11.90	2.89	8.33
	2014	276	3.28	6.04	3.03	43.62
Block 3	969	353	4.19	12.25	1.94	25.93
	793	172	3.58	10.09	2.33	14.29

Eggs deposited, % unfertilized eggs and % unhatched eggs were found to be significantly different (P.<.01).

TABLE 3

NUMBER OF EGGS DEPOSITED, % UNFERTILIZED EGGS AND % UNHATCHED EGGS IN A SAMPLE OF GUINEA A LEAVES.

	Number of eggs deposited		% Unfertilized eggs		% Unhatched eggs	
	25 cm Treatment	50 cm Treatment	25 cm Treatment	50 cm Treatment	25 cm Treatment	50 cm Treatment
Block 1	637	288	6.4	4.3	6.2	3.2
	337	118	3.2	2.8	2.4	2.8
Block 2	212	148	5.3	3.2	3.2	1.6
	368	208	4.2	3.3	4.6	2.2
Block 3	723	412	6.2	5.6	5.6	3.1
	612	486	7.2	4.9	5.1	3.6
Block 4	188	143	2.8	1.9	2.1	1.7
	225	118	3.1	2.3	1.9	1.8

Number of eggs deposited was found to be significantly different (P.<.05)
% unfertilized eggs and % unhatched eggs were not significantly different (P.>.05).

TABLE 4

NUMBER OF EGGS DEPOSITED, % UNFERTILIZED EGGS AND % UNHATCHED EGGS IN A SAMPLE OF GUINEA A LEAVES IN EXPERIMENT 3

	Member of eggs deposited		% Unfertilized eggs		% Unhatched eggs	
	12.5 cm Treatment	25.0 cm Treatment	12.5 cm Treatment	25.0 cm Treatment	12.5 cm Treatment	25.0 cm Treatment
Block 1	937	483	8.1	4.3	8.3	4.2
	628	376	6.7	5.2	7.2	3.9
Block 2	712	416	7.2	4.1	5.6	2.3
	488	311	3.2	2.1	4.2	3.1
Block 3	631	372	2.1	1.2	3.3	2.8
	565	261	1.8	1.4	4.6	3.1
	412	323	1.6	0.9	1.9	1.2
Block 4	317	218	1.1	0.7	2.1	0.9

Number of eggs deposited, % unfertilized eggs and % unhatched eggs were not significantly different (P.>.05).

J. Inland Fish., Vol. 3, December, 1986, pp. 96—107

THE MILKFISH SEED RESOURCES SURVEY IN SRI LANKA: STATUS, PROBLEMS AND RECOMMENDATIONS

Teodora Bagarinao[1]

Introduction :

Brackishwater fish farming in Sri Lanka has only recently been given the attention that its resources warrant. Among the species first considered for culture was milkfish (*Chanos chanos*). In 1954, Sri Lanka embarked upon a systematic survey of its coastal waters to locate the collection grounds for milkfish seed. Regular collections have since then been carried out, mostly from Mannar, Kalpitiya and Negombo, and it has been estimated that the seed potential of these areas is more than 600 million per annum (Ramanathan, 1969). However, the annual catches have been much less : 12-174 thousand in 1961-1969 and 0.2-1.3 million in 1979 - 1983 (Ramanathan, 1969; Ramanathan and Jayamaha, 1972 ; Thayaparan and Chakrabarty, 1984). The brackishwater aquaculture potential of Sri Lanka is 120,000 ha, of which some 10,000 ha are suitable for milkfish farming (Thayaparan and Chakrabarty, 1984). To stock this area would require some 30 - 60 million milkfish seed per crop, at a stocking rate of 3,000/ha and allowing for 5% mortality. To develop milkfish aquaculture in Sri Lanka, the government recognizes and foresees the need to collect more seed, to increase the fry supply. The program of study of the seed supply has come to be know as the milkfish seed resources survey.

To increase the milkfish seed supply in Sri Lanka, there are five possible approaches : (1) intensive collection to fully exploit the known collection grounds; (2) exploration of new collection grounds, necessarily through (3) development and use of suitable collection methods and gear ; (4) use of better handling techniques to improve the survial of seed presently available; and (5) artificial propagation of seed in the hatchery.

Approach 5 may be disregarded at this point in time in Sri Lanka. In view of the logistic problems involved in the full exploitation of the present collection grounds, and in expectation of the future increase in demand for seed, the government has more or less emphasized the second approach in which researchers and assistants go out and operate collection gear in likely tidal pool, lagoon or beach waters. Approach 3 requires understanding of the behavior of milkfish seed of different stages and sizes (fry vs. fingerlings) and of the environment in which they occur. Since approaches 2 and 3 will obviously take some time to realize, approach 4 will be most immediately fruitful.

Researchers from the SEAFDEC Aquaculture Department had been asked to assist in the milkfish seed resources survey, presumably because the Philippines leads in milkfish research and production, but also because the International Development Research Centre (IDRC, Canada) funds milkfish aquaculture research in both the Philippines and Sri Lanka. While co-operation between the two countries is necessary, it is now apparent that the effort cannot be mere technology transfer from the Philippines to Sri Lanka. The milk fish "climate" is very different in these two countries. Aside from milkfish being a tradition in one and a novelty in the other,

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many other differences (Table 1) may be noted. While these differences should not discourage co-operative effort they should be considered as an indication of the feasibility, and of the probable direction of such co-operation.

The purpose of this paper is to summarize findings, outline problems, recommend solutions and discuss directions for research, and thus highlight the need for the continuation of a realistic, more organized and well directed milkfish seed resources survey in Sri Lanka.

12 - 25 mm and 25 - 80 mm, and 11.5 - 50 mm (Ramanathan, 1969; Ramanathan and Jayamaha, 1972; Villaluz *et al.*, 1982 a; respectively), and correspond to the pre-fingerling (13 - 50 mm total length) and fingerling (40 - 100 mm TL) stages as defined in Philippine culture practice (Rabanal *et al.*, 1953). Ramanathan and Jayamaha (1972) reported a few translucent 10 mm larvae caught close to shore early in the season; presumably these correspond to the fry collected from shore waters in the Philippines. Only the fry are caught in the Philippines, fry being the 2 - 3 week old

TABLE 1

SOME DIFFERENCES IN THE MILKFISH SEED COLLECTION BETWEEN THE PHILIPPINES AND SRI LANKA

Aspect	Philippines	Sri Lanka
Seed requirement per annum	1.1 billion*	present : ca 1 million projected : ca 30-60 million
Catch per annum	high : 1.35 billion*	low : 0.6 - 1.3 million
Stage of seed collected	fry only 2-3 weeks old 10-17mm total length	fry to fingerlings 3-10 weeks old 12-80 mm total length
Collection ground	mainly shore waters and river mouths	inland waters : lagoons tidal pools and creeks and marsh flats
Collection season	mainly March-October (duration varies with latitude)	April-June (main) October-November (occasional)
Collection gear	diverse, many are unspecialized	only *Kaddipuwa*, unspecialized
Collectors	coastal villagers	Ministry of Fisheries personnel only

* Data from Smith *et al.* (1978) and Smith (1981).

Status and Findings :

Table 1 summarizes the various aspects of the milkfish seed collection in Sri Lanka.

The Sizes of milkfish seed collected have been variously reported as 15 - 30 mm,

10 - 17 mm TL (mostly 13 - 15 mm) transparent postlarvae (Kumagai, 1984.) The term 'fry' as used in Sri Lanka refers to fingerlings mostly. In this paper, "seed" refers to the fry and fingerlings collected in Sri Lanka, and "Fry" means only the stage collected in the Philippines.

Form No 7

The collection grounds in Sri Lanka are brackish to marine to hypersaline (as high as 75 ppt) inland waters : lagoons, tidal pools and creeks, and marsh flats, well described by Villaluz *et al.* (1982 a). These places share characteristics typical of coastal wetlands that serve as habitat-nursery grounds for wild juvenile milkfish in the Philippines (Kumagai and Bagarinao, 1981) : they are far or protected from immediate wave action, currents and winds; rich in food (vegetated by mangroves and associated plants, covered by thick algal mats, and manured by donkeys and cattle when dry), and shallow (about 10 - 50 cm during the season.) During a one-month visit in September 1984, it was seen that the marsh flats in Kalpitiya, Vankalai and Erukulampiddi (Fig. 1) were all dry and no milkfish was present. It seems that these marsh flats are reached only by the high waters of spring tide periods in April - June (the main collection season), and only by the rain flood waters in October - November (the occasional season). The collection seasons thus appear to depend on water reaching the shallow pools in these marsh flats, making them accessible to milkfish, and in this case do not actually reflect the spawning season or the season of occurrence and abundance of fry in more open waters.

Only the dragnet, *kaddipuwa*, a traditional unspecialized gear is used in seed collection. It is very efficient in catching a fish school already sighted in shallow water but otherwise it is quite ineffective. In May - June 1982, Villaluz *et al.* (1982 a) operated an 11 - m long filter bagnet and reported fry (not specified as to size or stage) catches of 20-112/30 min operation in Mannar and Kalpitiya, and 1-3/30 min in Negombo, Balapitiya, Kuchchaveli, Panichangkenei and Passekudah. In contrast, about 500 - 3000 fry and fingerlings could be captured per 15 - 20 min operation of the *kaddipuwa*. In September 1984, a small two-man dragged seine (*sagyap*, 1 x 2 m, mesh 0.3 - 1.3 mm) was operated in the shore waters (open sea side) of Erukulampiddi, Pesalai, South Bar, Kuchchaveli and near the lagoon mouth of Nilaveli (Fig.1). The net was too small to be really effective, but many fish and crustacean fry were caught, including one milkfish fry, 15.2 mm in total length.

At present, only personnel from the Ministry of Fisheries go out and collect milkfish, often as a team of less than ten. Collections could not be done every day but scheduled usually once a week due to lack of manpower. The same people who collect also transport the seed, through distances of 300 - 400 km from Kalpitiya and Mannar to holding ponds in Pitipana. Thus, even during the season, collection is far from being intensive (which on the other hand is a good thing, in terms of conservation and management).

Milkfish seed are transported in polythene plastic bags with 4-6 l of water and 8 - 12 l of oxygen at densities of 200 - 2000/bag, depending on size; transport takes 5 - 10 hr over relatively rough roads (Ramanathan and Jayamaha, 1972; Villaluz *et al.*, 1982a). Mortality during transport and subsequent stocking varied 0 - 10% for 15 - 80 mm milkfish transported at 36 - 38 ppt and stocked in 26 - 27 ppt ponds (Ramanathan and Jayamaha, 1972), but ranged 2 - 100% under similar conditions in another study (Vilalluz *et al.*, 1982a).

Taken all together, there have been very few studies on milkfish in Sri Lanka, and more studies are needed.

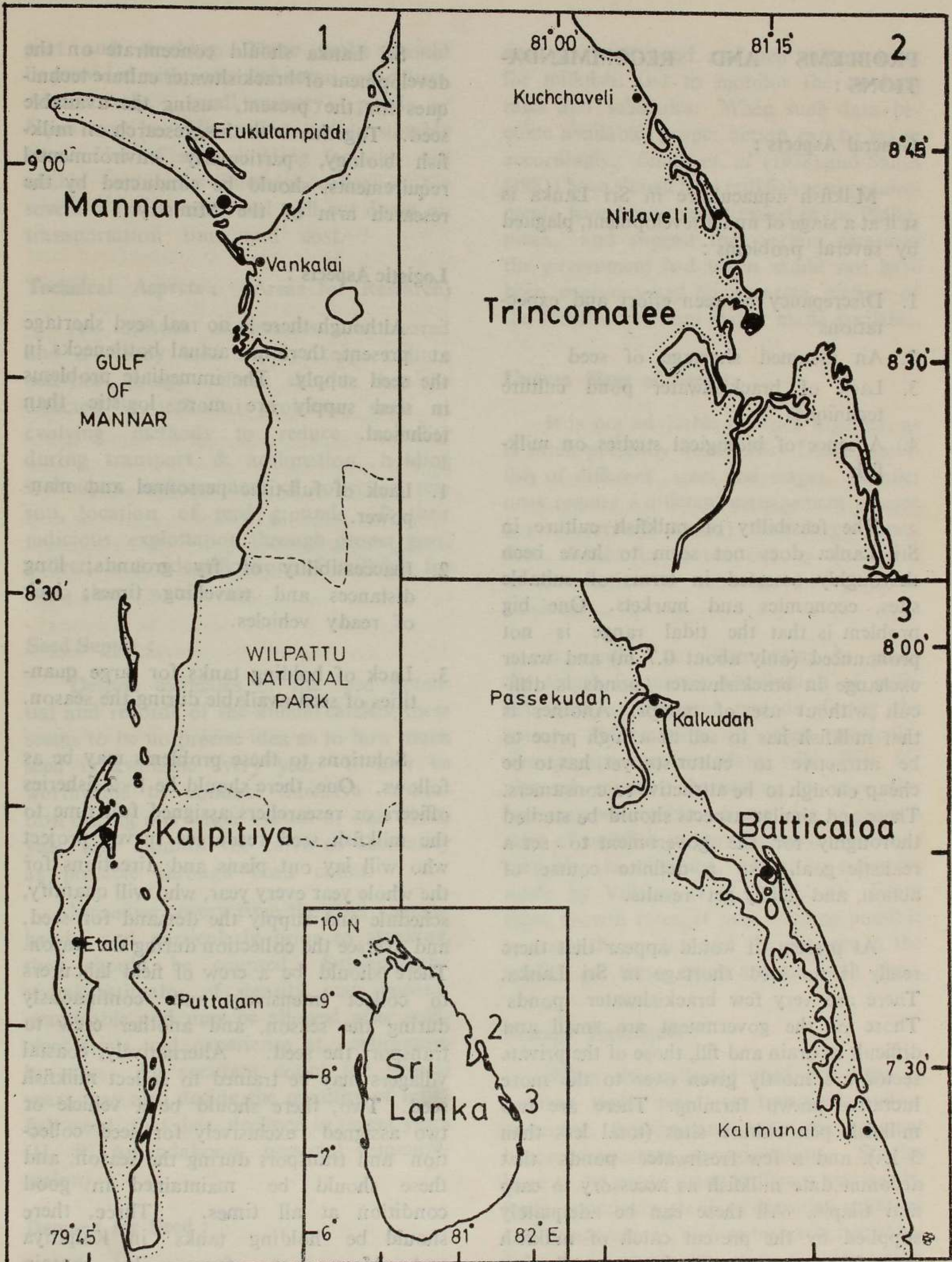

Fig. 7. Sri Lanka, showing the present milkfish seed collection grounds in Kalpitiya, Mannar, Vankalai and Erukulampiddi, the probable spawning ground, Gulf of Mannar, Kuchchaveli and Nilaveli north of Trincomalee where milkfish fry have been collected, and Batticaloa where most private fish farms are located.

PROBLEMS AND RECOMMENDATIONS :

General Aspects :

Milkfish aquaculture in Sri Lanka is still at a stage of underdevelopment, plagued by several problems :

1. Discrepancy between effort and expectations
2. An assumed shortage of seed
3. Lack of brackishwater pond culture techniques
4. Absence of biological studies on milkfish

The feasibility of milkfish culture in Sri Lanka does not seem to have been thoroughly assessed in terms of suitable sites, economics and markets. One big problem is that the tidal range is not pronounced (only about 0.7 m) and water exchange in brackishwater ponds is difficult without use of pumps. Another is that milkfish has to sell at a high price to be attractive to culturists, yet has to be cheap enough to be attractive to consumers. These and similar aspects should be studied thoroughly for the government to set a realistic goal, take a definite course of action, and finally get results.

At present, it would appear that there really is no seed shortage in Sri Lanka. There are very few brackishwater ponds Those of the government are small and difficult to drain and fill, those of the private sector are mostly given over to the more lucrative prawn farming. There are two milkfish pen culture sites (total less than 3 ha). and a few freshwater ponds that accommodate milkfish as accessory to carp and tilapia. All these can be adequately supplied by the present catch of milkfish seed from the already known collection grounds.

Sri Lanka should concentrate on the development of brackishwater culture techniques for the present, using the available seed. Together with this, research on milkfish biology, particularly environmental requirements, should be conducted by the research arm of the Ministry.

Logistic Aspects :

Although there is no real seed shortage at present, there are actual bottlenecks in the seed supply. The immediate problems in seed supply are more logistic than technical.

1. Lack of full-time personnel and manpower.
2. Inaccessibility of fry grounds; long distances and travelling times; lack of ready vehicles.
3. Lack of holding tanks for large quantities of seed available during the season.

Solutions to these problems may be as follows. One, there should be 1 - 2 fisheries officers or researchers assigned full time to the milkfish seed resources survey project who will lay out plans and directions for the whole year every year, who will quantify, schedule and supply the demand for seed, and oversee the collection during the season. There should be a crew of field labcurers to collect intensively and continuously during the season, and another crew to transport the seed. Alternatively, coastal villagers may be trained to collect milkfish seed. Two, there should be a vehicle or two assigned exclusively for seed collection and transport during the season, and these should be maintained in good condition at all times. Three, there should be holding tanks in Kalpitiya and Mannar to temporarily contain the seed after collection prior to transport and stocking. These tanks should be provided with water and aeration facilities. Alternatively, small nursery ponds or *hapas* may be built or installed in suitable sites. Use of such holding facilities will enable continuous intensive collection for several days at least, and will cut down on transportation time and cost.

Technical Aspects : (Areas for Research)

As logistics bottlenecks are cleared and a steady seed supply keeps culture activites going, efforts should then be directed at technical problems, such as evolving methods to reduce mortality during transport & acclimation, holding techniques, enhancement of collection season, location of seed grounds & their judicious exploitation through proper gear, collection & identification of milkfish fry from shore waters etc.

Seed Supply :

Despite estimates of the seed potential and records of the annual catches, there seems to be no precise idea as to how much seed is available every year. It may be worthwhile to conduct intensive collection during one whole season or one whole year, and monitor the catch as accurately as possible through head count.

Moreover, every time the seed changes hands, and particularly prior to stocking, they should be counted. Subsequently, visual estimates of density may become practicable and may be allowed after sufficient trials and experience at calibration by sizes. An accurate count for several years may also decide the quantity of milkfish seed that has declined in recent years (H. P. Amandakoon, personal communication).

Demand for Seed :

To determine the exact requirement for milkfish seed, there is need to survey and verify all pond and pen culture areas for milkfish, and to monitor the stocking rates and schedules. When such data become available, proper action can be taken accordingly. Smith *et. al* (1978) and Smith (1981) have shown how milkfish seed requirements have been overestimated in the Philippines, and suggest that certain measures the government had taken would not have been necessary had an accurate picture of the demand had been earlier made available.

Uneven Sizes of Seed :

It is not advisable to stock together, as is often presently done in Sri Lanka, milkfish of different sizes and stages. Smaller ones require a different management scheme (*e.g.* nursery period) than larger ones. Seed should be sorted out by size prior to distribution to culturists and prior to stocking.

It would be illuminating to study the length frequency distribution of milkfish seed at different periods during the season. Information on when particular size groups are abundant will allow for planned selective harvesting in case this becomes practicable. Some idea of growth rates of milkfish in these collection grounds may also be obtained, similar to estimates made by Villaluz *et al.* (1982 a). From these growth rates, it may become possible to assess the quality and the changes in the quality of these environments with time.

Storage Techniques :

When the collected seed are kept in holding tanks prior to transport and/or screening, feeding and water management become important considerations. Studies have to be made using different size seeds, feeds, containers, stocking densities, salinities and temperatures, and water exchange schedules, to determine the optimum combination for highest survival. Until these studies could be conducted, early storage trials may use the following technique (Villaluz *et al.*, 1982b; Villaluz, 1984). Pre-fingerlings may be kept in large flat basins up to 200 per 10 l of water, in a cool shady place, at relatively low salinity (about 20 ppt), fed with powdered egg yolk, rice bran or wheat flour, with the medium changed and sediment removed every day. Fingerlings have to be kept in larger tanks, or at lower density preferably with aeration, and would require more substantial food for longer than a few days storage.

Mortality ;

Mortality during transport, storage, acclimation and stocking could be kept at low levels by a simple rule : spare the fish from stress. They should be kept in favorable or at least not drastically changing conditions. Milkfish fingerlings can tolerate a wide range of salinity, probably 0 - 70 ppt as for three-week old fry (Duenas and Young, 1983); however, changes should not be so sudden. Milkfish fry do best at temperatures of 26-30° C, but tolerate temperatures down to 21° C (Villaluz and Unggui, 1983). Such lower temperature may be advantageous during transport; activity, metabolism and oxygen consumption would be reduced, thus allowing for higher packing density or longer transport times. On the other hand, there should be an acclimation period every time the seed is transferred from one set of conditions to another.

It is important to study the environmental requirements and tolerances of these wild fingerlings in Sri Lanka because there may be significant differences from those of fry and pond-grown juveniles as studied in the Philippines (Juliano and Rabanal, 1963; Quinitio and Juario, 1980; Baylon, 1983; Villaluz and Unggui, 1983).

Collection Season :

The milkfish seed collection season in Sri Lanka (mainly April - June) is much shorter than in the Philippines (mainly March - October, but almost the whole year in some places in the south; Kumagai, 1984). This short season is partly due to fingerlings being older and appearing later than the fry, and partly due to hydrographic patterns limiting the occurrence of fingerlings in the collection grounds only to periods of inundation. However, the younger fry should be available in shore waters earlier than April and for a longer period. Indeed, Kumagai's (1981) hypothesis on the spawning seasonality of milkfish predicts that in Sri Lanka (latitude 6 - 10 N), spawning would start around January - February and last till November - December. Assuming that this hypothesis is correct, the three-week old fry should first appear in shore waters in February - March and should be present till December - January unless currents and other factors affect them to the contrary. It is interesting to note that if some 600 million fingerlings are available in inland waters, even greater number of fry should be available in shore waters, if only collection from the latter is feasible.

Shore Waters and Other New Collection Grounds :

A survey of the open shore waters of Sri Lanka in September 1984 showed that it is quite difficult (though not impossible) to collect milkfish seed from these environments. Sri Lanka has relatively open exposed coasts and deep surrounding waters. The continental shelf extends only about 12 mi and is mostly 200 m deep except on the side facing India where it is only 30-50m deep. Beyond the shelf, the Indian Ocean plunges 3,000 m deep in 2 mi. The western coast from Mannar to Hikkaduwa and the eastern coast from Kuchchaveli to Panama are generally too surfy for milkfish fry collection (Fig. 2) A few beaches are protected by an offshore reef and are calm enough for gear operation, but these are isolated and are located in tourist strips (*e.g.* Passekudah). The ideal beach for fry collection is one (near a spawning ground) with a gradual bottom slope with little or no surf. A high-energy beach, one with heavy surf, steep slope and shifting bottom would render collection gear inoperable and collectors unwilling. In the Philippines, shore waters are generally calm during the milkfish season (Fig. 3); however, during storms, fry collectors operate specially set-up passive gear to use the strong surf to their advantage, and often catch large quantities of fry. The same can probably be done in Sri Lanka with some study and practice. The expertise of a fishing gear technologist-cum-milkfish ecologist/behaviorist, is required for this purpose.

Milkfish spawns near island, offshore reef banks and promontories with shallow, clear, saline waters where currents favour retention and return of spawn to shore waters (Johannes, 1978; Senta *et al.*, 1980 ; Kumagai, 1981). The Gulf of Mannar (Fig. 1) with the Kalpitiya peninsula and adjacent islands in the south, and Mannar and other islands in the north, is probably one general spawning ground of milkfish in Sri Lanka. This would explain the abundance of milkfish seed in the area, particularly in Kalpitiya, Vankalai and Erukulampiddi. The beach fronting the Wilapattu National Park, ordinarily closed off to the public, is probably a good fry collection ground, if the surf allows gear operation at all.

Other possible places for seed collection would be : the lagoons around Batticaloa where most private ponds are now located; the lagoons and beaches north of Trincomalee where some fry have been obtained (Fig 1); the Negombo lagoon where juvenile milkfish are fished quite frequently by subsistence fisherman, and the relatively sheltered beach waters near its mouth; and the southern coast near the Bass Islands.

In the future, there should be some effort to locate specific spawning grounds of milkfish, and to study the currents and other factors that influence the distribution and the transport of spawn and larvae. Such a study had been conducted by the SEAFDEC Aquaculture Department off Panay Island's western coast (Antique Province), one of the most productive milkfish fry collection grounds in the Philippines, and had contributed a great deal to the under-standing of milkfish reproductive biology and its relation to the fry fishery (Kumagai and Bagarinao, 1979; Senta *et al.*, 1980; Kumagai, 1981, 1984).

Development of Collection Methods and Gear :

For milkfish fingerlings in Sri Lanka's marsh flats and tidal pools, the dragnet (*kaddipuwa*) is probably the best collection gear. When the collection effort is shifted to shore waters, completely different gear would be required. The collection methods and gear used for milkfish fry in the Philippines may be modified and adopted where suitable in Sri Lanka. This requires first a study of the topography and current patterns in the collection grounds, and training in actual gear operation in the Philippines. In general, passive gear like barricades and fixed filter nets may be used where currents and surf are strong as in river and lagoon mouths and channels; active gear like seines and skimming nets work best in calmer waters with flat or stumpfree bottom (Kumagai *et al.*, 1980; Villaluz *et al.*, 1982 b).

Identification of Milkfish Fry :

Aside from the difficulty of gear operation in open shore waters to collect the fry,

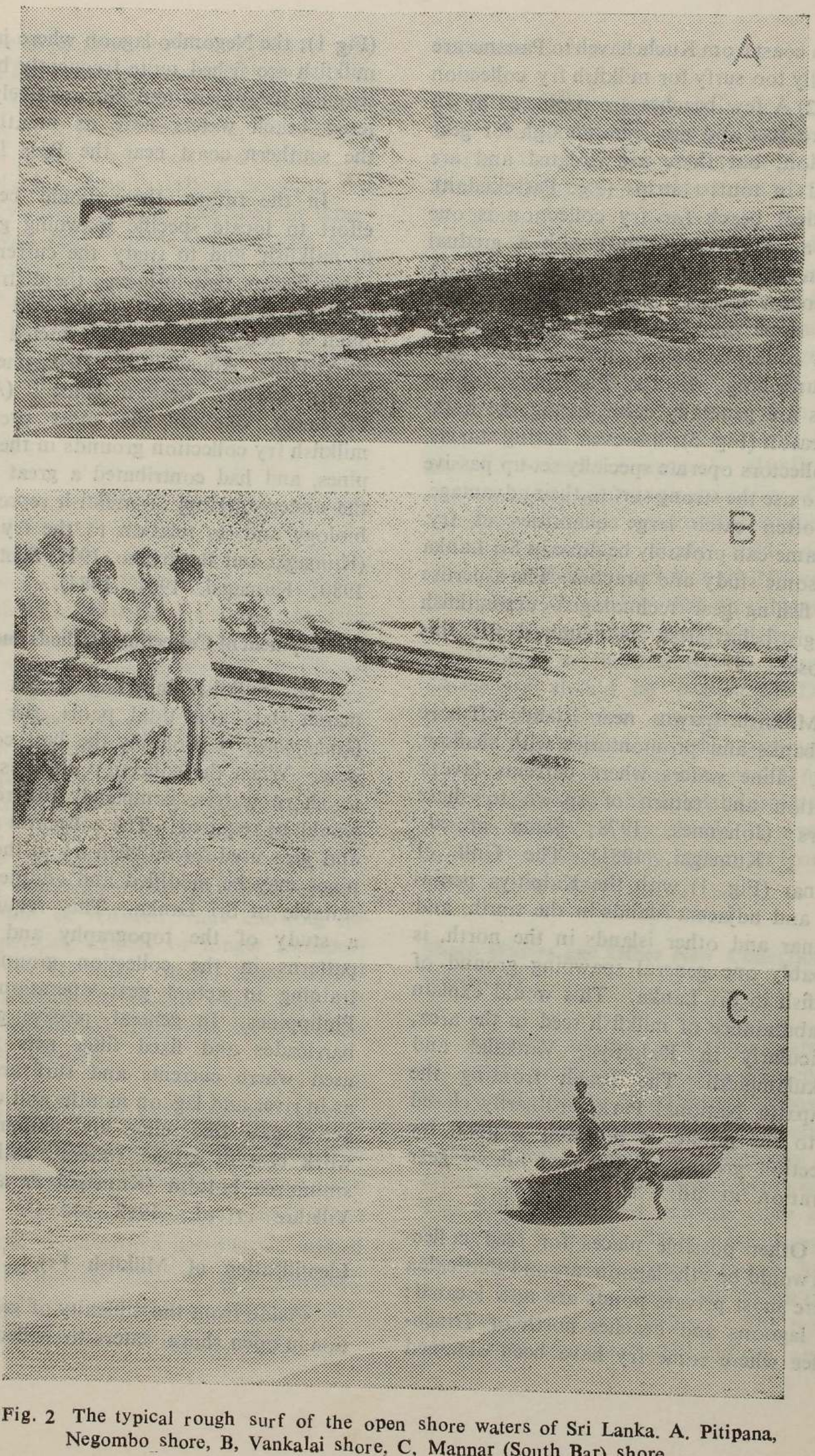

Fig. 2 The typical rough surf of the open shore waters of Sri Lanka. A. Pitipana, Negombo shore, B, Vankalai shore, C, Mannar (South Bar) shore.

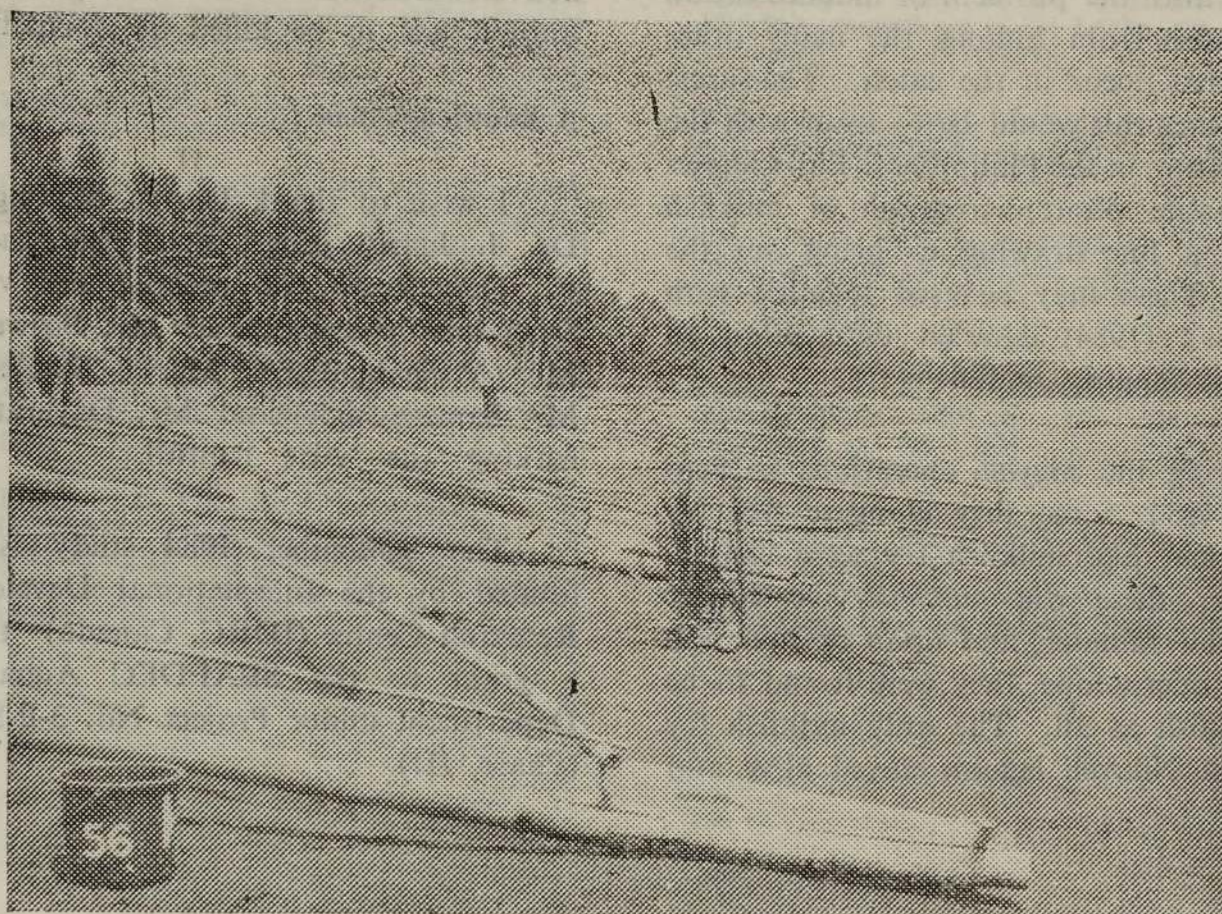

Fig. 3 A typical fry collection ground in the Philippines in may, the peak collection period. Note the number of gear lined up on the beach, (Hamtik, Antique,)

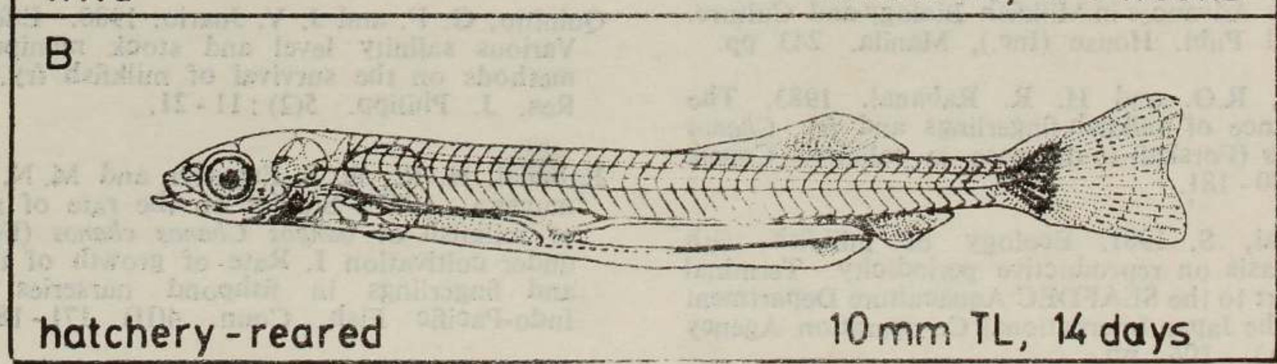

Fig. 4 A Photomicrograph of shore-caught milkfish fry and B, line drawing of twoweek old hatchery-reard equivalent. Note single line of pigments on the ventral edge and the non-striat edintestine.

there is also the problem of indentification of milkfish from among the many other species that occur in the catch. The surest way to learn this would be to train with the fry collectors in the Philippines. Fig. 4 shows a composite photomicrograph of milkfish fry and a line drawing to bring out the details. These may be used together with Kumagai's (1984) detailed description to definitely identify milkfish fry.

During the *sagyap* operations in September 1984, some fifty elongate fish fry that looked like milkfish fry were caught. However, these did not survive longer than a few minutes, and upon examination under a microscope, they were found to be not milkfish at all. The only milkfish fry caught at Nilaveli lagoon stayed alive and active in a small bucket for more than 2 hr until it had to be killed in formalin.

Acknowledgement :

I wish to thank Dr. A. Santiago, Jr., Dr. J. Juario, Engr. P. Torres and Dir. K. Thayaparan for making my visit to Sri Lanka possible; and Mr. Siriwardena, Mr. Poopalapillai, Mr. Sambasivam, Mr. Samarasinghe and Mr. Dayaratna for making the visit fruitful.

The September 1984 study-visit was funded by the International Development Research Centre (IDRC, Canada) through a grant to the SEAFDEC Aquaculture Department under Project No. 3-P-81-0171 (Phase III).

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J. Inland Fish., Vol. 3, December, 1986, pp. 108—114

OBSERVATIONS ON REARING CARP FRY IN CEMENT CISTERNS AND PLASTIC POOLS

S. Ariyarathana[1]

Introduction :

The demand for fish fingerlings of carp varieties, needed for stocking vast areas of perennial reservoirs, seasonal tanks and private fish ponds in Sri Lanka is very high. At present all the fingerlings of carp varieties are being produced only in government fisheries stations and the fry and fingerlings are reared in earthen ponds.

Attempts were made to rear carp post larvae in cement cisterns and plastic pools. The methodology adapted in rearing carp fry in cement cisterns and plastic pools along with results of some trials conducted to determine suitable stocking densities are presented in this communication.

Material and Methods :

Cement cisterns ($21m^2$) and plastic pools ($24m^2$) were used in these studies conducted at the Fresh Water Fisheries Station, Udawalawe. In all the experiments, Post larvae (6 - 7 mm in length) of carp species were reared up to fry stage (25 - 35 mm in length.)

For the trials, cement tanks (cisterns) as also the plastic pools were prepared in similar manner. Tanks/ Pools were cleaned and sundried for a day. Thereafter these were filled with water from the nearby right bank irrigation channel of the Udawalawe Reservoir, up to a depth of 1½ ft. The water used passed through a screen to prevent entering of unwanted fish species. Fertilization of the tank/pool was effected by sprinkling water in which fresh cowdung had been dissolved (10 kg. cowdung). Five days after such fertilization, Dipterex was sprayed (0.5 ppm). Three days after application of Dipterex, 250 ml of Kerosene was spread. The following day post larvae of carps were stocked. The water level however, had been increased to 3 ft. by the time of stocking. The fertilizer (cowdung) application was repeated once in 7 days from the first application (10 kg. of cowdung dissolved in water). When necessary water was added to compensate for evaporation losses.

Feed used in the course of rearing were of three kinds.

i. Soyabean milk

ii. Soyabean powder and Rice bran (1:1 ratio)

iii. Rice bran

After stocking, for a week the post-larvae were provided with soyabean milk each day. This was prepared by adding boiling water to soya powder, making it into a paste, which was mixed with tap water giving it milk like appearance. Soyabean powder used at 2 kg/100,000 post larvae, made up the feed. From 8th and 9th day onwards fry were fed with a mixture of soyabean and rice bran (1:1 ratio by weight) at the rate of 2.0 kg/100,000 post larvae per day. This feed was provided in two instalments. Only rice bran was given after tne 10th day. The powder was mixed with a binder (200g of tapioca (*manihot esculenta*) boiled in 300 ml. of water and made into a sticky gum) and made into a dough. One or two balls of the dough were put in a tray and lowered into the water.

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During these trials dissolved oxygen of Water (by Winkler method), air and water temperature, transparency of water (using a Secchidisc), pH (using a pH meter) were determined daily. In addition, volumetric measurements of phytoplankton and zooplankton present in 100 l of water were determined.

Trial I :

9 cement cisterns were used in rearing Bighead carp (*Aristichthys nobilis*) post larvae. Numbers stocked varied, being 10,000, 12,000 and 14,000 per cement cistern. One culture cycle was of 21 days.

Trial II :

Six cement cisterns were used for rearing Grass carp (*Ctenopharyngodon idella*) post larvae. In this instance, only two stocking densities were used, 10,000 and 12,000 post larvae per tank.

Trial III :

Rearing of post larvae of Silver carp (*Hypothalmichthys molitrix*) were carried out in plastic pools. The culture cycle was of 21 days. Stocking densities of 200, 400, 600, 800 and 1000 post larvae/m^2 were tried. Aeration was provided in the plastic pools continuously, during the culture period.

Results :

Table I, indicates survival and growth of the Bighead carp in trial I. Physico-chemical and plankton conditions in these tanks are given in table IV. No Major differences were observed in the growth of fry of bighead carp reared under different stocking densities. But the average survival of fry was very low with the highest stocking density adapted, compared to that obtained for fry reared under the other two stocking densities.

Table II shows the results of rearing Grass carp post larvae in cement cisterns. Physico-chemical and plankton conditions in these tanks are indicated in Table V. Not much difference can be seen in growth obtained of fry reared under the two different stocking densities. Survival of fry reared employing the lower stocking density is however higher.

Table III shows results of rearing of post larvae of Silver carp in plastic pools. Physico-chemical and plankton conditions obtained in these pools are given in Table VI. Average length attained after 21 days of rearing varied from 2.3 cm to 2.56 cm. Survival of fry of Silver carp was very high except for in plastic pool No. 1.

Discussion :

Growth and survival of carp post larvae reared in cement cisterns is found to be comparable with those of Bighead carp, Grass carp and Silver carp obtained by rearing the species in earthern ponds at the Udawalawe Fisheries Station, Sri Lanka (Muthukumarana, unpublished). Although the growth of Silver carp, reared in plastic pools was little less to that recorded in earthern ponds survival was found to be excellent.

In Hungary, Bighead carp, Silver carp and Grass carp post larvae reared at the rate of 300 - 500/m^2 registered survival rates ranging from 70% to 90% after 21 days of nursing (Horvath and Tamas, 1984).

Elimination of water insects such as backswimmers (*Notonectids*) and water centipede (*Cybister* sp) is very important in obtaining higher survivals of fry. Kerosene oil kills the back-swimmers and water centipede, which are enemies of fish fry. Before the spray of kerosene oil, cistern/pool walls may be swept to get the cybister larvae into the water.

Nursing will be successful and survival rates high when at times of stocking the groups of zooplankton present in the pond are of appropriate size for use of the larvae. Size of first feed of Grass carp, Bighead carp and Silver carp is reportedly 50-300 μm, in size. Macro-zooplanktons such as Copepods and Cladocerans, which develop in fertilized ponds, cannot be consumed by larvae during the first few days of rearing. In addition these macrozooplankton compete for natural food with the delicate carp post larvae, and by this further restrain the propogation of microzooplankton. Cyclops species are predators and may directly endanger the delicate fry of a few days (Horvath and Tamas, 1984.) Application of 0.2 to 3 ppm Organophosphate substances such as Sumithion or Dipterex kills copepods and cladocerans, while rotifers, which are the desired food for first feeding larvae, are not affected (Jhingran and Pullin, 1984). These rotifers reproduce rapidly under favourable conditions. Zooplankton observed after application of Dipterex in these studies consisted mostly of *Keratella* and *Brachionus* spp. In China, fish farmers have an age old practice of introducing 300 - 400 of bighead carp of 12 cm size into ponds few days prior to stocking of post larvae, in order to control the macro-zooplankton population in the ponds (Anon, 1975).

The organophosphate substances introduced into the pond decompose at 20°C in 5 - 6 days (Horvath and Tamas, 1984) and under temperatures that prevailed during the study (28°C - 32°C) decomposition must have been much faster. After few days of rearing, as the fry grow they will be able to feed on macrozooplankton. By this time decomposition process of the Dipterex would have been completed and copepods and cladocerans started to reproduce natu rally. To accelerate this process, Horvath and Tamas (1984) recommends innoculation of the pond with collected or propogated macrozooplanktons (*e.g. Moina* and later with *Daphnia*) and according to them innoculation must take place after decomposition of the chemical and before fry start to feed so that the possibility for their mass reproduction is not impeded.

In rearing Bighead carp in cement cisterns, stocking of 10,000 post larvae/tank appeared to be the best of the three stocking densities adapted. Similarly, in rearing grass carp post larvae in cement cisterns stocking of 10,000 post larvae/tank was found to be better than the others. It is necessary to undertake more studies employing more stocking densities. Similarly, more experimental work need to be carried out for determining suitable stocking densities for rearing carp fry in plastic pools.

The trials conducted revealed that with proper management and due care post larvae of carps can be raised in cement tanks and plastic pools. This is particularly useful for places, where pond construction is not feasible or practicable. The greatest advantage perhaps is that it can be undertaken in yards, indoor or out doors with water being available. Installation of plastic pools at sites near reservoirs, would help to raise fry of carps required for the stocking the particular reservoir and the work can be easily managed by the fishermen themselves. Post larvae can be reared up to fry stage in these plastic pools and further rearing to fingerling stages before releasing to the reservoir, can be carried out in net cages in the reservoir.

It is necessary to carry out more studies on this line in order to maximise carp seed production from these systems. Special emphasis should be laid on studies on the possibility of innoculating different kinds of zooplankton at different times, as suggested by Horvath and Tamas (1984).

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TABLE I

RESULTS OF REARING POST LARVAE OF BIGHEAD CARP IN CEMENT CISTERNS.

Tank No.	Stocking density	No. of PL stocked	Av. length of the fry at harvest (cm)	Survival %
8	476.1/m²	10,000 in each	3.19	34.5
9			3.12	91.6
10			3.39	62.0
Av.			3.23	62.7
16			3.11	42.2
17	571.4/m²	12,000 in each	3.09	53.4
18			2.98	81.8
Av			3.06	59.1
19			3.14	30.1
28	666.6/m²	14,000 in each	3.01	37.7
35			3.04	19.9
Av.			3.06	29.2

TABLE II

RESULTS OF REARING POST LARVAE OF GRASS CARP IN CEMENT CISTERNS.

Tank No.	Stocking density	No. of PL stocked	Av. length of the fry at harvest (cm)	Survival %
52			2.90	48.37
53	476.1/m²	10,000 in each	3.11	91.45
54			3.02	69.39
Av.			3.01	69.7
30			2.91	48.4
50	571.4/m²	12,000 in each	3.01	60.9
51			2.86	48.6
Av.			2.92	52.6

TABLE III

RESULTS OF REARING POST LARVAE OF SILVER CARP IN PLASTIC POOLS.

Pool No.	Stocking density No. of PL/m²	Av. length of the fry at harvest (cm)	Survival %
1	200	2.56	61.7
2	400	2.48	97.6
3	600	2.30	82.2
4	800	2.4	98.2
5	1000	2.56	96.5

TABLE IV

PHYSICO-CHEMICAL AND PLANKTON CONDITIONS IN CEMENT CISTERNS IN THE COURSE OF REARING POST-LARVAE OF BIGHEAD CARP (AVERAGE VALUES)

Tank No.	D.O. (mg/l)	PH	Temperature (°C) Air	Temperature (°C) H_2o	Turbidity (cm)	Zoo plankton (ml/100 l)	Phyto plankton (ml/100 l)
08	8.54	7.0	29.0	30 9	35.6	0.320	0.491
09	8.68	7.1	29.0	31.2	34.2	0 425	0.630
10	11.17	7.0	29.0	31.3	38.3	0.241	0.361
16	9.54	6.9	29.0	31.1	35.1	0.357	0.526
17	10.75	7.0	29.0	30.9	36.1	0.285	0.513
18	5.91	7.1	29.0	30.9	34.8	0.190	0.540
19	7.35	7.0	29.0	30.6	33.9	0.190	0.660
28	5.31	7.0	29.0	30.4	37.8	0.260	0.378
35	5.10	7.2	29.0	30.0	33.2	0.210	0.770

TABLE V

PHYSICO-CHEMICAL AND PLANKTON CONDITIONS IN CEMENT CISTERNS IN THE COURSE OF REARING POST-LARVAE OF GRASS CARP (AVERAGE VALUES)

Tank No.	D.O. (mg/l)	PH	Temperature (°C) Air	Temperature (°C) H_2o	Turbidity (cm)	Zooplankton (ml/100 l)	Phyto plankton (ml/100 l)
52	7.12	7.0	29.3	29.2	30.0	0.217	0.421
53	4.52	6.9	29.3	29.3	31.0	0.226	0.376
54	2.92	7.0	29.3	28.8	27.4	0.258	0.461
30	5.28	7.1	29.3	30.1	32.1	0.220	0.379
50	5.42	7.0	29.3	28.6	28.1	0.241	0.452
51	6.88	7.0	29.3	29 0	30.0	0.201	0.397

TABLE VI

PHYSICO-CHEMICAL AND PLANKTON CONDITIONS IN PLASTIC POOLS IN THE COURSE OF REARING POST-LARVAE OF SILVER CARP. (AVERAGE VALUES)

Pool No.	D. O. (mg/l)	PH	Temperature (°C) Air	Temperature (°C) H_2o	Turbidity (cm)	Zoo plankton (ml/100l)	Phyto plankton (ml/100 l)
1	7.66	7.1	29.1	31.3	31.0	0.262	0.586
2	6.96	7.1	29.1	30.7	18.6	0.195	0.877
3	8.98	7.1	29.1	30.5	17.4	0.253	0.881
4	5.91	7.1	29.1	30.8	27.2	0.130	0.358
5	5.85	7.1	29.1	30.9	34.2	0.137	0.402

J. Inland Fish., Vol. 3, December, 1986, pp. 115—125

FOOD RESOURCE PARTITIONING AMONG THE FISHES CO-EXISTING IN BRUSH PARKS, AN ARTIFICIAL HABITAT IN A LAGOON IN SRI LANKA

E. A. D. N. D. Edirisinghe[1] and M. J. S. Wijeyaratne[2]

Introduction :

Fish communities in tropical regions are found to be highly complex with many species co-existing in the same environment. This high diversity is considered to be maintained by localized environmental disturbances (Connell, 1978) and preference for different microhabitats and food items (Lowe-McConnel, 1975; Costa and Fernando, 1967).

Although a number of studies on the ecological segregation among the members of fish communities in tropical freshwater environments have been carried out (Lowe-McConnel, 1975; Saul, 1975; De Silva *et al.*, 1977; Connell, 1978; Moyle and Senanayake, 1984) resource partitioning among fish species in brackishwater habitats have received very little attention. In the present study, similarities in the diets of twelve fish species co-occurring in brush parks in the Negombo lagoon were examined with the objective of evaluating the degree of food resource partitioning existing among them. These are specialized man made habitats consisting of circular piles of mangrove wood placed in shallow areas of the lagoon less than 1.5m in depth. These provide shelter for fish and also act as substrates for epifauna and epiflora. Fish aggregated in brush parks are generally harvested one month after implantation (Senanayake, 1981). During the harvesting procedure, the brush park is encircled by a net supported by 12 - 14 mangrove poles. The mesh size of the net is 1.875 cm. The brush wood is then cast out over the net. When all brush wood is removed, the bottom line of the net is slowly drawn in and the trapped fish in this bag of netting are scooped up with a hand net. The gear is considered as the most non-selective type of gear operated in the lagoon. Recent studies have shown that brush parks account for about 29.41% of the total fish catch of the Negombo lagoon (Wijeyaratne, 1984).

Materials and Methods :

The present study was carried out on fish collected from the Negombo lagoon in west coast of Sri Lanka. The samples were obtained from the collections made from brush parks during March - August 1982. Although this gear is operated throughout the year, intensity of its use during this period was higher than in other months. The specimens collected for this study were fairly evenly distributed over the collection period. Sampling was done randomly so that individuals of all size groups were included in the samples in same proportions as they were present in the population. Since the objective of this study was only to determine the extent of food resource partitioning among the fishes co-existing in brush parks, the size of the samples of each species was not selected according to their relative abundance in the commercial catch. More than 75 individuals of each species were used in the

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study. The size range of the fish analysed is given in Table I. The fish, immediately preserved in ice were brought to the laboratory at the University of Kelaniya for further analysis. They were then dissected and the stomach contents were identified as far as possible using an optical microscope. The method described by Helawell and Abel (1971) was used in the quantitative analysis of stomach contents. The food niche overlap among the different species was calculated using the similarity index described by Schoener (1970).

Results and discussion :

Twelve species of fin fish collected from the brush parks were used in the present study. They were *Acanthopagrus latus, Ambassis commersoni, Callyodon ghobban, Epinepheles tauvina, Etroplus suratensis, Liza tade, Lutianus fulviflamma, Lutianus waigiensis, Monodactylus argenteus, Pelates quadrilineatus, Siganus javus* and *Siganus vermiculatus*. Of these, *E. suratensis, E. tauvina, L. tade, Lutianus* spp and *Siganus* spp are highly important as food fishes. The juveniles of *M. argenteus* are commercially valuable as aquarium fish.

The food items present in the stomach contents of the fish species analysed are listed in Table II. The relative importance of the food items is shown in Figs. 1 and 2. *A. latus, A. commersoni, E. tauvina* and *Lutianus* spp. were found to be strictly carnivorous. *C. ghobban, E. suratensis, M. argenteus, L. tade, P. quadrilineatus* and *S. javus* were observed to have an omnivorous feeding habit while the other species, *S. vermiculatus* was observed to be herbivorous.

As indicated by Moyle and Senanayake (1984), the similarity indices having values less than 33% were considered to indicate a low overlap while the values above 67% were considered to indicate a high overlap. The similarity indices of the diets among the different species studied are shown in Fig. 3. The maximum overlap in the diets was observed between *A. latus* and *A. commersoni*. Both these species were observed to feed on small shrimps and nauplii larvae. It was noted that the similarity indices of the diets between *A. latus* and other species are very similar to the values obtained between *A. commersoni* and other species. A very high overlap in the diets of *A. latus* and *A. commersoni* with those of *L. fulviflamma, L. waigiensis* and *P. quadrilineatus* was also noted. Like *A. latus* and *A. commersoni*, the two lutianids, namely *L. fulviflamma* and *L. waigiensis* were also carnivorous, feeding on crustaceans and small fish. Therefore, a high overlap between the diets of these two lutianids was also observed. Although *P. quadrilineatus* was found to be an omnivore (Table 1), major portion of its diet composed of crustaceans (Fig. 2) resulting in a fairly high dietary overlap with *A. latus, A. commersoni, L. fulviflamma* and *L. waigiensis* whose major food items were also crustaceans.

High dietary overlap was also noted for *C. ghobban* with *M. argenteus* and *S. javus*. These three species were found to be omnivores, feeding on algae, detritus and crustaceans. Diatoms formed the major food item of all three species (Figs. 1 and 2). The diets of the two siganids namely *S. javus* and *S. vermiculatus* also show a high similarity (Fig. 3.). The major food item of these two was diatoms with detritus accounting for a considerable portion (Fig. 2). Although *S. javus* could be considered as an omnivore, the amount of animal matter in the diet was very small as in *E. suratensis*.

The diet of the five carnivores namely *A. latus, A. commersoni, E. tauvina, L. fulviflamma* and *L. waigiensis* did not show any similarity with those of *L. tade* and *S. vermiculatus* (Fig. 3). The latter species was herbivorous while *L. tade* although omnivorous feeds mainly on polychaetes resulting in a zero overlap with the diets of the above five carnivorous species which feed on crustaceans and fish. The dietary overlap of *L. tade* with other omnivorous species too was very low because its major food item consisted of benthic polychaetes mainly *Serpula* spp.

The diet of *E. suratensis* show moderate overlap with those of *S. vermiculatus*, *S. javus*, *C. ghobban* and *M. argenteus* (Fig. 3). The latter three species although omnivorous mainly fed on plant matter and therefore showed a moderate dietary overlap with *E. surantensis*. *S. vermiculatus* mainly feeds on diatoms while the major food item of *E. suratensis* was found to be green algae and this resulted in a moderate overlap in the diets between these two species. The diet of *E. suratensis* show a very small overlap with that of *P. quadrilineatus* which although an omnivore mainly feeds on crustaceans.

The diet of *E. tauvina* shows little or no similarity to those of herbivorous and omnivorous fish species while with those of other four carnivorous species the overlap was moderate. The reason for this is that *E. tauvina* mainly feeds on small fish while the diet of other four carnivores consists mainly of crustaceans.

M. argenteus shows very little dietary overlap with the five carnivores. This omnivorous species mainly feeds on diatoms. The amount of sand particles in the stomach contents was fairly high in this species. Sand patricles were also observed in the grey mullet *L. tade* and the theraponid *P. quadrilineatus*. In grey mullets, sand particles are considered to be useful in the grinding of food particles in their thick walled pyloric stomachs which act like gizzards (Thomson, 1966). As in grey mullets, sand particles may be useful in the grinding of food items in the stomachs of *M. argenteus* and *P. quadrilineatus*.

Although the diet of *C. ghobban*, *E. suratensis*, *L. tade*, *M. argenteus*, *S. javus* and *S. vermiculatus* consisted of almost same food items (Table II), relative importance of these varied considerably (Figs. 1 and 2) resulting in a low or moderate dietary overlap among most of them.

About 19% of the values shown in Fig. 3 are in the high overlap range (above 67) while 21% and 60% are respectively in the moderate (33 -67) and low (less than 33) overlap ranges. This indicates that in this special habitat in Negombo lagoon, although fish live together in mixed schools, most of them show a low or moderate dietary overlap. Therefore, a certain amount of ecological segregation is evident among most of the co-occurring species in this special habitat. Ecological segregation has already been well demonstrated for fish communities in freshwater streams in tropical regions (Moyle and Senanayake, 1984) This is considered to be very useful in such environments because it helps to minimize interspecific competition. The brackish-water environments such as lagoons and estuaries are considered to be highly productive ecosystems in the biosphere (Odum, 1971) and it is very unlikely that food become limiting in such habitats. Therefore, even among the few species with high dietary overlap, interspecific competition for food may possibly not occur in these environments. However, it is necessary to carry out detailed studies on the productivity of Negombo lagoon for definite conclusions. In addition, since it is well known that food habits of at least some species of fish vary with the life history stage, further studies on the diets of different size groups, carried out preferably over a period of one year, would be useful.

The present study shows that ecological segregation and resource partitioning can occur at least to some extent among the co-existing fish species in brush parks. Therefore these artificial habitats created in Negombo lagoon as a system of specialized fishing can act as favourable habitats for different species of important food fishes and thus appear to play an important role in brackishwater fisheries. The results of the present investigation may be utilized to select suitable species combinations for brackishwater polyculture programme. which will be very useful to further the increase of inland fish production in Sri Lanka.

Summary :

The diets of twelve fish species collected from the brush parks in Negombo lagoon were examined to evaluate degree of food resource partitioning among them. Five species namely *Acanthopagrus latus*, *Ambassis commersoni*, *Epinepheles tauvina*, *Lutianus fulviflamma* and *L. waigiensis* were found to be strictly carnivorous while *Siganus vermiculatus* was observed to be herbivorous. The other six species namely *Callyodon ghobban*, *Etroplus suratensis*, *Monodactylus argenteus*, *Liza tade*, *Pelates quadrilineatus* and *Siganus javus* were observed to have an omnivorous feeding habit. It was evident that food resource partitioning and ecological segregation occur at least to some extent among these co-existing fish species in this brackishwater environment.

Acknowledgements :

We are thankful to Prof. H. H. Costa of the Department of Zoology, University of Kelaniya for his valuable comments on the manuscript and for providing facilities to carry out this study. Thanks are also due to the anonymous referee for useful criticisms and suggestions, to Mrs. S. de Silva for typing the manuscript and to Mr. W. D. Francis for assisting in the collection of samples.

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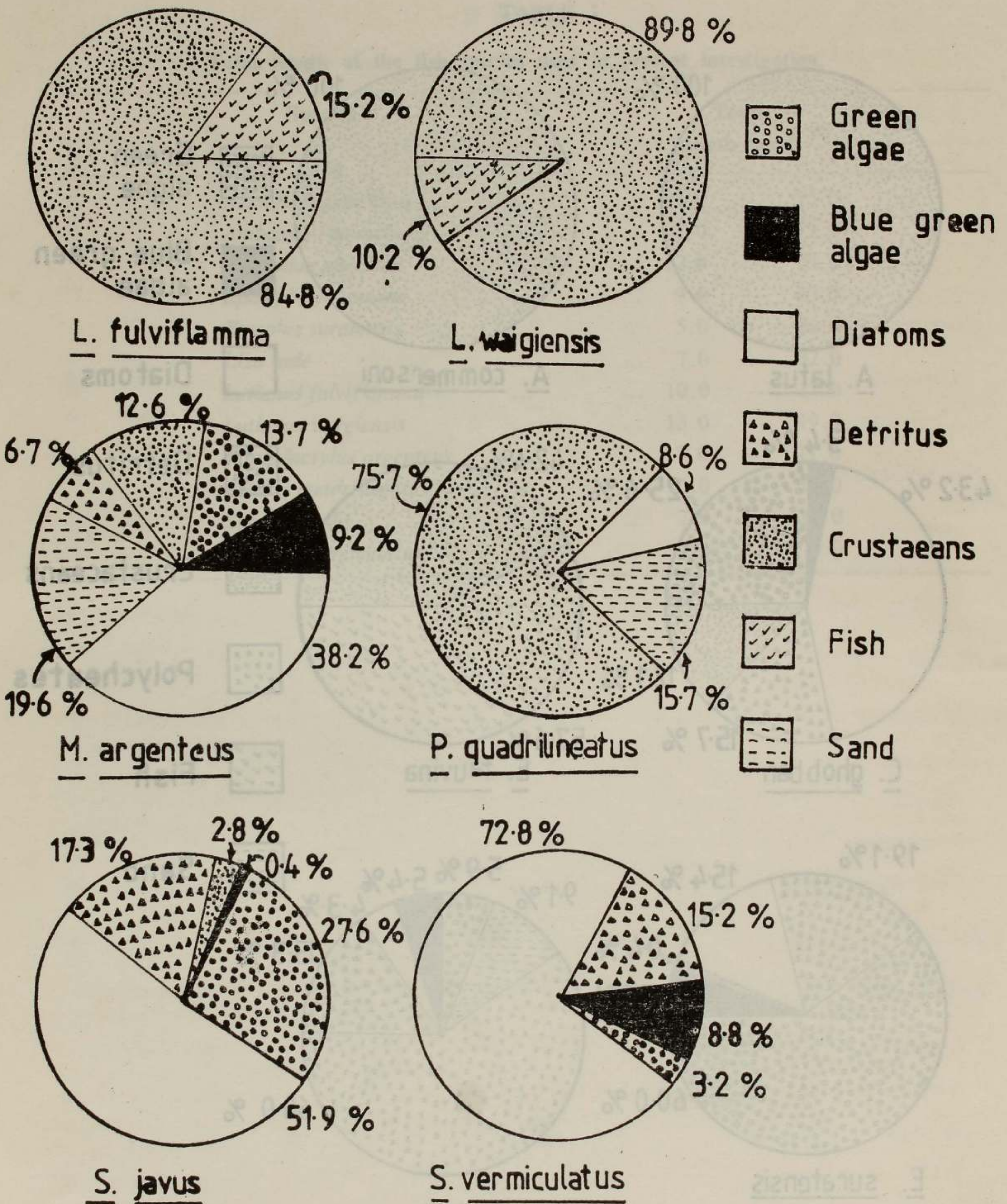

Fig: 1. Relative importance of the food items in the stomach contents of **Lutianus fulviflamma, Lutianus waigiensis, Monodactylus argenteus, Pelates quadrilineatus, Siganus javus and Siganus vermiculatus.**

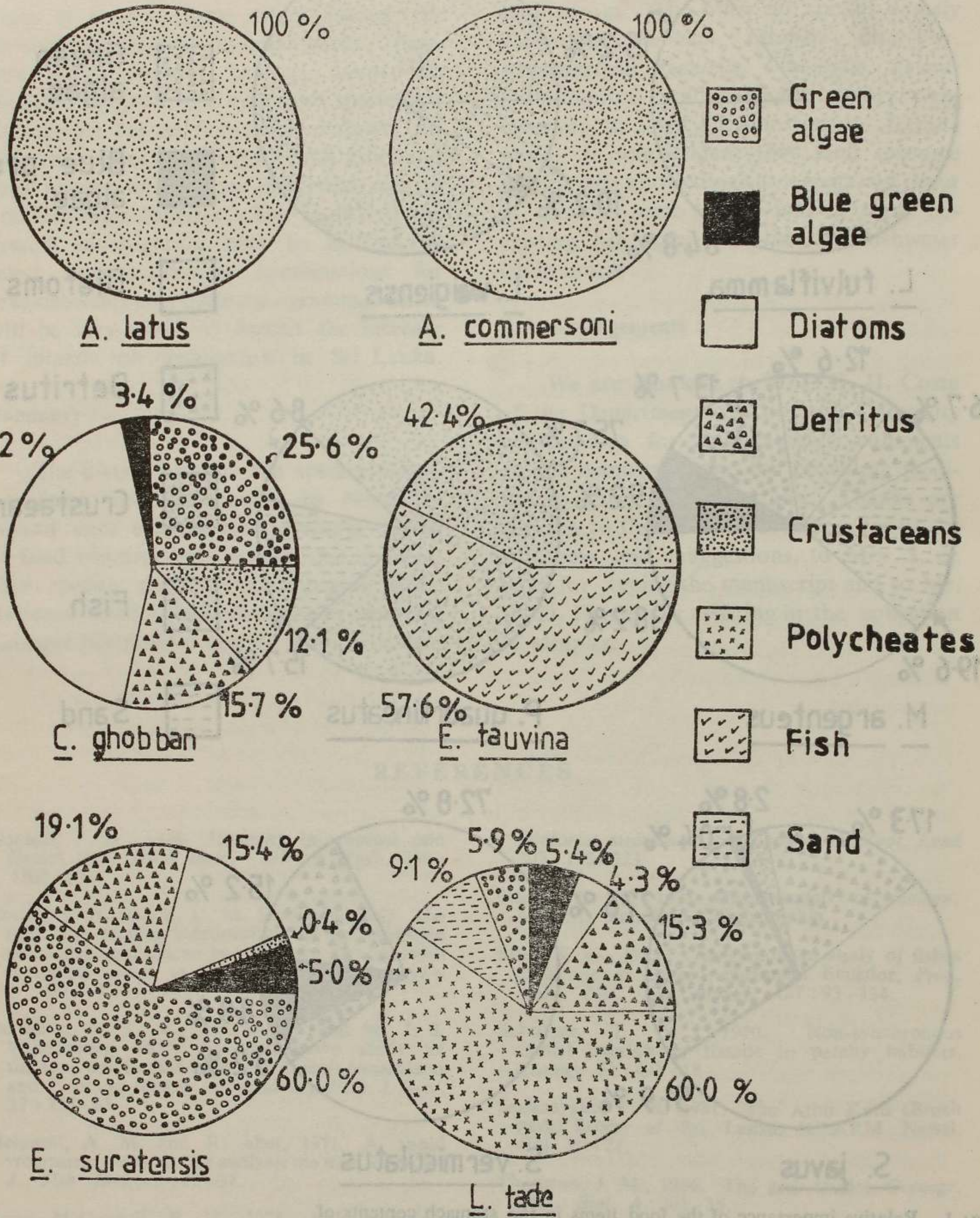

Fig: 2. Relative importance of the food items in the stomach contents of **Acanthopagrus latus, Ambassis commersoni, Callyodon ghobban, Epinepheles tauvina, Etroplus suratensis, and Liza tade.**

TABLE 1

Total length of the fish species used in present investigation.

Species	Total length (cm)
Acanthopagrus latus	12.0 — 25.0
Ambassis commersoni	7.0 — 13.0
Callyodon ghobban	12.0 — 20.0
Epinepheles tauvina	9.0 — 33.0
Etroplus suratensis	5.0 — 16.0
Liza tade	7.0 — 32.0
Lutianus fulviflamma	10.0 — 17.0
Lutianus waigiensis	13.0 — 19.0
Monodactylus argenteus	7.0 — 11.0
Pelates quadrilineatus	10.0 — 14.0
Siganus javus	7.0 — 10.0
Siganus vermiculatus	7.0 — 9 0

TABLE II

FOOD ITEMS OF THE FISH SPECIES ANALYSED

	A. latus	*A. commersoni*	*C. ghobban*	*E. tauvina*	*E. suratensis*	*L. tade*	*L. fulviflamma*	*L. waigiensis*	*M. argenteus*	*P. quadrilineatus*	*S. javus*	*S. vermiculatus*
Green alage												
Chlorella			+		+	+			+		+	+
Cladophora			+		+	+					+	+
Blue green algae												
Anabaena					+	+			+		+	+
Chroococcus			+		+	+			+		+	
Lyngbia					+	+					+	+
Diatoms												
Melosira			+		+	+			+		+	+
Navicula			+		+	+			+	+	+	+
Nitzchia			+		+	+			+		+	
Pinnularia					+	+			+	+	+	+
Pleurosigma					+	+					+	+
Detritus ...			+		+	+			+		+	+
Crustacea												
Copepods			+		+				+	+	+	
Nauplii	+	+								+		
Shrimps	+	+		+			+	+				
Crabs ...				+			+	+				
Polychaetes						+						
Fish ...				+			+	+				
Sand particles						+			+	+		

Fig. 3

PERCENTAGE OVERLAP AMONG THE DIETS OF THE SPECIES OF FISH STUDIED

	A. commersoni	*C. ghobban*	*E. tauvina*	*E. suratensis*	*L. tade*	*L. fulviflamma*	*L. waigiensis*	*M. argenteus*	*P. quadrilineatus*	*S. javus*	*S. vermiculatus*
A. latus	100	12.1	42.4	0	0	84.8	89.8	12.6	75.7	2.8	0
A. commersoni	—	12.1	42.4	0	0	84.8	89.8	12.6	75.7	2.8	0
C. ghobban	—	—	12.1	60.2	28.9	12.1	12.1	74.1	43.1	87.7	65.0
E. tauvina	—	—	—	0	0	57.6	5.36	12.6	42.1	2.8	0
E. suratensis	—	—	—	—	30.9	0	0	41.3	8.6	60.7	39.3
L. tade	—	—	—	—	—	0	0	31.4	13.4	25.9	28.1
L. fulviflamma	—	—	—	—	—	—	95.0	12.6	75.7	2.8	0
L. waigiensis	—	—	—	—	—	—	—	12.6	75.7	2.9	0
M. argenteus	—	—	—	—	—	—	—	—	39.1	61.8	56.9
P. quadrilineatus	—	—	—	—	—	—	—	—	—	11.4	8.6
S. javus	—	—	—	—	—	—	—	—	—	—	70.7

J. Inland Fish., Vol. 3, December, 1986, pp. 124—132

CULTURE OF PENAEID SHRIMPS IN PENS IN THE NEGOMBO LAGOON

B. N. B. O. Perera[1] and R. A. D. B. Samaranayaka[2]

Introduction :

The bulk of shrimp catches made in Sri Lanka come from the sea. The catches are not able to keep pace with the increasing demands for the commodity in the local and foreign markets. Sri Lanka is blessed with approximately 22,000 ha of brackish-water area made up of lagoons and marshy lands and some of these areas are suitable for Shrimp culture. Most of the lagoons could be utilized for operating pens and cages. Suitable marshy lands could be converted into Shrimp Pens.

In Sri Lanka the tidal variation is nearly about one meter. This makes operating costs for coastal pond culture higher than operating costs of pen culture. Pen construction requires low capital investment, and involves little by way of skills or manpower. A pen is ready for full scale production as soon as it is installed.

To ascertain the possibility of culturing shrimps in lagoon areas by encircling parts of it by construction of barricades forming a pen, a survey was conducted to locate sites that would be suitable for conducting such trials. Fig. 1 shows the Negombo lagoon (2957 ha) and indicates the areas surveyed and the site where the pen was constructed.

Materials and Methods :

A small meshed (10 mm) Nylon netting was used as the pen wall. The net bottom along with the attached foot rope was struck into the muddy bottom, about 30 cm deep. The pen wall height from the mud bottom was 2 meters. The upper end of the netting was attached to a series of hori - zontal bamboo poles supported on vertical poles, 3 meters apart. The pen area 0.2 ha in extent, was divided into 2 equal compartments.

Drag netting was employed to eradicate predaters from both sections of the pen. Brushpiles were scatered all over the pen enclosed water area to prevent cast netting by poachers to catch shrimps seeking shelter in these. These also provided protection to newly molted shrimps against cannibalism. Clay pots used as feeding trays were hung near the pen wall and also in the middle at every 10 meters.

Pens No. 1 and No. 2 were stocked on 30th Jan. and 01st March, 1985 respectively. The shrimp juveniles were obtained from the nearby departmental hatchery. The pens were harvested 80 days after stocking. Supplementary feed provided was a mixture of fish meal 30%, prawn head 30%, rice bran 15%, coconut poonac 15%, wheat flour 5%, water 5%. The ingradiants were mixed with cooked flour and made into compact balls (200 g) and these bowls were placed in the clay pots late in the evening. For the first 2 weeks, feed supplied daily was at 20% of body weight. This was reduced to 15% in the next 3 weeks. In the last few weeks this was only 8% by body weight. The clay pots were inspected daily, to check for feed utilization.

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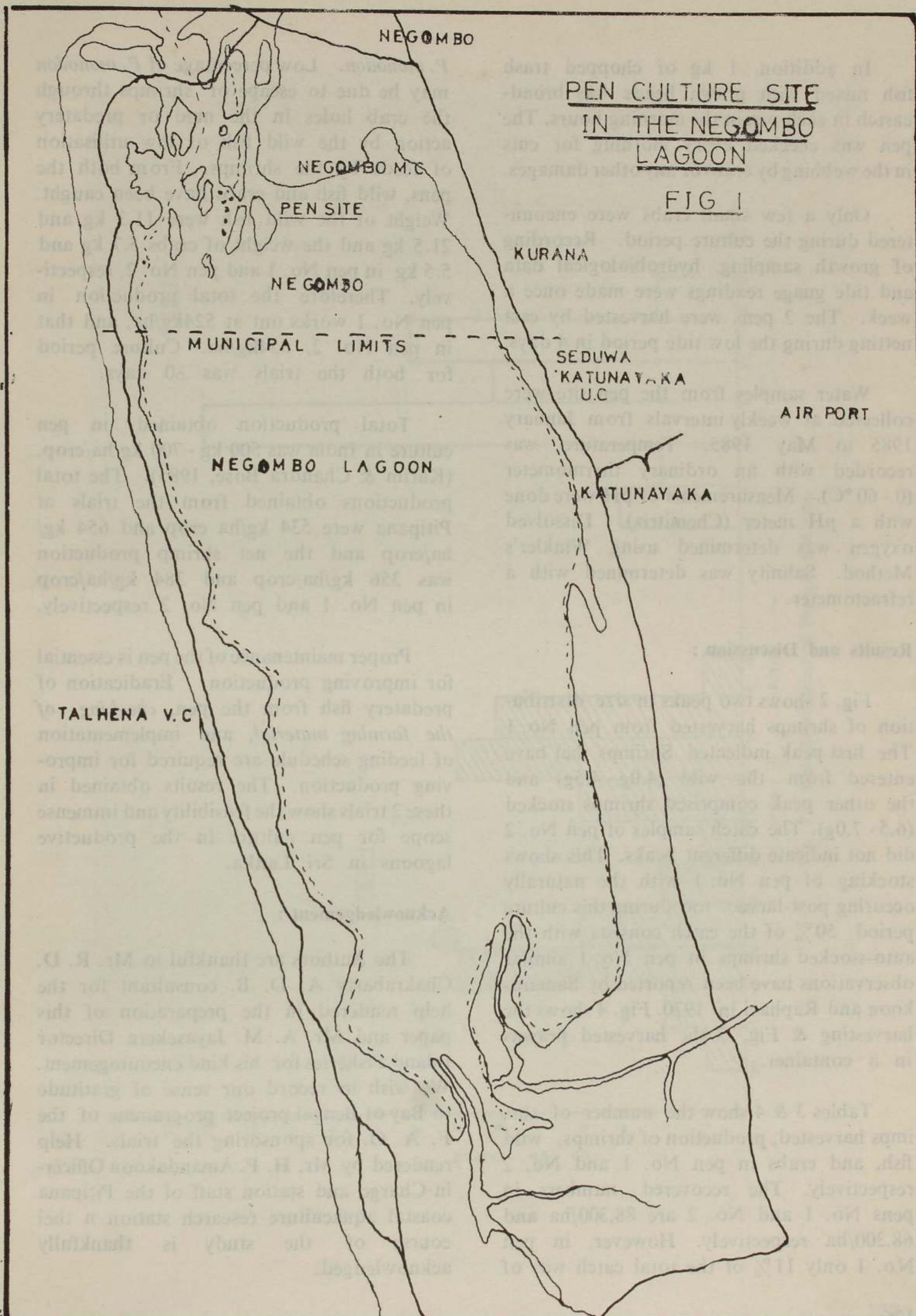
NEGOMBO
PEN CULTURE SITE
IN THE NEGOMBO
LAGOON
FIG 1
NEGOMBO M.C
PEN SITE
KURANA
NEGOMBO
MUNICIPAL LIMITS
SEDUWA
KATUNAYAKA
U.C
AIR PORT
NEGOMBO LAGOON
KATUNAYAKA
TALHENA V.C

In addition, 1 kg of chopped trash fish mixed with prawn heads was broadcastch in each pen in the morning hours. The pen was checked every morning for cuts in the webbing by crabs or any other damages.

Only a few small crabs were encountered during the culture period. Recording of growth sampling, hydrobiological data and tide guage readings were made once a week. The 2 pens were harvested by cast netting during the low tide period in 4 days.

Water samples from the pen site were collected at weekly intervals from January 1985 to May 1985. Temperature was recorded with an ordinary thermometer (0 - 60 °C). Measurements of pH were done with a pH meter (Chemitrix). Dissolved oxygen was determined using Winkler's Method. Salinity was determined with a refractometer.

Results and Discussion :

Fig. 2 shows two peaks in size distribution of shrimps harvested from pen No. 1 The first peak indicated Shrimps that have entered from the wild (4.0g - 4.5g) and the other peak comprised shrimps stocked (6.5 - 7.0g). The catch samples of pen No. 2 did not indicate different peaks. This shows stocking of pen No. 1 with the naturally occuring post-larvae, too during this culture period. 50% of the catch consists with the auto-stocked shrimps in pen No. 1 similar observations have been reported by Samarakoon and Raphael in 1970. Fig. 4 shows the harvesting & Fig. 5 the harvested prawns in a container.

Tables 3 & 4 show the number of shrimps harvested, production of shrimps, wild fish, and crabs in pen No. 1 and No. 2 respectively. The recovered numbers in pens No. 1 and No. 2 are 88,300/ha and 68,300/ha respectively. However, in pen No. 1 only 11% of the total catch was of *P. monodon*. Low percentage of *P. monodon* may be due to escape of shrimps through the crab holes in the mud or predatery action by the wild fish or low utilisation of feeds by the shrimps. From both the pens, wild fish and crabs have been caught. Weight of the wild fish were 11.3 kg and 21.5 kg and the weight of crabs 5.7 kg and 5.5 kg in pen No. 1 and pen No. 2, respectively. Therefore the total production in pen No. 1 works out at 524kg/ha, and that in pen No. 2, 654kg/ha. Culture period for both the trials was 80 days.

Total production obtained in pen culture in India was 500 kg - 700 kg/ha/crop. (Karim & Chandra Bose, 1985). The total productions obtained from the trials at Pitipana were 534 kg/ha crop and 654 kg/ha/crop and the net shrimp production was 356 kg/ha/crop and 384 kg/ha/crop in pen No. 1 and pen No. 2 respectively.

Proper maintenance of the pen is essential for improving production. Eradication of predatery fish from the pen, *checking of the farming material*, and implementation of feeding schedule are required for improving production. The results obtained in these 2 trials show the feasibility and immense scope for pen culture in the productive lagoons in Sri Lanka.

Acknowledgement :

The Authors are thankful to Mr. R. D. Chakrabarty A. D. B. consultant for the help rendered in the preparation of this paper and Mr. A. M. Jayasekera Director Inland Fisheries for his kind encouragement. We wish to record our sense of gratitude to Bay of Bengal project programme of the F. A. O. for sponsoring the trials. Help rendered by Mr. H. P. Amandakoon Officer-in-Charge and station staff of the Pitipana coastal aquaculture research station n thei course of the study is thankfully acknowledged.

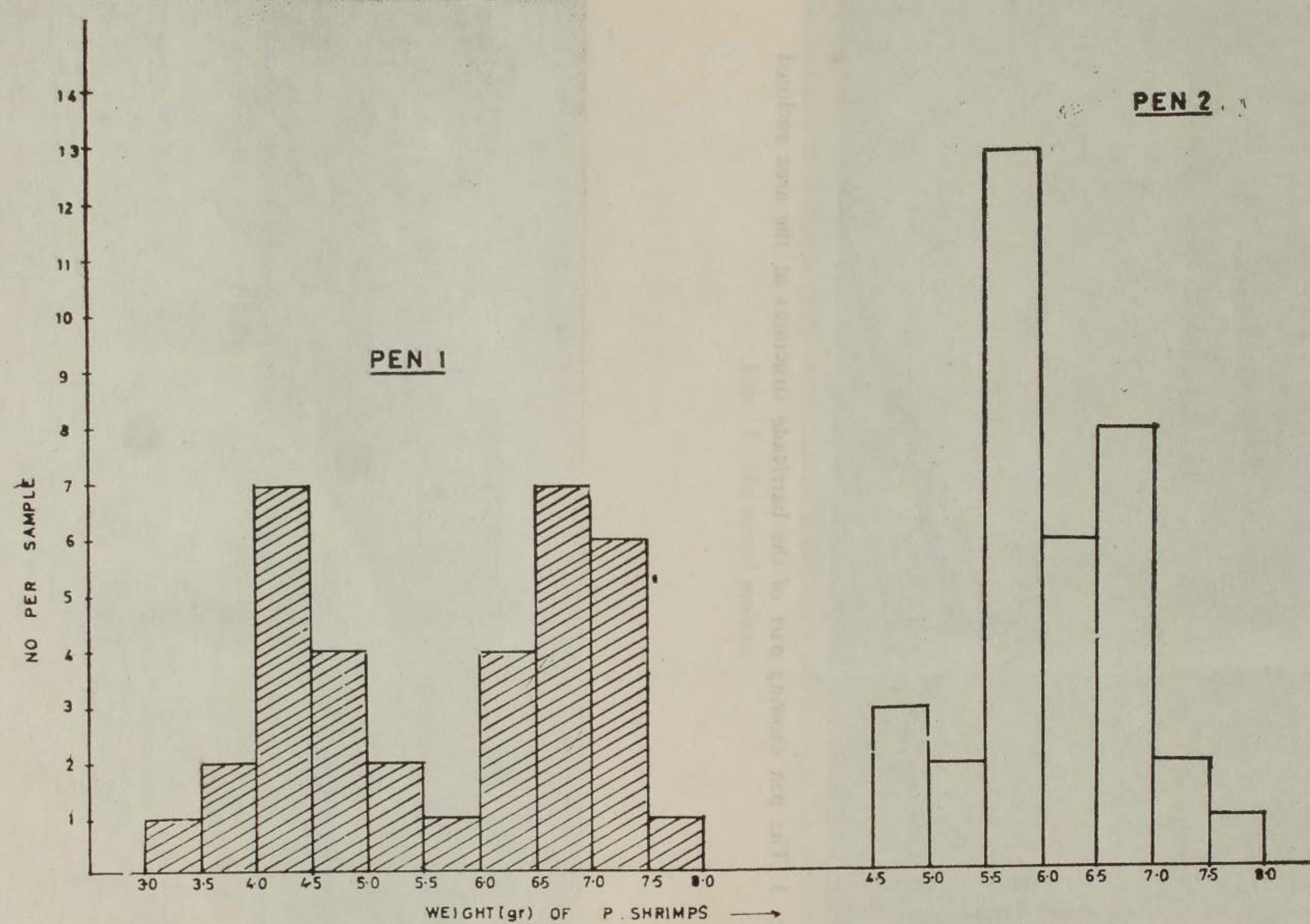

Fig. 2. Size distribution of Penaeid Shrimps

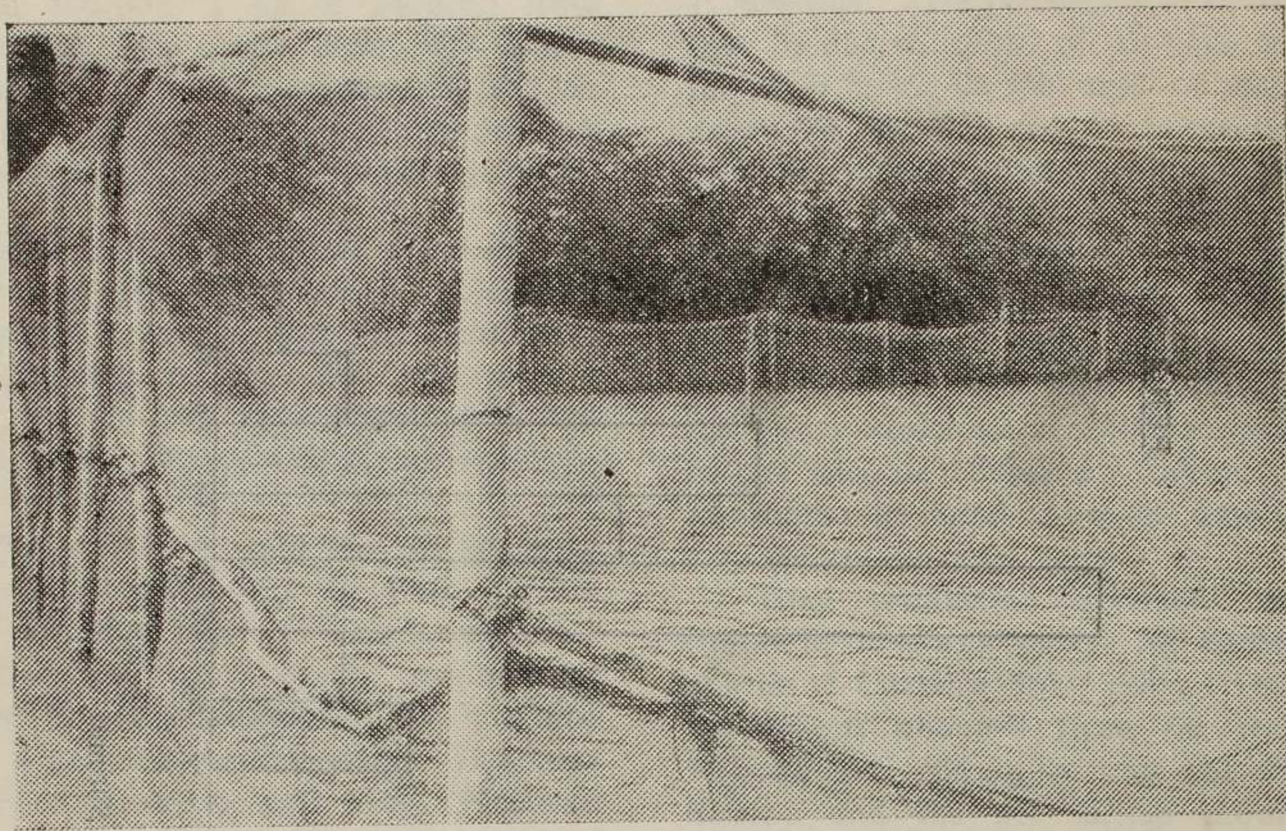

Fig: 3 The pen showing part of the barricade structures at the area enclosed

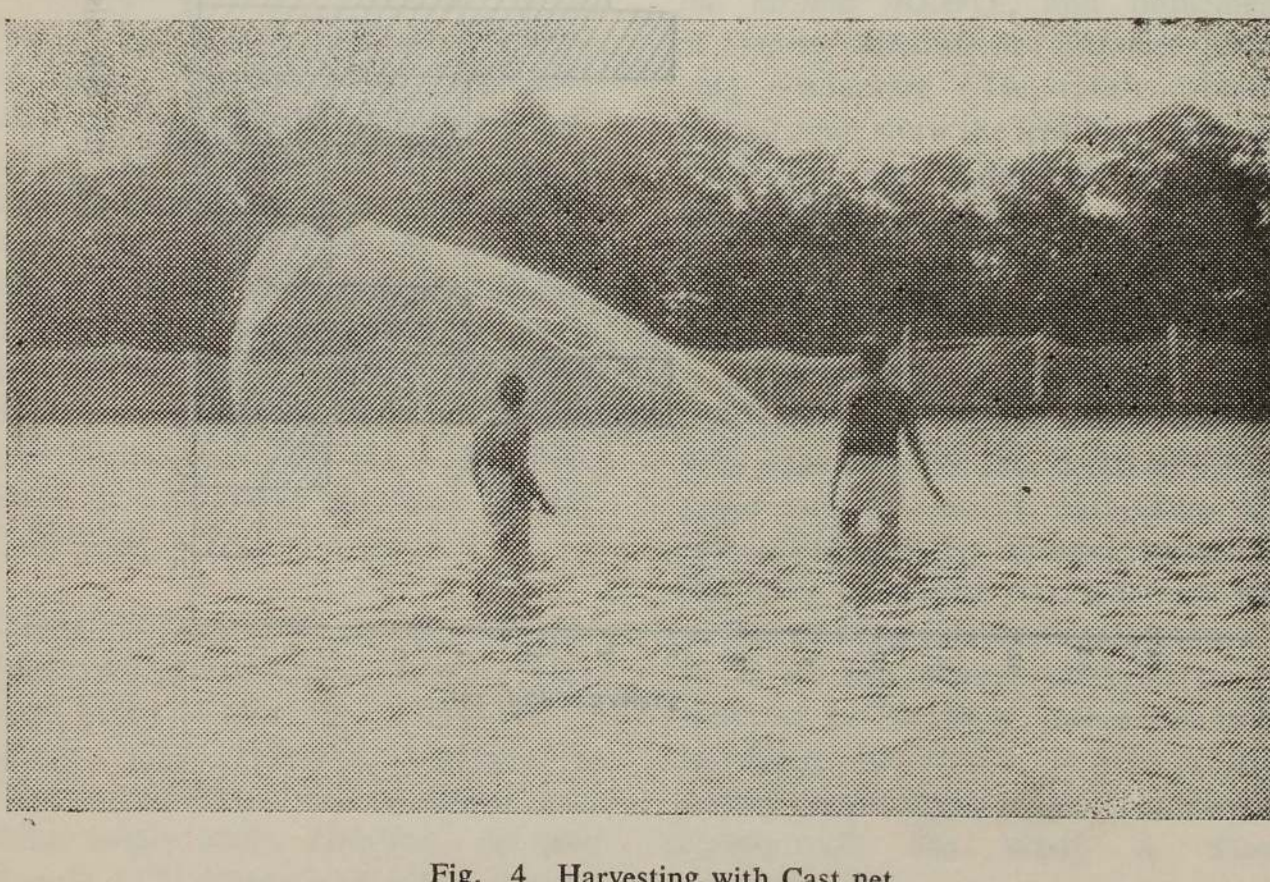

Fig. 4 Harvesting with Cast net.

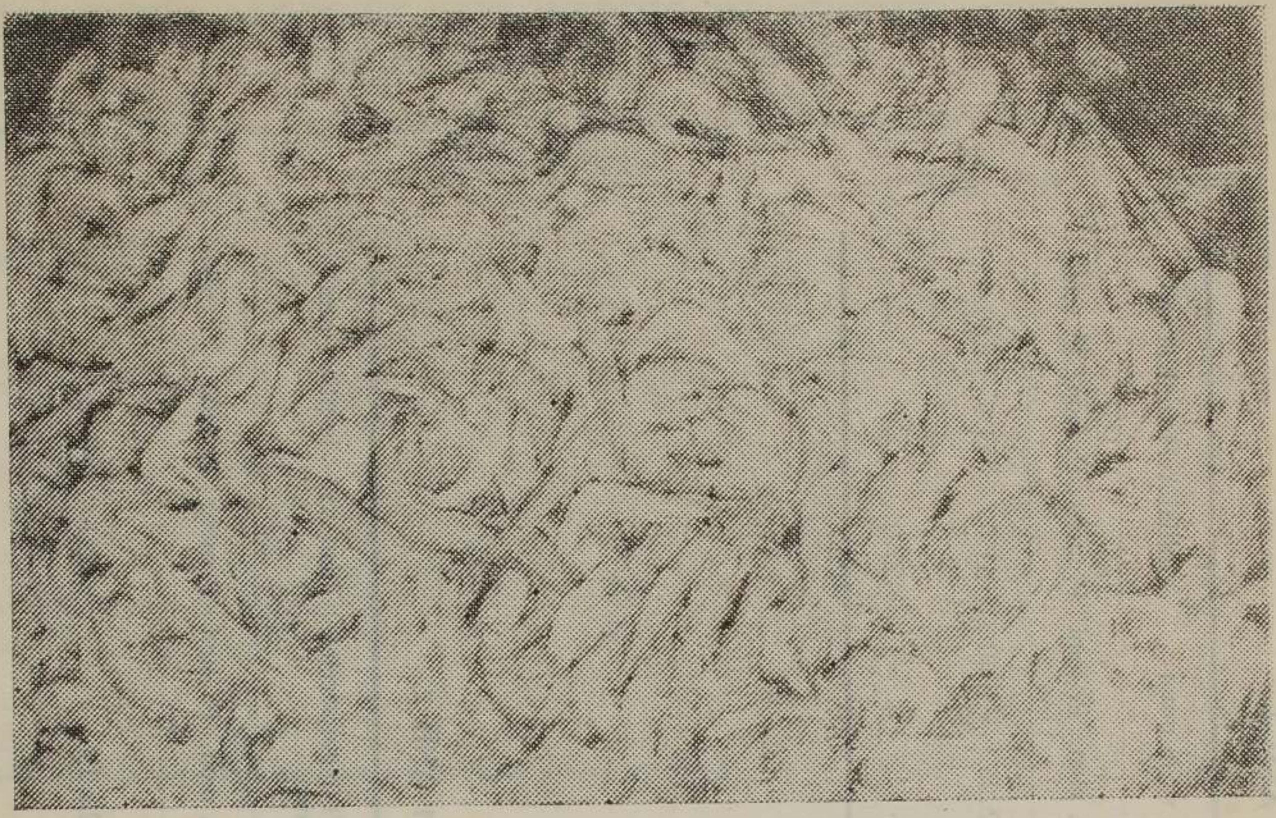

Fig. 5 Harvested prawns

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TABLE 1

STOCKING DETAILS IN PEN No. 1 AND 2.

Pen No.	Date of stocking	Effective water area	No. stocked (shrimps	species			Initial Av. wt in gram			Initial Av. length in mm.		
				P. merg	P. mon	P. semi	P. merg	P. mon	P. semi	P. merg	P. mon	P. semi
1.	30.1.85	$1000m^2$	5000	4400	500	100	1.7	2.06	1.60	53.0	55.5	40.8
2.	1.3.85	$1000m^2$	6000	6000	—	—	2.00	—	—	55.0	—	—

TABLE 2

SHRIMP HARVESTS FROM PEN No. 1 AND 2.

Pen No.	Date of harvest	No. recove red	No. recovered species wise			Final Av. Wt in gm species wise			Final Av. length (mm)		
			P.merg	P. mon	P. semi	P. merg.	P. mon	P. semi	P. merg	P. mon	P. semi
1.	20th - 24 April 1985	8883	8830	53	—	5.5	26.25	—	88.1	46.6	—
2.	20th - 23 May 1985	6850	6842	08	—	6.10	40.20	—	100.3	165.0	—

TABLE 3

HARVESTED NUMBERS AND WEIGHT OF SHRIMPS AND GROSS PRODUCTION IN PEN No. 1

Date of harvest	Penaeid Shrimps				Wild Fish	Crabs
	P. merg		P. mono			
	No.	Wt. (Kg)	No.	Wt. (Kg.)	Kg.	Kg.
20.04.85	3600	12.9	23	0.60	3.2	0.7
21.04.85	2735	11.4	17	0.35	2.7	0.7
22.04.85	1343	5.5	10	0.11	2.8	—
23.04.85	872	3.4	02	0.05	2.4	0.18
24.04.85	280	1.3	01	0.02	0.2	4.1
Total	8830	34.5	53	1.13	11.3	5.68

Total Shrimp production — 356Kg/ha 80 days
Overall yield — 524 Kg/ha 80 days

TABLE 4

HARVESTED NUMBERS AND WEIGHT OF SHRIMPS AND GROSS PRODUCTION IN PEN No. 2

Date of harvest	P. shrimps				Wild fish	Crabs
	P. merg.		P. mono			
	No.	Wt. Kg.	No.	Wt. Kg.		
20.05.85	2780	15.5	04	.15	7.4	1.3
21.05.85	2970	16.5	02	.13	10.3	2.0
22.05.85	936	5.2	01	.03	3.4	—
23.05.85	144	0.8	01	.08	1.4	2.2
Total	6830	38.0	80	.39	21.5	5.5

Total shrimp production — 384 Kg/ha/80 days
Overall yield — 654/ha/80 days

Printed at Sathosa Printers Ltd., 290, D. R. Wijewardena Mawatha, Colombo 10.
Published by : The Ministry of Fisheries

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