J.Nat.Aquat.Resour.Res.Dev.Agency 37 (2005)27-39
The National Aquatic Resources Research & Development Agency,
Crow Island, Mattakkuliya, Colombo15, Sri Lanka.

An artisanal shrimp fishery of Rekawa lagoon with special reference to the fishery, distribution and recruitment of *Penaeus indicus*

D. S. JAYAKODY[1] AND P. A. A. T. JAYAWARDANE[2]

[1&2] *National Aquatic Resources Research and Development Agency, Crow Island Colombo 15.*

Abstract

KEY WORDS: FISH KRAALS, *PENAEUS*, CAST NET, ARTISANAL

The shrimp fishery in the Rekawa Lagoon of southern Sri Lanka was monitored for two successive fishing seasons, 1993/94 and 1994/95. The shrimp fishery in this estuarine eco-system was entirely artisanal and was conducted either using wooden canoes or without a craft. The major gear used by the shrimp fishermen in the study area were set gillnets, fish kraals (Ja-kottu) and cast nets. Fishing was mostly restricted to the lagoon proper (1-2 m depth) and *Penaeus indicus* formed almost 90% of the shrimp catch from the system. The main fishing season was from September to April and shrimp catch rates varied from 0.1to 4.2 kg canoe^{-1} day^{-1} for traditional crafts operating set gillnets, 0.2 to 10.2 kg operation $^{-1}$ for Ja-kottu and 0.2 to 0.8 kg operation^{-1} for cast nets. The estimated annual shrimp production for the periods July 1993 to June 1994 and from July 1994 to June 1995 were 6.2 and 5.2 MT respectively. The size range of *P. indicus* exploited by the fishery was 5.0 – 16.2 cm (total length) and with the onset of maturity, females grow faster than males. The average growth rates for males and females of *P. indicus* were estimated at 1.9 and 1.05 year^{-1} respectively. Despite the decreasing monthly catch rates (from 4.2 to 0.1 kg operation^{-1} for canoes operating set gillnets and from 10.2 to 0.2 kg for kraals) sharply increasing market prices ascertained the viability of fishing operations.

Introduction

Rekawa Lagoon is a small coastal lagoon on the south coast of Sri Lanka with a surface area of around 240 ha. According to the unpublished information available, commercial shrimp fishery in Rekawa was initiated around 1960s, peaked in late 1970s and early 1980s and began to decline since late 1980s. The artisanal shrimp fishery which had been a subsistence fishery prior to 1970s, expanded rapidly with the high export demand for shrimps.

The general characteristic of shrimps is to spend their early life in the shallow inshore waters (lagoons, estuaries etc.) within the reach of traditional crafts (canoes), The less capital-intensive nature of the small scale fisheries helped the

sustenance of the artisanal fishery for shrimps in Rekawa lagoon and placed this industry in an advantageous position.

Presently, the shrimp resources in the Rekawa Lagoon and the adjacent coastal waters are entirely fished by the artisanal fishermen. Juvenile and sub-adult stages of shrimps in the lagoon are fished by set gillnets, cast nets and Ja-kottu (kraals) while the parent stock in the seas off Rekawa is exploited by the trammel nets operated using dug out canoes.

According to the concensus among of the fishermen in the area, Rekawa Lagoon has supported active and important fisheries for finfish and crustaceans in the recent past. However, it must be noted that regular and properly maintained records on the fish and shrimp production of Rekawa Lagoon are not available. According to the available information (Maitipe and de Silva, 1986) the annual shrimp production of the lagoon was around 5 MT. In addition the available limited information (Anon, 1985 ; Jayakody, 1993 & 1997) indicated that there has been a gradual decline in finfish and shellfish catches from the lagoon over the last several years. Therefore, the present study was undertaken to evaluate the shrimp fishery in Rekawa area in order to make recommendations for management of the shrimp resources in Rekawa Lagoon and the associated coastal region. Also included was a study to investigate the factors contributing to the decline of the finfish and crustacean fishery resources in the system.

Materials and Methods

The material for the present study was collected at fortnightly field visits to the major fish landing centres in the Rekawa Lagoon (Fig. 1) during the period, July 1993 to June 1995. More than 20% of the landings were sampled at random. The shrimps, fish and the crabs from the commercial catches were sorted out at the landing site and the respective quantities were estimated by counting the number of animals and also by obtaining respective weights unloaded. Representative samples from the commercial catches were examined in order to determine the composition of the catches, for species identification and morphometric studies.

Structured interviews were held with the fishermen at landing centres to obtain information on the area of operation, operational procedure, true fishing time, number of hauls, type of the gear used, gear specifications, total catch, species composition, and total income . Almost all the crafts at each sampling station were sampled, at each visit.

Size distribution of *P. indicus* of the shrimp fishery in the Rekawa Lagoon was determined in the catches of trammel nets, Ja-kottu, cast nets and set gillnet catches. Length compositions obtained from different gear types were pooled and size distributions of *P. indicus* for various months were analyzed using the ELEFAN software package (Gayanilo *et al.*, 1988) to estimate the growth constants and the recruitment pattern. The total lengths of shrimps was measured (from the tip of the rostrum to the tip of the telson) as this was the easiest measurement that can be obtained in the field.

Results

In Rekawa, the peak shrimp fishing season commences around September and continues until April of the following year. Fishermen operate cast nets and set gillnets since the beginning of the season while the operation of kraals takes place little later, frequently during October/November period. Fishing operations were conducted during night and catches were landed in the morning usually between 6.30 a.m. and 8.00 a.m.

Fishing grounds

Although, fishing is conducted all over the lagoon, different gear types are operated in different areas of the lagoon. Cast net fishermen operate their nets frequently in the canal part (Stations 1-6 of Figure 01) in proximity to the mangrove- fringed banks of the lagoon proper. At the beginning of the season (September/October), when the young shrimps are predominant, this fishery is conducted mostly in the canal part of the lagoon, wading to a depth of 0.6-0.9 m. Gradually, the fishery shifts towards the central part of the lagoon proper (Stations 7-12 of Figure 01, depth 0.9-1.5 m) and the fishing is conducted by canoe fishermen using 37.5 mm meshed nets.

Later in the season they use 43.75 mm and even 50 mm meshed nets to catch large shrimps. Towards November and December the major fishery for shrimps commences, using kraals. This fishery is conducted mainly in the narrow part of the lagoon proper, closer to the banks at depths of around 0.6-1.5 m.

Fishing gear types

In Rekawa, set gillnets, cast nets, kraals and the cast net operations associated with iri-weta were used by the fishermen to exploit shrimps inside the lagoon. The gillnets, cast nets and the kraals were the dominant fishing gear used. Around 25 traditional dug out canoes (close to the Stations 7 and 8) were engaged in the shrimp fishery during the peak season. Hettiyapokuna and

Boraluwa were the two major fish landing sites of the lagoon. This fishing fleet reduced to zero on certain days during the lean period (June and July).

Drift gillnets:

Drift gillnets were operated by the fishermen who live around the lagoon, using traditional dug out canoes. At the beginning of the fishing season fishermen used small meshed gillnets (37.5 mm and 43.75 mm stretched mesh/02 ply). As the fishing season proceeded they tended to use comparatively larger meshed gillnets targeting large *P. indicus*. Around 8-15 net pieces were used for a fishing operation. Analysis of the species composition of shrimps caught by these nets indicated the presence of 95% *P. indicus*, followed by 2.5% *Metapenaeus monoceros* and 2% *P. semisulcatus*. Annual catches from the drift gillnets declined during the period 1985 to 1992, followed by a sharp increase in 1993/94 fishing season with an estimated production of around 1.2 MT in 1993/94 and 2.6 MT in 1994/95. According to the field sampling studies conducted during 1994/95, drift gillnets produced around 2.6 MT of shrimps. Monthly breakdown of the shrimp yield from the set gillnets for 1993/94 and 1994/95 seasons is given in the Table 1.

Kraals (Ja- kottu)

Kraals were constructed of Palmyra strips and these act as vertical barriers leading to a number of traps. These strips were tied together using coir rope, and were supported by strong poles fixed to the bottom of the lagoon. Ja-kottu fishery in the Rekawa Lagoon commences around late October or November and continues until April/May of the following year. These are operated from around 6.00 p.m. to 6.00 a.m. of the following day. In Rekawa area 25 people were issued with the permits to operate Ja-kottu in the lagoon for which they have traditional user rights. In 1993/94 season, 22 kraals and in 1994/95 season, 8 kraals were operated. High catches were obtained in October, December and February and the number of Ja-kottu constructed in each month varied considerably. During 1994/1995 season, the Ja-kottu fishery produced around 1.05 MT of shrimps, which was a low figure when compared to the shrimp production from Ja-kotttu in the 1993/94 season (5.2 MT). Catch consisted mainly of *P. indicus* followed by *M. monoceros, P. semisulcatus and P. monodon.* Monthly breakdown of the shrimp production from Ja-kottu (kraals) is given in Table 2.

Cast nets

This is a traditional fishing gear operated in the lagoon periphery and on the fringes of mangrove swamps by small scale fishermen who live around the lagoon. They have the added advantage of being selective in their catches, exploiting mostly the juvenile shrimps, which mainly consists of *P. indicus* (82%). The estimated shrimp productivity for cast nets was 1.6 MT for 1994/95 season. Fishermen in the study area operate cast nets targeting shrimps/fish almost throughout the year even in the lean period around June-July. Monthly breakdown of the shrimp production from the cast nets for the seasons 1993/94 and 1994/95 are given in Table 3.

Iri-weta

This is a fishing device used to obstruct the migrating shrimps towards the lagoon mouth from the lagoon proper. Fishermen fix a rope across the narrow parts of the lagoon on which the mangrove twigs are hung. The rope floats on the water surface and mangrove twigs touch the bottom. A few fishermen conduct cast net operations from time to time quite close to this line, when shrimps are aggregated.

Catch composition

During the present investigation around 16 species of finfish and 06 species of crustaceans were identified in the catches. There was a slight difference of the percentage composition of the catches among different gear types and the fishing seasons.

Compared to the poor diversity observed among the gillnet catches, substantially high species diversity was observed in the catches of fish kraals. It was also noted that the juveniles of finfish and crustaceans formed substantial portion of the catches of the three major gear types employed in the Rekawa Lagoon.

Species composition of the penaeid shrimps caught by kraals, set gillnets, cast nets and iri-weta in the Rekawa Lagoon and their size ranges are given in Table 4.

Size composition of *P. indicus*

The pooled monthly length frequency distribution showed polymodal tendencies indicating the presence of several cohorts in a particular month. The modal size for males and females tends to be the same in the early stages but with the onset of maturity when the total length exceeds 14.0 cm, the model size of the female increases faster than that of the male. Though polymodal, it appears to be only a single dominant mode for each sex, indicating that the fishery primarily exploits the recruits from a single spawning season during the main fishing season. The size range of this group varied from 13.0 - 14.5 cm (total length) for males and 13.5 - 16.2 cm for females. The appearance of very small modal groups of less than 10 cm (total length) in the cast net and kraal catches presumably indicated new recruitment towards the estuarine environment. In accordance with the size range of *P. indicus* in the shrimp catches from Jakottu, it appears that substantial proportion of sub-adult stock is vulnerable to this fishery over a period of 4-5 months of the year (November - April period).

The shrimp catches of set-gillnets represented the size ranges of shrimps in the deeper parts of the lagoon (beyond the reach of kraals). The contribution of large sized *P. indicus* (mostly the shrimps of 14.0-16.5 cm in total length) to the above is substantial. Though set gillnets exploit relatively wider range of shrimps (size range 8.0-16.5 cm) owing to frequent utilization of larger mesh sizes (37.5, 43.75 and 50 mm), there is increased tendency of catching larger specimens of *P. indicus* (size range, 14.0-16.5 cm in total length) by set gillnets.

Changes in the salinity profile

The causeway constructed at Kapuhenwala across the lagoon (Fig. 1, Stations 4 & 5) acted as a major impediment and reduced the speed of the saline water flow especially during the period when the lagoon mouth was opened. High density saline water moved fast up to the causeway (Station 4) and penetrated via the culverts at a reduced speed. Beyond this point (Station 5), high-density saline water moved slowly towards Pamakapitiya (Station 6). Therefore, as a result of the process of mixing, salinity levels tend to decline. Beyond Parappuwa (Station 7), as the lagoon becomes more and more wider the saline water tends to dilute quickly, resulting more or less steady salinity level (4 -10 ppt) in the lagoon proper (Stations 8, 9, 10, 11 and 12). In general, a high salinity fluctuation (0-35.1 ppt) was observed in the canal portion of the lagoon (Stations 1-6), while more or less steady salinity level existed (4 -10 ppt) in the lagoon proper (Stations 7-12).

Recruitment pattern

The results of the analysis of recruitment pattern of *P. indicus* during the study period are shown in Fig. 2. This can be interpreted as a recruitment pattern with two peaks, different in magnitude. The means of two pulses of recruitment are separated by 04 months in terms of both sexes. Of these, first one is smaller in magnitude and the second seems to contribute substantially to the fishery.

Discussion

Rekawa Lagoon is fished extremely intensively. In this respect, it may be thought of as a large, extensive shrimp farm with shrimp larval and post-larval inputs occurring during occasional breaches of the sand bar between the lagoon and the sea. Nutritional input from natural sources is clearly sufficient for high growth rates for the penaeid species.

The Rekawa area of southern Sri Lanka supports around 5400 people, half of whom are involved in artisanal lagoon or sea fishing (Davenport *et al.,* 1999). Good historical data for the fishery are not available, though it is clear that catches of fish and shrimp were much higher in the past (Anon, 1985 ; Maitipe and de Silva, 1986) Several factors may have contributed to the present day decline, the most important being due to the building of a causeway that restricts exchange of water and shrimp recruitment between the sea and lagoon (Jayakody, 1997 ; Davenport *et al.,* 1999).

Present study identified the fish kraals and the set gillnets as the two major fishing gear types employed by the fishermen in the Rekawa Lagoon to exploit shrimps. These two fishing gear types alone account for almost 83% of the shrimp catch from the lagoon. Although cast net operations are conducted almost throughout the year, shrimp yield of cast nets was much smaller when compared to that from set gillnets and kraals.

The gear deployment in the lagoon takes place in accordance with the size distribution of shrimp. Fishing gear used in the shallow areas (eg. cast nets) catch small shrimp when compared to the gear types used in the central deeper areas of the lagoon (eg. set gillnets). Generally the set gillnets and kraals catch comparatively larger shrimps in the lagoon.

Five species of Penaeid shrimps are caught in the Rekawa Lagoon, but by far, the dominant species is the Indian white shrimp, *P. indicus.* Peak spawning of this species takes place during July and October and tiny larvae enter the lagoon with the opening up of the lagoon mouth, which coincides with period of

heavy precipitation to the catchment areas of the lagoon (Jayakody and Jayawardane, 1997). After hatching, *P. indicus* spend 4 - 6 months in the lagoon and during this period they are harvested by the cast nets, kraals and the set gillnets. The tiny larvae are carried passively into the lagoon along with the tide and the wave action, where they spend around 2 months, feeding on plankton and subsequently transform into a benthic form and spend 2 - 4 months in the lagoon. The duration of the larval life in the lagoon depends upon the rainfall pattern of Rekawa and the catchment area (Jayakody and Jayawardane, 1997). In addition the estimated growth rates for juvenile *P. indicus* in the Rekawa Lagoon during the present study (1.9 and 1.05 $year^{-1}$ for males and females respectively) were relatively low compared to that estimated during the study conducted by Davenport *et al.*, 1999 which were 3.53 and 2.44 $year^{-1}$ for males and females respectively.

Once the lagoon mouth is opened up, sub-adults move towards the sea both actively and passively. Substantial amount of larvae and sub-adults might die on account of predation while in the sea. However, the survivors eventually settle on the muddy bottom at a depth of around 5-10 m where they feed and grow to maturity. High percentage of gravid females was observed in July and October. They might also be available in the seas during rest of the year in low percentages.

During the period from October to December, heavy precipitation prevails for many days in Rekawa and the catchment areas of the lagoon with resulting floods in the study area. People of the area cut open the lagoon mouth facilitating the recruitment of both the sub-adults and the tiny planktonic larvae to the marine and the estuarine environments respectively.

However, once the lagoon mouth is opened, most of the shrimp larvae and sub-adults are flushed into the sea resulting in poor catches in the lagoon. Although lagoon fishermen are not very pleased with the opening up of the sand bar, this is an essential event in terms of the completion of the life cycle of most of the penaeid shrimps.

Construction of a causeway obstructing the sea mouth of the lagoon at Kapuhenwala (Fig. 1) had been an impediment for recruitment of shrimps to both estuarine and marine environments. Although it has been partially opened quite recently facilitating the shrimp recruitment and the water exchange between the lagoon and the sea, as the sand bar formation at the sea mouth is highly irregular, postlarval recruitment of shrimps to the nursery environment in the lagoon is still restricted to a very short period.

The present situation in the estuarine system emphasized the importance of careful handling of the shrimp fishing activities in the system. The present investigation was conducted prior to partial opening of the causeway constructed obstructing the sea mouth of the lagoon. Therefore, it is reasonable to expect a substantial alteration in the estuarine environment, crustacean and finfish fishery resources from this coastal eco-system. Therefore, it is advisable to conduct a comprehensive study to evaluate the population structure and the ecology of the shrimp resource, its exploitation and the alteration in terms of the salinity profile of the lagoon. The findings of the present investigation could be utilized as the background information for such a comprehensive study programme.

Acknowledgements

Authors wish to express their sincere gratitude to the Coastal Resources Management Project (CRMP) and National Aquatic Resources Research and Development Agency (NARA) for providing financial assistance and the laboratory facilities to conduct the present study. Special thanks are also due to messers S. S. C. Peiris and H. A. R. E. Perera for their assistance given in the field.

Table 1: The estimated catch rates and the total production of shrimps for set gillnets for the periods 1993/94 and 1994/95.

Month	Average number of crafts operated/day		Average catch rate (kg/ canoe)		Total production (kg)*	
	93/94	94/95	93/94	94/95	93/94	94/95
August	06	05	0.3	0.40	36.0	40.0
September	15	06	1.1	0.80	330.0	96.0
October	10	10	0.6	0.90	120.0	180.0
November	08	12	0.4	1.50	64.0	360.0
December	09	15	0.9	0.80	162.0	240.0
January	10	20	0.5	1.40	100.0	560.0
February	12	22	0.4	1.50	96.0	550.0
March	18	16	0.5	1.05	180.0	336.0
April	10	10	0.7	0.60	140.0	120.0
May	05	05	0.2	0.50	20.0	50.0
June	00	00	0.0	0.00	00.0	0.0
July	02	03	0.1	0.40	04.0	24.0
Total					1252.0	2556.0

*20 fishing days/month was assumed for calculations.

Table 2: The estimated catch rates and the total production of shrimps in kraals for the period from October 1993 to June 1995

Month	Average number of Kraals operated/day		Catch rate (kg/operation)		Total production (kg)*	
	93/94	94/95	93/94	94/95	93/94	94/95
October	12	6	1.00	2.20	240	264
November	18	4	1.60	0.70	576	56
December	18	4	1.65	1.15	594	92
January	20	5	2.60	1.60	1040	160
February	22	8	2.70	0.70	1188	112
March	16	3	2.40	0.50	768	30
April	18	6	1.75	2.00	630	240
May	12	5	0.00	0.90	000	90
June	10	1	0.75	0.20	150	4
Total					5186	1048

*20 fishing days per month was assumed for calculations.

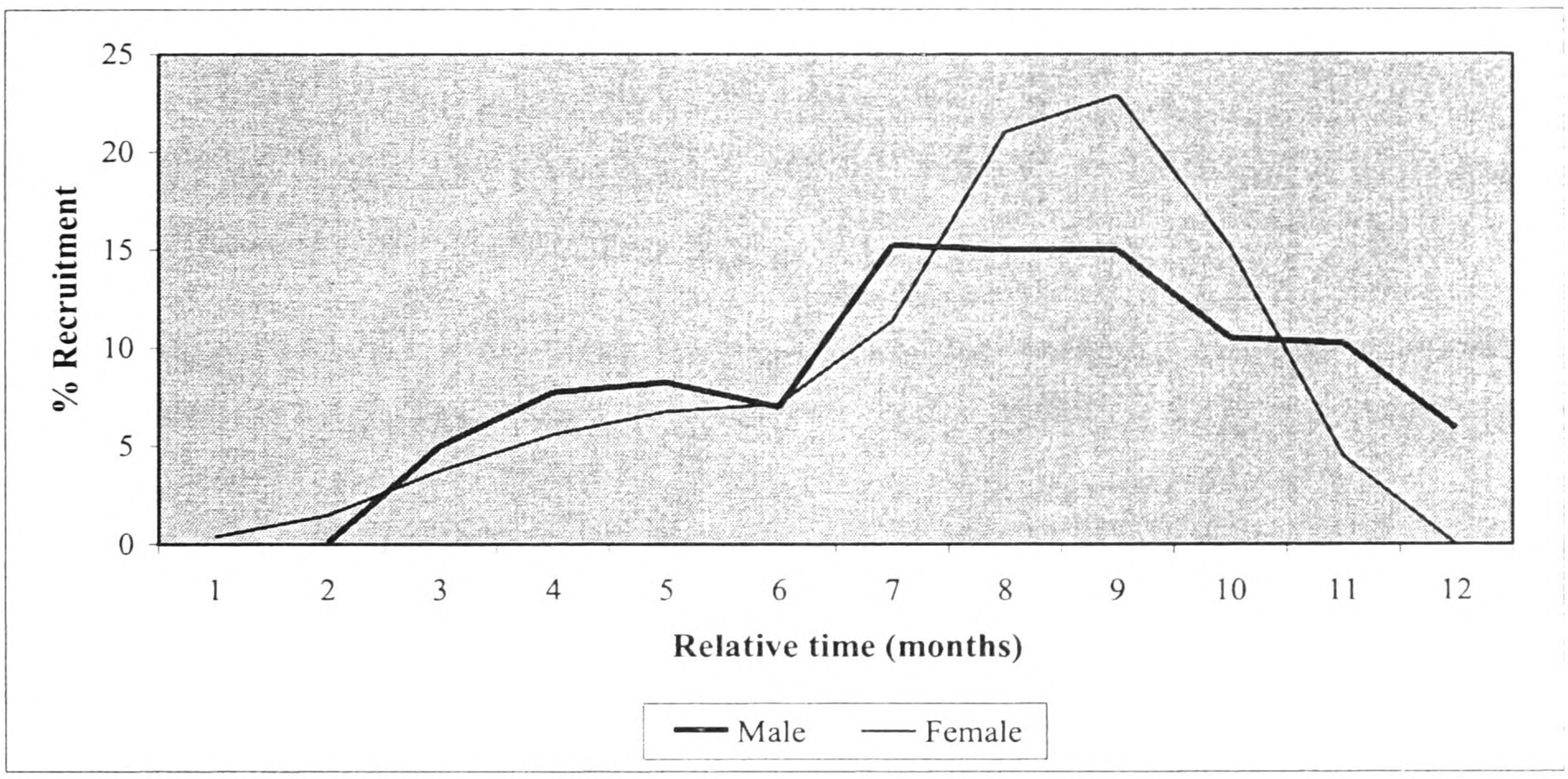
Table 3: The estimated average catch rates and the total production of shrimps for cast nets for the period from August 1993 to July 1995

Month	Average catch rate (kg/operation)		Number of Fishermen		Production (kg)*	
	93/94	94/95	93/94	94/95	93/94	94/95
August	0.50	0.55	2	6	20	69
September	0.40	0.60	6	8	48	96
October	0.75	0.85	6	8	90	136
November	0.80	0.65	3	9	48	117
December	0.80	0.50	4	10	64	100
January	0.40	0.85	1	16	08	272
February	0.60	1.00	2	16	24	320
March	0.30	0.45	3	18	18	162
April	0.40	1.00	4	10	32	200
May	0.60	0.45	3	8	32	72
June	0.60	0.03	5	2	60	12
July	0.65	0.20	5	5	65	20
Total					509	1573

*20 fishing days per month was assumed for calculations.

Table 4: Species composition and size ranges of shrimps caught by different gear types

Fishing Gear	Species composition/size range (cm)			
	P. indicus	***P. monodon***	***P. semisulcatus***	***M. monoceros***
Kraal	70% (5 - 16.0)	2%(8 - 17)	3%(96 - 10)	25%(6 - 13)
Set gillnet	95% (8 -16.5)	0.5%(8 - 17)	2% (8 - 13)	2.5%(8 - 14)
Cast net	82% (5 - 12)	2%(8 - 13.1)	3% (6 - 11.5)	13%(6.2-13.5)
Iri-weta**	86% (6 - 14)	4%(6.1 - 8.1)	1%(6.1 - 8.1)	9%(6.4- 13.4)



Note: Absolute time scale is unknown

Figure 2: Monthly relative recruitment of *P. indicus* in the Rekawa Lagoon

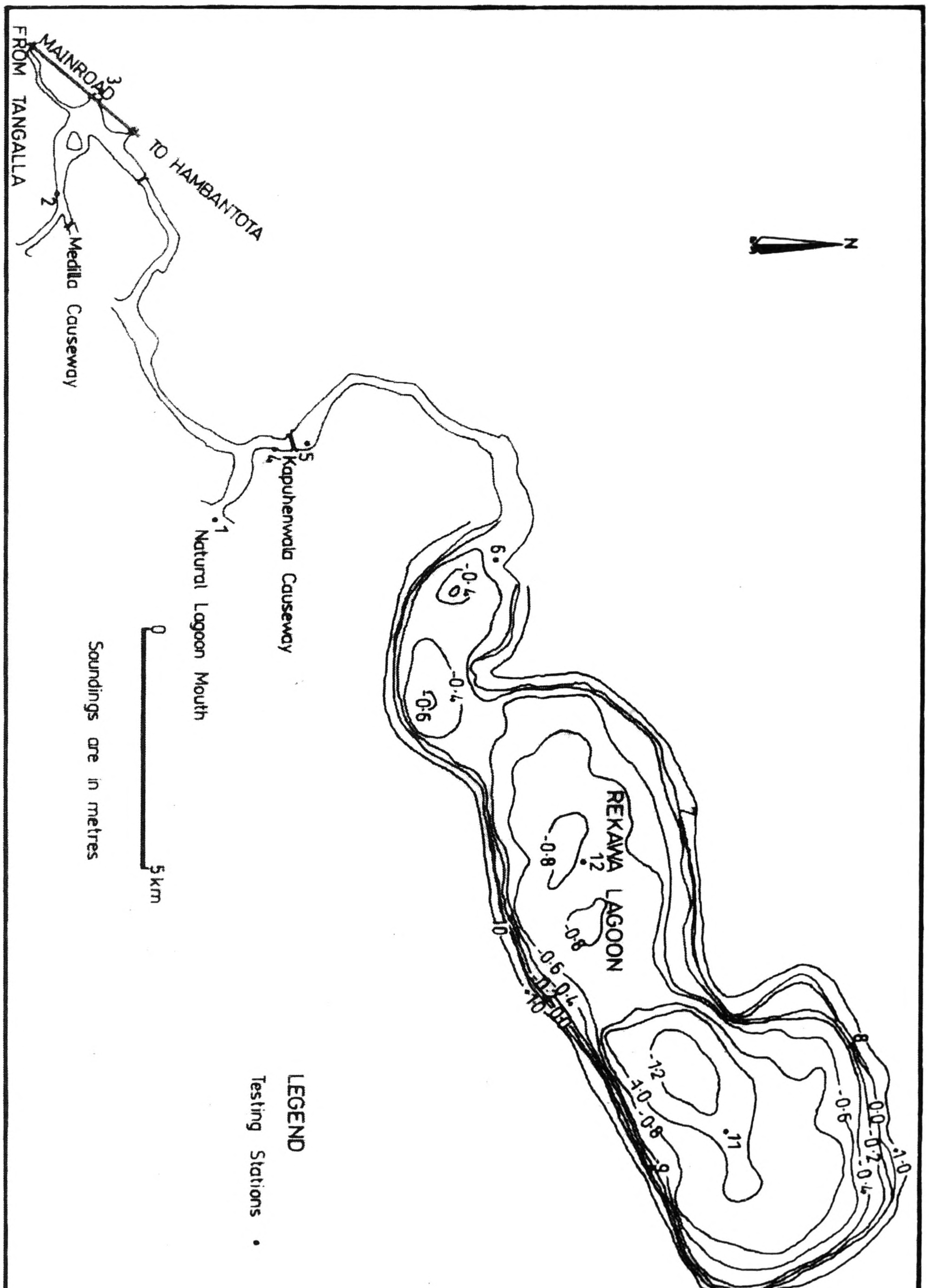


Figure 01:Bathymetry of the Rekawa Lagoon and the salinity testing locations

References

ANONYMOUS (1985). Environmental changes, Ecological conditions and sociological aspects of two lagoon eco-systems in southern Sri Lanka. M 851 (Marga Institute publication).

DAVENPORT, J., EKARATNE, S. U. K., WALGAMA, S. A., LEE, D. AND HILLS, J. M. (1999). Successful stock enhancement of a lagoon prawn fishery at Rekawa, Sri Lanka using cultured post-larvae of penaeid shrimp. *Aquaculture* : 180 (1/2) : pp 65-78

GAYANILO, F. C., JR., SORIANO, M. AND PAULY, D. (1988). A draft guide to Compleat ELEFAN software. International Centre for Living Aquatic Resources Management, Manila, Philippines. p 55

JAYAKODY, D. S. (1993). Causes for the decline of finfish and shellfish catches of three selected lagoons : Malala, Rekawa and Mawella on the south coast of Sri Lanka and the current ststus. NARA Annual Scientific Sessions, 1993. pp 11-13

JAYAKODY, D. S. AND ARIYAWANSA, M. A. (1994). Bathymetry of Rekawa lagoon. NHO/NARA Publication

JAYAKODY, D. S. (1997). Shrimp fishery and the related biological process, Rekawa lagoon, Tangalle. Working Paper No. 1/1997. Coastal Resources Management Project, Sri Lanka. p 31

JAYAKODY, D. S. AND JAYAWARDANE, P. A. A. T. (1997). The relationship between availability of life cycle stages of *Penaeus indicus* in Rekawa lagoon, its adjacent waters and sand bar formation. *The Journal of the National Aquatic Resources Agency Sri Lanka* 35 : pp 79-85

MAITIPE;- M. AND DE SILVA, S. S. (1986). The structure and function of Kraal; a fishing gear in a Sri Lankan lagoon. *Indian Journal of Fisheries* 33 : pp 137 - 143.