PRELIMINARY ASSESSMENT FOR THE SHRIMP TRAWL FISHERY OPERATED FROM KALPITIYA (SRI LANKA)

by

Michael Sanders
Stock Assessment Specialist
FAO Consultant

and

Prabath Jayasinghe
Shrimp Biologist
National Aquatic Resources Research
and Development Agency (NARA)

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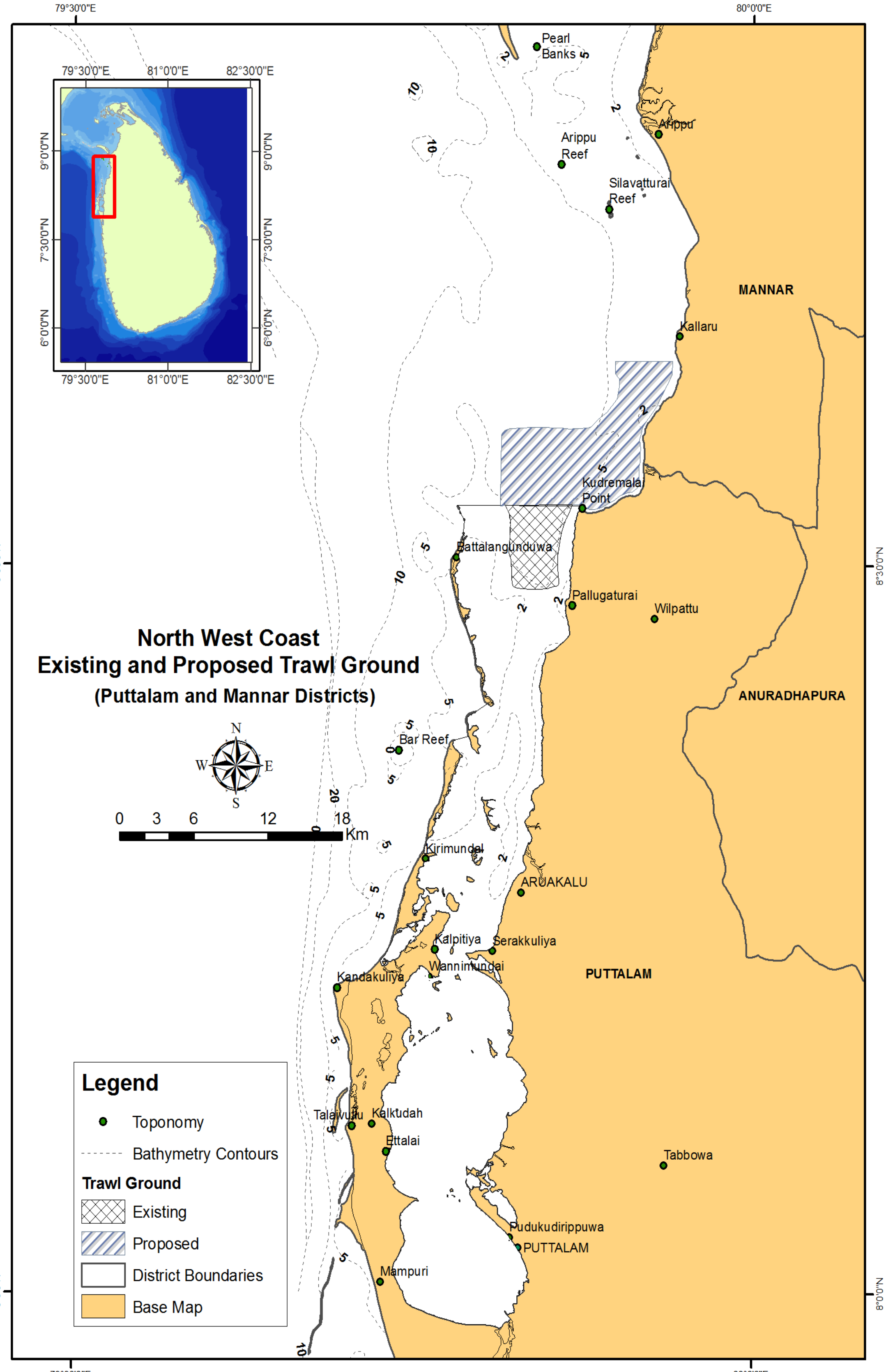
ST. ANTONYS
CEYLON SEA


North West Coast
Existing and Proposed Trawl Ground
(Puttalam and Mannar Districts)
Legend
Toponomy
Bathymetry Contours
Trawl Ground
Existing
Proposed
District Boundaries
Base Map
MANNAR
ANURADHAPURA
PUTTALAM
Pearl Banks
Arippu
Arippu Reef
Silavatturai Reef
Kallaru
Kudremalai Point
Battalangunduwa
Pallugaturai
Wilpattu
Bar Reef
Kirimundal
ARUAKALU
Kalpitiya
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82°30'0"E
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ACKNOWLEDGEMENT

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CONTENTS

INTRODUCTION

General

This study of the trawl fishery was done as a component of two jointly coordinated projects. The first is titled 'Capacity enhancement of the National Aquatic Resources Research and Development Agency (NARA) for marine resource surveys and stock assessments in selected fisheries/resources in the coastal waters of Sri Lanka'. It is funded by the Canadian International Development Agency (CIDA). The second is titled 'Support to conduct of resource surveys and stock assessments and the promotion of participatory fisheries management for selected fisheries/resources in the Tsunami affected districts' and is funded by the International Fund for Agricultural Development (IFAD). Local implementation is by the Ministry of Fisheries and Aquatic Resources (MFAR) and NARA.

The study seeks to assess the present performance of the shrimp trawl fishery based from Kalpitiya, a fishing town at the north-western end of the Puttalum Lagoon. Over recent years the fleet has comprised of nineteen 11 t boats, all constructed some thirty years ago as a component of an Asian Development Bank (ADB) Project. These are powered by inboard diesel engines of 96 to 102 HP. The fishing ground is in relatively sheltered waters of 5 to 7 m depth immediately at the entrance to the lagoon. Typically a fishing trip is of 4 days duration, with boats departing port on the morning of the first day. The journey to the ground takes approximately 3 hours. Unloading occurs in the mid-afternoon of the fourth day. There is no trawling during night-time. About 10 trawl hauls are undertaken per trip. Shooting and recovery of the nets is done manually. The ground is shared by small-scale fishermen using trammel nets, fishing at night and targeting fish.

The first part of the assessment is in respect to the well-being of the shrimp stock, particularly the extent to which it might be over-exploited or otherwise. The available data are from two sources. There were fishery-independent surveys conducted in October 2008 and January 2009, involving the charter of a fully manned trawler from the fleet. Use was also made of the commercial catch and effort data. All the data collections were undertaken by NARA and cover the period from October 2008. The second part concerns economic performance, including the financial viability of the fishery and the sharing of benefits. The available data for this were product prices, the operational costs associated with fishing, fixed costs, and the basis for sharing revenues between owners, skippers and crew. Again NARA staff collected these data, principally through questioning owners and skippers.

CATCH WEIGHTS AND FISHING EFFORTS

Introduction

A total of 129 landings were enumerated in the period from October 2008, this being about 15 % of the total landings for the period. At the time of unloading the trawlers, catch weights by species group were recorded, and skippers were questioned about the fishing effort. The catch and effort data for the enumerated boats were raised by the estimated total number of landings in each month. The latter derived from raising the number of landings recorded for a sample of boats. It was assumed that only 17 of the 19 trawlers were operated in each month, based on advice obtained during interviews. The estimates obtained for the monthly catch weights, fishing efforts and catches per unit effort (CPUEs) are given in Table 1.

Catches, Efforts and CPUEs

The fleet catch for the year was 444 t, comprised of 109 t of shrimp and 335 t of fish (small quantities of cuttlefish, squid and crab included). *Penaeus semisulcatus* was by far the most abundant shrimp species, accounting for some 87 % of the total. The other large shrimp in the catches were *P. indicus*, *P. merguensis,* and *P. monodon*. Of the small shrimp *Metapenaeus moyebi* was most abundant at 77 %. The others in this category were *M. dobsoni*, *M. elegans*, *M. monoceros, M. ensis* and *M. affinis*. *Leoignathus* spp. (pony fishes) accounted for some 43 % of the fish. The 'prime fish' species were cuttlefish, squid, crab, pomfrets, and barracudas. Almost nothing was discarded at sea. The 'salted fish' were those destined for use in animal food production. These were the least valuable component, accounting for some 26 % of the fish catch. The 'other fish' category was comprised of mid-value species. These accounted for another 25 %.

There was a substantial degree of seasonality particularly for the shrimp landings. Fleet catches were highest in March and April, and again in October and November. Both the fishing efforts and CPUEs were highest in these months. They are the months associated with monsoonal rains. The least productive months were January and February. Most of the boats were switched to fish trawling in these months due to the low CPUEs for shrimp. This was achieved by replacing the shrimp trawl nets with fish trawls. Almost no shrimp were caught from those boats targeting fish. Not surprisingly the highest CPUEs for fish were in January and February.

The total effort for the year was 803 landings (or trips) and 7,638 hauls. This equates to nearly 10 hauls per trip. It has been assumed that each of the nineteen boats comprising the fleet was operated for 11 months in the year. This gives an average of 3.84 landings per boat during these months, and accords with standard practice for fishing trips to be of four days duration. The trawl grounds are vacated during the night in favour of the small-scale trammel net fishermen. This arrangement resulted from a negotiation in 1989 when the trawler boat owners agreed to cease the previous practice of fishing during both day and night.

The average CPUE for shrimp of 14.3 kg/haul is from dividing the annual catch weight by the total number of hauls. As a reflection of the abundance of shrimp, this is an under-estimate, due to much of the effort in January and February being targeted at fish. After excluding these efforts, the estimated CPUEs from shrimp trawling were 10.0 kg/haul and 13.3 kg/haul respectively in those months. The adjusted average CPUE for the year was 15.79 kg/haul.

Discussion

These catches and efforts are the most comprehensive so far reported for the fishery. The ability to enumerate was assisted by there being relatively few landings per day. Catches were sorted and boxed on-board prior to landing, and readily able to be observed when unloaded. The premises of the small number of buyers were nearby. The enumerators copied the weights as recorded by the buyer. Skippers were invariably on hand and able to be interviewed. Nevertheless the estimates as reported here are not without error. Furthermore, there is no recognition of the quantities of shrimp and fish caught from the same ground by the trammel net fishermen. It was claimed they target fish exclusively. Nevertheless, it would be desirable that such data are collected in the future.

Table 1: Catch weights, fishing efforts and CPUEs.

	Oct '08	Nov	Dec	Jan '09	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year	Oct
Catch Weights (kg)														
P. semisulcatus	10,231	10,197	8,116	1,123	3,207	18,182	14,414	6,368	4,412	4,112	7,778	6,919	95,060	10,918
Other large shrimp	763	510	418	0	265	231	284	690	741	663	901	845	6,310	833
M. moyebi	292	1,268	258	0	123	313	139	1,210	1,003	556	373	484	6,019	722
Other small shrimp	226	195	151	0	79	118	63	262	131	156	277	107	1,765	314
shrimp totals	11,512	12,170	8,942	1,123	3,673	18,844	14,900	8,531	6,287	5,487	9,330	8,355	109,154	12,786
Leoignathus spp.	12,827	15,750	17,133	17,883	20,147	10,831	8,943	4,508	12,108	6,588	6,465	9,690	142,874	11,630
Prime fish	1,558	1,924	1,686	800	1,361	1,440	3,121	4,522	1,334	938	1,889	1,494	22,067	1,806
Salted fish	6,267	6,601	6,122	0	3,547	2,087	6,439	8,534	7,703	6,969	13,459	18,126	85,852	27,940
Other fish	6,551	8,270	5,994	14,700	12,490	9,303	3,905	5,433	4,550	4,353	3,263	5,494	84,307	2,623
sub-totals	27,202	32,545	30,935	33,383	37,545	23,662	22,408	22,998	25,695	18,847	25,077	34,804	335,100	43,998
all species totals	38,714	44,715	39,877	34,507	41,218	42,507	37,308	31,528	31,981	24,334	34,407	43,159	444,254	56,784
Fishing Efforts														
No. of Landings	80	82	77	50	63	82	79	68	59	50	52	61	803	78
No. of Hauls	698	779	685	500	611	835	766	707	439	487.5	563	566	7,638	718
CPUEs (kg/landing)														
P. semisulcatus	128	124	105	22	51	222	182	94	75	82	150	113	118	140
Other large shrimp	10	6	5	0	4	3	4	10	13	13	17	14	8	11
M. moyebi	4	15	3	0	2	4	2	18	17	11	7	8	7	9
Other small shrimp	3	2	2	0	1	1	1	4	2	3	5	2	2	4
shrimp totals	144	148	116	22	58	230	189	125	107	110	179	137	136	164
Leoignathus spp.	160	192	223	358	320	132	113	66	205	132	124	159	178	149
Prime fish	19	23	22	16	22	18	40	67	23	19	36	24	27	23
Salted fish	78	81	80	0	56	25	82	126	131	139	259	297	107	358
Other fish	82	101	78	294	198	113	49	80	77	87	63	90	105	34
fish totals	340	397	402	668	596	289	284	338	436	377	482	571	417	564
all species totals	484	545	518	690	654	518	472	464	542	487	662	708	553	728

CPUEs (kg/haul)														
P. semisulcatus	14.7	13.1	11.8	2.2	5.2	21.8	18.8	9.0	10.0	8.4	13.8	12.2	12.4	15.2
Other large shrimp	1.1	0.7	0.6	0.0	0.4	0.3	0.4	1.0	1.7	1.4	1.6	1.5	0.8	1.2
M. moyebi	0.4	1.6	0.4	0.0	0.2	0.4	0.2	1.7	2.3	1.1	0.7	0.9	0.8	1.0
Other small shrimp	0.3	0.3	0.2	0.0	0.1	0.1	0.1	0.4	0.3	0.3	0.5	0.2	0.2	0.4
shrimp totals	16.5	15.6	13.0	2.2	6.0	22.6	19.4	12.1	14.3	11.3	16.6	14.8	14.3	17.8
Leoignathus spp.	18.4	20.2	25.0	35.8	33.0	13.0	11.7	6.4	27.6	13.5	11.5	17.1	18.7	16.2
Prime fish	2.2	2.5	2.5	1.6	2.2	1.7	4.1	6.4	3.0	1.9	3.4	2.6	2.9	2.5
Salted fish	9.0	8.5	8.9	0.0	5.8	2.5	8.4	12.1	17.5	14.3	23.9	32.0	11.2	38.9
Other fish	9.4	10.6	8.7	29.4	20.4	11.1	5.1	7.7	10.4	8.9	5.8	9.7	11.0	3.7
fish totals	39.0	41.8	45.1	66.8	61.4	28.3	29.2	32.5	58.5	38.7	44.5	61.4	43.9	61.3
all species totals	55.5	57.4	58.2	69.0	67.4	50.9	48.7	44.6	72.8	49.9	61.1	76.2	58.2	79.1

BIOMASS ESTIMATION

Introduction

Two sources of data were available to enable the estimation of shrimp biomass. The first were from 'fishery-independent' surveys conducted in October 2008 and January 2009. A fully manned trawler from the fleet was chartered for the purpose. During the October 2008 survey there were 15 hauls at a spread of locations across the fishing ground, with the direction of trawling as decided by the skipper. Forty two hauls were undertaken during the January 2009 survey, all in a north to south or south to north direction.

The trawl net used was as standard for the fleet, with a horizontal distance between the doors of 14.2 m, and between the wings of 9.4 m (Binduhewa, 2009)[1]. Fishing operations were conducted as if trawling commercially, except for the haul duration. In the earlier survey the length of haul were mostly around 1,200 m, as determined by GPS readings. Hauls were of longer duration during the later survey, with distances covered ranging from 1,686 m to 2,173 m. As defined here each haul commenced immediately following the shooting of the net, and ceased immediately prior to the recovery of the net.

Species, lengths, weights and other biological data were determined in respect to the catch from each haul. Of most relevance to the estimation of shrimp biomass were the catch weights. The 'nominal' area of seabed covered during a haul is the product of trawl net width and haul length. The 'effective' area is the product of the 'nominal' area and the haul efficiency. Haul efficiency was defined as the percentage of shrimp in the path of the net that were caught.

In the initial analysis hauls were assumed to be 100% efficient and the trawl net width to be 9.4 m. Dividing each catch weight by the relevant 'effective' area covered provided estimates for the biomass density for each haul. These densities are shown in Figures 1 and 2. The shrimp biomass over the entire exploited ground was then estimated as the mean of the densities multiplied by the area of the ground. The latter had previously been determined with reference to charts as 26 km^2.

The second source of data was the monthly mean CPUEs from the commercial operations of the fleet. These were as catch weights per haul. According to interviews the typical duration of a haul was 3 hours (with an additional 25 minutes required for hand hauling and shooting of the net). Assuming the width of the trawl track as 9.4 m, the 'nominal' area of seabed covered per haul was estimated as the product of this width, the 3 hour haul duration, and the trawling speed. The latter was assumed to be 4 km/hr, as given in Binduhewa (2009) and confirmed from the timing of hauls while undertaking the 'fishery-independent' surveys.

Accordingly the 'nominal' area is 0.1128 km^2 (= 9.4/1000 x 3 x 4) and the same as the 'effective' area when assuming 100% efficiency. The biomass density for each month was determined by dividing the catch weights per haul by the 'effective' area. The product of the densities and the 26 km^2 area of the fishing ground in turn provided estimates for the shrimp biomass. The estimates of biomass in each month from the CPUEs, along with the biomass as determined from the surveys are given in Table 2. The associated worksheet is given in Appendix I.

[1] Binduhewa, C. Bottom trawl survey for shrimp in Kalpitiya area. CENARA Project document. February 2009.

Biomass Estimates

The estimate of biomass from the October 2008 survey was 2.29 t, when 100 % trawl net efficiency is assumed. Repeating the calculations with efficiencies of 80 % and 60 % gave biomass estimates of 2.87 t and 3.82 t respectively. The biomass from the January 2009 survey was 1.33 t when 100 % efficiency was assumed, and 1.66 t and 2.22 t with efficiencies of 80 % and 60 % respectively. Those determined from the trawl fleet CPUEs range from 2.30 t in January 2009 and 5.20 t in March. These are with an assumed 100 % efficiency. They are highest in the most productive months of March, April, October and November. Table 2 also includes biomass values which are 25 % greater and lower. These were used in the analyses described in the following section.

Discussion

Biomass from the surveys are lower than from the fleet CPUEs by about 20 - 25 %, when an efficiency of 100 % is used. There are several reasons why this might be so. The survey hauls were spread across the trawl ground generally, while the fleet would seek to trawl on local concentrations of shrimp. This biasing effect may not be large, however, having in mind the difficulty of remaining on a local concentration when the distance covered during a commercial haul is about 12 km.

The time of day when hauling took place could also produce a biasing. The advice from interviews was that CPUEs from early and late morning hauls were generally higher. One interviewee claimed that night-time CPUEs were as much as 25 % higher than from day-time hauls. A commercial trawler on a four day trip would undertake six hauls during the more productive early and late day-time hours; the afternoon haul on the first three days, and the morning haul on the last three days. As indicated all the hauls during the surveys were during the middle of the day. As such, the trawl haul efficiency during the surveys must be less than the assumed 100 %.

The findings presented so far are indicative of the shrimp stock being heavily exploited. The monthly catch weights are some 2 to 4 times the respective biomass values. The same is reflected by comparing the area of seabed covered by the trawl fleet in each month with the total area of the fishing ground. The 'nominal' area covered during a single haul (0.1128 km^2) multiplied by the number of hauls in each month gives values which are again about 2 to 4 times the area of the ground. When considering the annual coverage, the fishing ground is being trawled over at least thirty times.

Figure 1: Shrimp densities in October 2008.

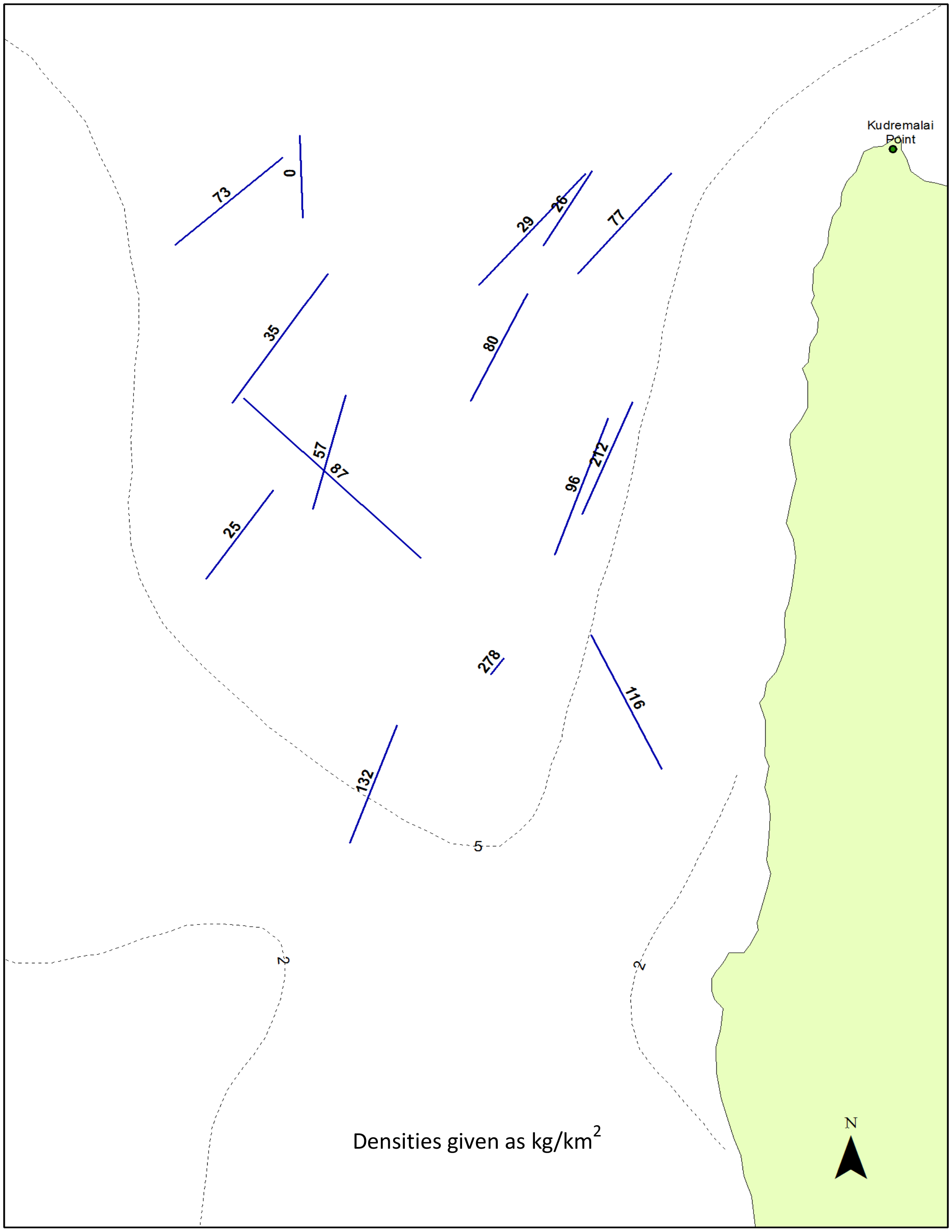


Figure 2: Shrimp densities in January 2009.

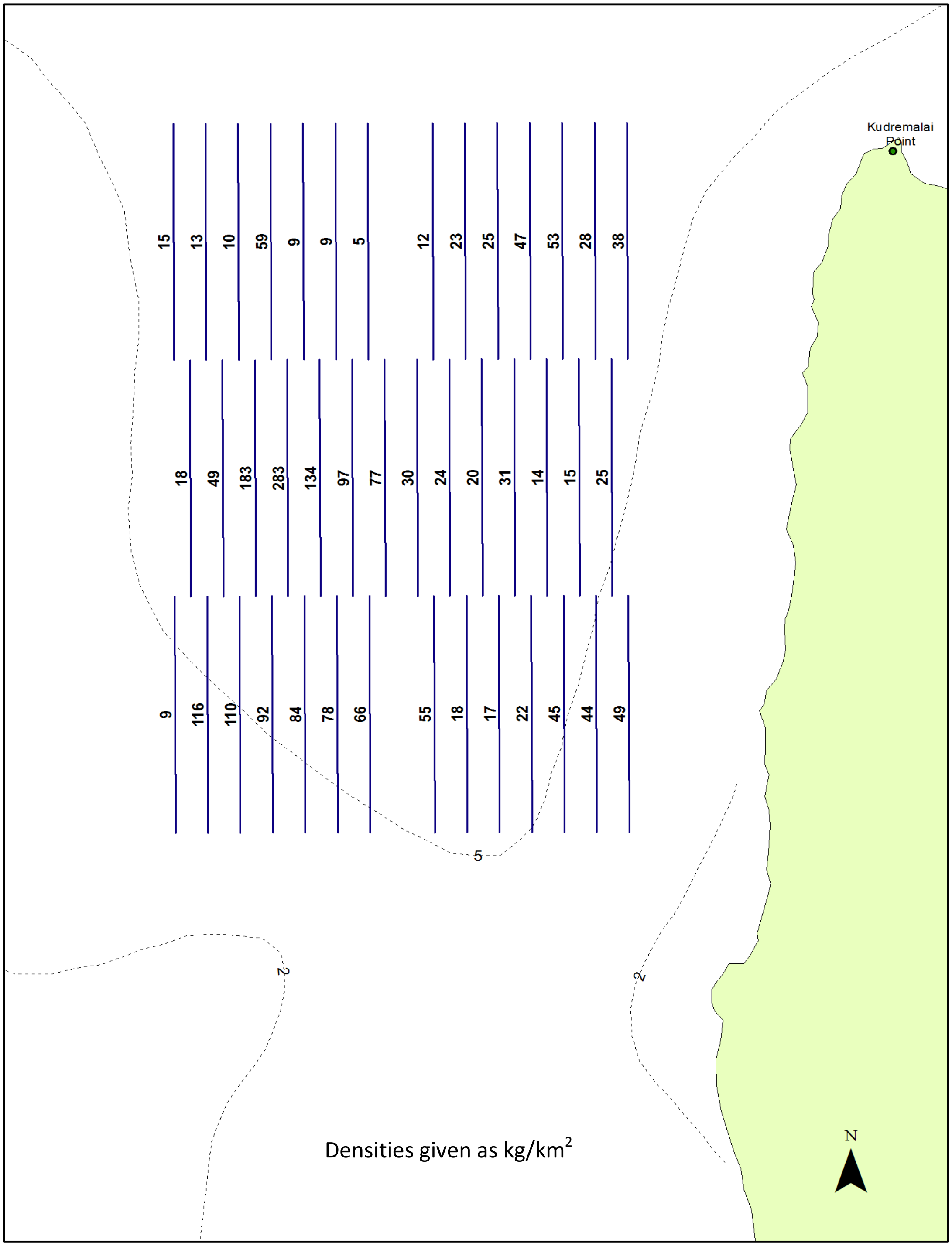


Table 2: Biomass estimates.

	Oct' 08	Nov	Dec	Jan '09	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Biomass from fleet CPUEs:						(tonnes)							
- haul efficiency 100%	3.80	3.60	3.01	2.30	3.07	5.20	4.48	2.78	3.30	2.60	3.82	3.40	4.10
- biomass increased by 25 %	4.75	4.50	3.76	2.88	3.83	6.50	5.60	3.48	4.13	3.25	4.77	4.25	5.13
- biomass decreased by 25%	2.85	2.70	2.26	1.73	2.30	3.90	3.36	2.09	2.48	1.95	2.86	2.55	3.08
Biomass from surveys:													
- haul efficiency 100%	2.29			1.33									
- haul efficiency 80%	2.87			1.66									
- haul efficiency 60%	3.82			2.22									

YIELD ASSESSMENT

Introduction

This section seeks a more comprehensive examination of the current exploitation levels. The important inputs were the monthly biomass estimates from the fleet CPUEs given in the previous section. These were taken as being mean values for each of the months in question. In all months the values are less than the observed catch weights. As such it can be presumed that the monthly catches are highly dependent on the recruitment of additional shrimp biomass during the month, probably from nursery areas within the Puttalum Lagoon. The assessment attempts to give due recognition to this phenomena of inward migration of shrimp biomass occurring in each month.

Method

The first procedure involved plotting the mean biomass values on a chart against the mid-point of the month. A 'smoothed' line joining all the mean values was then drawn, and the biomass at the beginning and end of each month read directly from the chart. The next procedure was to estimate the weight of shrimp recruiting to the biomass in each month. It was presumed that the end-of-month biomass is the sum of the start-of-month biomass and the recruitment biomass, less the combined loss of biomass from capture and natural deaths. An underlying assumption is that there is no outward migration.

In respect to the above, the loss of biomass from capture in each month is the monthly catch weights given in an earlier section. The loss of biomass from natural deaths was estimated for each month from multiplying the natural mortality coefficient (M) and the respective mean monthly biomass. A value of M = 2.7 (annual) was used for this purpose. It is from Sanders, Jayawardena and Ediriweena (2000)[2] and relevant to *P. semisulcatus*, by far the most abundant species in the catches.

The final procedure required formulating a mathematical 'spreadsheet' model of the fishery. This was to enable prediction of likely yields (annual catch weights) for a range of annual fishing efforts (trawl hauls) spanning contemporary values. The required inputs were the start-of-year biomass, the recruitment biomass in each month, the catchability coefficient ('effective' area per haul divided by the area of the trawl ground), and the assumed natural mortality coefficient. The value used for the catchability coefficient was $q = 4.23 \times 10^{-3}$ (= 0.1128 km^2/26 km^2). The values inside the brackets are from the earlier section.

The model calculations commence with the chosen start-of-year biomass (read from the above-mentioned chart). In respect of each chosen level of fishing effort, the catch weights, natural death weights and end-of-month biomass were estimated in a month-to-month stepwise process ceasing at year's end. As an approximation to the recruitment of biomass being continuous within each month, the months were sub-divided, with the recruitment occurring at the start of the 2nd, 3rd and 4th intervals.

The analysis was initially undertaken using the biomass values determined with a trawl net efficiency of 100 %, and then repeated with biomass values both 25 % higher and 25 % lower. The

[2] Sanders, M.: Jayawardena, A.: Ediriweera, S. Preliminary assessment for the shrimp fisheries of the Negombo Lagoon (Sri Lanka). *FAO Fisheries Circular*. No. 958. Rome, FAO. 2000. 98p.

resulting yield and CPUE plots for a range of fishing effort multipliers from zero to twice the contemporary effort are given in Figure 3. Example worksheets, including the model spreadsheet and mathematical equations, are given in Appendices II to IV.

Predictions of Yield and CPUE

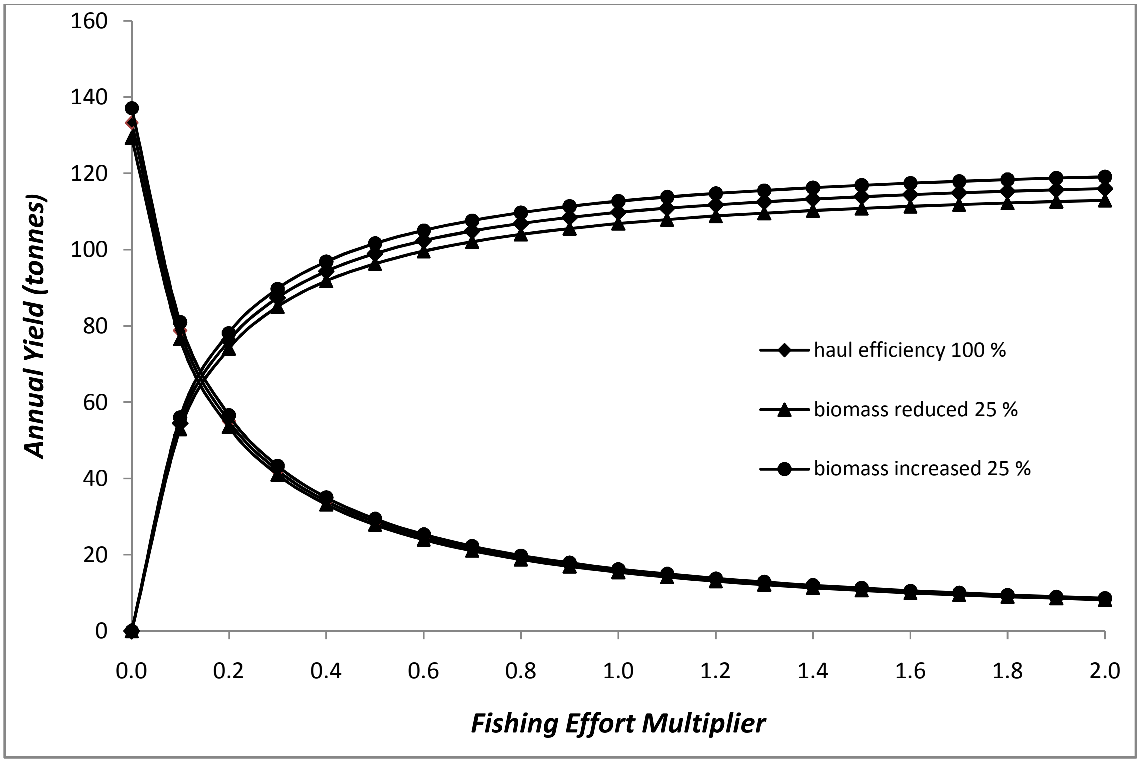
The main finding is confirmation that the shrimp stock is heavily exploited. Any attempts to increase annual fishing efforts from present values would result in very little additional yield. In the extreme case of doubling the effort the estimate of additional yield is some 6 t. The associated lowering of fleet CPUE is close to 50 %, from the current 15.8 kg/haul to 8.4 kg/haul. The outcome is essentially the same for all of the three biomass scenarios depicted. As expected, lower fishing efforts are associated with lower yields, although the decline is modest for fishing efforts down to about half the current effort. In the event of a 50 % reduction in fishing effort the estimated fleet CPUE increases to 28.6 kg/haul. This is almost a doubling of the present fleet CPUE.

Discussion

Underlying this assessment is the assumption that the recruitment of shrimp biomass in each month remains generally constant over the years. Unfortunately there are no catch and effort data for prior years upon which to judge this assumption. One owner thought there had been a slight decline. On the other-hand none of those interviewed identified declining stock as a management issue. The extent to which the assumption is reasonable will be revealed over time. It will be important for this purpose that comprehensive statistics of catches and efforts are collected into the future.

A conclusion about whether the stock is over-exploited or otherwise will have both a biological and a financial component, and be dependent on the management objectives for the fishery. If management is seeking to maximise long-term employment then the current high levels of exploitation might well be appropriate. The caveat to this is that the fishery participants (boat owners, skippers and crews) are receiving adequate financial remuneration. This matter is investigated in the following section.

Figure 3: Yield and CPUE curves.



FINANCIAL ANALYSIS

Introduction

This section concerns the financial performance of a 'standard' trawler. In fact the fleet is highly standardised, with all vessels being of generally the same length, design, and horsepower. It was assumed the 'standard' boat is operated for 11 months and undertakes 3.84 trips per month. The latter is the fleet average from an earlier section. Shrimp and fish prices and the costs of fishing operations and investments were from interviews with skippers and owners. These were applied to the catch composition and CPUEs from the fleet data. The results are presented as cash flows over a 10 year period, with each of the fishing operations, CPUEs, product prices and costs assumed to remain constant. Annual net remuneration to each of the owner, skipper, and crew were the outputs of principal concern. Internal rates of return (IRR) and the net present value (NPV) were also estimated. The cash flow spreadsheet is shown in Table 3.

Gross Revenue

The estimate of gross revenue for a 'standard' trawler is close to Rs 4.4 million. This is equivalent to about US$ 38.5 thousand, assuming the current exchange rate for changing rupees into dollars of US$ 1 = Rs 114. The contribution from shrimp is 75 %. The product prices used were 600 Rs/kg for large shrimp and 200 Rs/kg for small shrimp. In respect to the fish component, nearly 48 % of the fish revenues were from the *Leoignathus* spp. (pony fishes). The product price used for these was 70 Rs/kg. Despite the substantial quantities landed, the revenues from 'salted' fish are small, at less than 3 % of the fish component.

Total Costs

The total costs estimate is Rs 3.3 million, and equivalent to about US$ 29 thousand. Almost 40 % of this was for trip supplies of fuel and oil, ice, salt, water, and food. Remuneration to the skipper and crew was another 42 %. Of the remaining costs the most important was for on-going repairs, maintenance, and replacement. These were some 15 % of the total. More than half this amount was for the annual purchase of nets and associated hauling ropes. Costs associated with insurance, boat registration and fishing licences were negligible. The depreciation rates applied to the hull (with superstructure) and engine were 5 % and 10 % respectively. These were against replacement costs given during interviews of Rs 1.8 million and Rs 0.4 million. In fact none of the original boats have been replaced since constructed thirty years ago.

Remunerations

The standard practice is for 40 % of net operating revenues to be equally divided between the skipper and crew, with the skipper then receiving an additional 5 % from the owner's share as a bonus. Net revenue was determined as gross revenue less the trip costs for fuel and oil, ice, water, salt and food. On this basis the skipper of the 'standard' boat receives Rs 565 thousand, while each of the crew receives Rs 411 thousand. These are equivalent to about US$ 5.0 thousand and US$ 3.6 thousand respectively. Almost universally the skippers are non-owners. The return to the owner is after subtracting total costs, including a depreciation charge for future investment in a replacement boat and gear, from the gross revenue. On this basis the owner of a 'standard' boat would receive

Rs 1,073 thousand, equivalent to US$ 9.4 thousand. This can be considered as the return to investment and management.

Internal Rate of Return

The estimate of IRR is quite high at 49 %. It looks less attractive when considering that bank interest charges for investments were around 24 % until very recently. Bank interest on commercial loans is now 12 %, about the same as for 'known' borrowers seeking loans from within the local community. IRR is a measure of financial performance from the viewpoint of potential investors. It has little relevance to this fishery where the opportunities being sought have more to do with subsistence and employment. The entry of additional boats is in fact prevented by the Kalpitiya Trawlers Association. The estimated NPV is Rs 4.8 million, which is very similar to the Rs 5 million which one owner suggested would be the price sought if he were to sell his boat with a continuing entitlement to the fishery.

Discussion

The remunerations to skippers and crews are considered within the local community to be quite high. It was claimed at interview that they were greater than available from similarly skilled occupations within Kalpitiya. Owners are considered also to be well remunerated in respect to their investments. In most cases the boats were purchased a long time ago, often with government assistance. None of the persons interviewed during the study considered that the fishery lacked financial viability.

In the previous section it was shown that reducing the number of boats would substantially increase catch rates and hence viability without much loss of yield. The downside would be reduced employment within the fishery. Also, unless otherwise prevented, the present difference in earnings between the fishery participants and the general community would become larger. These matters of relevance to future management are discussed again in the next section.

Table 3: Cash flow spreadsheet.

				Year 0	1	2	3	4	5	6	7	8	9	10
1. Definition of fishery change scenarios														
assumed annual change in catch rates		0	%											
estimated catch rate index					100	100	100	100	100	100	100	100	100	100
projected catch rates	large shrimp	126.3	kg/trip		126	126	126	126	126	126	126	126	126	126
	small shrimp	9.7	kg/trip		10	10	10	10	10	10	10	10	10	10
	Leoignathus spp.	177.9	kg/trip		178	178	178	178	178	178	178	178	178	178
	other prime fish	27.5	kg/trip		28	28	28	28	28	28	28	28	28	28
	salted fish	106.9	kg/trip		107	107	107	107	107	107	107	107	107	107
	other fish	105.0	kg/trip		105	105	105	105	105	105	105	105	105	105
assumed annual change in product price		0	%											
estimated price index					100	100	100	100	100	100	100	100	100	100
observed product prices	large shrimp	600	Rs/kg		600	600	600	600	600	600	600	600	600	600
	small shrimp	200	Rs/kg		200	200	200	200	200	200	200	200	200	200
	Leoignathus spp.	70	Rs/kg		70	70	70	70	70	70	70	70	70	70
	other prime fish	200	Rs/kg		200	200	200	200	200	200	200	200	200	200
	salted fish	7	Rs/kg		7	7	7	7	7	7	7	7	7	7
	other fish	70	Rs/kg		70	70	70	70	70	70	70	70	70	70
2. Efforts and estimated catch weights														
months fishing		11	months/yr											
fishing trips/month		3.842	trips/month											
catch weights (kg)	large shrimp				5338	5338	5338	5338	5338	5338	5338	5338	5338	5338
	small shrimp				410	410	410	410	410	410	410	410	410	410
	Leoignathus spp.				7518	7518	7518	7518	7518	7518	7518	7518	7518	7518
	other prime fish				1162	1162	1162	1162	1162	1162	1162	1162	1162	1162
	salted fish				4518	4518	4518	4518	4518	4518	4518	4518	4518	4518
	other fish				4438	4438	4438	4438	4438	4438	4438	4438	4438	4438
3. Gross revenue (Rs'000)														
	large shrimp				3203	3203	3203	3203	3203	3203	3203	3203	3203	3203
	small shrimp				82	82	82	82	82	82	82	82	82	82
	Leoignathus spp.				526	526	526	526	526	526	526	526	526	526
	other prime fish				232	232	232	232	232	232	232	232	232	232
	salted fish				32	32	32	32	32	32	32	32	32	32
	other fish				311	311	311	311	311	311	311	311	311	311
	Total				4386	4386	4386	4386	4386	4386	4386	4386	4386	4386

4. Investment (Rs'000)														
	hull (11 tonne)			1,800										
	engine (96 HP diesel inboard)			400										
	fishing gear (3 trawl nets, plus ropes and doors)			210										
	Total			2,410										
5. Fuel & oil costs (Rs'000)														
fuel	fuel consumption	300	litres/trip		926	926	926	926	926	926	926	926	926	926
oil	fuel price (diesel)	73	Rs/litre		39	39	39	39	39	39	39	39	39	39
	oil consumption	3	litres/trips											
	oil price	310	Rs/litre											
6. Other trip costs (Rs'000)														
	ice (15 x 50 kg blocks x Rs140/block)	2,100	Rs/trip		89	89	89	89	89	89	89	89	89	89
	Food	3,000	Rs/trip		127	127	127	127	127	127	127	127	127	127
	water (70 litres @ 2.2 Rs/l for drinking and 300 litres @ 0.5 Rs/l for washing)	304	Rs/trip		13	13	13	13	13	13	13	13	13	13
	Salt	1,600	Rs/trip		68	68	68	68	68	68	68	68	68	68
	other (extra labour for unloading)	1,000	Rs/trip		42	42	42	42	42	42	42	42	42	42
7. Crew payments (Rs'000)														
	Crew share (shared by 3 persons)	40	% of net trip revenue		1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
	Skipper bonus	5	% of net trip revenue		154	154	154	154	154	154	154	154	154	154
	Crew (incl.. skipper)	3	persons											
8. Repairs/Maintenance/Replacement Costs (Rs'000)														
	hull	10	% of investment		180	180	180	180	180	180	180	180	180	180
	engine (reconditioned every 4 years)	400,000	Rs/4 years		100	100	100	100	100	100	100	100	100	100
	fishing gear (replaced yearly)	100	% of investment		210	210	210	210	210	210	210	210	210	210
9. Registration and licences (Rs'000)														
	boat registration	500	Rs/vessel		1	1	1	1	1	1	1	1	1	1
	fishing licences	250	Rs/vessel		0	0	0	0	0	0	0	0	0	0
10. Insurance costs (Rs'000)														
	total boat loss incl. crew third party	2,000	Rs/yr		2	2	2	2	2	2	2	2	2	2
11. Depreciation costs (Rs'000)														
	Hull	5	% of investment		90	90	90	90	90	90	90	90	90	90
	Engine	10	% of investment		40	40	40	40	40	40	40	40	40	40
12. Total costs (Rs'000)					3313	3313	3313	3313	3313	3313	3313	3313	3313	3313

13. Return to owner's investment and management (Rs'000)			1073	1073	1073	1073	1073	1073	1073	1073	1073	1073
14. Discounted cash flow analysis (Rs'000)												
inflow												
	gross revenue		4386	4386	4386	4386	4386	4386	4386	4386	4386	4386
	capital recovery											1300
	total inflow		4386	4386	4386	4386	4386	4386	4386	4386	4386	5686
outflow												
	Investment	2,410	0	0	0	0	0	0	0	0	0	0
	fuel & oil costs		965	965	965	965	965	965	965	965	965	965
	other trip costs		338	338	338	338	338	338	338	338	338	338
	crew costs (incl. skipper)		1387	1387	1387	1387	1387	1387	1387	1387	1387	1387
	repairs/maintenance/replacement		490	490	490	490	490	490	490	490	490	490
	registration and fishing licences		1	1	1	1	1	1	1	1	1	1
	Insurance		2	2	2	2	2	2	2	2	2	2
	total outflow		3183	3183	3183	3183	3183	3183	3183	3183	3183	3183
net cash flow to investment		-2,410	1203	1203	1203	1203	1203	1203	1203	1203	1203	2503

internal rate of return (IRR) 49%

net present value (NPV) 4,804 Rs'000 (assumed rate = 12.00%)

FISHERY PROFIT

Introduction

Fishery profit as defined here is the difference between the combined gross revenue of the fleet and the associated total costs. The matter to be investigated is the extent that fishery profit is being foregone by maintaining the present number of boats in the fishery. This required estimating fishery profit not just for the present nineteen boats, but also for a range of fleet size. The biological input to the analysis utilised the output from the earlier section where shrimp yields and CPUEs were estimated for a range of fishing efforts.

In respect to each choice of boat numbers the proportions of large and small shrimp, and the various categories of fish, were kept constant as presently observed. Product prices were also kept constant at present values. It was necessary to assign an annual remuneration to each of the owners, skippers, and crews. This was fixed somewhat arbitrarily at 90 % of present remunerations. The estimates for each of fleet revenues, total costs, and fishery profit are given in Figure 4. An example worksheet (for a boat number multiplier of 1) is given in Appendix V.

Fleet Gross Revenues

As anticipated the plot of gross revenues has the same shape as the earlier plot of shrimp yields. It rises sharply then quickly flattens out. At the present fleet size, when the boat number multiplier is 1, the estimate of gross revenue is Rs 83 million, and equivalent to US$ 731 thousand. It seems that boat numbers could be reduced substantially without much loss of revenues, while having more boats would result in very little additional revenues.

Fleet Total Costs

The fleet costs increase in a straight line in proportion to the number of boats. It crosses the plot of gross revenues at only slighter greater than the present fleet size. This results from having fixed the remunerations to the owners, skippers, and crews at 90 % of present values. The plots would have crossed at exactly the present number of boats if the remunerations had been fixed at 100 % of present values.

Fishery Profit

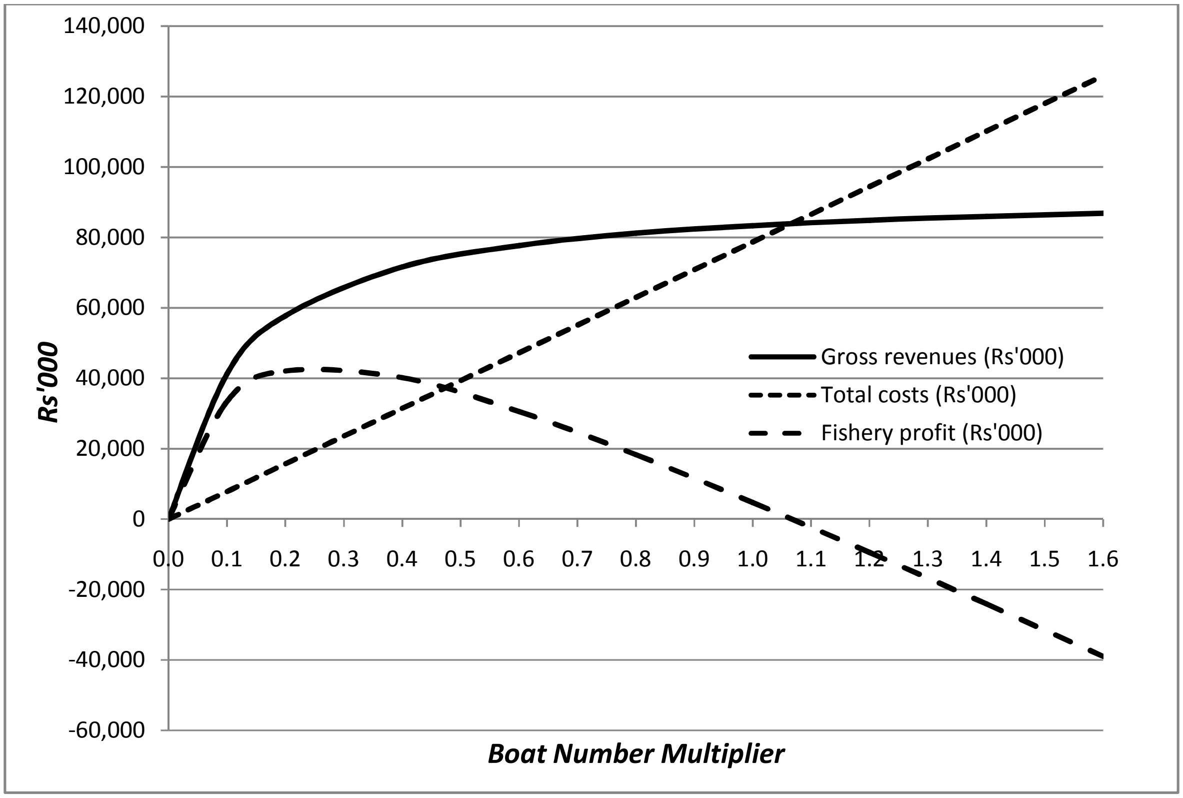
Fishery profit is presently close to zero. An increase in boat numbers would quickly cause fishery profits to be negative, unless there was a compensatory increase in product prices. In order to maximise fishery profit, it seems the number of boats would need to be reduced by more than 50 %. The magnitude of the profit foregone by maintaining the present fleet size is about Rs 42 million, and close to half the estimate of present gross revenue. The latter is being foregone principally in favour of the owners, skippers and crews who otherwise would not be employed in the fishery.

Discussion

Managing a fishery in order to maximise employment is obviously a worthwhile objective where employment opportunities are scarce. The extent of fishery profit foregone in this fishery is nevertheless substantial. In the theoretical scenario of reducing the fleet from 19 to 10 boats, the estimate of fishery profit so generated is Rs 35 million. As the direct consequence 36 owners, skippers and crews would be 'displaced'. There would be about the same quantity of catch from the fewer boats, so the numbers of people employed in handling, distribution and sales would be largely unaffected. The important underlying issue, nevertheless, concerns who would be the actual beneficiaries in the event of reducing the size of the fleet.

Unless otherwise prevented the benefit would go to the owners, skippers, and crews on the boats remaining in the fishery. The reduced fishing effort from fewer boats would result in increased CPUEs and catch weights per boat, and this would in turn flow through to increased remunerations. Potentially these remunerations could be greatly increased. In the theoretical scenario depicted here, the remaining 40 owners, skippers, and crews would share the Rs 35 million. If this were the outcome (fewer owners, skippers, and crews earning much more than at present) there would likely be substantial disquiet within the local community.

Figure 4: Fishery profit plot.



SHRIMP LENGTHS AND MORPHOMETRICS

Introduction:

Data collected during the surveys in October 2008 and January 2009 included the individual lengths and weights of the shrimp caught. While not of direct relevance to the analyses presented in the earlier sections, they are nevertheless useful in understanding the fishery. The lengths are plotted here as histograms, separately for each sex in recognition of their different growth characteristics. The relationships between total weight and each of carapace length and total length, and between carapace length and total length, are also plotted separately for each sex. Carapace length was measured from the postorbital margin to the mid-dorsal termination of the carapace. Total length was measured from the tip of the rostrum to the tip of the telson. The length frequencies and morphometric plots are shown in Figures 5 to 10.

Length frequencies:

The plots for *P. semisulcatus* indicate a wide spread of lengths in October 2008, while the smaller sizes are largely absent from the January 2009 data. This is apparent for both the males and females. It is presumed to reflect the recruitment of biomass at the time of the earlier survey, and not at the later time. The comparison of fleet CPUEs at these times provides support to this conclusion. The average CPUE was 16.5 kg/haul in October and 10.0 kg/haul in January (see Appendix I).

The plots also provide information concerning the individual growth of shrimp. For both males and females, the plots show a shift to the right for the main modal group. There are also separate modal groups far to the right, at about 4.8 cm for females and 3.6 cm for males. These are believed to be 6 months older than the main modal groups, in which case they indicate growth rates of 0.67 mm/week for the females and 0.54 mm/week for the males. These values are in agreement with those given in Sanders, Jayawardena, and Ediriweera (2000).

The plots for *M. moyebi* are less informative. There appears to be a separate modal group to the far right at about 2.7 cm for the females. Assuming 6 months difference in age with the main modal group indicates a growth rate of about 0.41 mm/week. Again this accords with values given in the above-mentioned reference.

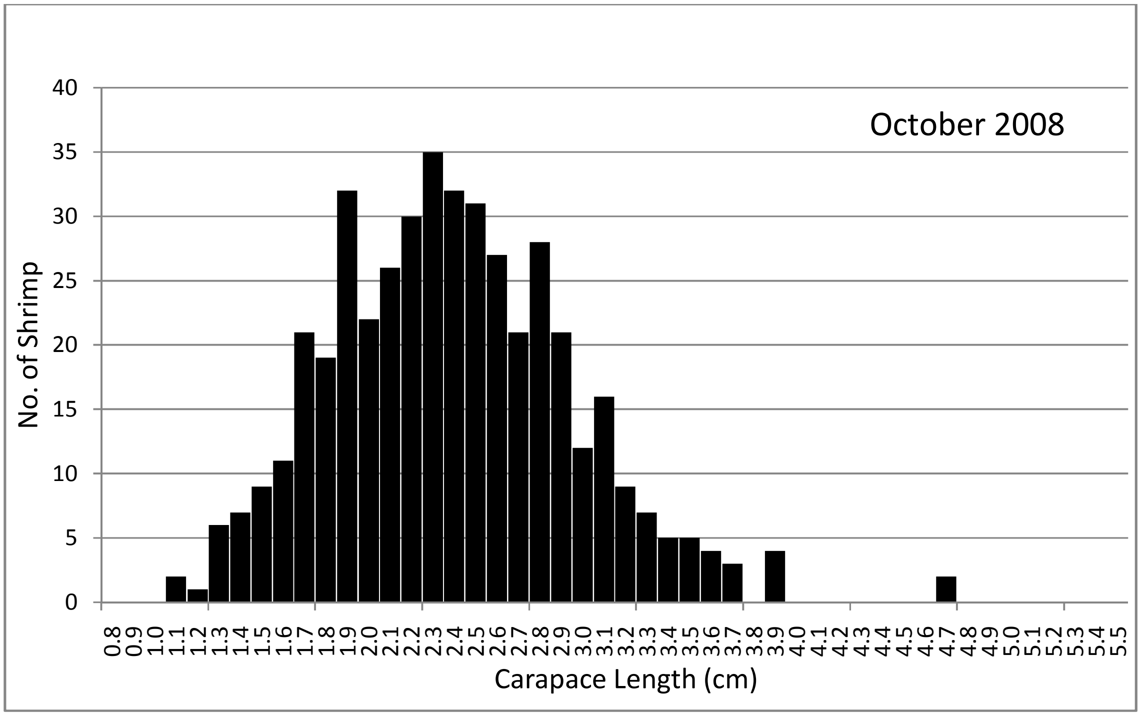
Morphometrics:

These relationships have little significance other than enabling conversions from one dimension to another.

Discussion:

Apart from providing information about growth, length frequencies can also be useful as an indicator of mortality rates. Where separate cohorts can be readily identified, the relative numbers of individuals in successive cohorts can be used for this purpose. In respect to the plots for *P. semisulcatus*, the previously mentioned modal groups to the far right, at about 4.8 cm for females and 3.6 cm for males, contain very few shrimp compared to the main modal groups. That is, almost no shrimp appear to be remaining six months after entering the fishery. This agrees well with the finding of high exploitation reported in the earlier sections.

Figure 5: Length frequencies for P. semisulcatus females.



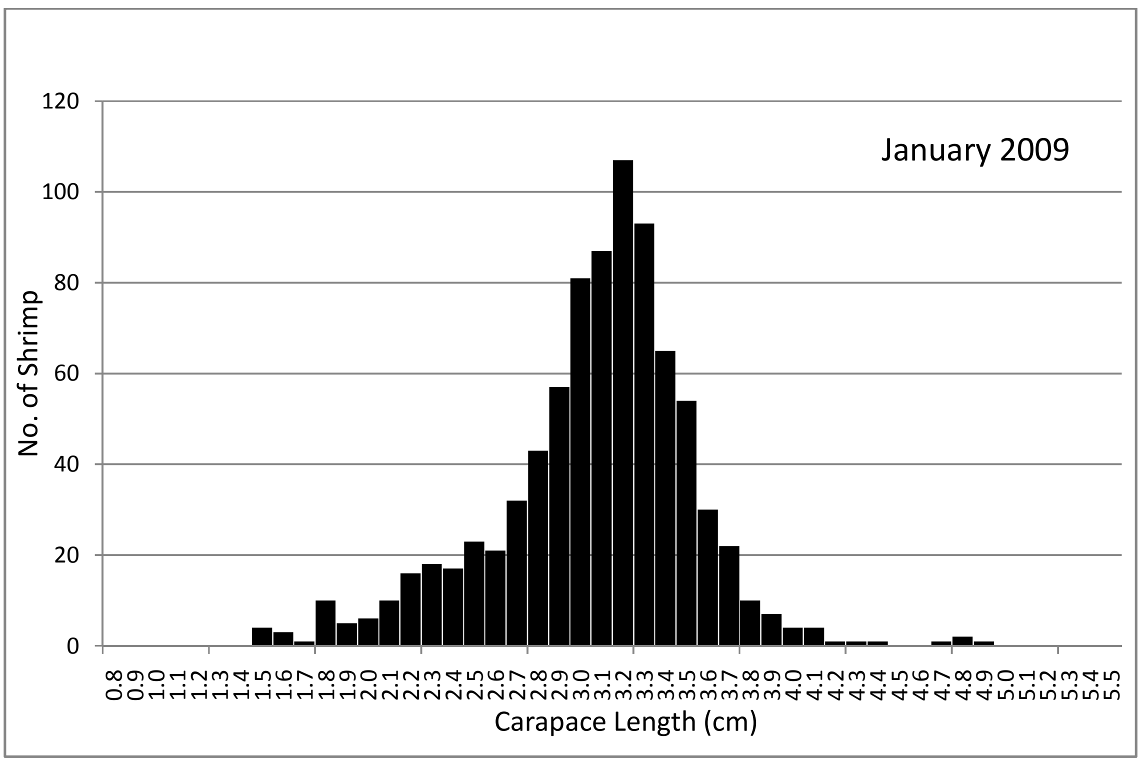
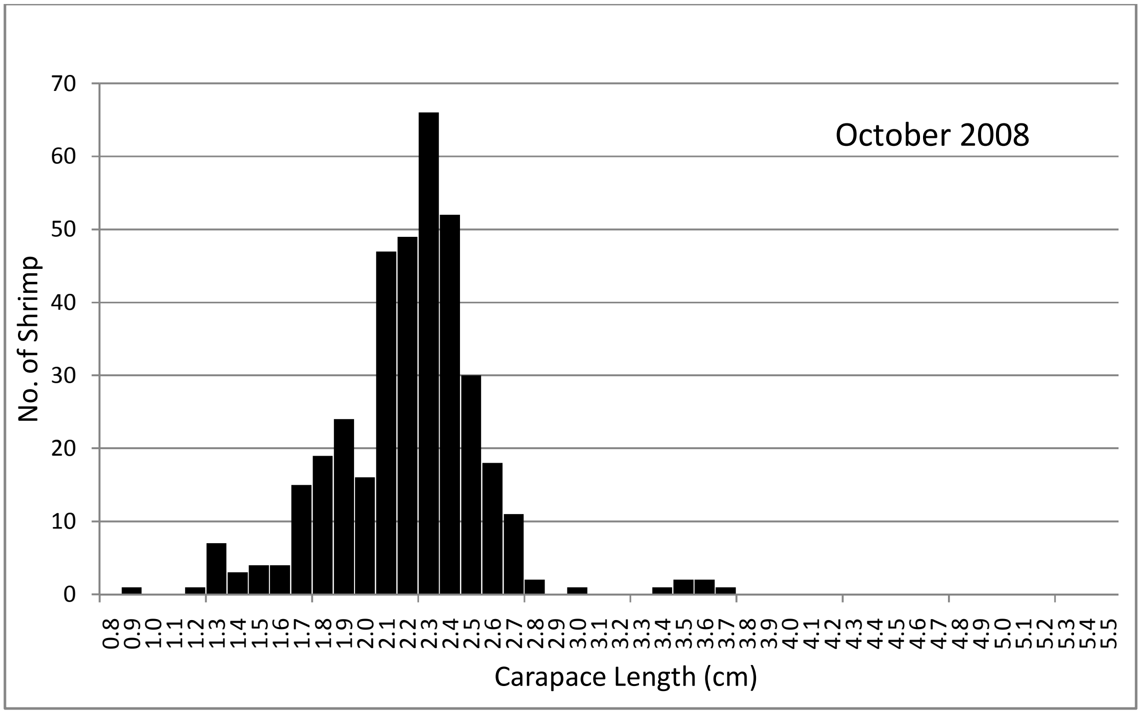


Figure 6: Length frequencies for P. semisulcatus males.



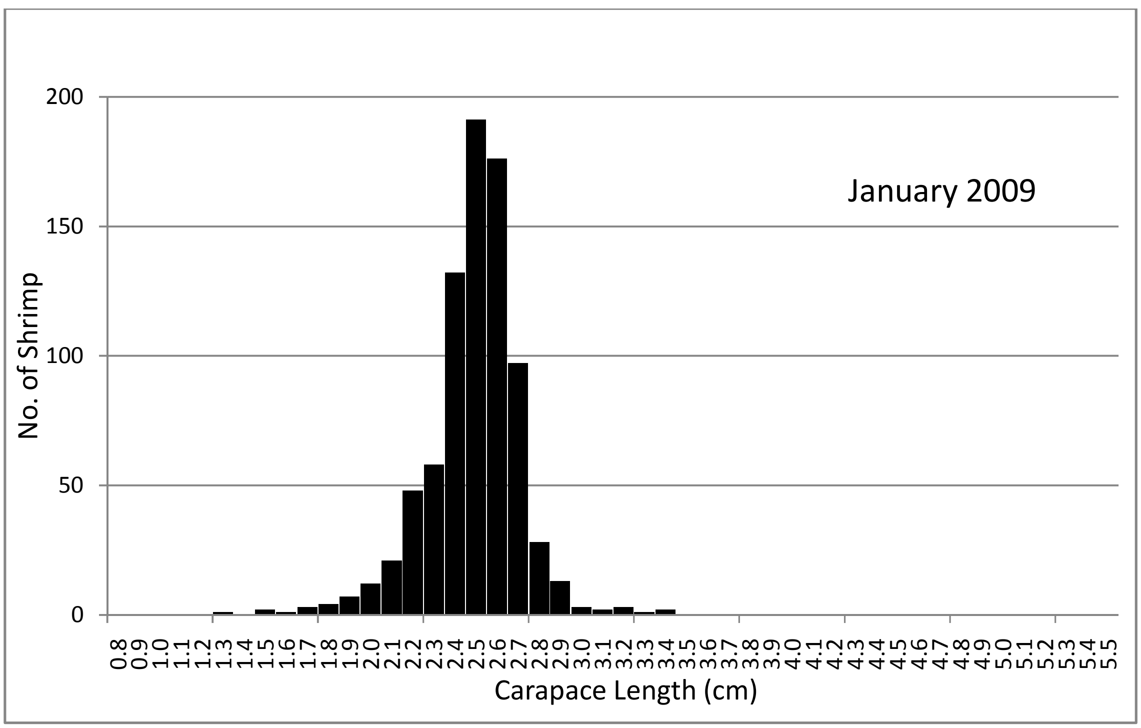


Figure 7: Length frequencies for M. moyebi females.

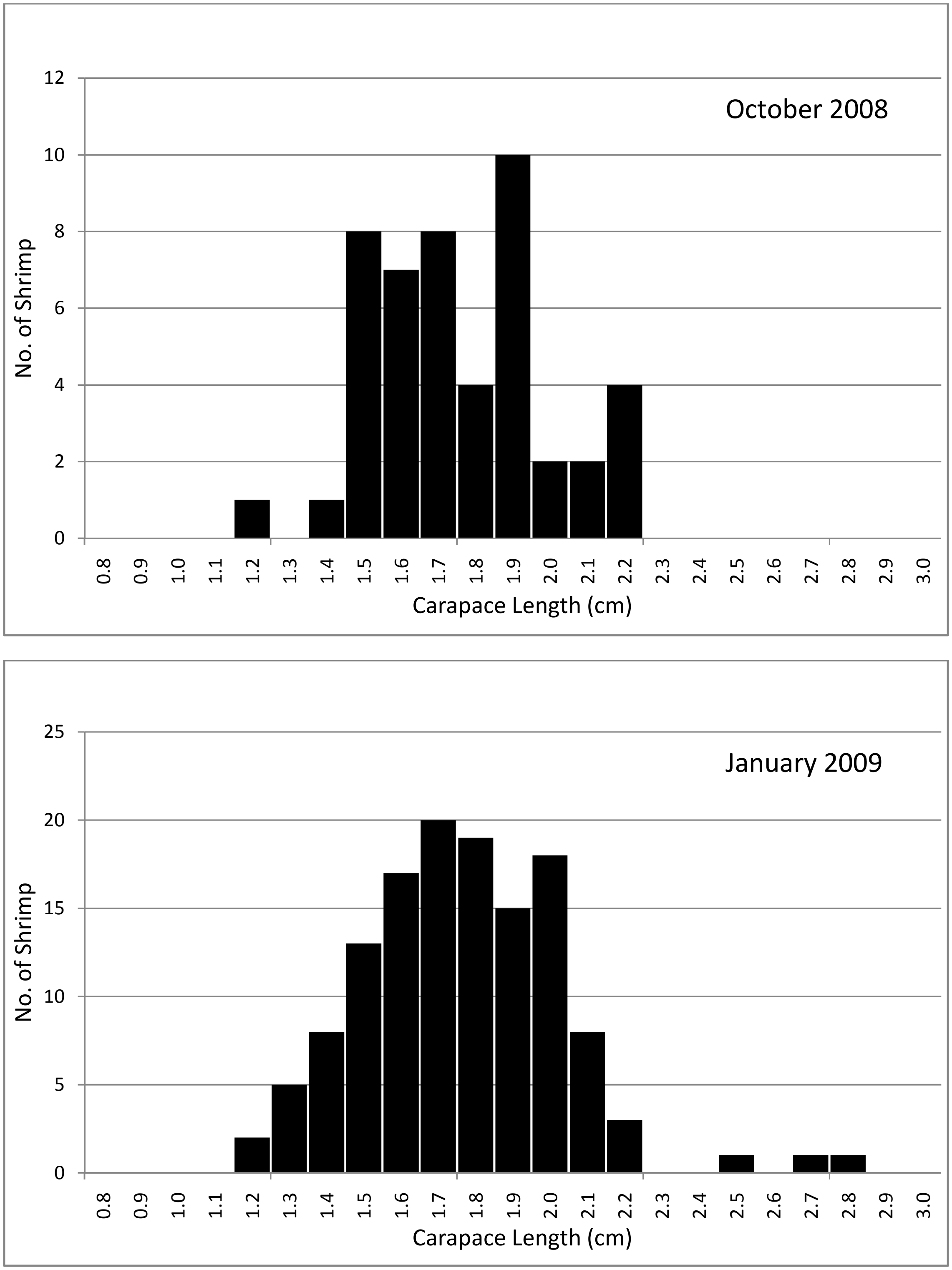
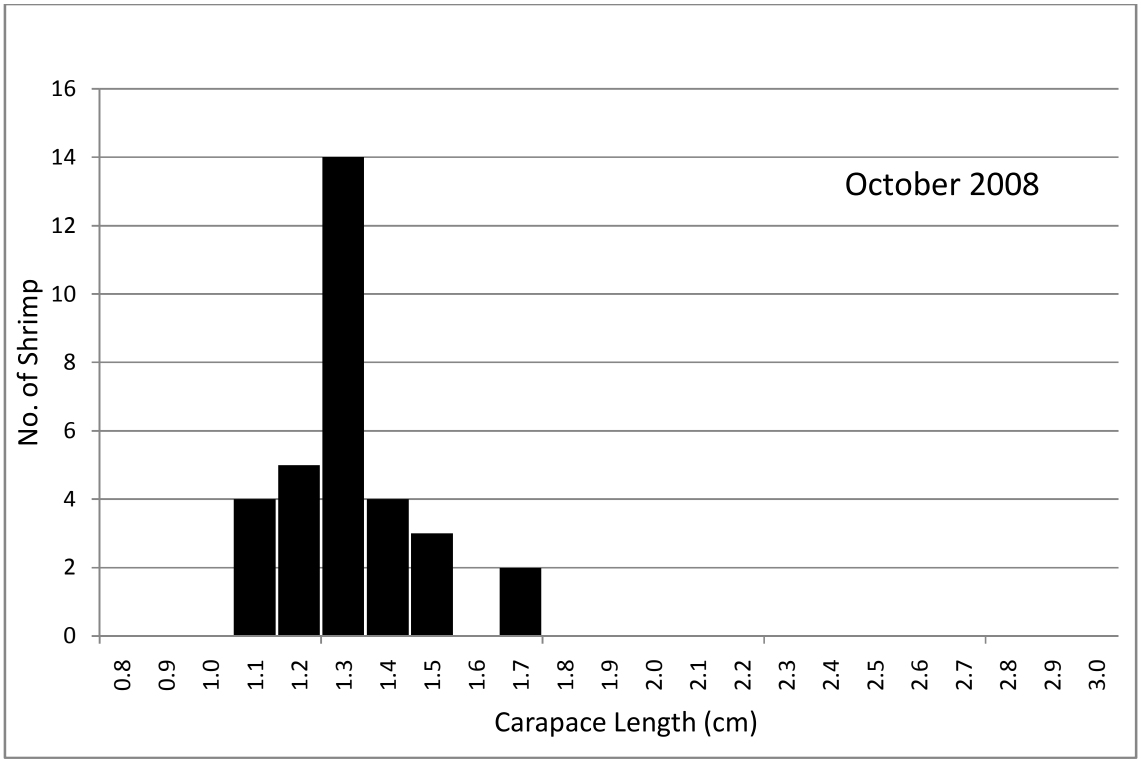


Figure 8: Length frequencies for M. moyebi males.



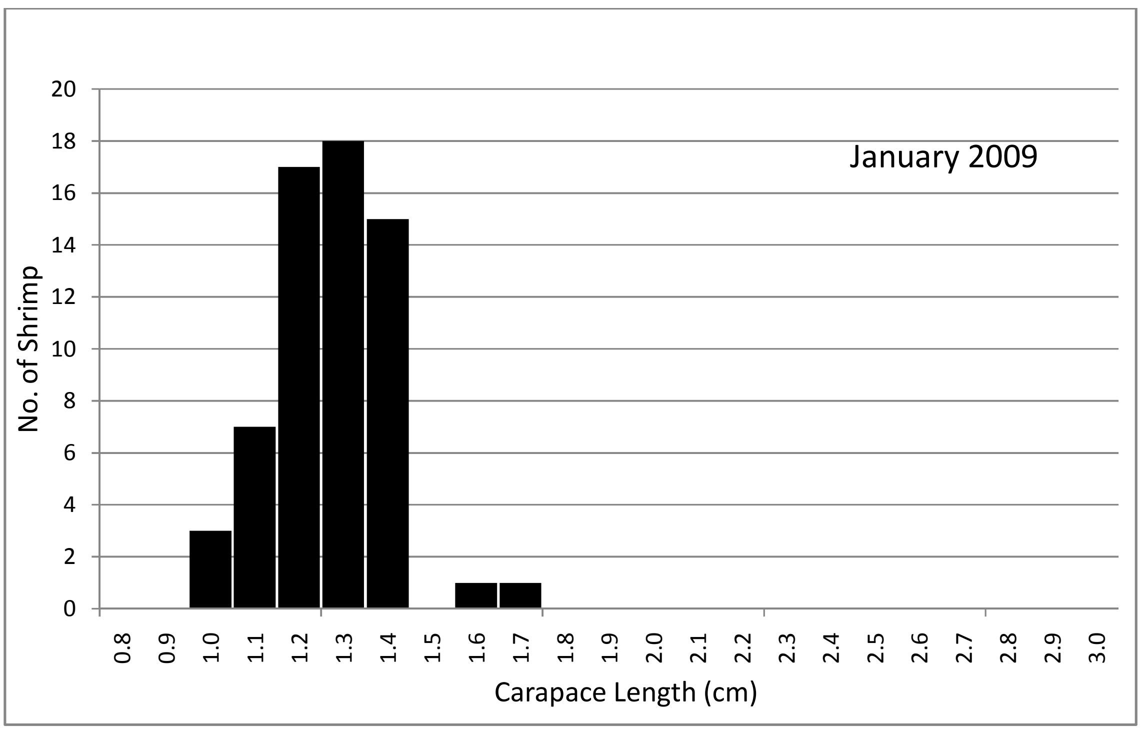


Figure 9: Morphometrics for P. semisulcatus.

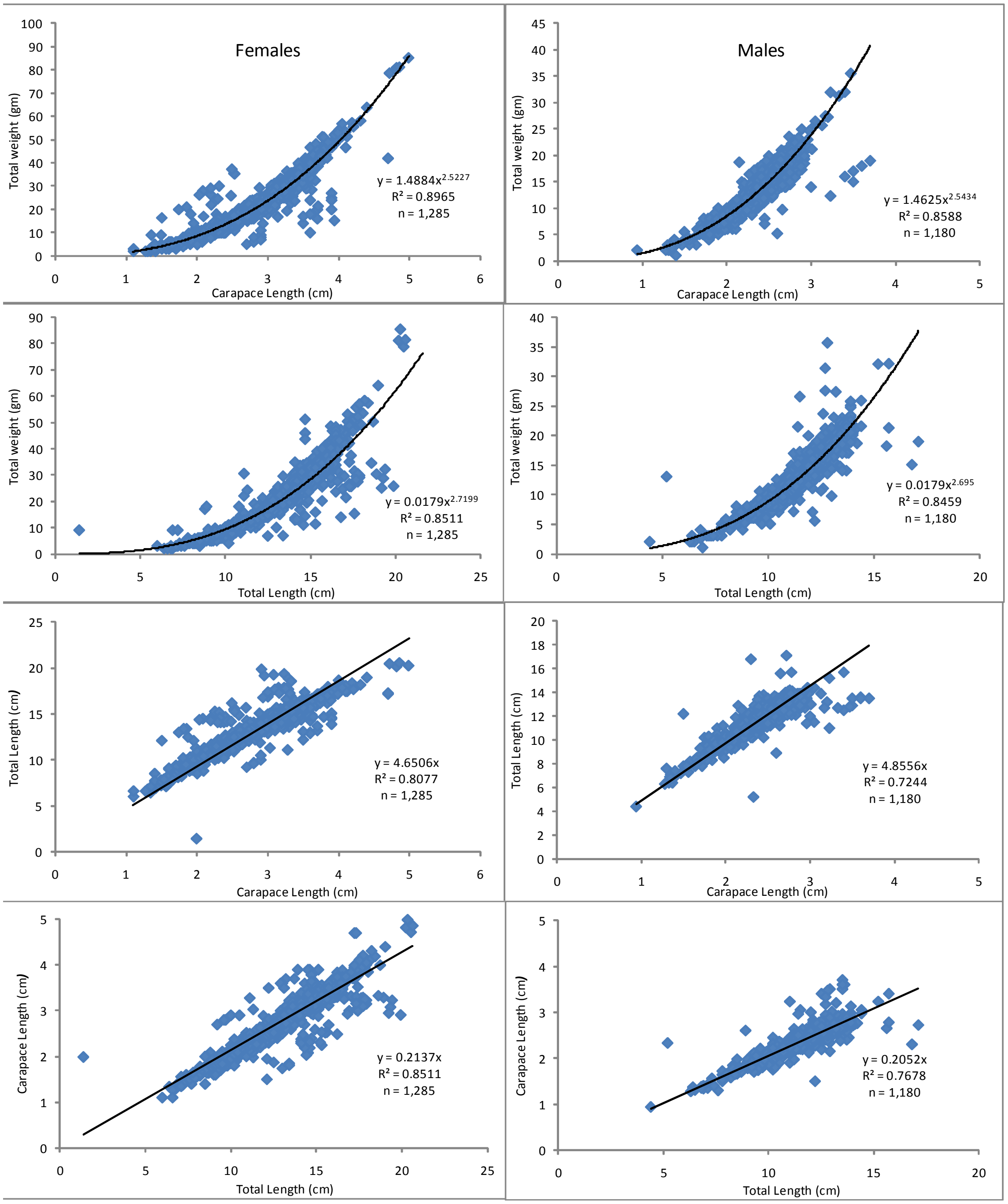
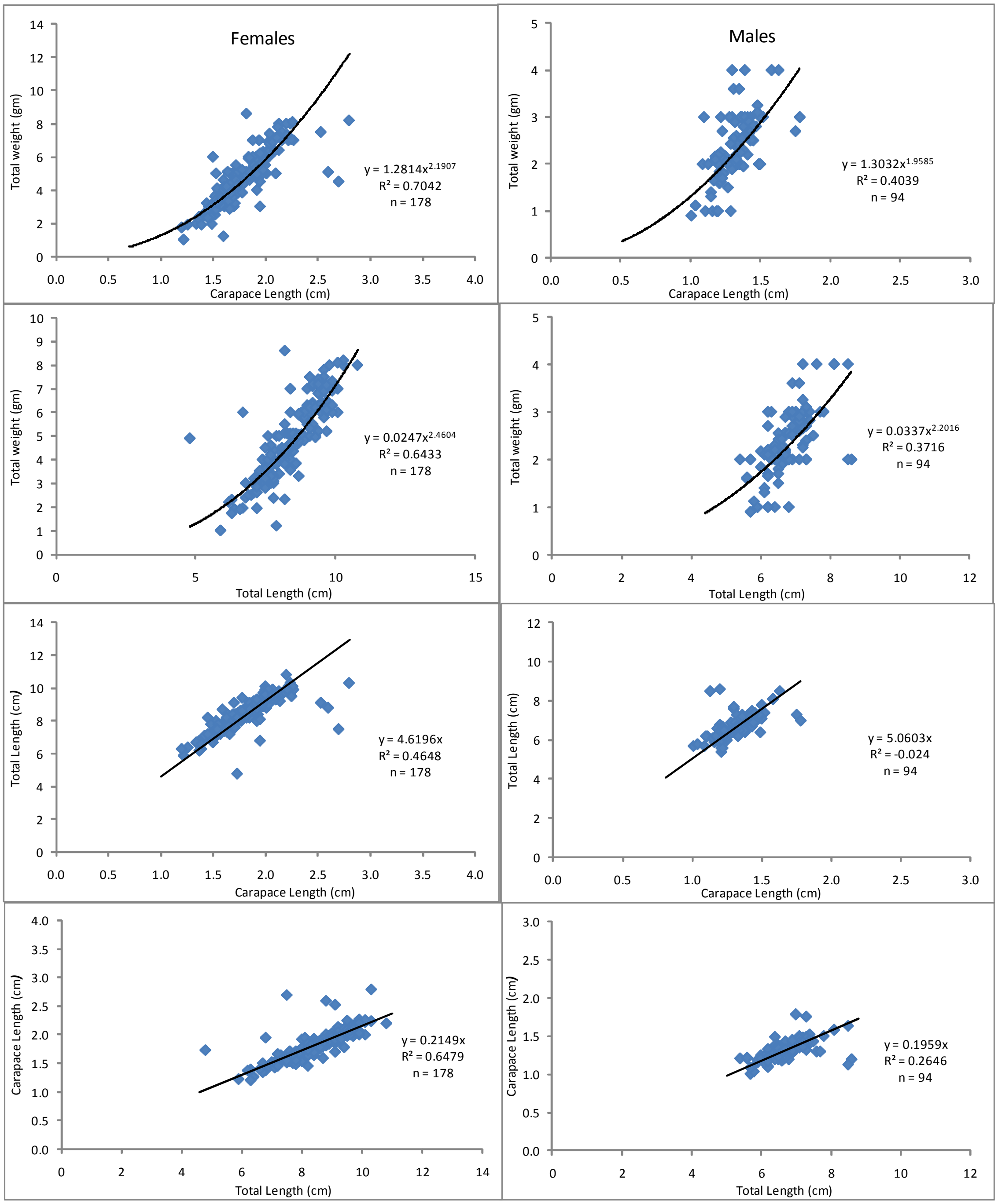


Figure 10: Morphometrics for M. moyebi.



MANAGEMENT ISSUES

Introduction

This section briefly describes two current management issues. They are included here as both are directly relevant to the findings from this study. The first concerns a possible extension to the existing trawl ground. The second concerns a likely and imminent increase in the trawler fishing effort and hence the exploitation levels being exerted on the shrimp stock.

Trawl ground extension

Over several decades fishing immediately to the north of the present trawl ground has not been allowed because of the security risk. This prohibition has been enforced from the naval base nearby to Kalpitiya. With the recent cessation of hostilities in the north of the country, the prohibition has now been lifted. Boat owners have chosen, nevertheless, not to exploit the new ground until it can be established that viable quantities of shrimp exist there.

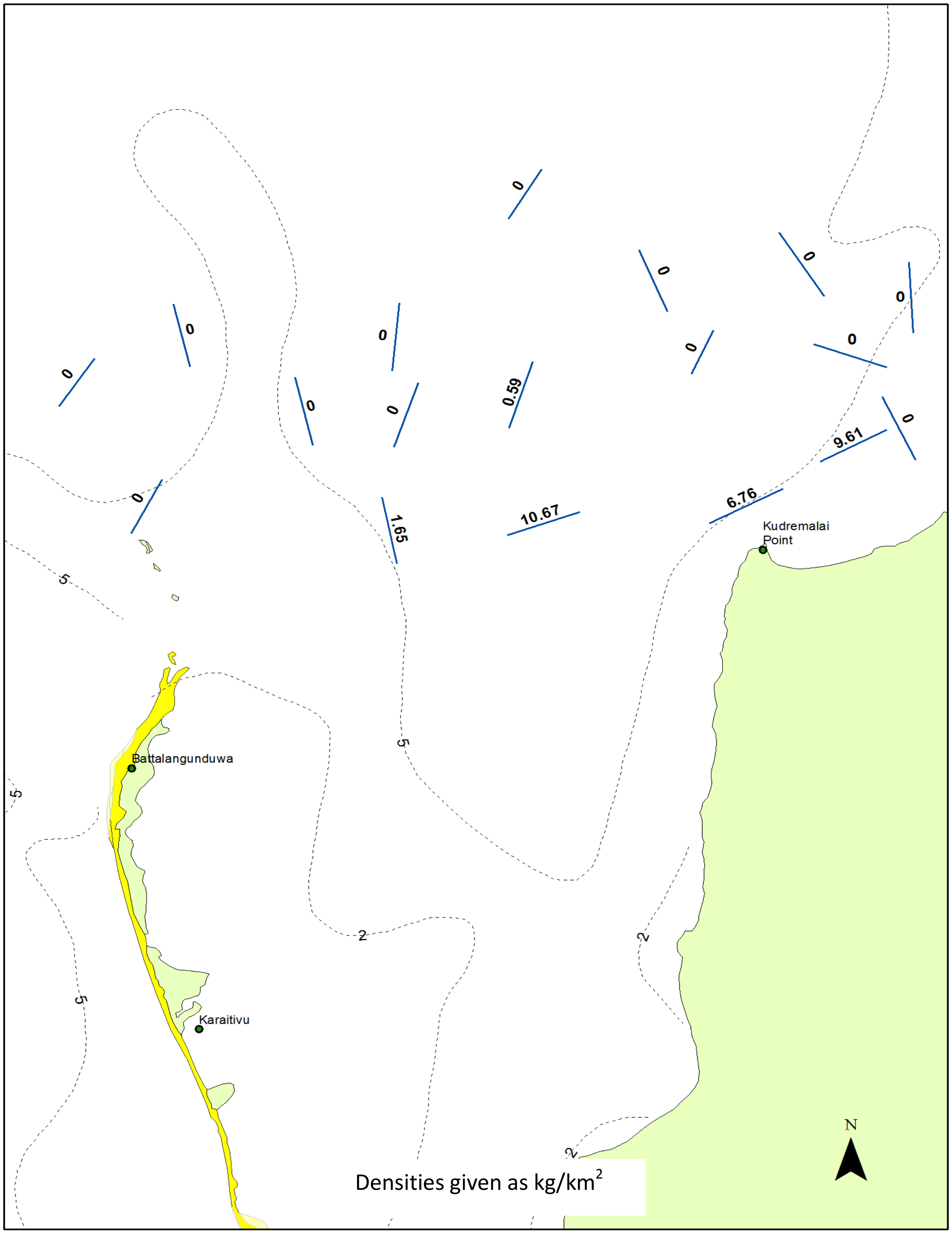
In this regard there was a survey using divers in 2008 which located 84 km^2 of seabed considered suitable for shrimp. These were areas found to contain fine silts. During the October 2008 trawling survey, 18 hauls were made within the area. Haul lengths ranged from 867 m to 1,370 m. The estimated shrimp densities as shown in Figure 11 range from zero (no shrimp were caught during 13 hauls) to 11 kg/km^2, assuming 100 % trawl net efficiency. These were considered disappointing and a more comprehensive survey of the ground is planned for early 2010.

3.5 tonne trawlers

In addition to the nineteen 11 tonne trawlers there are ten 3.5 tonne trawlers (with 32 HP diesel engines) operated from Kalpitiya. These are also old boats resulting from an earlier Asian Development Bank (ADB) funded project. During the past several decades the boats have been deployed in trawling for sea cucumbers in nearby waters within the Puttalum Lagoon. This activity has very recently been banned, and it is anticipated the boats will be shifted to shrimp trawling in competition with the 11 tonne trawlers. In this event the fishing effort from shrimp trawling will increase.

Already several boats have been fitted with shrimp trawls and commenced fishing during the past week. Trip duration was 5 days for two of the boats and 4 days for the other. The combined fishing effort was 21 hauls each lasting about 4 hours. The horizontal width of the trawl nets used was given during interview as 6 m. The combined catches from the boats was 179 kg of shrimp and 162 kg of mostly fish. This quantity of shrimp is about what would be landed following a single trip from an 11 tonne trawler. On this basis the fishing power of a 3.5 tonne trawler seems roughly a third that of the larger trawlers. Accordingly, should all the 3.5 tonne trawlers engage in the fishery as expected, the increase in fishing effort could be as much as 15 %.

Figure 11: Shrimp densities on trawl ground extension.



OBJECTIVES, INDICATORS AND REFERENCE POINTS

Introduction

This section seeks to identify a suitable suite of objectives, indicators and reference points for the fishery, that recognise the vulnerability of the shrimp stocks to over-exploitation, the need for adequate financial returns to the stakeholders, the importance of harmony amongst the fishery participants (and others), and governance measures that are effective, efficient, and fair.

Objectives

The following are generally relevant to a wide range of fisheries, and would also seem appropriate to this fishery. They are intended as an integrated package, and are indicative of the status of the fishery to be achieved in the foreseeable future. Those concerned with ensuring sustainability of the shrimp stocks and associated ecosystem would have paramount importance.

Ecological Objectives:

- Productive capacity of the shrimp stocks sustained into the future at low levels of risk.
- Ecosystem health not jeopardised by the fishing practices.
- Management responsive to changes in ecosystem health.

Economic Objectives:

- Economic opportunities from production fully utilised.
- Economic efficiency within the fishery.
- Equitable sharing of the financial benefits between fishery participants.
- Recovery from the fishery of the ‘attributable’ costs of management, including research and compliance costs, to the extent allowed by government policy.

Social Objectives:

- Social harmony within the fishing communities and beyond.
- Equitable assignment of productive capacity between stakeholder groups.
- Appropriate community return (compensation) where there is exclusive exploitation of the shrimp stock in recognition of public ownership, to the extent allowed by government policy.

Governance Objectives:

- Clear identification of the persons/entities responsible for managing the fishery.
- Fishery stakeholders and government fisheries administration sharing the responsibilities of management.
- Adequate manpower, financing, and associated infrastructure for managing the fishery.
- Management which is cost effective and transparent.
- Illegal activities prevented and targets for reduction of unlawful activities monitored and achieved.

Indicators and Reference Points

Performance indicators are defined here as the quantities or items to be measured in order to track the status of the fishery relevant to the objectives. Target reference points represent the status that management wishes to achieve, while trigger reference points indicate that the status may be unacceptable to the extent that immediate remedial action is required. In choosing suitable indicators and reference points, the practical realities of implementation necessitate focusing on those of immediate importance. The manpower and money to collect and process the necessary data are limiting, and will possibly become more so following termination of the project.

A possible indicator relevant to 'productive capacity being sustained into the future at low level of risk' is the density of shrimp on the trawl ground. These can be determined through trawl surveys, as occurred in October 2008 and January 2009, and from the commercial fleet CPUEs, as also shown here. The virtue of the former approach is greater control and precision. The main disadvantage is the cost of chartering a vessel. The pre-requisite in respect to the second approach is a fully functioning and comprehensive collection of catch and effort data.

Accepting shrimp density as the appropriate performance indicator, a possible target reference point could be future densities not significantly different (as in the statistical sense) from those determined during the past year. An associated trigger reference point might be densities at 90% (or some lesser value) of the values for the past year. Comparison against mean densities measured for a span of years (eg. the past 3 years) would be preferable when this becomes possible.

Concerning the first of the economic objectives, 'economic opportunities from production fully utilised', the remuneration to owners, skippers, and crews would seem an appropriate performance indicator. The associated target reference point might be maintaining remunerations at some previous level (after adjusting for changes in the CPI), and the trigger reference point might be remunerations at 70% of the previous values. The estimation of remunerations for this purpose could be determined from annual cash flow analysis. This all pre-supposes the continued collection of product prices, fishing costs and investment data as from interviews with boat owners and skippers.

In respect to the social objective 'social harmony within the fishing community and beyond', the performance indicator might be the number and severity of disputes dealt with by the local fisheries office (in Puttalum). This would require that all serious disputes are adequately recorded and tabulated. Recorded disputes would be the performance indicator. The target reference point could be a progressive lessening of disputes over time. The trigger could be a 30% increase in disputes over the previous year or span of years.

Concerning governance, it seems obvious that there be 'adequate manpower, financing, and infrastructure for managing the fishery'. The minimum requirement would be adequate funds to undertake the collection of catch and effort statistics, and costs and earnings data relevant to cash flow analysis, and for 'fishery-independent' surveys if these are to continue. The performance indicator would presumably be the budget and manpower allocations in each year. The target reference point could be 'full' funding. The trigger reference point might be a 10 % reduction in funding from previous years.

CONCLUDING COMMENTS AND RECOMMENDATIONS

The shrimp stocks are being heavily exploited. While it seems from interviews that the high exploitation levels have existed for several decades, without any (or much) noticeable downturn in production, the increased risk of a decline in the seasonal recruitment of shrimp if fishing effort and hence exploitation levels were allowed to increase, must not be ignored. The further downside to allowing increased fishing efforts would be for CPUEs to drop, in which case the remunerations to owners, skippers, and crews would decline, unless compensated by increased product prices.

The virtues within the fishery are that employment opportunities are at or close to being maximised, and at the same time remunerations to owners, skippers, and crews are quite good, judged by others in the local community. The fishery also benefits from being low cost. This arises in part from the low technology nature of the boats, powered by engines of modest horsepower, without motorised winches, refrigeration, or expensive electronics. The fishing ground is only a few hours travel from the landing site, which in combination with the practice of remaining overnight helps to keep fuel costs down.

A shortcoming at present is that the fishery makes no contribution to its costs of research and management. The collection and compilation of catch and fishing effort statistics must continue, as also the conduct of costs and earning studies. Assessments of the performance of the fishery as undertaken here are also associated with costs. There would be costs in order to conduct trawl surveys, if these are to continue into the future. These types of costs are ‘attributable’ in the sense that they would not exist in the absence of the fishery. The direct beneficiaries of the fishery would normally be expected to contribute in part or fully to meeting ‘attributable’ costs.

The finding that substantial fishery profit would be generated from any reduction in the number of boats has relevance in the above context. While a reduction is not anticipated, if this were to occur in the future, it would provide the opportunity to extract the costs of research and management from the fishery, without affecting the remunerations of the remaining fishery participants. A fishery contribution could be achieved through substantially increased licence fees, provided there was some mechanism for ensuring the moneys became available for research and management. An alternative less formal approach would be for the fishery participants themselves to set up a joint trust account. This could be within the context of co-management, and be administered through the Kalpitiya Trawlers Association.

An important issue not investigated here concerns the linkages between the trawl fishery and the exploitation of shrimp by small-scale fishermen operating inside the Puttalum Lagoon. All the species in the trawl catches are also caught within the lagoon. Furthermore, it can reasonably be expected that the lagoon is the major nursery ground for the shrimp that are subsequently caught from trawling. It would seem highly important that the extent of this inter-dependence be thoroughly investigated.

This would require the comprehensive collection of catch and fishing effort statistics for the small-scale fisheries, and the sampling of catches to study the species and sizes of shrimp being caught. Such a study would need to cover all seasons, and hence be done over one or two years. Ideally there should also be a tagging component, in which small shrimp are tagged (or marked) and released inside the lagoon, possibly to be recaptured by trawlers at the entrance.

Recommendations

The recommendations that follow are principally aimed at the Trawl Fishery Management Committee. This is a newly formed entity under the umbrella of the 'Interim Committee'. The latter has broad responsibilities for management of the North Western Fisheries Management Area, established under the *Fisheries and Aquatic Resources Act of 1996*.

Governance:

As the initial priority task the Trawl Fishery Management Committee must formulate the management objectives for the fishery, as would be incorporated in a management plan. These need not be long-term objectives, but rather the objectives to be achieved within the life of the management plan. This might be for a period of three years from the commencement of the plan, with the latter possibly being from March 1 2010. According to the catch and fishing efforts given in the earlier section, January and February are largely unproductive for shrimp, followed by the substantial influx of shrimp biomass occurring in March. As such the commencement of each 'fishery management' year on March 1 would seem sensible.

> Recommendation 1: Management objectives to be formulated by the Trawl Fishery Management Committee.
>
> Recommendation 2: The initial management plan for the fishery to be for a 3-year period.
>
> Recommendation 3: The management year for the fishery commence on March 1.

In association with the formulation of management objectives, the Fishery Management Committee should decide on the performance indicators, target and trigger reference points, against which the performance of the fishery can be judged. As indicated in an earlier section, a useful performance indicator relevant to the well-being of the shrimp stock would be density (kg/km^2). Annual remunerations to owners, skippers, and crews as determined from cash flow analysis, would be a useful indicator of economic performance, being directly relevant to the well-being of the fishery participants.

> Recommendation 4: Performance indicators and reference points relevant to the initial management plan to be decided by the Trawl Fishery Management Committee.
>
> Recommendation 5: Choose shrimp biomass density as determined from CPUEs (and trawl survey data if available), as the performance indicator relevant to the well being of the shrimp stock.
>
> Recommendation 6: Choose annual remunerations to owners, skippers and crews determined from cash flow analysis, as the performance indicator relevant to the well being of the fishery participants.

The process of monitoring fishery performance should be clearly identified within the management plan. It is proposed here that NARA be assigned responsibility for an annual assessment report, to be prepared during January each year. At least in the first few years this should follow the methodology utilised in this report, and include the findings from updated catch and effort statistics, density and biomass estimations, cash flow analyses, and all related issues. This assessment report and any other relevant documentation should be available to the Fishery Management Committee by the end of January. The Committee would presumably meet shortly after to decide details of the management regime to apply in the coming year.

> Recommendation 7: An annual assessment report to be prepared by NARA and lodged with the Trawl Fishery Management Committee before the end of January.

> Recommendation 8: The Trawl Fishery Management Committee to meet in early February to decide the management regime for the coming fishery year.

An issue to be considered by the Fishery Management Committee is the extent to which the fishery participants meet the on-going costs of research and management. As indicated earlier, it seems highly reasonable that the fishery contribute either in part or fully to the 'attributable' costs. This could be achieved in a formal process as through increased licence fees, which in turn would need to be legislated. An alternative, and possibly preferable approach, might be for the Kalpitiya Trawlers Association to exact some form of levy on its members. These moneys then could be lodged in a joint trust account, to be utilised at the discretion of the Association members.

> Recommendation 9: The Kalpitiya Trawlers Association levy its members and establish a joint account to be utilised at its sole discretion for funding at least part of the fishery research and management costs.

> Recommendation 10: As an initial contribution, funds be made available from the account, to employ a suitable person(s) from the local community, to record catch weights and fishing efforts for every landing (ie. total enumeration). The person(s) would be responsible directly to the Kalpitiya Trawlers Association. (Advice suggests this might cost some Rs 240 thousand annually, equivalent to a bit over US$ 2 thousand.)

The quality of the assessment advice to the Fishery Management Committee will be dependent on the continuation and strengthening of the data collection systems presently in place. The total enumeration of catches and fishing efforts by a local person on-site would be a great contribution. In respect to length frequencies and other biological data NARA must continue the sampling of trawl catches at the landing site, and interviewing skippers. The collection of product prices and costs data relevant to cash flow analysis must continue. The conduct of annual 'fishery-independent' trawl surveys is problematical, in the absence of a future funding source.

> Recommendation 11: NARA staff to take responsibility for the monthly collation and tabulation of the catch and fishing effort data, utilising the enumeration records to be made available from the Kalpitiya Trawlers association.

> Recommendation 12: During monthly visits to Kalpitiya, NARA staff to sample trawl catches and collect length frequency data, and in the process interview skippers for information on product prices and fishing costs.

> Recommendation 13: The Trawl Fisheries Management Committee to consider whether the 'fishery independent' trawl surveys are to continue, and how these might be financed.

Shrimp Stock:

Having in mind that the shrimp stock is already heavily exploited, it would be important that the fishing effort exerted by the fleet not be increased. There is an increased risk of causing a downturn in the seasonal recruitment of shrimp biomass, if the fishing effort is allowed to become greater. As indicated the nineteen 11 tonne trawlers are being joined by ten 3.5 tonne trawlers. As such the fishing effort is certain to increase unless prevented. The proposal here is to fix the fishing effort at close to the level observed for last year and to allocate this between the boats. This could be implemented through the Kalpitiya Trawlers Association, which is representative of all the 11 tonne and 3.5 tonne boat owners.

Recommendation 14: The Trawl Fishery Management Committee to agree that the trawl fishery effort not be allowed to increase beyond the level of the past year, and for this to be implemented through the Kalpitiya Trawlers Association.

There are two components to the above proposal. The first is for all boats to be targeted at fish exclusively (with fish trawl nets) in January and February. The second component is to limit the shrimp trawling effort in the remaining 10 months to 33 trips per boat, each of 4 days duration. The allocation would apply equally to the 11 tonne and 3.5 tonne boats. It is assumed that the CPUEs of the 3.5 tonne boats is one third that of the larger boats. This allocation regime represents an effort reduction (and probably a remunerations reduction) for each of the 11 tonne trawlers of about 15 %. This outcome can be considered as the direct consequence from the entry into the fishery of the ten 3.5 tonne trawlers.

Recommendation 15: During January and February all trawlers to operate with fish trawls, for the purpose of targeting fish and avoiding the capture of shrimp, to be administered through the Kalpitiya Trawlers association.

Recommendation 16: During the remaining ten months, all trawlers to be limited to 33 (four day) trips per boat for the purpose of catching shrimp, to be administered by the Kalpitiya Trawlers Association.

As commented earlier, there is likely to be a linkage between the trawl fishery and the small-scale fisheries for shrimp operating within the Putallum Lagoon. NARA should strengthen its collection of data for the within lagoon fisheries. As a minimum there must be comprehensive catch and fishing effort statistics. This should be complemented by sampling catches at the landing sites to determine species compositions and length frequencies. Also highly desirable would be the conduct of shrimp tagging (or marking) within the lagoon, to determine what proportions are subsequently recaptured either in the lagoon or at the entrance from trawling. There is presently little or no expertise within NARA to do this type of research. It is proposed here that 'outside' aid funds be sought, including provision for an experienced shrimp tagging biologist, to guide and train local staff in this work.

Recommendation 17: NARA staff to undertake a comprehensive study of the small-scale shrimp fisheries operating inside the Putallam Lagoon, including the collection of catch and fishing effort data, sampling of catches for length frequency and biological data, and product prices and costs data.

Recommendation 18: FAO in collaboration with NARA seek 'outside' funding for a comprehensive shrimp tagging study, with the aim of better understanding the linkages between the small-scale and trawl fisheries.

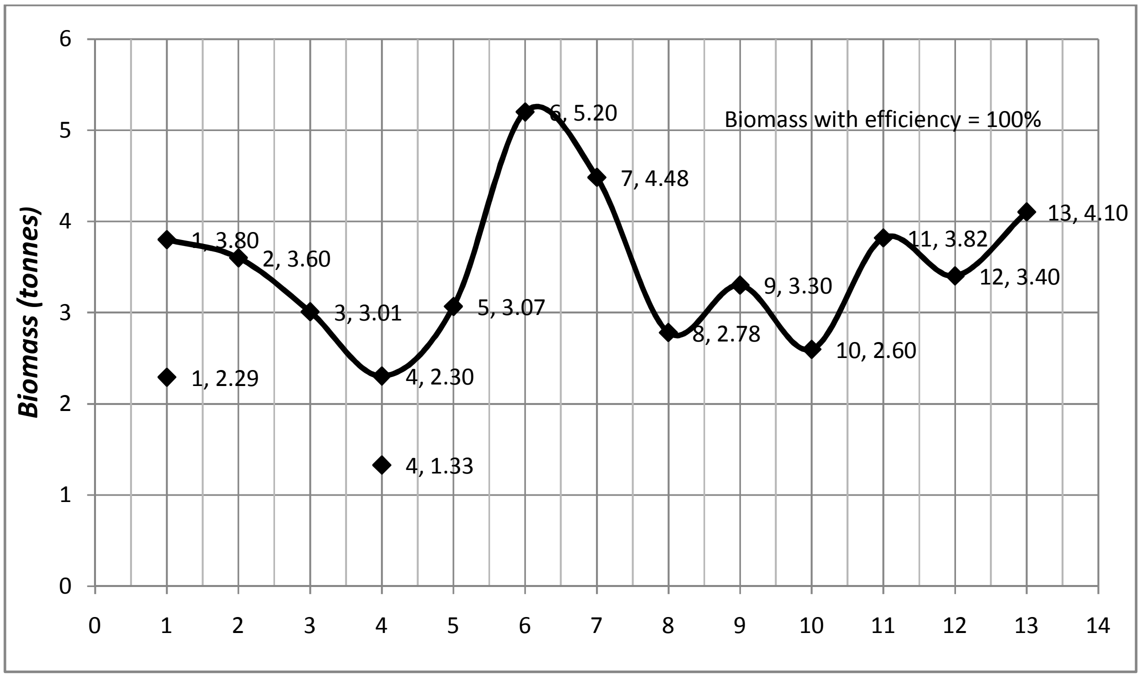
Recommendation 19: NARA to be responsible for annual reporting to the Trawl Fishery Management Committee of its findings from any studies it undertakes on the small-scale shrimp fisheries within the lagoon.

Mean Biomass Spreadsheet

Inputs:				**Equations:**
Area of fishing ground	A =	26	km2	a = w.l
Width of haul track	w =	9.4	m	a' = e.a
Length of haul track	l =	12,000	m	B3 = (Cw/X).A/a'
Nominal area per haul	a =	0.1128	km2/haul	
Efficiency of haul	e =	100	%	
Effective area per haul	a' =	0.1128	km2/haul	

		Oct. '08	Nov.	Dec.	Jan. '09	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Year	Oct.
Observations:															
Catch weight (kg)	Cw =	11,512	12,170	8,942	1,123	3,673	18,844	14,900	8,531	6,287	5,487	9,330	8,355	109,154	12,786
Fishing effort (hauls)	X =	698	779	685	112	276	835	766	707	439	487	563	566	6,913	718
CPUE shrimp (kg/haul)	Cw/X =	16.49	15.62	13.05	10.00	13.31	22.57	19.45	12.07	14.32	11.27	16.57	14.76	15.79	17.81
Estimations:		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		Oct
Mean biomass (tonnes)	B3 =	3.80	3.60	3.01	2.30	3.07	5.20	4.48	2.78	3.30	2.60	3.82	3.40		4.10

Mean Biomass Chart



Net Recruitment Spreadsheet

Month	Start biomass B1 (tonnes)	End biomass B2 (tonnes)	Mean biomass B3 (tonnes)	Catch weight Cw (tonnes)	Natural death weight D (tonnes)	Net recruitment R (tonnes)
Oct. '08	3.69	3.72	3.80	11.51	0.86	12.40
Nov.	3.72	3.34	3.60	12.17	0.81	12.60
Dec.	3.34	2.57	3.01	8.94	0.68	8.85
Jan. '09	2.57	2.52	2.30	1.12	0.52	1.59
Feb.	2.52	4.20	3.07	3.67	0.69	6.04
Mar.	4.20	5.09	5.20	18.84	1.17	20.90
Apr.	5.09	3.60	4.48	14.90	1.01	14.42
May	3.60	2.98	2.78	8.53	0.63	8.54
Jun.	2.98	2.90	3.30	6.29	0.74	6.95
Jul.	2.90	3.20	2.60	5.49	0.58	6.37
Aug.	3.20	3.66	3.82	9.33	0.86	10.65
Sep.	3.66	3.69	3.40	8.36	0.77	9.15
sums				109.15	9.31	118.46

Assumed haul efficiency = 100 %
Assumed natural mortality coefficient M = 2.7/yr
Equations: $D = B3 \times (M/12)$
$R = (B2 - B1) + (Cw + D)$

Yield Model Spreadsheet

Month	Week	Natural mortality coef. M'	Fishing effort X' (hauls)	Fishing mortality coef. F'	Start biomass B1' (t)	Net recruitment R' (t)	End biomass B2' (t)	Mean biomass *B3'* (t)	Natural death weight D' (t)	Catch weight Cw' (t)	CPUE Cw'/X' (kg/haul)
Oct.'08											
	1	0.056	174.5	0.757	3.69	0.00	1.64	2.53	0.14	1.91	10.96
	2	0.056	174.5	0.757	5.77	4.13	2.56	3.95	0.22	2.99	17.13
	3	0.056	174.5	0.757	6.69	4.13	2.97	4.58	0.26	3.47	19.86
	4	0.056	174.5	0.757	7.10	4.13	3.15	4.86	0.27	3.68	21.08
	sums/means	0.225	698	3.0		12.40			0.89	12.04	17.26
Nov.	1	0.056	194.8	0.845	3.15	0.00	1.28	2.07	0.12	1.75	9.00
	2	0.056	194.8	0.845	5.48	4.20	2.22	3.61	0.20	3.05	15.66
	3	0.056	194.8	0.845	6.42	4.20	2.61	4.23	0.24	3.58	18.37
	4	0.056	194.8	0.845	6.81	4.20	2.77	4.49	0.25	3.79	19.47
	sums/means	0.225	779	3.4		12.60			0.81	12.17	15.63
Dec.	1	0.056	171.3	0.743	2.77	0.00	1.24	1.90	0.11	1.41	8.26
	2	0.056	171.3	0.743	4.19	2.95	1.89	2.89	0.16	2.15	12.53
	3	0.056	171.3	0.743	4.84	2.95	2.17	3.33	0.19	2.47	14.44
	4	0.056	171.3	0.743	5.12	2.95	2.30	3.53	0.20	2.62	15.31
	sums/means	0	685	3.0		8.85			0.66	8.65	12.63
Jan.	1	0.056	28.1	0.122	2.30	0.00	1.93	2.11	0.12	0.26	9.16
	2	0.056	28.1	0.122	2.46	0.53	2.06	2.25	0.13	0.27	9.77
	3	0.056	28.1	0.122	2.59	0.53	2.17	2.37	0.13	0.29	10.29
	4	0.056	28.1	0.122	2.70	0.53	2.26	2.47	0.14	0.30	10.72
	sums/means	0.225	112	0.5		1.59			0.52	1.12	9.98
Feb.	1	0.056	69.0	0.299	2.26	0.00	1.58	1.90	0.11	0.57	8.24
	2	0.056	69.0	0.299	3.60	2.01	2.52	3.03	0.17	0.91	13.13
	3	0.056	69.0	0.299	4.53	2.01	3.18	3.82	0.21	1.14	16.55

	4	0.056	69.0	0.299	5.19	2.01	3.64	4.37	0.25	1.31	18.95
	sums/means	0.225	276	1.2		6.04			0.74	3.92	14.22
Mar.	1	0.056	208.8	0.906	3.64	0.00	1.39	2.34	0.13	2.12	10.14
	2	0.056	208.8	0.906	8.36	6.97	3.19	5.37	0.30	4.86	23.29
	3	0.056	208.8	0.906	10.16	6.97	3.88	6.53	0.37	5.91	28.32
	4	0.056	208.8	0.906	10.85	6.97	4.15	6.97	0.39	6.31	30.24
	sums/means	0.225	835	3.6		20.90			1.19	19.20	23.00
Apr.	1	0.056	191.5	0.831	4.15	0.00	1.71	2.75	0.15	2.28	11.93
	2	0.056	191.5	0.831	6.51	4.81	2.68	4.32	0.24	3.59	18.74
	3	0.056	191.5	0.831	7.49	4.81	3.08	4.97	0.28	4.13	21.54
	4	0.056	191.5	0.831	7.89	4.81	3.25	5.23	0.29	4.35	22.70
	sums/means	0.225	766	3.3		14.42			0.97	14.34	18.73
May	1	0.056	176.8	0.767	3.25	0.00	1.43	2.21	0.12	1.70	9.61
	2	0.056	176.8	0.767	4.27	2.85	1.88	2.91	0.16	2.23	12.63
	3	0.056	176.8	0.767	4.72	2.85	2.07	3.22	0.18	2.47	13.96
	4	0.056	176.8	0.767	4.92	2.85	2.16	3.35	0.19	2.57	14.54
	sums/means	0.225	707	3.1		8.54			0.66	8.97	12.69
Jun.	1	0.056	109.8	0.476	2.16	0.00	1.27	1.67	0.09	0.80	7.27
	2	0.056	109.8	0.476	3.58	2.32	2.10	2.78	0.16	1.32	12.06
	3	0.056	109.8	0.476	4.42	2.32	2.60	3.43	0.19	1.63	14.87
	4	0.056	109.8	0.476	4.91	2.32	2.88	3.81	0.21	1.81	16.53
	sums/means	0.225	439	1.9		6.95			0.66	5.57	12.68
Jul.	1	0.056	121.8	0.528	2.88	0.00	1.61	2.18	0.12	1.15	9.48
	2	0.056	121.8	0.528	3.73	2.12	2.08	2.83	0.16	1.49	12.26
	3	0.056	121.8	0.528	4.20	2.12	2.34	3.18	0.18	1.68	13.81
	4	0.056	121.8	0.528	4.47	2.12	2.49	3.38	0.19	1.79	14.68
	sums/means	0.225	487	2.1		6.37			0.65	6.11	12.56
Aug.	1	0.056	140.8	0.611	2.49	0.00	1.28	1.82	0.10	1.11	7.88
	2	0.056	140.8	0.611	4.83	3.55	2.48	3.52	0.20	2.15	15.29
	3	0.056	140.8	0.611	6.03	3.55	3.09	4.40	0.25	2.69	19.09
	4	0.056	140.8	0.611	6.64	3.55	3.41	4.85	0.27	2.96	21.04
	sums/means	0.225	563	2.4		10.65			0.82	8.91	15.82
Sep.	1	0.056	141.5	0.614	3.41	0.00	1.74	2.49	0.14	1.53	10.78
	2	0.056	141.5	0.614	4.80	3.05	2.45	3.49	0.20	2.15	15.16
	3	0.056	141.5	0.614	5.50	3.05	2.82	4.01	0.23	2.46	17.40

4	0.056	141.5	0.614	5.87	3.05	3.00	4.27	0.24	2.62	18.55
sums/means	0.225	566	2.5		9.15			0.80	8.76	15.47
grand sums/means	2.7	6,913	30		118.46			9.37	109.78	15.88

Fishing effort multiplier = 1

Equations:

M' = M/48

F' = q.X' where q = a'/A

B2' = B1'.exp (-(F' + M'))

B3' = (B1' - B2')/(F' + M')

D' = M'.B3'

Cw' = F'.B3'

Fishery Profit Spreadsheet

1. Projected catch rates	large shrimp	126.3	kg/trip	126
	small shrimp	9.7	kg/trip	10
	Leoignathus spp.	177.9	kg/trip	178
	other prime fish	27.5	kg/trip	28
	salted fish	106.9	kg/trip	107
	other fish	105.0	kg/trip	105
2. Observed product prices	large shrimp	600	Rs/kg	600
	small shrimp	200	Rs/kg	200
	Leoignathus spp.	70	Rs/kg	70
	other prime fish	200	Rs/kg	200
	salted fish	7	Rs/kg	7
	other fish	70	Rs/kg	70
3. Efforts and estimated catch weights				
No. of boats		19.0		
months fishing		11	/yr	
fishing trips/month		3.842	trips/month	
catch weights (kg)	large shrimp			101,416
	small shrimp			7,789
	Leoignathus spp.			142,850
	other prime fish			22,082
	salted fish			85,838
	other fish			84,313
4. Gross revenue (Rs'000)				
	large shrimp			60,850
	small shrimp			1,558
	Leoignathus spp.			9,999
	other prime fish			4,416
	salted fish			601

	other fish				5,902
	total				83,326
5. Investment (Rs'000)					
	hull (11 tonne)			1,800	
	engine (96 HP diesel inboard)			400	
	fishing gear (3 trawl nets, plus ropes and doors)			210	
	total			2,410	
6. Fuel & oil costs (Rs'000)					
fuel	fuel consumption	300	litres/trip		17,585
oil	fuel price (diesel)	73	Rs/litre		747
	oil consumption	3	litres/trips		
	oil price	310	Rs/litre		
7. Other trip costs (Rs'000)					
	ice (15 x 50 kg blocks x Rs140/block)	2,100	Rs/trip		1,686
	food	3,000	Rs/trip		2,409
	water (70 litres @ 2.2 Rs/l for drinking and 300 litres @ 0.5 Rs/l for washing)	304	Rs/trip		244
	salt	1,600	Rs/trip		1,285
	other (extra labour for unloading)	1,000	Rs/trip		803
8. Remunerations (Rs'000)					
	Owner	1,073	Rs		18,342
	Skipper	565	Rs		9,664
	Crew	411	Rs		14,056
	No. of crew	2	persons		
	% of 2009 remunerations	90%			
9. Repairs/Maintenance/Replacement Costs (Rs'000)					
	hull	10	% of investment		3,420
	engine (reconditioned every 4 years)	400,000	Rs/4 years		1,900
	fishing gear (replaced yearly)	100	% of investment		3,990
10. Registration and licences (Rs'000)					
	boat registration	500	Rs/vessel		10
	fishing licences	250	Rs/vessel		5
11. Insurance costs (Rs'000)					
	total boat loss incl. crew third party	2,000	Rs/yr		38

12. Depreciation costs (Rs'000)				
	hull	5	% of investment	1,710
	engine	10	% of investment	760
13. Total costs (Rs'000)				78,653
14. Fishery profit (Rs'000)				4,673