Resource assessment of the tiger shrimp, *Penaeus monodon* of Kuala Baram, Miri-Sarawak.

By
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Abstract

Two commercial trawlers; a twin–outrigger trawler, (SF3-779) and a stern trawler, (SF3-118) were chartered to carry out the surveys for the assessment of the tiger shrimp resource. The area survey extended seaward beyond the coast to the 50m depth from Tanjong Baram to Kuala Bakam, Miri. The total area covered was estimated to be 295.5 NM^2. A total of 23 stations were completed; 13 stations surveyed by SF3-779 in depth stratum 11-50m and the other 10 stations by SF3-118 for the depth stratum 5-10m. A total of 131 tails of *Penaeus monodon* were caught by SF3-779 in the >10m deep stratum. The catch includes 51 male and 80 female shrimps. The average catch rate obtained was 0.22 $kghr^{-1}$ for male shrimp and 0.47 $kghr^{-1}$ for female shrimp. *Penaeus monodon* only occupied 0.4% - 5.6% of the catch with an average of 2.16%. The other penaeid shrimps contributed an average of 5.74% to the total catch. The rest of the catch (92.10%) consists of fish. In the shallower waters (5-10m), SF3-118 caught only 7 male and 1 female tiger shrimps throughout the 10 stations sampled. The average catch rate obtained for the tiger shrimp was 0.03 kg/hr and 0.006 kg/hr for the male and female shrimp respectively. *Penaeus monodon* catch contributed an average 0.75% to the total catch. The rest of the catch was attributed to other penaied shrimp (10.16%) and fish (89.09%). The male shrimp size ranges from 28.3mm carapace length (103.5mm total length and weighed 20g) to 59.3mm (220.7mm total length and weighed 156g). The size of female shrimps caught ranges from 37.0mm carapace length (163mm total length and weighed 30g) to 75.0mm carapace length (282mm total length and weighed 210g). The survey shows that the majority (68.9%) of the broodstocks was ready to spawn with 9.9% have already shed their egg. About 62.5% of the tiger shrimp resources were found in the area 11 to 50m deep with the rest caught in the shallow waters, 5 to 10m deep. The biomass estimated were 2695kg for male and 3076kg for female shrimp based on catchability coefficient, q of 1.0. At current yield (1987kg for male and 3749kg for female shrimp) and current biomasses derived, the Maximum SustainableYields were 4362kg and 5720kg for male and female tiger shrimp respectively. The exploitation rate, E was 0.4 per year for both male and female shrimp. The E values obtained indicate that the tiger shrimp resource has not been exploited at optimum, E=0.5 per year. The tiger shrimp, *Penaeus monodon* resource on the coast of Miri, specifically off Kuala Baram should be sustained at the present level.

Keywords: *Penaeus monodon*, biomass, maximum sustainable yield

Abstrak

Dua bot pukat tunda komersial, SF3-779 dan SF3-118 telah disewa khas bagi menjalankan survei udang. Kawasan survei ialah dari Tanjong Baram ke Kuala Bakam, Miri merangkumi persisiran pantai hingga ke kedalaman 50m. Keluasan kawasan survei ialah kurang lebih 295.5 batu nautika persegi. Dua puluh tiga stesen menunda telah dijalankan; 13 stesen dibuat oleh bot SF3-779 di kedalaman air 11-50m dan 10 stesen di kendalikan oleh bot SF3-118 di kedalaman air 5-10m. Sebanyak 131ekor (51 jantan dan 80 betina) udang harimau berjaya ditangkap oleh bot SF3-779 dimana kadar tangkapan ialah 0.22 kgjam^{-1} bagi udang jantan dan 0.47 kgjam^{-1} bagi udang betina. Tangkapan udang harimau merupakan antara 0.4% - 5.6% (purata 2.16%) dari hasil tangkapan keseluruhan (5.74% spesis udang lain dan 92.1% ikan). Manakala bagi kawasan perairan cetek, bot SF3-118 berjaya mendarat sebanyak 7 ekor udang jantan dan seekor udang betina dengan kadar tangkapan masing-masing 0.03 kgjam^{-1} dan 0.006 kg/jam dimana tangkapan udang harimau merupakan hanya 0.75% dari tangkapan keseluruhan (10.16% spesis udang lain dan 89.09% ikan). Saiz udang harimau jantan yang didarat ialah dalam julat 28.3mm panjang karapas (103.5mm panjang badan dan mempunyai berat 20g) hingga 59.3mm panjang karapas (220.7mm dan berat 156g). Bagi udang harimau betina, saiz yang didarat ialah dari 37.0mm panjang karapas (163mm panjang badan dan berat 30g) hingga 75.0mm panjang karapas (282mm panjang badan dan berat 210g). Survei ini menunjukan bahawa kebanyakan (68.9%) dari induk udang harimau betina bersedia menetaskan telor, manakala 9.9% telah mengeluarkan telor. Kira-kira 90% dari sumber udang harimau didapati di perairan dalam 11–50m. Anggaran biomas adalah 2695kg bagi udang harimau jantan dan 3076kg bagi udang harimau betina berdasar kepada koeffisien tangkapan (q), bernilai 1.0. Pada tahap pendaratan semasa (1987 kg bagi udang jantan dan 3749 kg bagi udang betina) dan dari anggaran biomas, Hasil Mampan Maksima, ialah 4362kg dan 5720kg masing –masing bagi udang harimau jantan dan betina. Kadar eksploitasi, E adalah 0.4 setahun bagi kedua-dua udang harimau jantan dan betina. Kadar eksploitasi masih lagi rendah dengan mengambil kira tahap optimum ialah 0.5 setahun. Dengan keputusan ini, sumber udang harimau di perairan laut Miri, khasnya Kuala Baram perlulah dikekalkan pada tahap eksploitasi sekarang.

Kata-kunci: *Penaeus monodon*, biomas, hasil mampan maksima

1.0 Introduction

Shrimp surveys carried out since 1980 (Bejie 1981, 1982 and 1983, Yong 1990, Hadil 1994b) indicated that the majority (80%) of the shrimps were caught in waters from 6 to 20 meters deep in Sarawak. Results of these surveys suggested that shrimps were more abundant in the Kuching Bay.

Twenty-one species of penaeid shrimps were recognized in Sarawak waters (Tamaei 1979, Hadil 1994b). Eventhough, the area concentration of the shrimp resource is in the coastal water of western Sarawak, species distribution is more diverse. Tiger shrimp,

Penaeus monodon is the largest of the penaeid found, but were caught in small quantities, (0.2-2.0kg hr^{-1} – Hadil 1994b), landings of shrimp increase from October onward and reached the peak during the monsoon months of January to March (Hadil 1994b). Past surveys (Bejie 1981, 1982 and 1983, Hadil 1994b) indicated that the species was caught in relative abundance in coastal waters from Bintulu to Miri specifically off Kuala Suai in water depths ranging from 10 to 20m with mud-sandy bottom. Occasionally, *P.monodon* was caught in Kuching Bay (Hadil 1994b).

Hadil and Faazaz (1998) have identified the area of more than 30m off Tanjong Batu to Kuala Baram as a potential for tiger shrimp sanctuary. This area has been used as a tiger shrimp broodstock collection area since 1997 by the local trawlers.

The State Government of Sarawak has initiated the setting up of the task force to look into the possibility of utilizing the state own broodstock resource for the fast growing shrimp aquaculture industry. Two commercial trawlers; a twin–outriggered trawler, (SF3-779) and a manually operated stern trawler, (SF3-118) were chartered to carry out the surveys in July 1999. This paper presents results of the assessment of the resource based on the data obtained during the surveys.

2.0 Materials and Methods

2.1 Description of the survey area.

(a) The area survey extended seaward beyond the coast to the 50m depth from Tanjong Baram to Kuala Bakam, Miri (Figures 1 and 2). The total area covered was estimated to be 295.5 NM^2, which comprised 168.5 NM^2 surveyed by stern trawler SF3-779 and 92 NM^2 surveyed by twin-out rigger trawler SF3-118. The remaining areas which are the restricted areas of the west Lutong and Baram oilfields were not taken into account in the biomass estimation.

2.2 Research vessel and fishing gear specifications

Trawlers SF3-779 and SF3-118 were deployed to survey the shallower (5-10m) and the deeper (10-50m) part of the survey area respectively. Some of the principal details of the vessels and the equipment are given below,

Principal characteristic	**SF3-118**	**SF3-779**
Hull	wooden	wooden
Length overall (m)	12.8	18
Breadth (m)	3.0	4.2
Gross tonnage (tons)	15	62
Main engine	16hp. Yanmar diesel	315hp Nissan diesel
Type of vessel	Stern trawler	Twin-outrigger trawler

The designs of the trawl net and otterboard used and some of their principal features are shown in Figures 3,4,5 and 6. The nets were made of polyethylene with a cod-end mesh size of 63mm and 50mm for SF3-779 and SF3-118 respectively.

2.3 Survey design and sampling stations

The survey methodology used followed the standard methodology outlined in Mackett (1973) and Sparre and Venema (1992). Sampling was conducted using the stratified random sampling technique. Within each stratum (5-10m and 11-50m), trawl stations were selected randomly. A total of 23 stations were completed; 13 stations surveyed by SF3-779 and the other 10 stations by SF3-118 (Appendices 1 and 2). The distribution of stations is shown in Figures 1 and 2. Fishing was carried out both during day and night time.

2.4 Sampling procedure

Samples were taken using the bottom trawl. The trawling duration ranged from 49 minutes to 2.95 hours with an average speed of 3.23 and 2.43 knots for vessels SF3-779 and SF3-118 respectively (Appendices 1 and 2). The trawling duration and speed varied because of the limited area to maneuver since a big portion of the coastal waters off Kuala Baram and Lutong were oilfields (Figures 1 and 2). Once the catch was landed onboard the vessel, large size fish and shrimps as well as dangerous and poisonous specimens were sorted. All commercial species irrespective of size were weighed and recorded. Tiger shrimp caught were weighed and measured to the nearest millimeter in term of total length and carapace length. Length frequency measurements were taken and recorded on to length frequency forms by station. The female shrimp egg maturity stage was determined based on criteria mentioned by Motoh (1981). All catch data were processed and analyzed to produce catch rates, species composition using the software Microsoft Excel.

2.5 Data Analysis

2.5.1 Biomass determination

The "swept" area method was used to determine the density of tiger shrimp per square nautical mile. The trawl sweeps a well path, which is called the "swept area", or the "effective path swept". The swept area, a can be estimated using the equation below:

$a = D*h*x, \quad D = V*t,$

where V is the velocity of the trawl over the ground during trawling, t is the time spent trawling, h is the length of the headrope and x is that fraction of the headrope which is equal to the width of the path swept by the trawl. For Southeast Asia the values of x from

0.4 to 0.66 were suggested (Shindo 1973, SCSP 1978). Pauly (1980) suggests 0.5 as the best compromise x value for tropical waters. In this study, the value 0.5 was adopted.

The density of the shrimp was calculated from the catch rates recorded in kg/hour from this survey. If the weight of catch per haul is Cw, then Cw/t is the catch per hour when t is the duration the trawl haul. If "a" is the area swept by the trawl haul, the a/t represents the area swept per hour. In this survey, trawling for duration of one hour with a trawl net having a headrope length of 17.6m and 11.7m for SF3-779 and SF3-118 respectively covered the swept area. Thus for SF3-779, since two nets were used at the same time the total headrope used in the calculation of biomass was 35.2m. One nautical mile is equals to 1852 meters. The weight of catch per unit area is:

(Cw/t)/ (a/t) = Cw/a kg per sq. nm

The mean weight of catch per unit area (Cw/a) divided by q (catchability coefficient) gives the average biomass per unit area. The catchability coefficient represents the amount of the shrimp caught by the trawl relative to the amount that escaped being caught. When q = 1.0, all the shrimp in the path of the trawl was assumed to be caught. Thus biomass, B, of the whole area survey, A is:

B = (Cw/a)/q *A

2.5.2 Estimation of exploitable potential

This tiger shrimp resource has been exploited since the introduction of the trawl in early seventies (Hadil 1994a), but was not that prominent due the fact that shrimp farming was not really popular then. **For stocks that are exploited, the maximum sustainable yield, MSY was calculated using the equations proposed by Cadima (in Sparre and Venema 1992) as given below.**

MSY = 0.5*(Y+MBc)

In this equation, Y is the current yield, M is the natural mortality coefficient and Bc is the current biomass determined.

In the determination of MSY, the value of q equals to 1.0 was used on the assumption that commercial trawler catches all along its swept area. The natural mortality coefficient used was 2.5 based on the value recommended by Garcia (1985). The current yield at 5736 kg (Table 1) taken from the area surveyed was estimated from the landings of commercial trawlers of all size categories in Miri, Sarawak (Anon. 1999). Based on the current survey results (total catch of *Penaeus monodon* from the two vessels), the ratio of male to female shrimp in term of weight was 0.53 to 1.00.

2.5.3 Estimation of Exploitation rate (E)

Exploitation rate (E) is a fraction of the total death (Z) caused by fishing (F). Since F=Y/Bc and Z=F+M, the exploitation rate can be estimated following the equation below:

$E = (Y/Bc)/(Y/Bc+M)$

2.5.4 Morphometric relationship analysis

The length frequency data for the shrimp were analysis using FISAT Version 1.10 program (FAO-I CLARM Stock Assessment Tools). The relationships between weight and length and between carapace length (CL) and total length (TL) were also done using the same program.

3.0 Results and discussion

A total of 23 hauls (Appendices 1 and 2) were successfully conducted from 29th July 1999 to 3rd August 1999.

3.1 Catch composition

Tables 2 and 3 show the overall catch composition obtained by trawlers SF3-779 and SF3-118 respectively. The dominant species of penaeid shrimps caught by SF3-779 in the deeper waters were *Penaeus monodon* at 13.22 kg followed by *Metapenaeus affinis* at 9.01kg. Several species of fish and cephalopods were caught and the dominant species in term of weight and numbers were *Leiognathus bindus* (3.25kg), *Sepia* spp. (14.06), *Ariomma indica* (5.6kg), *Muraenesox cinereus* (5.23kg) and Teraponidae (2.27kg) and others in meager quantity.

The dominant shrimps caught in the shallow waters by SF3-118 were *Metapenaeus affinis* (4.01kg) and *Penaeus merguiensis* (2.33kg). The other component of the catch comprises smaller size fish, which include jellyfish (54.1kg), *Lutjanus equulus* (12.22kg), Sciaenidae (6.79kg), Opisthopterus tardoore (5.81kg), Gizza minuta (5.25kg) and others in small quantity.

The assemblage of shrimps and fishes seem to show a simple differentiation in species composition from shallower to deeper waters. Presumably, the reason for this simple different was due the fact that the food availability was different between the shoreline mangrove fringes and that of open sea with muddies bottom.

3.2 Catch rates

In order to avoid biases, the catch data of SF3-779 and SF3-118 were converted to kilogrammes per hour and log-tranformed to obtained the average catch rate from normal distribution.

A total of 131 tails of *P. monodon* were caught by SF3-779 (Table 4) in the >10m deep stratum. The catch includes 51 male and 80 female shrimps. The catch ranged from 1 tail per station to 25 tails per station. The high number of *P. monodon* caught were at stations 7,9,10 and 11, where the numbers caught ranges from 18 to 25 tails per station. The average catch rate obtained was 0.22 kg hr^{-1} for male shrimp and 0.47 kg hr^{-1} for female shrimp. In term of numbers, the average catch per hour was 2.7 tails and 4.2 tails for male and female tiger shrimp respectively. The average catch rates obtained for other peneaid shrimps and fish were 2.14 kg hr^{-1} and 28.91 kg hr^{-1} respectively. *P. monodon* only occupied 0.4% - 5.6% of the catch with an average of 2.16%. The other penaeid shrimps contributed an average of 5.74% to the total catch. The rest of the catch (92.10%) consists of fish.

In the shallower waters (5-10m), SF3-118 caught only 7 male and 1 female tiger shrimps throughout the 10 stations sampled. (Table 5). There were only 5 stations that landed between one and two tails of tiger shrimp per haul. The average catch rate obtained for the tiger shrimp was 0.03 kg/hr and 0.006 kg/hr for the male and female shrimp respectively. In term of numbers caught, the figures were relatively small; 0.4 tail for male and 0.05 tail for the female shrimp. *P.monodon* catch contributed an average 0.75% to the total catch. The rest of the catch was attributed to other penaied shrimp (10.16%) and fish (89.09%).

There was obviously a variation in the average total catch rates recorded between the two strata (5-10m and 11-50m deep waters). Part of the reason was probably due to life cycle of the shrimp that the bigger size and matured shrimp inhabit deeper waters for spawning. In this survey, the deeper stratum was found to be most productive. Therefore, the fishing grounds beyond the 10m isobath are richer than the shallow waters.

3.3 Shrimp size and maturity stage

The male shrimp sizes ranges from 28.3mm carapace length, (103.5mm total length, and weighed 20g) to 59.3mm carapace length (220.7mm total length and weighed 156g). The size of female shrimps caught ranges from 37.0mm carapace length (163mm total length, 30g) to 75.0mm carapace length (282mm total length, 210g). Most of the female shrimps were distributed in the deeper waters and 77.8% were matured. According to Motoh (1981), the minimum size at maturity was 37mm carapace length for male and 47mm carapace length for female shrimp.

The morphometric analyses involving the relationship between total length and carapace length and between weight and total length followed the equations below:

Total length = a + b [carapace length]
Log weight = a + b log [total length]

Table 6 shows the outcome of the analyses using FiSAT software program.

The maturity stages of the female shrimp caught were 22.2% stage 1; 33.3% stage 2; 22.2% stage 3; 12.4% stage 4 and 9.9% stage 5 (spent). The survey shows that the majority (68.9%) of the broodstocks was ready to spawn with 9.9% have already shed their egg. Stage 2 and 3 were the most appropriate for hatchery to produce fry. Stage 4 is the best broodstock for immediate spawning but the timing of the delivery to the hatchery is critical, considering that the egg might be released at anytime.

3.4 Biomass estimates

In shallow waters, the density of male shrimp was 15.58kg nm^{-2}. Since only one tail of female shrimp caught in the shallow water, the density was low at 7.79kg nm^{-2}. The density of female shrimp resource in the shallow water was about half (Table 7) of the deeper water, interestingly was vice versa for male shrimps.

Biomass estimates of the tiger shrimp resource off Kuala Baram, Sarawak calculated using Swept Area method were summarized in Table 7. The biomass were 2695kg and 3076kg for male and female shrimp respectively. **The biomass difference between the two depth strata; 5-10m and 11-50m was roughly in the ratio of 6:10.** The 11-50m stratum has a slightly bigger area. About 62.5% of the tiger shrimp resources were found in stratum 11 to 50m deep (Table 7).

The biomass of tiger shrimp resource estimated here was based on the results of only one survey conducted over a limited period only. A better biomass estimate using the average result from a series of surveys conducted in different months in the same area would provide a better estimate of the actual standing stock. A series of surveys should cover the seasonal variation in the standing stock.

3.5 Exploitation potential

The available data on current yield (Y) taken from the survey area are the landings of commercial trawlers in 1999. Table 1 gives the landings of trawlers of all sizes category in Miri, Sarawak. Out of the total 5736kg landed, the estimated yields of male and female shrimps followed the ratio of 0.53 to 1.00 estimated in the current study, giving 1987kg male and 3749kg female shrimp landed in 1999.

No natural mortality, M values for tiger shrimp in Malaysian waters were ever recorded. However, by critically analyses all the available M values for penaeus shrimp, Garcia (1985) points towards an average natural mortality rate for penaeids of the order of 2.4 $\pm$ 0.3 per year for adults. A compromised average value of 2.5 was taken for this assessment study.

Table 8 gives the MSY for both male and female tiger shrimp. At current yield (1987kg for male and 3749kg for female shrimp) and current biomasses derived, the MSY was between 2620 to 3843kg and between 4622 to 6653kg for male and female tiger shrimp respectively. During the present survey, the average weight of male shrimp was about 80g and 110g for female shrimp. These sizes were considered to be matured (having carapace length of >37mm for male and >47mm for female shrimp) (Motoh, 1981). In term of number, the MSY for male was estimated to be 54,525 tails and that of female shrimp, the MSY estimated was 52,000 tails.

These MSY estimates were derived from using assumptions for values like catchability coefficient (q), natural mortality (M) and yield from the fisheries (Y), which was estimated, from the landings of commercial trawlers. In such a situation, a change in either one of the three variables used will change the estimate of MSY and potential yield.

The choice of average M value used also affects the MSY estimated. A monthly series of length frequency data were currently been collected from commercial trawlers in Kuala Baram and the M value derived will be very useful in refining the MSY value later on.

In the estimates of current tiger shrimp yield, the assumption made was that the present survey result reflects the overall commercial landings in term of weight ratio between male and female shrimp catch. Frequent surveys will certainly improved on the ratio between male and female shrimp catch.

3.6 Exploitation rate

Table 9 shows the exploitation rates derived. The exploitation rate, E was 0.4 per year for both male and female shrimp. The E values obtained indicate that the tiger shrimp resource has not been exploited at optimum, E=0.5 per year. And if the value stands at <0.5 per year, this is a healthy scenario and that the broodstock resource can sustain further exploitation.

4.0 CONCLUSIONS

Bearing in mind fishery precautionary approach, the tiger shrimp, *Penaeus monodon* resource on the coast of Miri, specifically off Kuala Baram should be sustained at the present level.

In order to evaluate the effectiveness of any management measure implemented, continuous monitoring and research preferably by annual experimental surveys should be undertaken following the implementation and effective enforcement of such a measure. Monitoring the performance of commercial fishing boats should be conducted parallel to experimental fishing by research vessels. This is to ensure that the current status of the fisheries is known, and that new and additional information is made available for the formulation of new and the refinement of the old ones.

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Table 1: Landings (kilogram) of *Penaeus. monodon* by trawlers in Miri, Sarawak in 1999

Year	Month												
	Jan	Feb	Mac	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total (kg)
1999	630	704	1140	680	545	340	468	298	208	216	307	200	5736

**Source: Annual Fisheries Statistics For 1999 (Anon. 1999)

Table 2: Catch composition of dominant shrimp and fish species caught by SF3-779 in July/August off Kuala Baram.

Species	Total Catch (kg)
SHRIMP	
Penaeus monodon (M)	4.25
Penaeus monodon (F)	8.97
Metapenaeus affinis (M)	1.05
Metapenaeus affinis (F)	7.96
Mixed shrimp species	3.62
FISH	
Leioghnathus bindus	3.25
Teraponidae	2.27
Ariomma indica	5.60
Muraenesox cinereus	5.23
Sepia sp.	14.06
Mixed fish	98.84

Table 3: Catch composition of dominant shrimp and fish species caught by SF3-118 in July/August off Kuala Baram.

Species	Total Catch (kg)
SHRIMP	
Penaeus monodon (M)	0.56
Penaeus monodon (F)	0.12
Metapenaeus affinis (M)	1.695
Metapenaeus affinis (F)	2.41
Penaeus merguensis (M)	0.795
Penaeus merguensis (F)	1.535
Mixed shrimp species	3.75
FISH	
Gizza minuta	5.253
Lutjanus equulus	12.22
Opisthopterus tardoore	5.81
Sciaenidae	6.79
Jellyfish	54.1
Mixed fish species	42.38

Table 4: Catch rates (by haul) of shrimps and fish caught by SF3-779 in July/August 1999 off Kuala Baram.

Station	1		2		3		4		5		6		7		8		9		10		11		12		13		TOTAL		Average Catch rate	
Date	29.07.99		29.07.99		29.07.99		02.08.99		02.08.99		02.08.99		02.08.99		02.08.99		02.08.99		02.08.99		02.08.99		02.08.99		03.08.99					
Fishing	1503-1612		1615-1812		1832-2025		0820-1030		1100-1219		1232-1335		1340-1442		1448-1554		1630-1756		1813-1902		1950-2117		2145-2348		0842-1020					
Substrate	Mud		Mud		Mud		Mud		Mud		Mud		Mud		Mud		Mud		Mud		Soft Mud		Mud		Mud					
Sea condition	Choppy		V. Choppy		Choppy		Choppy		Choppy		Choppy		Choppy		Choppy		Calm		Calm		Calm		Choppy		Rough					
Water colour	Greenish		Muddy		Muddy		Dk.Green		Dk.Green		Greenish		Greenish						Greenish		Green/Blue		Greenish		Greenish					
(Wt. In kg)	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails
***P.monodon* (M)**			0.43	4	0.43	4	0.10	1			0.62	5	0.50	7	0.08	1	0.44	8	0.27	4	0.43	12	0.70	4	0.25	1	4.25	51	0.22	2.7
***P.monodon* (F)**	0.20	1	0.56	4	0.44	3			0.14	1	0.26	2	1.45	11	0.48	4	2.06	16	2.11	16	0.83	13	0.44	9			8.97	80	0.47	4.2
Total	**0.20**	**1**	**0.99**	**8**	**0.87**	**7**	**0.10**	**1**	**0.14**	**1**	**0.88**	**7**	**1.95**	**18**	**0.56**	**5**	**2.50**	**24**	**2.38**	**20**	**1.26**	**25**	**1.14**	**13**	**0.25**	**1**	**13.22**	**131**	**0.69**	**6.9**
Other Shrimps	0.48		1.60		7.14		0.96		0.75		4.73		2.55		1.19		9.70		9.71		1.50		0.50				40.81		2.14	
Fish	12.50		15.00		58.00		12.00		25.00		80.00		70.00		20.00		90.00		70.00		60.00		40.00				552.50		28.91	
Total catch	**13.18**		**17.59**		**66.01**		**13.06**		**25.89**		**85.61**		**74.50**		**21.75**		**102.2**		**82.09**		**62.76**		**41.64**		**0.25**		**606.5**		**31.74**	
(Wet Wt.)																														
%***P.monodon***	1.50		5.60		1.30		0.77		0.42		1.02		2.62		2.57		2.40		2.90		2.09		2.74				25.93		2.16%	
% Shrimp	3.64		9.11		10.82		7.35		2.26		5.52		0.08		5.47		9.49		11.40		2.50		1.20				68.84		5.74%	
Catch rates ($kghr^{-1}$)	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails			Wt*	Tails*
P. monodon (M)			0.22	2.05	0.23	2.13	0.05	0.46			0.59	4.76	0.49	6.80	0.07	0.91	0.31	5.59	0.33	4.87	0.30	8.28	0.34	1.95	0.15	0.61			0.23	2.41
P. monodon (F)	0.17	0.87	0.29	2.05	0.23	1.60			0.11	0.76	0.25	1.91	1.41	10.68	0.44	3.64	1.44	11.19	2.57	19.5	0.57	8.97	0.22	4.39					0.43	3.62

* Mean catch rates after log-tranformed

Table 5: Catch rates (by haul) of shrimps and fish caught by SF3-118 in July/August 1999 off Kuala Baram.

Station	1		2		3		4		5		6		7		8		9		10		TOTAL		Average Catch rate	
Date	29.07.99		29.07.99		29.07.99		02.08.99		02.08.99		02.08.99		02.08.99		02.08.99		03.08.99		03.08.99					
Fishing	1410-1536		1605-1806		1820-2000		0949-1143		1227-1342		1355-1513		1526-1720		1739-1908		0728-0846		0957-1022					
Substrate	Mud		Mud		Mud		Mud		Mud		Mud		Mud		Mud		Mud		Mud					
Sea condition	Choppy		V. Choppy		Choppy		Choppy		Choppy		Choppy		Calm		Calm		Choppy		Choppy					
Water colour	Greenish		Muddy		Muddy		Greenish		Greenish		Greenish		Greenish		Dk. Green		Dk. Green		Dk. Green					
(Wt. In kg)	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails	Wt.	Tails
***P.monodon* (M)**	0.13	2	0.19	2									0.05		0.09	1			0.11	1	0.56	7	0.03	0.40
***P.monodon* (F)**													0.12								0.12	1	0.01	0.05
Total	**0.13**	**2**	**0.19**	**2**									**0.17**		**0.09**	**1**			**0.11**		**0.68**	**8**	**0.04**	**0.45**
Other Shrimps	2.19	286	0.82	65	1.05	156	0.90	238	1.21	188	1.53	343	1.17	96	0.27	29			0.33	15	9.50		0.50	
Fish	4.71	57	11.20	73	8.27	68	2.55	116	16.95	107	25.98	333	40.21	4681	4.18	100	17.31	512	5.74	648	137.10		7.25	
Total catch	7.03	345	12.21	140	9.32	224	3.44	354	18.16	295	27.51	676	41.54	4777	4.54	130	17.31	512	6.18	663	147.3		7.79	
% P. monodon	1.85		1.52										0.4		1.98				1.78					
% Shrimps	31.08		6.72		11.26		26		6.67		5.57		2.915		6.02				5. 34					
Catch rate ($kghr^{-1}$)	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt	Tails	Wt*	Tails*
P. monodon (M)	0.09	1.4	0.09	0.99									0.03	0.5	0.06	0.68			0.26	2.38			0.12	1.02
P.monodon (F)													0.06	0.5									0.06	0.50

* Mean catch rates after log-tranformed

Table 6 : Morphometric analysis on the relationship between total length and carapace length and between weight and total length of *Penaeus monodon.*

Parameters	total length TL Vs. carapace length CL		Weight Vs. TL total length	
	male	female	male	female
a	59.24	58.93	0.0009	0.0002
b	2.72	2.96	2.16	2.43
Relation coefficient, r	0.56	0.97	0.71	0.82

Table 7: Abundance of *Penaeus monodon* estimated by depth strata for July/August 1999 off Kuala Baram.

Area	No. of Station	Area (nm^2)	Catch Rate ($kghr^{-1}$)		Density ($kgnm^{-2}$)		Total Biomass ($kgnm^{-2}$)	
			Male	Female	Male	Female	Male	Female
5-10m	10	92.0	0.120	0.060	15.58	7.79	1433	717
11-50m	13	168.5	0.230	0.430	7.49	14.00	1262	2359
Total	**23**	**260.5**					**2695**	**3076**

Table 8: Estimation of Maximum Sustainable Yield (MSY) of *Penaeus monodon* resource for Kuala Baram area.

At yield of 1,987kg for male and 3,749kg for female

Reference	Formula	Male Bc= 2695kg q = 1.0, m=2.5	Female Bc=3076kg q=1.0, m = 2.5
Cadima (in Sparre & Venema, 1992)	MSY=0.5*(Y+MBc)	**4362kg**	**5720kg**

Table 9: Estimation of exploitation rate (E) of *Penaeus monodon* for Kuala Baram area in July/August 1999.

A yield of 1,987kg for male and 3,749kg for female

	Male	Female
Natural Mortality (M)	2.5	2.5
Catchability coefficient (q)	1.0	1.0
Current biomass, Bc (kg)	2695	3076
Exploitation rate E = (Y/Bc)/(Y/Bc x M)	0.4	0.4

Appendix 1: Trawl log for twin outrigger trawler SF3-779.

	Station No.	Time net released	Start trawling		Position (Lat/Long)	Speed (knot)	Stop trawling		Position (Lat/Long)	Time net lifted	Trawling time (hr)
			Time (hour)	Depth (m)			Time (hour)	Depth (m)			
29.07.99	1	1458	1503	35	04 43 36 113 59 68	3.2	1612	30.2	04 43 10 114 01 89	1609	1.15
29.07.99	2	1610	1615	20	04 42 29 114 00 00	3.2	1812	20	04 47 80 113 59 40	1812	1.95
29.07.99	3	1828	1832	20	04 42 29 114 59 50	3.2	2025	27	04 40 70 114 03 64	2025	1.88
02.08.99	4	815	820	28	04 23 52 113 51 23	3.3	1030	23	04 25 00 113 52 78	1036	2.31
02.08.99	5	1056	1100	27	04 25 23 114 52 69	3.2	1219	24	04 25 87 113 52 713	1224	1.31
02.08.99	6	1230	1235	25	04 41 88 114 02 161	3.2	1335	25	04 60 60 114 01 737	1336	1.00
02.08.99	7	1339	1340	28	04 40 16 113 54 680	3.1	1442	28	04 38 305 113 53 117	1443	1.03
02.08.99	8	1443	1448	30	04 37 856 113 52 56	3.4	1554	26	04 35 611 113 53 515	1556	1.10
02.08.99	9	1625	1630	34	04 35 646 113 53 334	3.4	1756	33	04 38 326 113 53 464	1808	1.43
02.08.99	10	1810	1813	31	04 38 350 113 53 448	3.4	1902	26	04 36 958 113 53 258	1905	0.82
02.08.99	11	1945	1950	27	04 37 142 113 53 448	3.2	2117	23	04 36 825 113 53 547	2120	1.45
02.08.99	12	2140	2145	48	04 37 173 113 53 768	3.1	2348	29	04 36 630 113 53 35	2400	2.05
03.08.99	13	840	842	-	04 37 173 113 53 768	3.1	1020	-	04 36 630 113 52 35	1024	1.63

Appendix 2: Trawl log for stern trawler SF3-118

Date	Station No.	Time net released	Start trawling		Position (Lat/long)	Speed (knot)	Direction (degrees)	Stop trawling		Position (Lat/Long)	Time net lifted	Trawling time (hr)
			Time (hour)	Depth (m)				Time (hour)	Depth (m)			
29.07.99	1	1405	1410	8.1	04 39 473 113 58 97	2.8	67	1536	10.7	04 40 10 114 00 62	1553	1.43
	2	1601	1605	7.5	04 40 47 114 00 79	2.4	33	1806	10.4	04 40 29 114 01 82	1812	1.03
	3	1817	1820	10.9	04 40 31 114 01 08	2.2	137	2000	9.5	04 39 21 114 01 71	2007	2.55
02.08.99	4	945	949	6.3	04 38 78 113 57 53	2.5	30	1143	7	04 38 67 113 59 151	1154	2.95
	5	1224	1227	8.5	04 39 85 113 57 15	2.3	25.1	1342	10.2	04 38 43 113 54 91	1347	1.42
	6	1352	1355	9.9	04 38 49 113 54 97	2.4	324	1513	8.3	04 35 55 113 54 61	1515	1.70
	7	1523	1526	7.6	04 36 65 113 54 71	2.4	151	1720	10	04 35 95 113 54 36	1726	2.95
	8	1736	1739	9.0	04 36 07 113 54 52	2.3	36	1908	10.5	04 36 208 113 54 320	1916	2.25
03.08.99	9	726	728	12.9	04 23 05 113 54 76	2.5	184	846	10.3	04 21 00 113 54 17	854	1.50
	10	954	957	10.5	04 23 09 113 55 67	2.5	27	1022	9.3	04 23 67 113 57 13	1058	1.13