FIELD STUDIES OF THE DEPTH DISTRIBUTION OF RECRUIT-SIZED PRAWNS, *PENAEUS MERGUIENSIS* AND *P. MONODON*, IN THE GULF OF PAPUA: IMPLICATIONS FOR MANAGEMENT

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ABSTRACT

During 25th March to 11th April 1996, transects and commercial operations covering the fishing grounds, from 8 to 30 m depth indicated that catch per unit of fishing effort (CPUE) of recruit-sized banana prawns was highest in 8 to 12 m depth. Relative abundance decreased with increasing depth (p = 0.031, single-tail test for negative correlation). Similarly, the CPUE of recruit-sized black tiger prawns decreased with depth from 8 to 30 m (p = 0.046). The percentage catch (by weight) of recruit-sized banana prawns and black-tiger prawns were similarly each negatively correlated with depth (p = 0.018 and p =0.012 respectively). The permanent closure of the 3-mile zone, i.e. trawl-able areas extending seawards 3 miles from the mean low-water mark, to industrial trawling, is supported by these findings. Extension of the eastern boundary of the area closure for 1997 (and subsequent years) eastward from Cape Cupola to the fishing grounds as far south-east as lokea village is recommended in order to include and protect the mangrove nursery areas and adjacent offshore recruitment areas located in 4 to 8 m depth in Freshwater Bay (Lesi Creek, Lakekamu Estuary and Mopu inlet) during the principal recruitment season, January through April. There is increasing interest from resource owners to develop the nearshore prawn resources within the 3-mile zone in a sustainable manner, by opening the 3-mile zone to small-scale, beam trawling, i.e. a limited number of relatively small beam trawls towed by dory. The nets used should be of relatively large mesh sizes in the net body and cod-end, because the results of the present study indicate that, particularly during January through June each year, a large proportion of the catch in the 3-mile zone will probably be new recruits which have not realised their growth potential. Studies to assess the impact of beam trawls should ideally be conducted prior to allowing this kind of fishery to develop. From the transect studies (25th March - 2nd April) alone, the average CPUE (the recruitment index) of banana prawns was 8.23 +/- SE 2.30 kg of tails/ trawl-hour. Similarly, for black tiger prawns the recruitment index was 1.53 +/- SE 0.34 kg (head-on)/trawl-hour. The average depth trawled during the transect studies was 17.7 m (SD 6.39 m). Similar field transect studies to determine comparable recruitment indices in future years could be undertaken.

Keywords: *Penaeid-prawns, recruitment-index, -monitoring, depth-distribution, Gulf-of-Papua.*

INTRODUCTION

The fishery for banana (*Penaeus merguiensis*), black tiger (*P. monodon*) and endeavour (*Metapenaeus* spp) prawns in the Gulf of Papua is currently the largest domestic fishery in Papua New Guinea. The catch consists chiefly of *P. merguiensis* (over 50% by weight), and secondly of *P. monodon* with lesser amounts of *Metapenaed* Prawns. Approximately 700-1000 t of prawn tails per year are caught by 13-14 otter trawl vessels, either quad-rigged or double-rigged and of not more than 28 m overall length. Only companies with more than 50% ownership by PNG citizens are permitted in the fishery. A 3-mile conservation (prohibited trawl) zone was estimated in the 1980s to protect young prawns in the inshore

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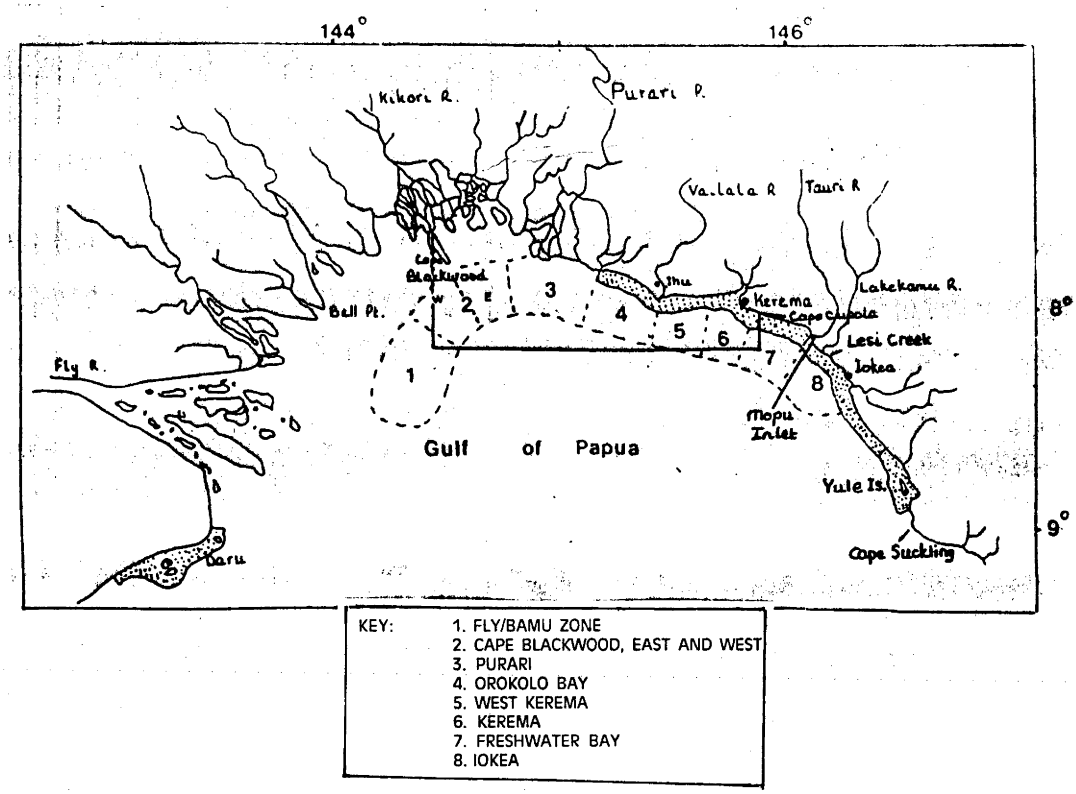
Figure 1. **Gulf of Papua prawn fishing zones, capes, large villagesand towns, and the 3-mile zone (stippled).**



areas from trawling.

The principal risk and concern in recent years has been growth of over-fishing with trawler captains targeting new recruits as they enter the fishery in the northern areas adjacent to extensive nursery areas for *P. merguiensis* and *P. monodon* (the mangrove swamps of the Rivers Fly, Kikori and Purari, and as they enter the fishery in the south-eastern areas adjacent to other similar nursery areas of lesser extent associated with the Vailala River mouth, Kerema Bay and Inlet and the Lakekamu Estuary/ Mopu Inlet). There has also been suspected growth over-fishing from illegal fishing of the 3-mile conservation zone.

Management in 1995 and 1996 has featured (i) a 6-week closed season 1st February to 15th March (1995) (Opnai and Evans 1994) and (ii) a 14 week area closure of the fishing zones East Cape Blackwood, Purari, Orokolo Bay, West Kerema and Kerema Bay (which are the principal recruitment windows), from 1st January to 15th April 1996 (Evans *et al.* 1995; Evans *et al.* 1995 a; Kare *et al.* 1995). Prawn operators have generally respected and understood the area closure measure and there have been only minor incursions into areas near the boundary. However, the provision of surveillance in the prawn industry is insufficient because of a shortage of manpower. The trawl grounds are large and distant from the National Capital District, surrounding Port Moresby, which lies off map to the south-east (Figure 1). In recent years, 1993-96, there have been many reported, and a few prosecuted cases, of illegal trawling within the established 3-mile conservation zone (Figure 1). These included citizens' arrests and vessel seizures by resource owners, sightings by airline pilots with navigational fixes and a boarding by staff of the Research Branch of the National Fisheries Authority.

The Lakekamu Estuary, the Kikori River Delta, and the small channels of the lower Purari River and of the Vailala river mouth are the major nursery areas for banana prawns that migrate and recruit into the grounds of ten south-eastern area (Frusher 1980; Gwyther 1980 a). The Fly River Estuary is the principal nursery area for juveniles that recruit into

the offshore fishing areas associated with the Fly River (Ursula Kolkolo), (PNG Department of Fisheries and Marine Resources, pers. comm. 1995).

Gwyther (1980 a) found that the percentage of female prawns in the Gulf of Papua having ripe or ripening ovaries is greatest in the months of March-April and July-November. Catch per unit effort (CPUE) of commercial grades of *P. merguiensis* showed a progression through the year according to mean monthly data 1978-87 (Polovina and Opnai 1989). From this, Polovina and Opnai inferred that postlarval *P. merguiensis* settle in the estuaries mainly during November and recruit to the fishery in February.

Earlier studies of the distribution of new prawn fishery recruits from January to August (Gwyther 1980 b) suggested a migration of new recruits from the area around C. Blackwood to Kerema Bay. Recruit-sized prawns occur in temporal-spatial sequence, from C. Blackwood in January to Kerema Bay in June (Frusher 1980; Gwyther 1980 b).

Based upon the results of these studies, a recruitment monitoring field study was carried out during the 1995 closure of the Gulf of Papua fishery (1st February to 15th March) (Evans *et al.* 1995 b). The East Cape Blackwood, Purari, Fly/Bamu, West Cape Blackwood and Kerema Bay zones (ranked in that order in CPUE of 41-50+51-60 grade prawns caught) were found to be the chief recruitment areas of *P. merguiensis* during this period in 1995, which was in an El Nino with low rainfall (Evans *et al.* 1995 b). Evans and Kare (1996) found evidence that the beginning of the chief recruitment pulse to the northern fishing zones near Cape Blackwood coincides with the onset of monsoon rains in the upper Kikori Basin, and occurs on an average during mid-February to mid March.

The primary objective of the present study was to document the depth distribution of recruit-sized banana prawns (*Penaeus merguiensis*) and black tiger prawns *(P. monodon)* by depth, in a year of reasonable rainfall, in order to determine if the populations of these species in inshore areas (i.e. the 3-mile prohibited trawl zone) would be endangered by illegal fishing inside the 3-mile limit.

The second objective of the study was to estimate a mean catch per unit effort (CPUE) for recruit-sized banana prawns and for black tiger prawns by transect surveys, in the entire fishing grounds during the period of peak recruitment to the northern fishing zones (approximately late March to early April: Evans and Kare 1996).

Such a survey could be undertaken annually to provide data on the approximate level of fishery recruitment of *Penaeus merguiensis* and *P. monodon.*

MATERIALS AND METHOD

The study consisted of two parts: phase 1, systematic transect studies in all the fishing zones, from 25th March to 2nd April, 1996 and phase 2, normal commercial operations, from 2nd to 11th April, 1996.

The quad-rigged *Delta Seafoods* industrial prawn trawl vessel *Leremori* with four 7 fathom nets of 2 inch mesh in the cod-end was *chartered* for the survey.

During phase 1, in each fishing zone, from Fly/Bamu in the west to Iokea in the east, one main shot was made in each of 3 differing depth categories, by day and by night. These categories were wherever possible 8-12 m, 12-20 m and 20-30 m. The 3-mile zone was generally shallower than 8 m depth, so no trawling with main nets was carried out inside the 3-mile limit, for conservation purposes and so as to prevent upsetting local communities of resource owners and to reduce the potential for vessel seizure.

The number of cartons of each grade of banana and black tiger prawns caught were recorded along with carton weight. The time winched down, time winched up, and the position down and the position up were also recorded. During each man net shot, echosounder depth measurements were made at 30 minute intervals, so that the mean depth trawled during the shot could be calculated.

During phase 2, the normal commercial operations were adopted so that the trawler could have an economic return from the charter. Search across depth contours with the try net was followed by trawling along contours with the main net once commercial quantities of prawns were located. Number of cartons by grade of prawns caught, mean depth trawled, and time and positions were recorded, as for phase 1.

Table 1. **CPUE of recruit-sized prawns in the Gulf of Papua. A. Cruise 1, Transect Studies, 25th March to 2nd April (WB = banana prawns, *Penaeus merguiensis* chiefly, with minor proportion of < 5% of *P. Indicus*; BT = black tiger *P. monodon*; % = percentage of new recruits in total catch of the species, by weight)**

Date	Day or night	Fishing area	mean depth (m)	WB-CPUE (kg/hr)	%WB	BT-CPUE (kg/hr)	%BT
25/03/96	D	F/BAM	29.5	0	-	0	-
26/03/96	N	F/BAM	18.0	5.8	100	0	-
26/03/96	N	F/BAM	9.4	0.96	22	0	-
26/03/96	D	F/BAM	13.8	2.9	32	0	-
26/03/96	D	F/BAM	21.7	4.0	55	0	-
26/03/96	D	F/BAM	19.7	0.45	33	6.8	19
27/03/96	N	WCB	20.1	0	0	0	-
27/03/96	N	WCB	18.2	1.5	43	0	-
27/03/96	D	ECB	18.5	1.3	50	0	-
27/03/96	N	ECB	29.3	0	-	0	-
28/03/96	N	ECB	25.5	2.5	38	0	0
28/03/96	N	ECB	26.5	0.91	38	0.96	34
28/03/96	D	P	8.0	1.7	100	0	-
28/03/96	D	P	14.5	12.0	69	1.1	50
28/03/96	D	P	25.3	2.6	38	1.8	51
28/03/96	N	P	27.7	1.7	50	0	0
28/03/96	N	P	15.3	18	50	4.0	57
28/03/96	N	P	8.4	9.1	80	0	-
29/03/96	N	WK	24.9	18	50	5.1	26
29/03/96	D	WK	24.1	45	53	1.2	27
29/03/96	D	WK	12.3	45	85	1.4	100
29/03/96	D	WK	8.7	26	78	3.7	40
29/03/96	D	WK	9.3	18	53	4.0	67
29/03/96	D	WK	20.6	46	43	7.4	29
29/03/96	N	KB	9.7	1.9	54	2.7	27
30/03/96	D	KB	11.4	9.4	37	3.1	27
30/03/96	D	KB	11.4	1.5	17	1.1	21
30/03/96	N	I	14.5	0.96	40	0.72	33

A. Cruise 1, Transect Studies, 25th March to 2nd April continued.

Date	Day or night	Fishing area	mean depth (m)	WB-CPUE (kg/hr)	%WB	BT-CPUE (kg/hr)	%BT
31/03/96	N	I	20.9	0	-	1.1	45
31/03/96	D	FWB	18.3	0	0	1.5	38
31/03/96	N	FWB	19.7	0.4	20	1.4	66
01/04/96	N	FWB	17.5	0	-	0.38	18
01/04/96	N	CC	12.6	1.9	22	1.8	39
01/04/96	N	CC	17.3	0.48	11	0.72	21

Key to fishing areas:

KB = Kerema Bay.
FWB = Freshwater Bay.
F/Bamu = Fly Bamu.
CC = Cape Cupola.
I = Iokea.
WK = West Kerema
P = Purari.
WCB = West Cape Blackwood.
ECB = East Cape Blackwood.

B. Cruise 2, Commercial Operations, 2nd to 11th April.

Date	Day or night	Fishing area	mean depth (m)	WB-CPUE (kg/hr)	%WB	BT-CPUE (kg/hr)	%BT
11/04/96	N	KB	9.0	29	63	0	-
10/04/96	D	KB	11.3	27	65	27	49
10/04/96	D	KB	12.3	27	58	3.9	27
10/04/96	D	KB	10.9	2	50	0.5	30
10/04/96	N	KB	13.7	2.7	11	4.6	44
08/04/96	N	KB	14.7	1.8	15	6.7	28
07/04/96	D	KB	14.0	0.57	17	1.6	37
07/04/96	D	KB	11.3	0	-	0.68	18
07/04/96	N	KB	14.9	5.3	28	7.9	48
07/04/96	N	KB	14.2	9.1	36	7.5	40
05/04/96	N	KB	14.0	11	42	2.5	35
04/04/96	D	KB	11.4	2.1	13	2.7	34
04/04/96	D	KB	14.9	6.8	33	4.8	48

B. Cruise 2, Commercial Operations, 2nd to 11th April Continued.

Date	Day or night	Fishing area	mean depth (m)	WB-CPUE (kg/hr)	%WB (kg/hr)	BT-CPUE	%BT
04/04/96	N	KB	14.9	4.1	39	1.7	42
03/04/96	N	KB	15.5	5.2	34	1.9	27
03/04/96	D	KB	10.2	1.6	18	3.7	57
03/04/96	D	KB	8.9	8.8	34	5.1	39
03/04/96	N	KB	9.8	4.5	39	0.68	31
03/04/96	N	KB	11.6	30	71	2.4	41
03/04/96	N	KB	11.0	31	85	2.7	47
02/04/96	D	KB	10.8	16	68	5.7	53
02/04/96	D	KB	10.3	31	62	4.3	47
06/04/96	D	P	13.2	26	66	2.8	36
06/04/96	N	P	12.7	7.0	58	0	0
06/04/96	D	P	14.2	15	52	2.9	44
09/04/96	D	Ak	12.4	15	80	3.7	65
09/04/96	D	Ak	13.0	15	90	2.4	53
09/04/96	D	Ak	12.0	21	44	1.2	28
08/04/96	N	Ak	9.5	19	73	4.5	24
08/04/96	D	Ak	10.0	47	64	13	54
10/04/96	N	KK	12.7	5.4	53	1.7	41
08/04/96	N	KK	12.9	0	-	2.7	53
08/04/96	N	KK	19.9	10	35	4.4	40
05/04/96	N	CC	14.0	9.0	32	3.3	35
05/04/96	N	CC	14.5	12	32	5.6	48

Key to fishing areas:

KB = Kerema Bay,
CC = Cape Cupola,
I = Iokea,
KK = Kea Kea, West Kerema,
P = Purari,
Ak = Akoma, boundary of Purari and West kerema zones.

Carton weights of head-less b/tiger prawns were transformed to head-on weights. A conversion factor of 1.33 x head-less weight was used to transform carton weights of head-less black-tiger prawns to estimated carton weights of head-on black tiger prawns, where necessary (the majority of black tiger prawn cartons were packed with head-on prawns).

RESULTS

Depth distribution

The CPUE for recruit-sized banana prawns (*Peneaus merguiensis*) and for recruit-sized black tiger prawns (*P. monodon*) in the Gulf of Papua in March/April 1996 were each negatively correlated with the mean depth of individual main net trawls ($p = 0.031$ and $p = 0.046$ respectively, by a single tail test for negative correlation) (Figures 2-3, based upon Tables 1 A-B, and Table 2).

Recruit-sized prawns were defined as follows:-

1) banana prawns: the lowest 2 grades combined: 41-50 and 51-60 prawn tails to the pound weight, corresponding to approximately 24-28 mm carapace length (CL).

2) black-tiger prawns: 16-20 (head-on) + 21-25 (head-on) + 26-30 (head-less) + 31-35 (head-less) grades (to the pound weight), corresponding to 33-37 mm CL, approx.

Percentage catch (by weight) of recruit-sized banana prawns and black-tiger prawns were similarly each negatively correlated with mean depth ($p = 0.018$ and $p = 0.012$ respectively, single tail test) (Figures 4-5, based upon Tables 1 A-B, and Table 3).

Indices of recruitment

A t-test on the day-time CPUE and night-time CPUE of banana prawns caught during the transect studies (25th March to 2nd April) indicated that there was no statistical difference between day and night-time CPUE ($p=0.34$, 32 df).

The descriptive statistics of the CPUE of recruit-sized banana prawns caught during the transect studies indicate that the mean CPUE (recruitment index) was 8.23 +/- SE 2.30 kg of tails/trawl-hr (96% CI 3.56 to 12.91 kg of tails/trawl-hr) (Table 4A; and Figure 6, Appendix I).

The descriptive statistics of the CPUE of recruit-sized black tiger prawns caught during the transect studies indicate that the mean CPUE (recruitment index) was 1.53 +/- SE 0.34 kg (head-on)/trawl-hour (95% CI 0.84 to 2.22 kg (head-on)/trawl-hour) (Table 4 B; and Figure 7, Appendix II).

Descriptive statistics of the mean depth of main shots during the transect studies showed the mean depth trawled was 17.73 m (SD 6.39 m) (Table 4 C; Figure 8 Appendix III). During March/April, 1996 recruit-sized banana prawns were found in greatest abundance in 8 to 12 m depth, based upon catch per unit of fishing effort (CPUE), from transects and commercial operations covering the whole of the fishing grounds, from 8 to 30 m depth. CPUE decreased with depth from 8 to 30 m (correlation/regression, $p = 0.031$, single-tail test).

Similarly, the CPUE of recruit-sized black tiger prawns decreased with depth from 8 to 30 m (correlation/regression, $p = 0.046$, single-tail test).

DISCUSSION, INCLUDING IMPLICATIONS FOR MANAGEMENT

This study documents the association between the CPUE of recruit-sized prawns (*Penaeus merguiensis* and *P. monodon*) and depth and the results support the conservation value of the 3-mile zone. The associations found are negative correlations, statistically significant at the 5% level. The high catch rates of recruit-sized banana prawns at about the 10 m depth contour (up to 46 kg/trawl-hr) and black tiger prawns (up to 29 kg/trawl-hr) suggest that the 1996 seasonal spatial closure (from Cape Blackwood to Cape Cupola, from 1st January to 15th April 1996) and/or the more substantial rains of the 1996 monsoon season have had good effect.

The results indicate that the value of the 3-mile zone as a conservation measure for the protection and growth of recruit-sized banana and black tiger prawns (and the protection and growth of finfish) cannot be over-emphasised. Even smaller individuals of these prawn species were found and measured in a try shot survey of the 4-10 m depth band made during

Table 2. **Correlation of CPUE of recruit-sized prawns and depth (including slope and intercept for equations of the associations).**

A. Spearman rank correlation of CPUE of recruit-sized banana prawns on mean depth.

R_s	t	df	p
-0.3630	-3.189	67	0.0022

B. Correlation/regression of CPUE of recruit-sized banana prawns on mean depth.

r	t	df	p(single-tail*)
-0.2265	1.904	67	0.0307

	Value	se	95% CI
Slope	-0.53	0.28	-1.09 to 0.03
Intercept	18.74	4.48	9.79 to 27.68

C. Spearman rank correlation of CPUE of recruit-sized b/tiger prawns on mean depth.

R_s	t	df	p
-0.1847	-1.539	67	0.1286

D. Correlation/regression of CPUE of recruit-sized b/tiger prawns on mean depth.

r	t	df	p(single-tail*)
-0.2044	1.709	67	0.0461

	Value	se	95% CI
Slope	-0.15	0.09	-0.32 to 0.02
Intercept	5.09	1.37	2.35 to 7.83

* Single-tail test for negative correlation.

Table 3. **Correlation of percentage of recruit-sized prawns (by weight) an depth, Gulf of Papua (including slope and intercept for equations of the associations).**

A. Spearman rank correlation of percentage of recruit-sized banana prawns on mean depth.

R_s	t	df	p
-0.3412	-2.835	61	0.0062

B. Correlation/regression of percentage of recruit-sized banana prawns on mean depth.

r	t	df	p(single-tail*)
-0.2641	2.138	61	0.0183

	Value	se	95% CI
Slope	-1.26	0.59	-2.44 to 0.08
Intercept	64.79	9.08	46.63 to 82.95

C. Spearman rank correlation of percentage of recruit-sized b/tiger prawns on mean depth.

R_s	t	df	p
-0.1847	-1.394	55	0.1690

D. Correlation/regression of percentage of recruit-sized b/tiger prawns on mean depth.

r	t	df	p(single-tail*)
-0.2975	2.311	55	0.0123

	Value	se	95% CI
Slope	-1.06	0.46	-1.97 to -0.14
Intercept	53.78	7.08	39.59 to 67.98

* Single tail test for negative correlation.

Figure 2. **Association of CPUE of recruit-sized banana prawns (41-50 + 51-60 grades combined) and mean depth for individual main-net trawl shots (quad-rig) in the Gulf of Papua, March/April 1996. Trawler *Laremori*. Depths shallower than 8.0 m were not trawled, in the interests of conservation and safety.**

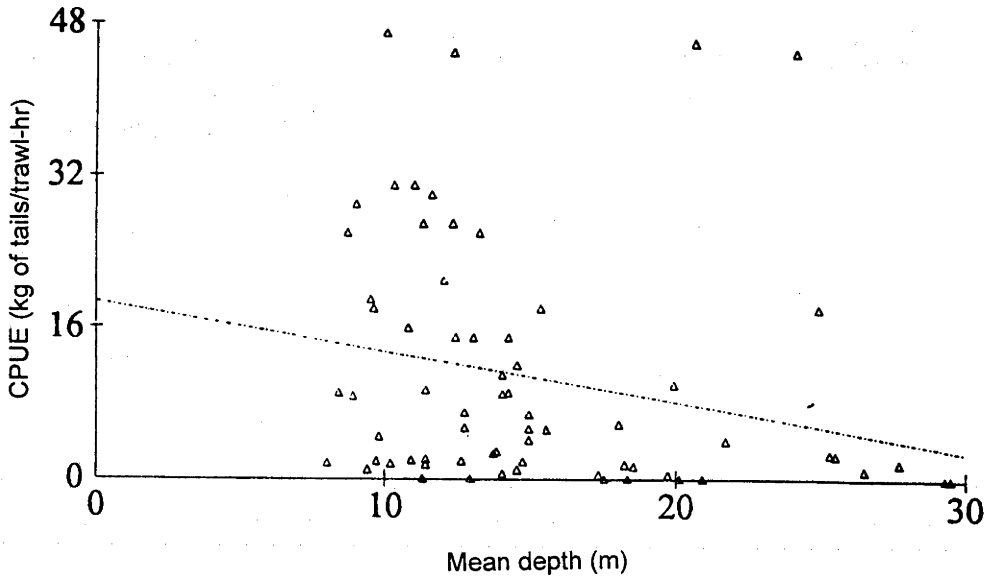


Figure 3. **Association of CPUE of recruit-sized black tiger prawns, comprised of 16-20 (head-on) + 21-25 (head-on) + 26-30 (head-less) + 31-35 (head-less) grade, and mean depth for individual main-net trawl shots (quad-rig) in the Gulf of Papua, March/April 1996. Trawler Laremori. It should be noted that (i) depths shallower than 8.0 m were not trawled, and (ii) a conversion factor of 1.33 x head-less weight was used to transform carton weights of head-less prawns to estimated carton weights of head-on prawns.**

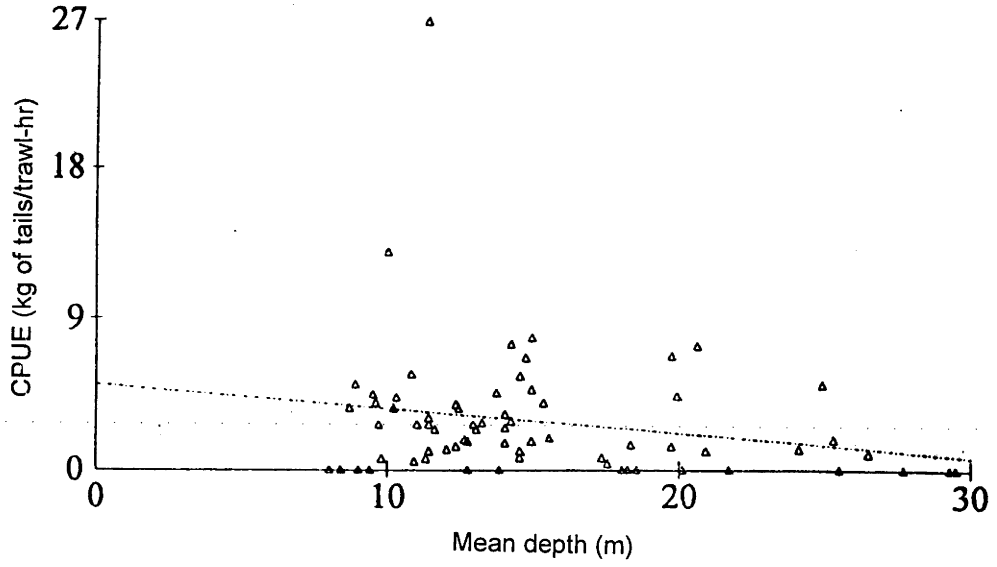


Figure 4. **Association of the percentage catch (by weight) of recruit-sized banana prawns and mean depth for individual main-net trawl shots (quad-rig) in the Gulf of Papua, March/April 1996. Trawler Laremori (Depths shallower than 8.0 m were not trawled).**

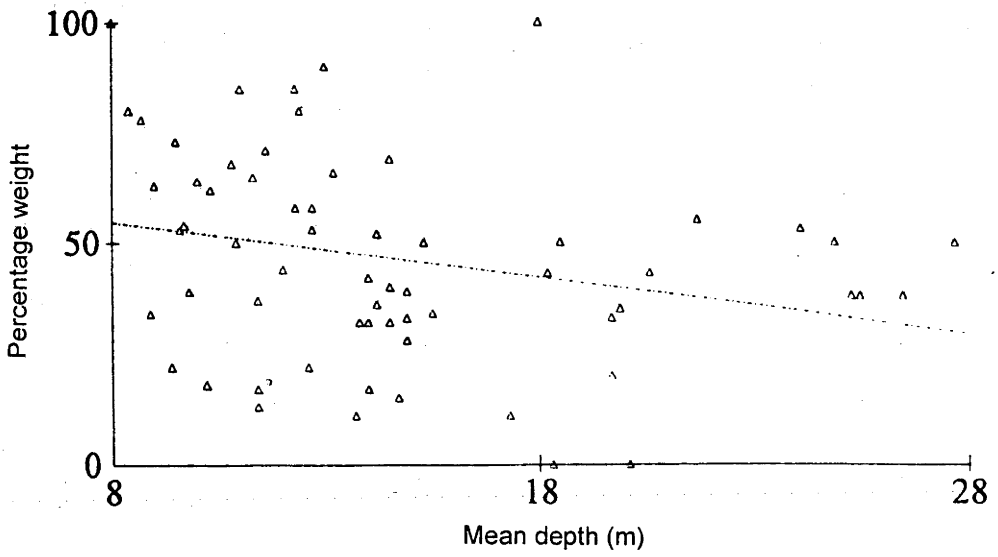
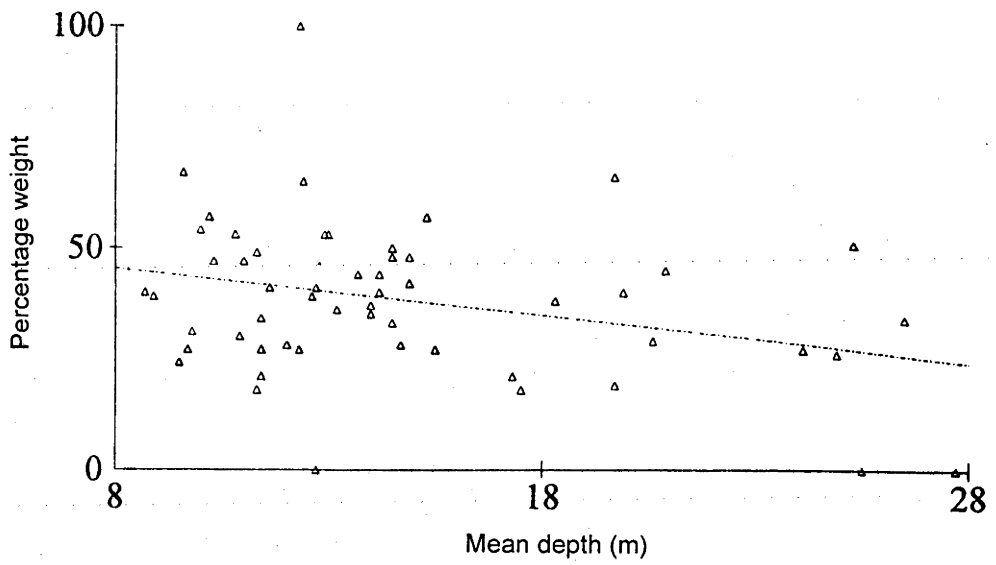


Figure 5. **Association of the percentage catch (by weight) of recruit-sized black tiger prawns and mean depth for individual main-net trawl shots (quad-rig) in the Gulf of Papua, March/April 1996. Trawler laremori (Depths shallower than 8.0 m were not trawled; a conversion factor of 1.33 x head-less weight was used to transform carton weights of head-less prawns to carton weights of head-on prawns).**



the transect study period from Lesi Creek, Freshwater Bay, to Cape Cupola, Kerema Bay (Kare *et al.* 1996). Finfish were also smaller (personal observations). The results of Kare *et al.* (1996) study inferred that Lesi Creek, Lakekamu estuary and Mopu inlet were prawn nursery areas.

KEY RECOMMENDATIONS FOR MANAGEMENT

It is likely that industrial-scale prawn trawl operators will continue to illegally fish the 3-mile zone until a vessel tracking (transponder) system is established. However, operators do understand, respect and support the concept of a seasonal spatial closure (personal communications, Lady Morauta, November 1995 and July 1996).

Considering the findings of the present study, 2 key recommendations emerge:-

(1) The 3-mile conservation zone should remain in place; and

(2) The eastern boundary of the seasonal area closure for 1997 and subsequent years should be extended eastward from Cape Cupola to the fishing grounds as far south and east as Iokea village, so that the mangrove nursery areas and adjacent offshore recruitment areas located in 4-8 m depth in Freshwater Bay (Lesi Creek, Lakekamu Estuary and Mopu In-let) are included in the seasonal spatial closure and will thus be protected during the principal season of recruitment (January through April). Prawn trawl operators would be forced to fish the established seasonal grounds of West Cape Blackwood and Fly/Bamu and the newly opened grounds from Cape Suckling to Iokea (including the prawn resource associated with Yule Island, outside the 3-mile limit). Resource owners in this southern area near Yule Island are protective of their inshore fishery resources (as at Orokolo Bay) so incursion may not be a problem there.

Five further important points relating to conservation of the prawn fishery resources are the following:-

(3) There is mounting interest from resource owners to develop the nearshore prawn resources within the 3-mile zone in a sustainable manner, by opening the 3-mile zone to small-scale beam trawling, i.e. a limited number of relatively small beam trawls towed by dory (draft Gulf of Papua prawn fishery plan for 1997, Research & Management Branch, NFA). The nets used should be of relatively large mesh sizes in the net body and cod-end, because the results of the present study indicate that, particularly during January through June each year, a large proportion of the catch in the 3-mile could be new recruits which have not realised growth potential. It should be noted that even with this preventative measure many juveniles passing through the net may still die.

(4) Studies to assess the impact of beam trawls should ideally be conducted prior to allowing this kind of fishery to develop (pers. comm. from Referee 2, 24th April, 1998).

(5) Studies on artisanal trawl fisheries in Mexico indicate that they compete directly with the offshore fishery and that overall production would be increased by removing the artisanal trawl component of their prawn fisheries (per.comm. Referee 2, 24th April).

(6) Establishment of a vessel monitoring (i.e. tracking) system (VMS) would provide much needed surveillance capability for both the seasonal spatial closure and the 3-mile conservation zone.

(7) A prawn observer programme during April through November each year would assist surveillance until a vessel tracking system is established and provides important data on secondary recruitment pulse(s) during the latter half of the year.

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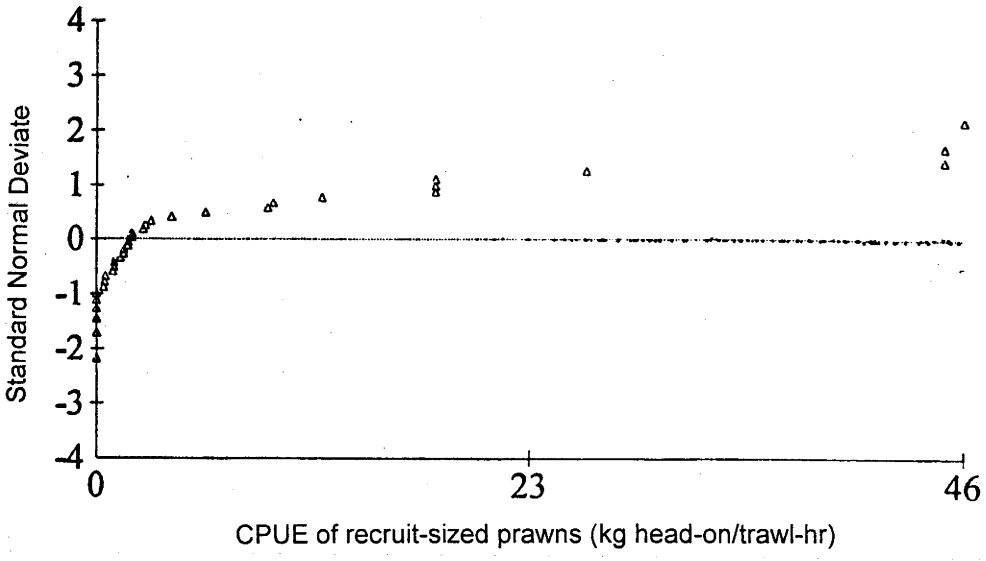
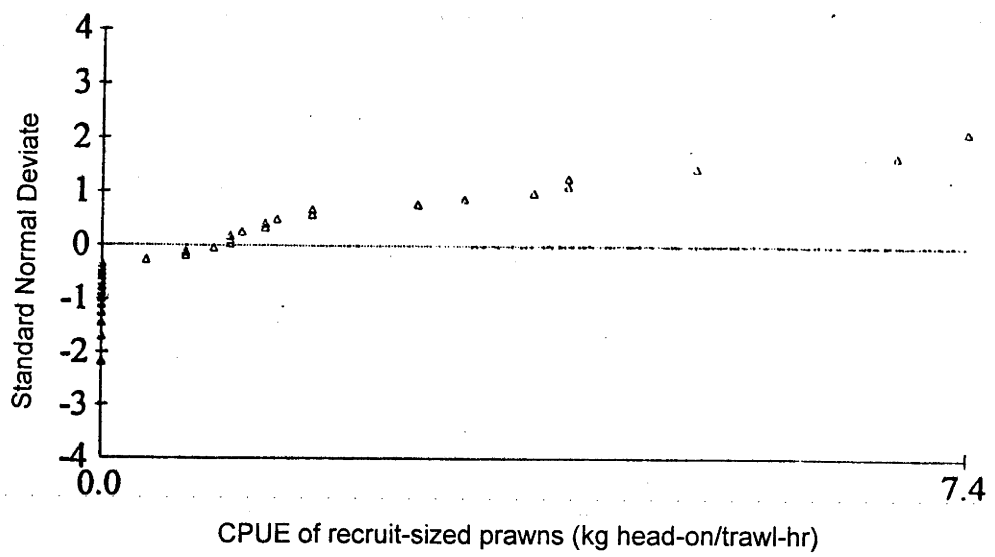
Appendices

Appendix I: Figure 6. **Descriptive statistics of CPUE of recruit-sized banana prawns, Gulf of Papua, during transect studies 25th March to 2nd April 1996.**



Appendix II: Figure 7. **Descriptive statistics of CPUE of recruit-sized black tiger prawns, Gulf of Papua, during transect studies 25th March to 2nd April 1996.**



Appendix III: Figure 8. **Descriptive statistics of mean depth of main net shots in the Gulf of Papua, during transect studies 25th March to 2nd April 1996.**