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**RESEARCH AND MANAGEMENT OF THE INDUSTRIAL PRAWN
FISHERY OF THE GULF OF PAPUA**

BY

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Research and Management of the Industrial Prawn Fishery of the Gulf of Papua

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Abstract

The industrial fishery for prawns in the Gulf of Papua is described and reviewed. The prawn stock is assessed. The effect of rainfall on yield is reported and discussed. Development of a comprehensive management plan for the Gulf of Papua Prawn fishery is outlined and new management recommendations for 1996, arising from field research in the 1995 closed season, are presented.

Background

The commercial fishery for prawns in the Gulf of Papua (GOP) commenced in 1969 and quickly became Papua New Guinea's largest export fishery. The catch is primarily banana prawn (*Penaeus merguensis*). Around half of the total yield of prawns comprises this species (Polovina and Opnai, 1989). By 1988, annual harvests of around 1100 metric tonnes of prawn tails (Table 1) were worth about 10 million kina (A\$10 million) (Polovina and Opnai, 1989). The number of vessels varies from year to year. During the initial years of prawn surveys, the number of vessels was as high as 30. The number of companies also fluctuates but there were three main companies. As usual in fast breeding and fast growing species, the initial biomass has been reduced to a lower level more suitable for optimal growth and natural survival in the local marine environment. This level was initially estimated at 800 to 1300 tonnes per year, all species. The fishery was dominated by the Japanese operators until recently when they were forced to give equity to nationals in joint venture arrangements.

There is a 3-mile limit to trawling in the Gulf of Papua, which is the reserve of the traditional resource owners. Historically, the fishery has been an offshore fishery, but since early 1993, because of somewhat poorer catches resulting from growth overfishing or environmental fluctuations (low rainfall from the extended El Nino-Southern Oscillation effect), the fleets have fished further inshore, including grounds within the 3-mile

limit, especially in the southeast including Kerema Bay. In the north, nearshore shallows prevent fishing within the 3 mile.

Fishing Methods

Prawn trawlers operate 24 hours a day for around 250 days per year. The vessels are twin rigged and have two main nets, each with a small try net. The main nets are set for three to four hours. The try net is set from mid-ship, somewhere before the main nets and is checked every 15 minutes to see what is being caught in the main net. Whenever a good school is caught the vessel can make a U-turn, and go over the same ground several times, before the main net is winched up.

Approximately 65-85 per cent of the trawl catch by weight is made up of by-catch. The prawns are separated from the by-catch, washed, graded by species and sizes, and packed in cartons of 2 kg, 5 kg, or 10 kg, depending on the company. The product is snap-frozen in freezer plates for 3 hours and then packed in 'master' cartons and stored in a store room. These prawns are ready packed for export. Each trip lasts 4-6 weeks. The only port is in Port Moresby, because there is no natural harbour between Yule Island and Daru. The prawns are caught by trawlers working between the Fly River in the southwest and the village of Iokea in the east (Gwyther, 1980). Fishing effort and intensity is greatest in Kerema Bay (Gwyther, 1980).

Gulf of Papua Prawn Fishery Interim Management Plan, 1988.

From 1988 to 1994, the Gulf of Papua prawn fishery operated under an interim management plan set up in 1988. The plan was based on the result of a number of projects and investigations, on catch and effort data since 1977, and on the operations of the 3 main companies. It was found that on average, the individual vessels of the core companies were catching an average of 80 tonnes per vessel per year. The management plan was developed under full consultation with the prawn operators who agreed to reduce the number of vessels in the fishery.

An allowable catch of 80 tonnes per vessel was set, and as a result the number of vessels was set at 15, based on the estimated yield of 1200 mt, and the fishery was declared closed to foreign companies. Two were reserved for the resource owners (Gulf coastal people) and are presently available if they organise themselves to purchase two vessels.

Research

A three year (1990-92) intensive Public Investment Program funded project was implemented with the following aims:

1. Setting up the catch reporting system and the computerised Prawn Database Management System (PDMS) in Kanudi, Fisheries Research Headquarters;
2. Establishing an observer programme to sample the catch on board the commercial vessels;
3. Running an independent sampling programme using the research vessel, Melisa;
4. Setting up a computer programme for the research data.

A complimentary programme was also carried out to monitor the Prawn Recruitment Experimental Project (PREP) and Rainfall Experimental Project (REX) looking at recruitment of juveniles into the fishery and the relationship between rainfall and prawn production, respectively. Both of these were part of an Australasia Regional Project. The full results of the PREP and REX projects are currently being analyzed.

Two detailed fishery reports on the GOP prawn fishery are a comprehensive commercial and biological survey in the late 1970's (Gwyther, 1980) and a comprehensive stock assessment and management analysis produced in 1989 (Polovina and Opnai, 1989). The latter included studies indicating that rainfall in the last four months of the year was inversely correlated with prawn production in the following year.

From August 1994 to April 1995, there was a series of DFMR technical reports and papers, and fresh stock assessment for the Gulf of Papua prawn fishery (Evans and Opnai, 1994; 1995; 1995a). The analyses built upon the previous work and resulted in a proposal for a comprehensive prawn management plan (Opnai and Evans, 1994) and the agreement of a comprehensive prawn fishery management plan for the Gulf of Papua prawn fishery with industry in November 1994 (Opnai and Evans, 1994a), which was revised after a further meeting with industry in December 1994 (Evans and Opnai, 1994a). The main feature of the final plan was a seasonal closure to enhance the growth and survival of new recruits in the first quarter of the year (1st-February to 15th of March for 1995).

Field studies in the Gulf of Papua in February and March 1995 on the distribution and apparent abundance of recruit-sized banana

and black tiger prawns (Evans et al, 1995) and on the size frequency distribution of these species by area, sex and depth (Kare et al, 1995) resulted in the formulation of revised prawn management recommendations for 1996, featuring a timed area closure of the East Cape Blackwood, Purari, Orokolo, West Kerema and Kerema Bay fishing zones. It is hoped that this will enhance the survival and growth of new recruits to the fishery in a more effective way whilst at the same time assisting industry to survive the closure. The revised management recommendations for 1996 are presented in detail below (Management Recommendations for 1996).

Patterns of Change in Abundance

Catch per unit of fishing effort, CPUE (all species catch) in the Gulf of Papua fishery remained the same overall 1974 to 1993, as did the CPUE for banana prawns (Fig. 1A). The stability of the fishery over this period is striking. In contrast, the CPUE of banana prawns in the Kerema Bay area of the Gulf of Papua decreased overall 1977 to 1987 perhaps due to an over-concentration of effort at Kerema (Evans and Opnai, 1994).

Medium-term change in CPUE in the Gulf was perhaps one of cycles of 8-9 years periodicity superimposed upon short-term inter-annual cycles of change of 2-4 years periodicity (Fig. 1A). The time series is not long enough to be certain. These may be related to cycles in the local oceanographic climate including the effects of rainfall and river discharge (Polovina and Opnai, 1989; Wafy, 1991). This in turn may be related to global changes in oceanographic climate such as the El Nino effect.

The monthly change in CPUE for the Gulf of Papua fishery is presented in Fig. 1B, which is based upon the average of ten years catch and effort data from industry. There is an annual peak in April-May. This agrees with evidence for continuous fishery recruitment with an annual pulse in February (Polovina and Opnai, 1989).

From September 1992 to September 1994, catch rates appear to decline overall (Fig. 2), perhaps due to the detrimental effect of environmental variables (low rainfall 1991-1994; Evans et al, 1995a) and the illegal fishing of sub-adult nursery areas inside the prohibited fishing zone (which extends three miles offshore). Wafy, (1991) reported the detrimental effect of inshore fishing.

Sustainable Yields.

The long-term maximum sustainable yield (MSY) of banana prawns in the Gulf fishery is ca. 600 mt of tails (Tables 2-3; Fig. 3A). During its history, the fishery has reached, but not exceeded, its peak of productivity (Figure 3A). Recent annual yields of banana prawn were relatively low (Table 1), perhaps as a result of relatively low rainfall in the Gulf of Papua region from the El Nino/Southern Oscillation (ENSO) Effect (protracted El Nino, personal observations).

Long-term MSY of Gulf of Papua prawns is approximately 1500 tonnes of tails, all species (Tables 2-3; Fig. 3B). In contrast to the banana prawn fishery, the total (all-species) fishery has not yet reached the optimum yield of 1500 tonnes. This infers that, in the long-term, the catch of species other than P. merguensis, which essentially comprises the shallow water catch, could be increased if targeted by fishing slightly deeper waters of the fishing zones. These species include the endeavour prawns.

The giant black tiger prawn (Penaeus monodon) could also perhaps be targeted more as our knowledge of its biology and management increases. It is a high value species. This could perhaps be achieved by targeting P. monodon in the Purari Zone in 10-12 metres depth as trawling in this depth range was found to be suitable for commercial fishing (and yielded fair catches) off the Purari (Evans et al, 1995).

Association of Yield and Effort.

Yield and effort in the Gulf of Papua prawn fishery were closely associated in regard to the all species catch, but deviated somewhat for the banana prawn catch, especially after 1982, at the higher levels of effort (Fig. 4). This is perhaps associated with the over-riding regulatory effect of environment at high levels of effort.

Distribution and Apparent Abundance of Recruit-Sized Prawns in the Gulf of Papua in the 1995 Closed Season.

In the Gulf of Papua during the 1995 closure (1st February to 15th March) banana prawn recruits Penaeus merguensis (of grades 51-60 and 41-50 prawns to the pound) appeared to be most abundant in the East Cape Blackwood fishing zone (6.15 kg of tails/trawl-hr), comprising 62.8 per cent of the total catch (Table 4) (Evans et al, 1995). The CPUE of recruits caught in the Purari fishing

zone was the next greatest, at 4.68 kg/trawl-hour, and these recruits in total comprised a similar percentage of the total catch (62.1 per cent) (Table 4). After Purari fishing zone, Fly/Bamu fishing zone ranked third in importance with 4.32 kg/trawl-hour) but this only comprised 32.8 per cent of the total catch (Table 4). Taurama/West Cape Blackwood ranked fourth in importance with 4.31 kg/trawl-hour, with the recruits comprising a high percentage of the total catch (71.9 per cent) (Table 4). Kerema Bay ranked fifth with 2.44 kg/trawl-hour, comprising 66.2 per cent of the total catch (Table 4).

The *P. merguensis* recruits had been carried a long way off shore. The grade 51 recruits were caught in commercial quantities 15-18 miles from the coastline in the East Cape Blackwood Zone and 25-33 miles from the coast in the West Cape Blackwood Zone during the 1995 closed season (Evans et al, 1995). Similar findings were reported by Kare et al (1995). Recruit-sized banana prawns *Penaeus merguensis* were predominant in catches from a large area at the north of the Gulf, viz. the area due south of Cape Blackwood (Kumul Oil-Rig) (20-30 metres deep) east to Kerema Bay (4-10 metres deep).

The Evans et al (1995) observations suggested that the closed season of 1995 was appropriately timed in that it was coincident with the spatial and temporal distribution of *P. merguensis* prawns in the fishing grounds. The relatively great distance from the shore that recruit-sized banana prawns were caught indicated that the Gulf of Papua Prawn Management Area should be changed and redesignated to include these offshore areas. A line from Parama Island to Cape Suckling was therefore recommended for the new southern boundary of the management area (Fig. 5). A timed area closure to include the East Cape Blackwood, Purari, Orokololo, West Kerema and Kerema Bay fishing zones (Fig. 6) from 1st January to the 15 of April was recommended for management of the Gulf of Papua Prawn fishery in 1996, based on these observations, a parallel study of size frequency distributions (Kare et al, 1995) and the previous work in this field by Gwyther (1980a).

Recruit-sized (16-20 and 13-15 grades) black tiger prawns (*Penaeus monodon*) appeared to be most abundant in the Kerema Bay fishing zone in 6-7 metres depth (CPUE = 7.97 kg of whole animal/trawl-hour) and the next most abundant in Freshwater Bay and Purari (2.35 and 1.6 kg/trawl-hr respectively) (Table 5) (Evans et al, 1995). In Freshwater Bay, *P. monodon* recruits were found off the Lakekamu Estuary and Mopu Inlet and in Port Chalmers). In Kerema Bay, recruits formed 86 per cent of the

total catch of P. monodon. The mean depths at which P. monodon were caught in these zones were 6.6 m (s.d. 1.5 m), 6.4 m (s.d. 1.1 m) and 9.8 m (s.d. 0.9 m) respectively (Table 5). Wooden debris (small black twigs and branches) were frequently trawled up in these three zones, which generally consisted of a firm mud substrate.

Penaeus monodon recruits were caught between the 4 to 8 metre depth contours of Kerema Bay (Evans, 1995; Evans et al, 1995). Slightly larger P. monodon were caught off the mouths of the Vailala, Karova, Tauri and Lakekamu Rivers (Ivorika and Port Chalmers areas) and off the Purari River Delta (Nomu and Akoma areas) in 5-10 m (Evans, 1995). Over half of the total catch by weight in these areas consisted of recruits (grade 16 and 13 prawns) (Evans et al, 1995) (Table 5).

This information indicates that the Kerema Bay, Lakekamu Estuary, and Purari Delta areas are likely nursery areas for black tiger prawns. Kerema Bay Zone is especially significant in this regard. Similarly, the East Cape Blackwood and Purari Zones have special significance for the fishery recruitment of white banana prawns.

Association of Prawn Yield and Rainfall

Analyses of the present study suggested that annual rainfall at Bereina Agricultural Station, near Kerema Bay, in Central Province is associated with the yields of banana prawns from Kerema Bay and from the Gulf of Papua (as a whole) in a parabolic way with maximum catch at around 1000 mm and 1050 mm of rainfall respectively (Figs. 7-8). CPUE also appears to be associated with annual rainfall in a similar way (Fig. 9). The association may result in part from the rainfall which falls at the onset of the monsoon season (Fig. 10), when prawns recruit offshore. It is suggested here that there may perhaps be a link between Penaeus merguensis postlarval recruitment, juvenile survival and rainfall.

Large rivers (the Fly, Kikori and Purari) run into the northern part of the Gulf of Papua, which inshore forms a prawn nursery area, comprised of dense mangrove forest, to the east and west of Cape Blackwood. The mouths of rivers (the Vailala and Lakakamu) which run in the southeastern region of the Gulf of Papua also consist of nursery areas (Wafy, 1991). Fluctuations in the discharge rates of rivers entering the nursery areas have been shown to affect the timing and biomass of the prawn recruitment (Wafy, 1991).

Polovina and Opnai (1989) found an inverse relationship between the minimum monthly rainfall at Baimuru, in the northern coastal area of the Gulf of Papua, during September through December and prawn catches in the subsequent calendar year, demonstrated from time series analysis, based on a ten year average. The Polovina and Opnai (1989) time series also suggested that fishery recruitment chiefly occurs in February in the Gulf of Papua following a major pulse of postlarval settlement in November.

In the Karumba area of the Gulf of Carpentaria, Australia, the correlation between rainfall and subsequent fishery catches is positive - high rainfall increases the number of juveniles which migrate from the nursery grounds to the fishery (Staples, 1985). In the Weipa area of the Gulf of Carpentaria, the prawn catch is negatively correlated with summer rainfall, suggesting that rather than enhancing prawn catches, as seen in the southern parts of the Gulf of Carpentaria (Karumba), high rainfall results in lowered catches (Vance and Staples, 1985). Weipa has a relatively high level of annual mean rainfall (1726 mm) compared to Karumba (878 mm). Vance and Staples (1985) and Staples and Vance (1987) hypothesized that high levels of summer run-off make the rivers in this region less suitable for postlarval settlement and juvenile survival. Polovina and Opnai (1989) similarly hypothesized that in the Gulf of Papua rainfall in the nursery grounds during or shortly after postlarval settlement is positively correlated with larval and postlarval prawn mortality. This effect has also been observed in the coastal waters of Louisiana, where catches of P. aztecus and P. setiferus are inversely correlated with river discharge (Barrett and Gillespie, 1973). Thus the observations both in Papua New Guinea and in Australia could be the result of two opposing effects. An adequate amount of rainfall is needed for juvenile recruitment offshore into the fishing grounds, but too much rainfall is deleterious to postlarval settlement and subsequent juvenile recruitment.

Further studies of rainfall and apparent abundance are being carried out with the technical assistance of David Vance and David Die at CSIRO so that the yield model of Polovina and Opnai (1989) can perhaps be developed further.

CSIRO currently use rainfall data to make predictions of each year's commercial catch for the fishing industry (personal communication, David Vance, 18th April, 1995).

Management Recommendations for 1996

National and specific area regulations currently being gazetted in April 1995 are given as Annexes 1-2 below. Annexe 3 is the Management Plan agreed with industry in December 1994, with a modification to redefine the Gulf of Papua Management Area to have the southern boundary as a line from Parama Island to Cape Suckling (the 9 degree 00 minute line of latitude) (Fig. 5), which was recommended after the field studies in the February to March closed season. A further major change to the management plan is recommended for 1996: a timed area closure from 1st January to 15th April to enhance the growth and survival of new recruits where they enter the fishery, allow industry to continue fishing in adjacent areas and thereby facilitate their short-term economic survival, and to provide opportunity for vessel or gear repair and maintenance.

The fishery is fully developed for the target species banana prawn. Fishing effort will therefore continue to be restricted by a limitation of the number of vessels to 14 (13 in 1997) and the limit on vessel size (30 metres overall length) will be continued). The continuation of protection of juveniles and sub-adults inside the 3-mile limit is recommended, with both stiff fines for contravention and the additional measure of fitting transponders to prawn trawlers (fishing will only be allowed seaward of 3 miles from the territorial baseline).

Redefinition of the Gulf of Papua Prawn Fishery Management Area to include the outer Gulf of Papua by the permanent establishment of the southern boundary as the 9 degree 00 minutes South line of latitude (Fig. 5) would not preclude the establishment of other fisheries such as bottom-set gill-net fishing for demersal fish within the deeper areas of the prawn management area. This could be encouraged to reduce the abundance of predators of prawn such as the snappers (incl. mangrove jack) and jewfish. Prawns were found in the gut of these fishes (Evans, 1995).

The mesh size in the cod-end should be increased from 2" to 2.25" to preclude the capture of small 61 grade prawns. This was recommended in the Evans et al (1995) study.

Prawn operators should target more of the prawns which inhabit trawlable grounds in deeper waters of the fishing zones (25-35 metres, such as endeavour prawns. Black tiger prawns could be targeted in the Purari, which yields a reasonable size of prawn and a CPUE of 3.0 kg/trawl-hr) at 10 m depth (Evans et al, 1995).

An environmental (rainfall-yield) production model should be developed from further analyses carried out with the technical assistance of CSIRO Division of Fisheries, Cleveland, so that prediction of catch may be possible.

Management Measure for 1996: A Timed Area Closure to Protect Areas Which are Fishery Recruitment Windows for the Banana and Back Tiger Prawn Stocks and to Conserve Stocks of Demersal Fish.

The following boundaries for the timed area closure are illustrated in Fig. 6:

A. Northern Boundary

The coastline from the southern point of Cape Blackwood to Cape Cupola in the east.

B. Western Boundary

The line 144 degrees 28.00 minutes East from the southern point of Cape Blackwood to the latitude 8 degrees 12.00 minutes South.

C. Southern Boundary

The line 8 degrees 12.00 minutes South from 144 degrees 28.00 East to 145 degrees 50.00 minutes East.

D. Eastern Boundary

The line 145 degrees 50.00 E from 8 degrees 12.00 S to C. Cupola.

Advantages of Area Closure

The advantages of an area closure are the following:

(1) An area closure would give an unbroken period of 3.5 months closure in five fishing zones adjacent to the principal (mangrove) nursery areas of the Gulf of Papua.

(2) Banana prawns annually recruit offshore into these five zones at the onset of the monsoonal rain season. The 3.5 month period would allow time for protection and growth of the prawns before harvest. The large area would allow for natural variability in the timing of offshore emigration and recruitment and for long-distance migration of new recruits during the closure (easterly movement towards Kerema and Freshwater Bays).

(3) It would allow the mobile fish population the required large area (a seasonal marine reserve) and 3.5 months to recover.

(4) It would offer 3.5 months protection from trawling for the inshore nursery areas of Purari, Orokol Bay, West Kerema and

Kerema Bay (which are frequently, illegally trawled at all times).

(5) It would be relatively easy to enforce with three observers (trained, or with clear instructions), one with each FleetMaster (of the three main companies).

(6) It is a simple management plan that will not cause confusion.

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Table 1: Annual landings (mt of tails) and fishing effort (in thous. of trawl hours) of all prawn species combined, and banana prawns in the Gulf of Papua, and banana prawns in Kerema Bay.

Year	G.O.P.			Kerema Bay	
	Effort (x 10 ³)	All prawns	Banana prawns	Effort (x 10 ³)	Banana prawns
1974	49	733	442	---	---
1975	17	410	258	---	---
1976	48	780	462	---	---
1977	46	562	291	26	221
1978	71	997	531	38	378
1979	78	1221	636	35	350
1980	81	1178	668	38	404
1981	73	1026	517	34	314
1982	69	891	426	33	264
1983	62	1151	638	32	376
1984	75	1114	477	38	296
1985	78	1334	673	37	371
1986	93	1321	571	48	344
1987	91	1165	601	47	304
1988	76	1100	557	---	---
1989	95	1174	---	---	---
1990	70	873	449	---	---
1991	46	649	371	---	---
1992	41	860	475	---	---
1993	47	756	375	---	---

Sources: Fisheries Annual Report 1985-91, Prawn Database Management System 1990-93; and Gulf of Papua Prawn Fishery Proposed Management Plan (i.e. data from Polovina & Opnai, 1989). Checked by entry of data in individual annual ledgers to Microsoft Excel for years prior to 1990.

Table 2: Stock Assessment, Gulf of Papua Prawn Fishery, 1974 to 1987. From Polovina and Opnai (1989). (Average Yield and Hours Trawled Figures are Based on the Years 1974 to 1987).

	Banana Prawn	All Species
MSY (mt)	575	1538
Optimum effort trawl-hours)	98000	198000
Average yield/vessel/yr (mt)	36.8	71.0
Average hours trawled/vessel	4889	4889

Table 3: Stock Assessment, Gulf of Papua Prawn Fishery, 1974 to 1993. From Evans and Opnai (1994). (Average Yield and Hours Trawled Figures are Based on Data for the Years 1990 to 1993).

	Banana Prawn	All Species
MSY (mt)	620	1520
Optimum effort (trawl-hrs)	110000	160000
Average yield/vessel/yr (mt)	41	75
Average hours trawled/vessel	4956	4956

Table 4: Analysis for CPUE of the recruit-sized banana prawns in the Gulf of Papua, 1st February to 15th March 1995.

ZONE	GRADE	TOTAL HOURS TRAWLED	TOTAL CATCH (kg)	CPUE (kg/hr)	MEAN DEPTH (m)	MEAN DEPTH ST.DEV. OF CATCH (m)	PÉR CENT WT
Fly/Bamu							
	51	115.25	68	0.59	13.3	3.0	4.5
	41	115.25	430	3.73	13.3	3.0	28.3
	51+41	115.25	498	4.32	13.3	3.0	32.8
	All	115.25	1518	13.17	13.3	3.0	100.0
Taurama/ W. Cape Blackwood							
	51	80.8	116	1.44	23.0	4.3	24.0
	41	80.8	232	2.87	23.0	4.3	47.9
	51+41	80.8	348	4.31	23.0	4.3	71.9
	All	80.8	484	5.99	23.0	4.3	100.0
East Cape Blackwood							
	51	35.1	108	3.08	20.6	2.3	31.4
	41	35.1	108	3.08	20.6	2.3	31.4
	51+41	35.1	216	6.15	20.6	2.3	62.8
	All	35.1	344	9.80	20.6	2.3	100.0
Purari							
	51	163.25	292	1.79	9.7	1.9	23.7
	41	163.25	472	2.89	9.7	1.9	38.4
	51+41	163.25	764	4.68	9.7	1.9	62.1
	All	163.25	1230	7.53	9.7	1.9	100.0
Orokolo							
	51	0	0	-	-	-	-
	41	0	0	-	-	-	-
	51+41	0	0	-	-	-	-
	All	0	0	-	-	-	-
West Kerema							
	51	10.95	0	0.00	11.5	3.0	0.0
	41	10.95	20	1.82	11.5	3.0	55.6
	51+41	10.95	20	1.82	11.5	3.0	55.6
	All	10.95	36	3.27	11.5	3.0	100.0
Kerema Bay							
	51	35.23	34	0.97	7.3	1.6	26.2
	41	35.23	52	1.48	7.3	1.6	40.0
	51+41	35.23	86	2.44	7.3	1.6	66.2
	All	35.23	130	3.69	7.3	1.6	100.0
Freshwater Bay							
	51	72.65	26	0.36	6.6	1.1	5.8
	41	72.65	124	1.71	6.6	1.1	27.6
	51+41	72.65	150	2.06	6.6	1.1	33.3
	All	72.65	450	6.19	6.6	1.1	100.0
Iokea							
	51	5.6	0	0.00	16.6	9.0	0.0
	41	5.6	6	1.07	16.6	9.0	16.7
	51+41	5.6	6	1.07	16.6	9.0	16.7
	All	5.6	36	6.43	16.6	9.0	100.0

Table 5: Analysis for CPUE of the recruit-sized black tiger prawns in the Gulf of Papua, 1st February to 15th March 1995.

ZONE	GRADE	TOTAL HOURS TRAWLED	TOTAL CATCH (kg)	CPUE (kg/hr)	MEAN DEPTH (m)	MEAN DEPTH ST.DEV. (m)	PER CENT WT OF CATCH
Fly/Bamu							
	16	2.0	0	0	15	-	0
	13	2.0	0	0	15	-	0
	16+13	2.0	0	0	15	-	0
	All	2.0	4	2.0	15	-	100.0
Taurama/ W. Cape Blackwood							
	16	5.0	2	0.4	32.75	-	20.0
	13	5.0	4	0.8	32.75	-	40.0
	16+13	5.0	6	1.2	32.75	-	60.0
	All	5.0	10	2.0	32.75	-	100.0
East Cape Blackwood							
	16	4.0	2	0.5	21.6	-	33.3
	13	4.0	2	0.5	21.6	-	33.3
	16+13	4.0	4	1.0	21.6	-	66.7
	All	4.0	6	1.5	21.6	-	100.0
Purari							
	16	42.42	14	0.3	9.8	0.9	10.9
	13	42.42	54	1.3	9.8	0.9	42.2
	16+13	42.42	68	1.6	9.8	0.9	53.1
	All	42.42	128	3.0	9.8	0.9	100.0
Orokolo							
	16	0	0	-	-	-	-
	13	0	0	-	-	-	-
	16+13	0	0	-	-	-	-
	All	0	0	-	-	-	-
West Kerema							
	16	0	0	-	-	-	-
	13	0	0	-	-	-	-
	16+13	0	0	-	-	-	-
	All	0	0	-	-	-	-
Kerema Bay							
	16	25.08	54	2.15	6.6	1.5	23.3
	13	25.08	146	5.82	6.6	1.5	62.9
	16+13	25.08	200	7.97	6.6	1.5	86.2
	All	25.08	232	9.25	6.6	1.5	100.0
Freshwater Bay							
	16	71.41	14	0.20	6.4	1.1	4.5
	13	71.41	154	2.16	6.4	1.1	49.0
	16+13	71.41	168	2.35	6.4	1.1	53.5
	All	71.41	314	4.40	6.4	1.1	100.0
Iokea							
	16	0	0	-	-	-	-
	13	0	0	-	-	-	-
	16+13	0	0	-	-	-	-
	All	0	0	-	-	-	-

ANNEXE 1: APRIL 1995 GAZETTAL FOR THE CONTROL OF PRAWN FISHING
IN PAPUA NEW GUINEA (NATIONAL REGULATIONS)

I, Titus Philemon, Minister for Fisheries and Marine Resources, by virtue of the powers conferred by the National Fisheries Act 1994, with effect from the date of gazettal of this instrument, prohibit the taking of penaeid prawns at all times:-

1. by boats owned by non-citizen companies or individuals; and
2. by boats whose registry is offshore; and
3. by boats exceeding 30 metres according to Papua New Guinea registered survey length; and
4. by boats with main engines with shaft power exceeding 410 kilowatts or 550 horsepower, as set out in the manufacturer's specifications; and
5. by method of more than 4 main nets and 1 try net towed at the same time; and
6. by a method whereby the aggregate head rope (with mesh attached) for the main nets exceeds 60 m, and the one try net exceeds 6 m head line; and
7. by a method whereby the head line of any one single main net exceeds 30 m; and
8. by a method whereby the meshes for all nets, when measured diagonally stretched from knot to knot, are less than 50 mm in body or cod end; and
9. by method of an otterboard that is more than 5 square metres in area, per board; and
10. by a beam trawl of greater than 6m beam length.

Where an area fishery management plan for a prawn fishery exists, additional restrictions may be applied and enforced under the plan. From time to time, notices may be given for emergency measures by the Secretary of the DFMR, and these may override any of the national or specific regulations.

ANNEXE 2: APRIL 1995 GAZETTAL FOR THE CONTROL OF PRAWN FISHING
IN THE GULF OF PAPUA PRAWN FISHERY MANAGEMENT AREA (SPECIFIC
REGULATIONS)

I, Titus Philemon, Minister for Fisheries and Marine Resources, by virtue of the powers conferred by the National Fisheries Act 1994, with effect from the date of gazettal of this instrument, prohibit the taking of penaeid prawns in the Gulf of Papua Prawn Fishery Management Area:-

1. during a period beginning at the commencement of the major annual fishery recruitment of juveniles in specified areas of the Gulf of Papua Prawn Fishery Management Area as defined and notified by the DFMR annually; and
2. in Orokolo Bay fishing area, from the Vailala River mouth to the easternmost point of the Purari River Delta (longitude 145 degrees, 14 minutes, 00 seconds East) during the second period of fishery recruitment of juveniles during a period specified and notified by the DFMR annually; and
3. in Kerema Bay fishing area during the remainder of the calendar year after the cumulative catch of banana prawns from Kerema Bay has exceeded a pre-determined annual limit, set annually by the DFMR.
4. by a fishing fleet of more than 14 vessels in 1995 (preference will be given to resource owners) and by a fishing fleet of more than 13 vessels in 1998 (preference will be given to resource owners); and
5. by boats operating from a port other than Daru or Port Moresby or a port located other than within the defined Gulf of Papua Prawn Fishery Management Area; and
6. by methods and practices which contravene the Gulf of Papua Prawn Fishery Management Plan (given in Annexe 3 attached).

ANNEXE 3 - GULF OF PAPUA PRAWN FISHERY MANAGEMENT PLAN 1995.**1. Management Objectives**

1.1 to restore the stock and maintain it at a level capable of producing a maximum sustainable yield, as qualified by relevant environmental and economic factors.

1.2. To adopt necessary conservation and management measures for bycatches and appropriate utilisation of the bycatch so as to avoid wastage.

1.3. To prepare the way for participation in the prawn industry by the immediate resource owners.

1.4. To apply a cautionary approach to conserving the stock when there is a lack of scientific information. Prawn operators should be more cautious when there are uncertainties.

The absence of adequate scientific information should not be used as a reason for postponing to take hard decisions on conserving and managing the resource.

1.5. To establish a long-term management unit or project to monitor the prawn resources in PNG and carry out biological and fisheries ecological research. This unit or project will be technical and its operations to be funded by the prawn industry. An economic impact analysis of management measures will also be carried out. The terms of reference for the management unit, or project, are to be drawn up after consultations with Industry.

2. Management Measures

2.1. Introduction of a closed fishing season from 1995 to allow new juvenile recruits to the fishery a period of growth before harvest. In 1995, the closure will extend from 1 February to 15 March as agreed in consultation with the prawn industry on 16th December 1994.

Prawn trawling in Orokolo Bay fishing area, i.e. the trawl grounds from the mouth of the Vailala River to the easternmost point of the mouth of the Purari River (the Purari River mouth at a line 145 degrees, 14 minutes, 00 seconds East) will additionally be prohibited during a second period of fishery recruitment there, in order to promote the conservation and rapid growth of the recruit-sized prawns in Orokolo Bay during this period. In 1995, the closure of Orokolo Bay fishing area will extend from 1st November to 31st December as agreed by the prawn industry on 16th December, 1994.

The Wafy studies on rainfall and juvenile recruitment should be completed as soon as possible and an on-going research programme to monitor the level of juvenile recruitment should be established.

The timing and duration of the closed season will be adjusted annually on the basis of results of the annual research and monitoring programme of the DFMR. Industry will assist the monitoring each year by making two vessels available (which will retain their catch) during the first quarter of the year and these will work (one vessel from the west and one from the east) according to a programme of research that will be detailed by the DFMR, based on the method of transect survey with depth. Transect studies will similarly be carried out in collaboration with Industry at Orokolo Bay during the fishery recruitment in the latter part of the calendar year with one chartered fishing vessel.

During the closed season artisanal prawn fishing will also be prohibited other than for research. The following potential prawn trawling grounds in waters outside of the 3-mile limit will be opened to prawn trawling by research permits, as requested by the Fishing Industry Association: (1) in Western Province near the border with Indonesia; (2) in Oro Province; and (3) in Central Province from Cape Possession to the border between Central and Milne Bay Provinces. Research permits will also be available for other trial fisheries, eg scampi, finfish trawling etc.

2.2. Identification and permanent closure of the prawn nursery areas to commercial trawling: the 3-mile zone from Parama Island (Fly River) to the Vailala River, and the 3-mile zone associated with the Lakekamu Estuary, from the 146th Meridian of Longitude to Cape Possession (nr. Iokea). Areas of the three-mile zone in the Gulf of Papua Prawn Fishery Management Area which are not defined above will remain closed to trawl fishing.

2.3. In order to regulate the concentration of fishing effort at Kerema Bay, the Kerema Bay area will be closed for a period each year, as specified and notified by the DFMR. The basis for closure will be that the cumulative annual catch of banana prawns from the area exceeds a pre-determined limit set annually by the DFMR. When this limit is reached the prawn operators will be notified and all commercial fishing effort in Kerema Bay will be relocated to the other fishing areas.

2.4. Reducing fishing effort by a reduction of the number of licenses: 14 licenses in 1995 (preference will be given to the resource owners); reduce to 13 licenses by 1998 (preference will be given to the resource owners).

2.5. Policy guidelines for the issue of licenses will be given to the general public by the DFMR in 1995.

2.6. Bycatch will be reduced and utilised as follows:

(A) Trials will begin in 1995 to minimise the fish bycatch by use of fish escape panels and fish exclusion grids, as agreed by industry on 16th December 1994.

(B) It will be a condition of the licenses in the long-term that industry will utilise all of their commercial fish bycatch. The offloading of fish to small tenders and dinghies owned by coastal fishing communities in the Gulf, is to be encouraged. Bycatch log-books will be implemented in 1995 by industry to record the total weight of marketable fish caught, thrown overboard, and landed, according to aggregate group, as specified, eg. sharks, turtles. Prawn trawl shots of greater than ninety minutes duration are to be discouraged, in the interests of conservation of turtles. In regard to the use of marketable trash fish, the objectives of the Gulf Fisheries Project should be met in the long-term by industry (reference pp. 71-74, Working Paper No.3, Report of the Marine Resources Specialist, November 1994, Draft Final Report of ANZDEC Consultants, Asian Development Bank Technical Assistance No. 2022 - PNG: Institutional Strengthening of the Department of Fisheries and Marine Resources.

(C) Pilot projects will be established to investigate other ways of utilising the fish: (i) baitfish for tuna long-lining; (ii) aquaculture of grouper and barramundi utilising trash fish as feed; (iii) bait for trapping mud crabs in Western Province; (iv) feed for crocodile farms (v) fish silage or meal for pig or poultry farms (eg. the new poultry farm in Port Moresby).

2.7. In the long-term, the Prawn Fishing Industry will fund research and management of the Gulf of Papua Prawn Fishery. A *stand-alone* (independently-run) prawn management unit will be established under a memorandum of agreement between Industry and Government. Staff will be selected jointly by an equally-represented committee of Industry and Government. Funding will be partly from Government and partly from Industry. There will be defined management objectives and plans for achieving them, and prioritisation of the objectives. Fisheries sociological aspects will also be addressed. The unit will utilise the existing resources of the DFMR for trials of new fishing technology and analyses of data. Fishing vessels may be chartered for agreed periods to monitor the recruitment and migration of juveniles. The prawn management unit would be based in Port Moresby. In consultation with Industry, terms of

reference, objectives and sources of funding are to be drawn up.

2.8. To facilitate the estimation of maximum economic yield, prawn operators will be required, at the close of each calendar year, to submit their average costs per trawl hour in the calendar year, to the Principal Scientist, Industrial Fisheries.

2.9. The observer programme will commence on 15th March 1995. From a date yet to be specified, all prawn fishing vessels will be required to carry tracking devices to enable radio position fixing by DFMR in Port Moresby. These tracking devices will also facilitate management and increase safety in navigation.

2.10. The southern boundary of the Gulf of Papua Prawn Fishery Management Area will commence on the west at the point of latitude 9 degrees 00 minutes 00 seconds South (9 00' 00" S), longitude 143 degrees 27 minutes 00 seconds East (143 27' 00" E), being a point off Parama Island, thence run east along the line of until intersecting Cape Suckling in the southeast.

The two vessels currently licensed to trawl for prawn in both the waters of Torres Strait and Western Province (which are of < 22 m overall length) will be permitted to trawl in the Fly River areas of the new Gulf of Papua Prawn Fishery Management Area from 16 April to 31 December, and to have a joint license for Torres Strait waters (PNG Area of Jurisdiction).

Prawns in the Gulf of Papua will be managed as one stock from Parama Island to Cape Possession, though it is recognised that there is some localisation of stock in both the Fly River and Freshwater Bay areas of the Gulf of Papua.

FIGURE 1A: CHANGE IN CPUE GULF OF PAPUA PRAWN FISHERY 1974-1993

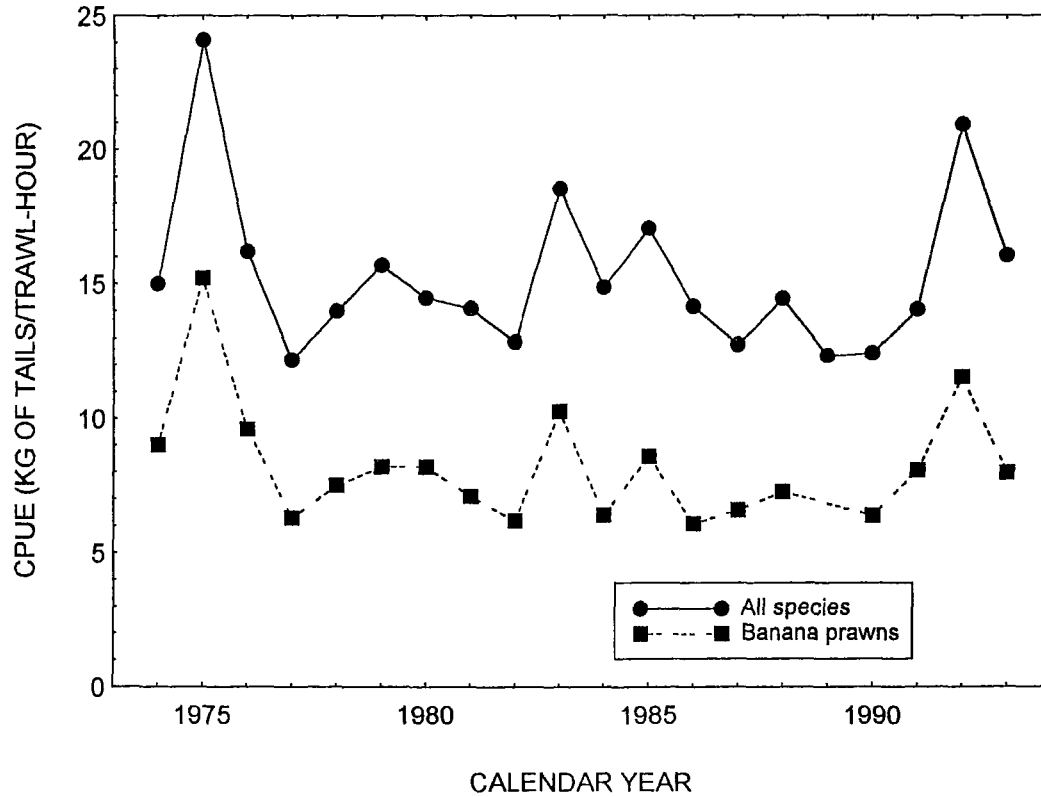


FIGURE 1B: GULF OF PAPUA FISHERY: BANANA PRAWNS,
10-YEAR AVERAGE, 1976-81, 1990-93, WITH SE

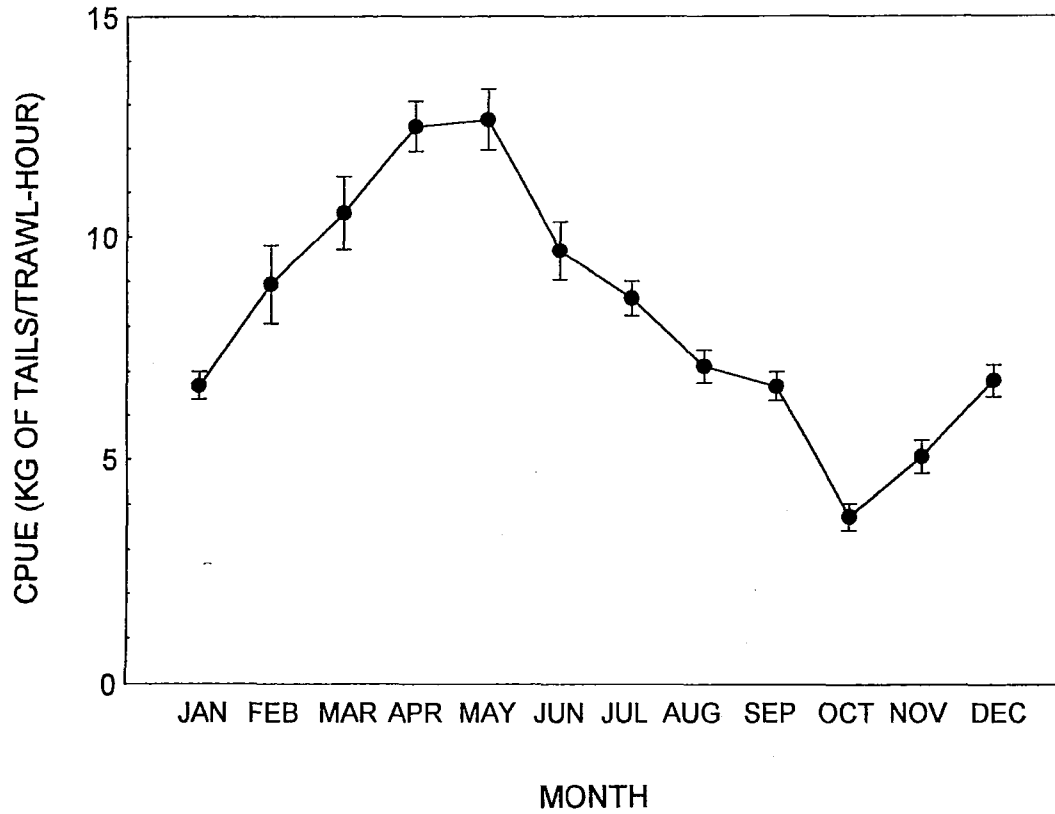


FIGURE 2: CHANGE IN CPUE OF PRAWNS, GOP FISHERY, SEPTEMBER 1992 - SEPTEMBER 1994

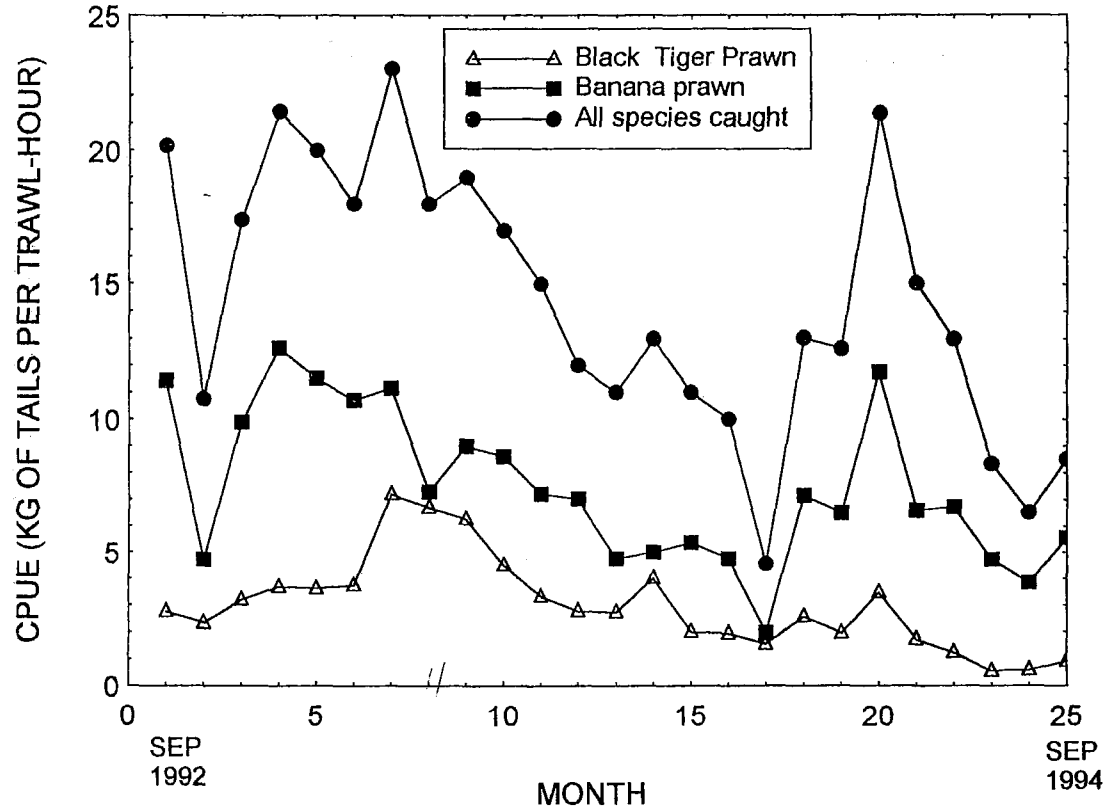


FIGURE 3A: LONG-TERM MEAN SUSTAINABLE YIELD OF BANANA PRAWNS, GULF OF PAPUA

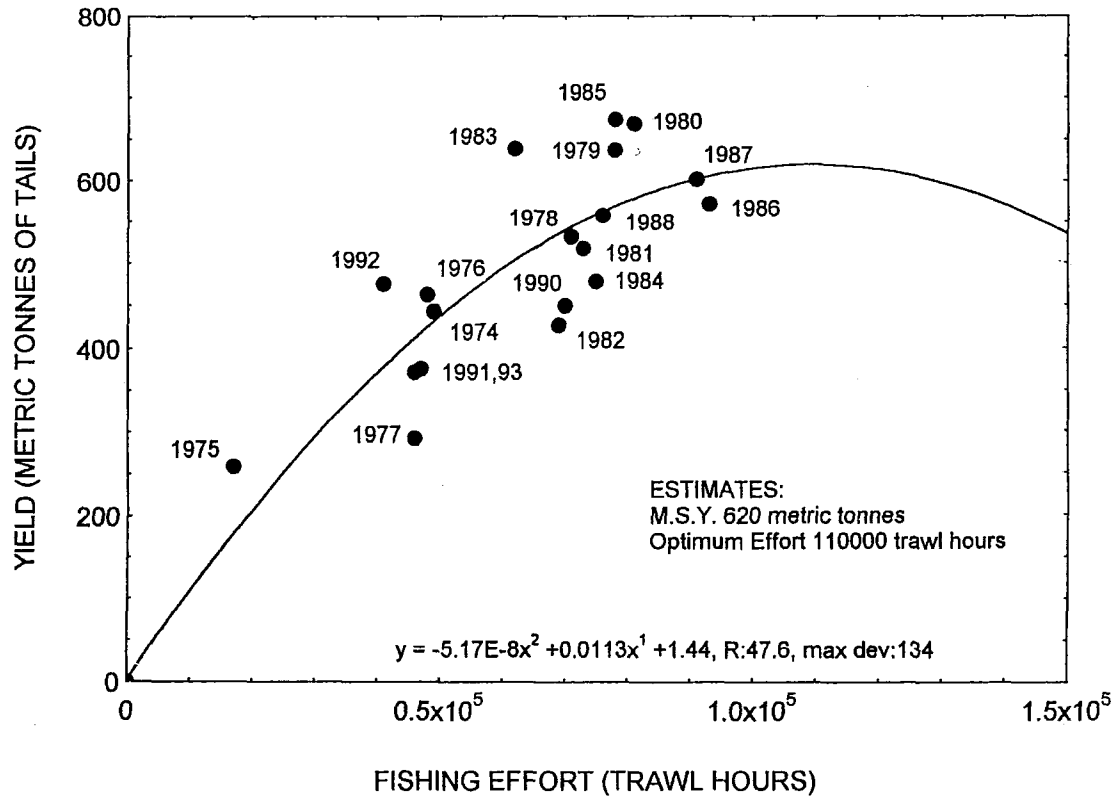


FIG. 3B: LONG-TERM MEAN SUSTAINABLE YIELD OF PRAWNS (ALL SPS), GULF OF PAPUA

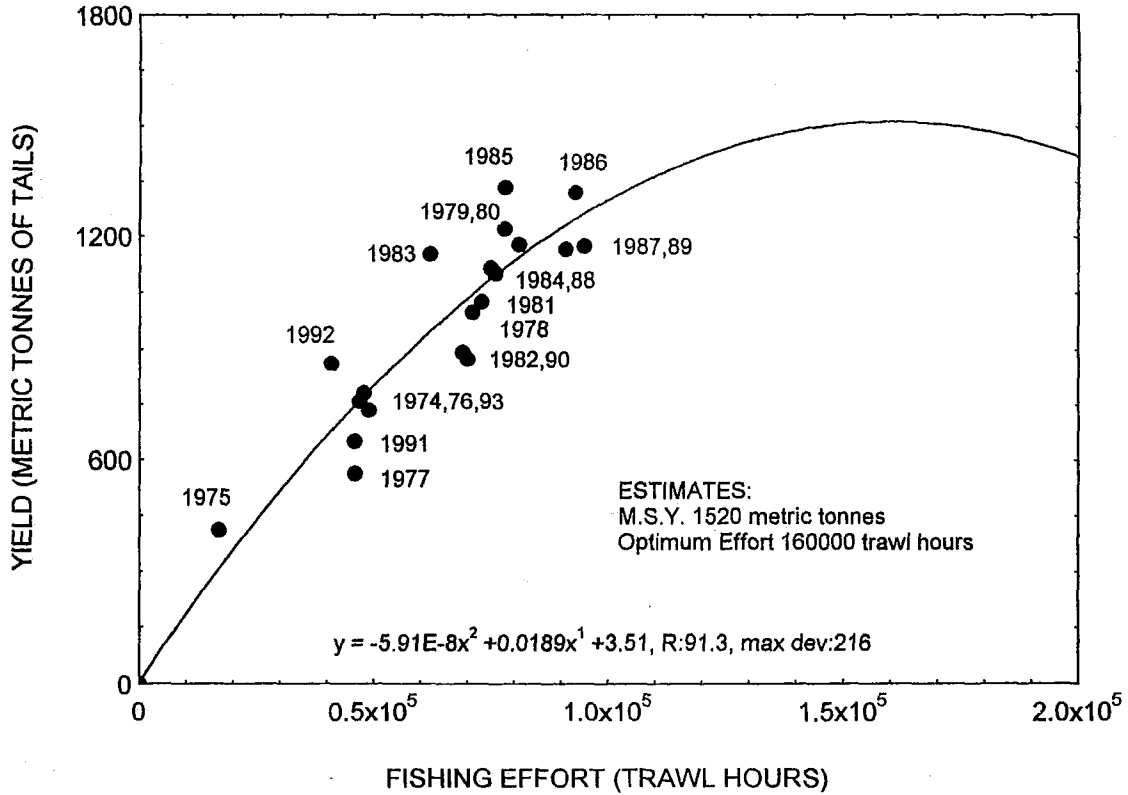


FIGURE 4: YIELD AND EFFORT IN THE GULF OF PAPUA PRAWN FISHERY

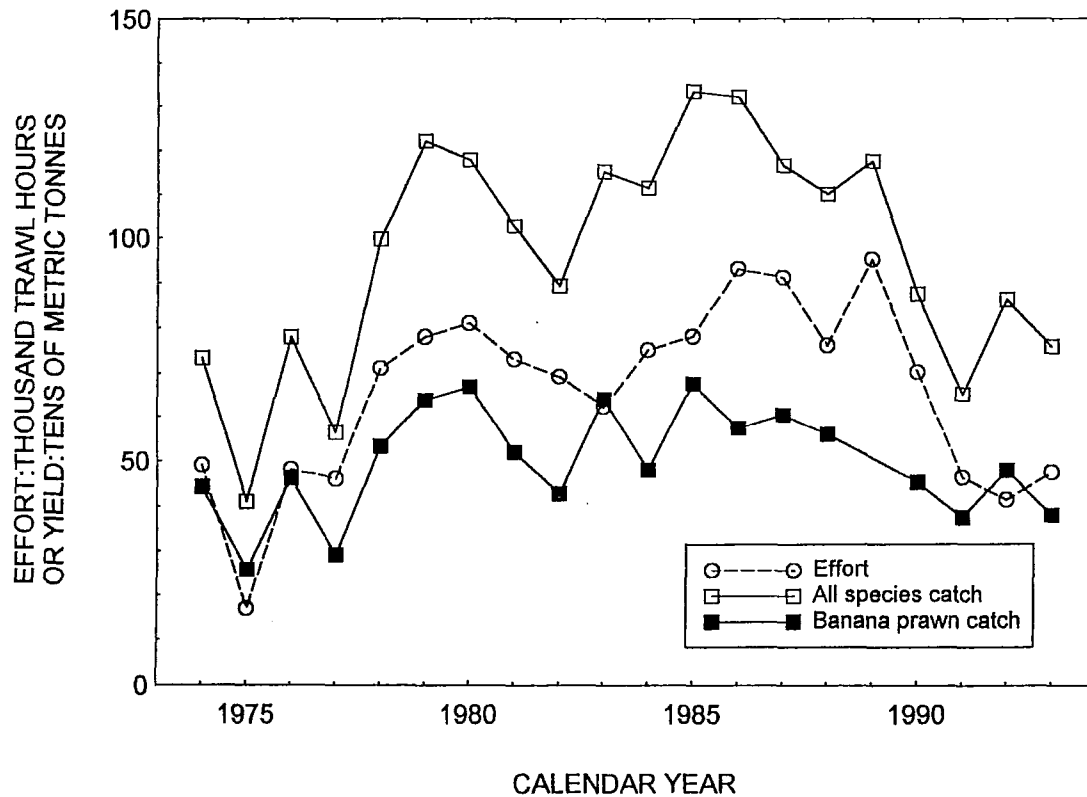
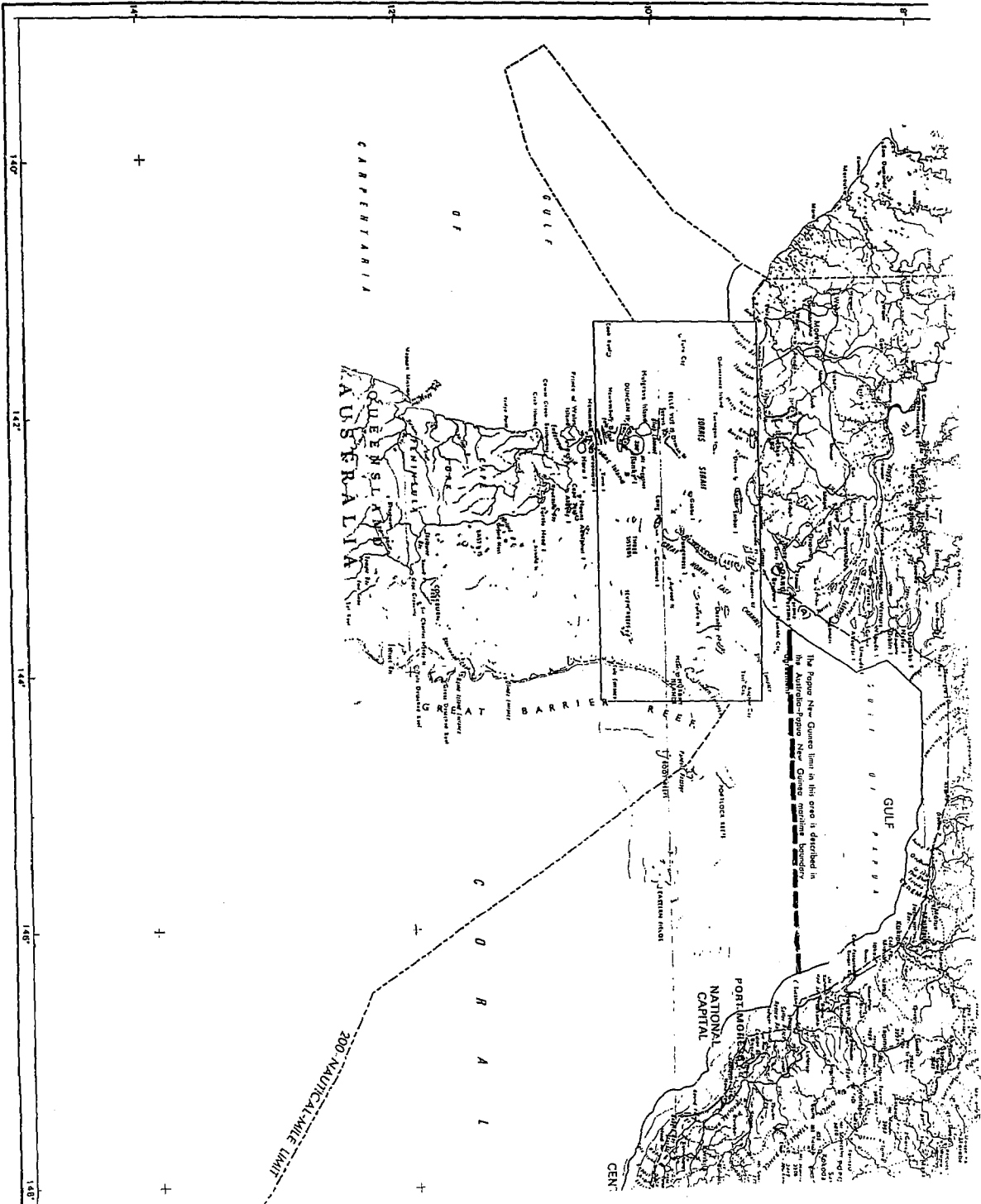


Fig. 5: Redefinition of the Gulf of Papua Prawn Fishery Management Area.



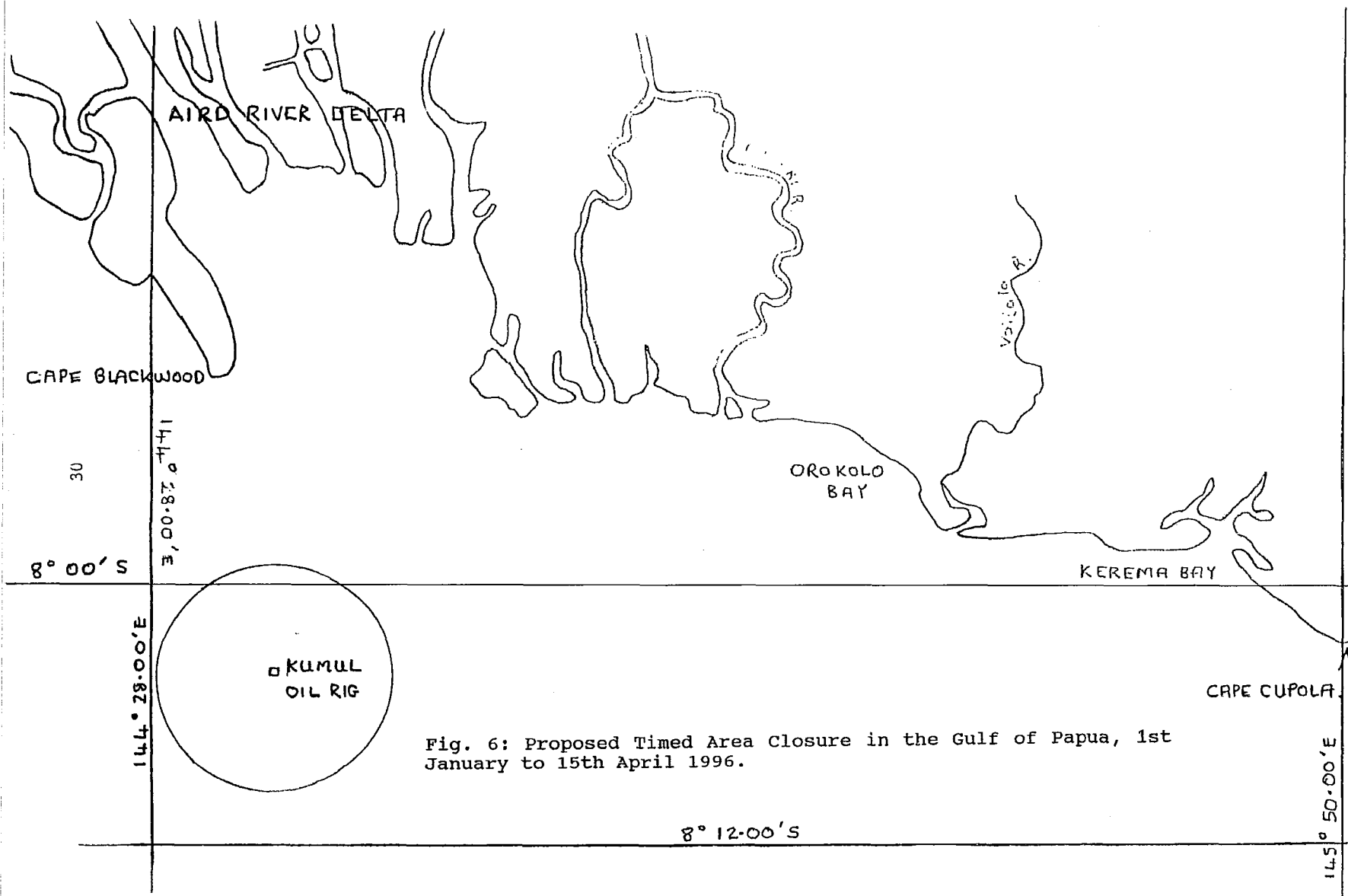


FIGURE 7:
 ANNUAL RAINFALL BEREINA, CENTRAL PROVINCE,
 AND YIELD OF BANANA PRAWN IN THE KEREMA BAY AREA, 1977-1987

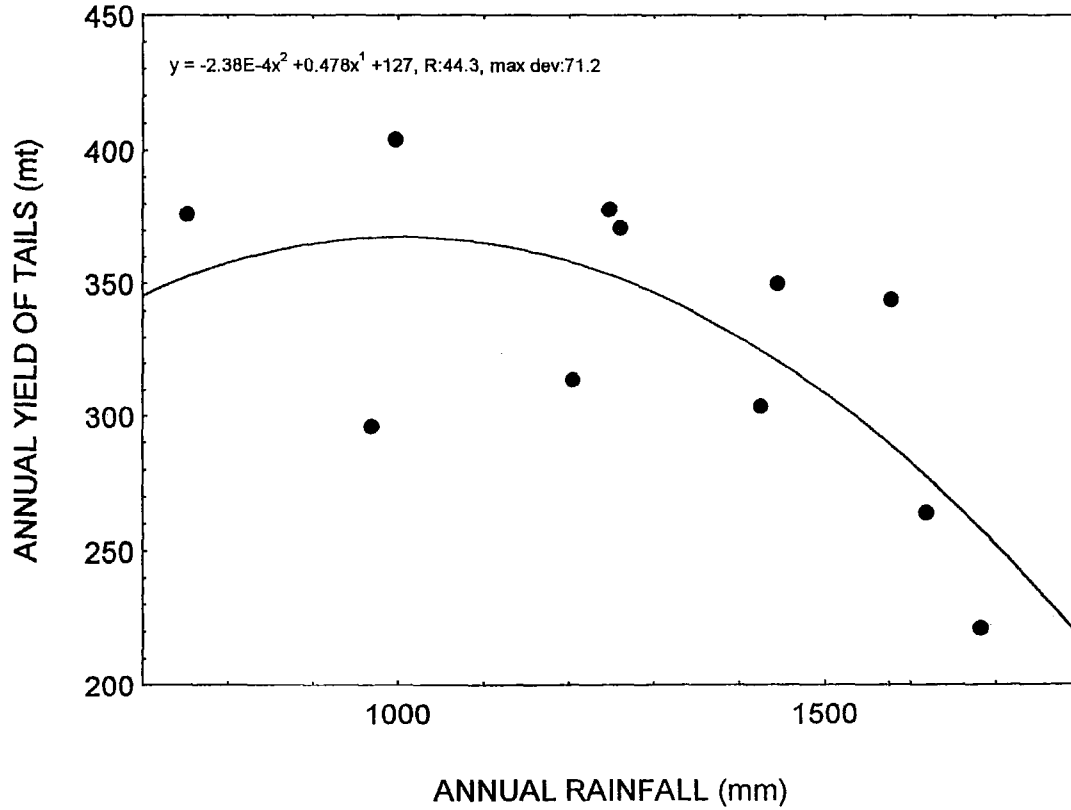


FIGURE 8: ANNUAL RAINFALL BEREINA, CENTRAL PROVINCE,
AND YIELD OF BANANA PRAWN IN THE GULF OF PAPUA FISHERY, 1977-1987

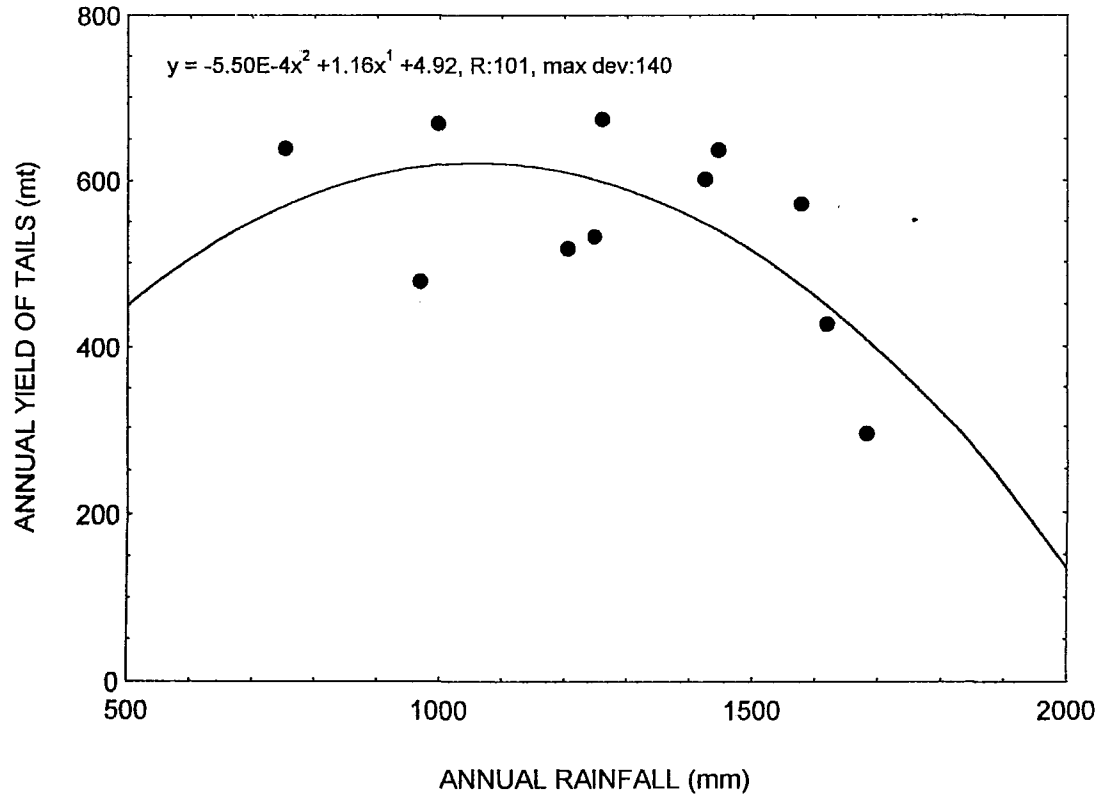


FIGURE 9: ASSOCIATION BETWEEN ANNUAL RAINFALL, BEREINA, AND CPUE OF BANANA PRAWNS IN THE GULF OF PAPUA, 1977-1987

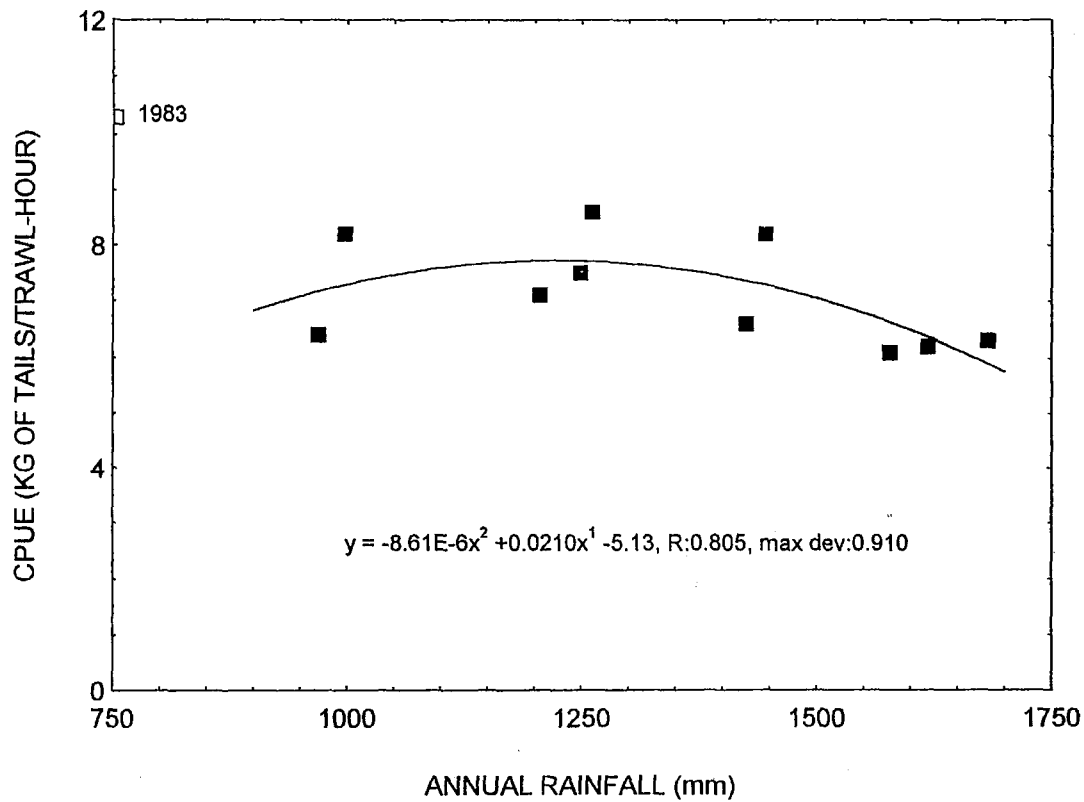


FIGURE 10: ASSOCIATION OF GOP PRAWN CPUE ON JANUARY RAINFALL AT BAIMURU, 1974-1993, 1986-88 MISSING

