ASSESSMENT OF THE PRAWN RESOURCES OF ORANGERIE BAY, MILNE BAY PROVINCE

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ABSTRACT

The maximum sustainable average yield (MSY) for the multi-species prawn resources at Orangerie Bay was estimated at 28.6 +/- s.e. 1.2 t per year by correlation/regression of catch per unit of fishing effort (CPUE) on fishing effort for the period 1981-1994 (p = 0.0007). The optimum effort was similarly estimated to be 1329 +/- s.e. 165 trawl-hours per year, and the year (C_f) for a given effort (f) was as follows: $C_f = 43.5f - 0.01681^2$. A total allowable catch (TAC) in the region of 30-35 t per year (multi-species, whole weight) is recommended, with in-season revision should unfavourable environmental conditions become established.

***Keywords**: Assessment, multi-species, surplus-production, penaeid prawns, TAC, management plan, Orangerie Bay*

INTRODUCTION

The Orangerie Bay prawn fishery is located in Milne Bay Province, south-west of Alotau. It is a relatively small fishery compared to the Gulf of Papua prawn fishery, and has operated with only one or two smaller vessels since 1981. The bottom comprises rocky ground, reefs and sand compared to the soft substrate which forms the sea bed of the Gulf of Papua; the principal industrial trawling grounds are located between Baibara Island and Saubina, from 2 to 10 m (approximately 1 to 5 fathoms) depth, but chiefly between Laimodo and Saubina (figure 1). The seaward limit of the trawl grounds is the 5 fathom (10 m) depth contour (shown on Figure 1).

Based upon the reported annual catches and associated fishing effort (there may have been some under-reporting), the fishery had a 16.2 t average annual yield during 1981-1994, n = 13 years (Table 1).

There is only one company, *Nako Fisheries,* operating. They company has two vessels, the Streaker, of approximately 13 m length and the much smaller Trekka, of approximately 8 m length. they each have two main nets and no try nets.

Vessels have traditionally spent the months of March to October trawling in Orangerie Bay chiefly between Saubina and Laimodo (Figure 1).

The principal catch is the white banana prawn *Penaeus merguiensis,* with a smaller proportion of black tiger prawn *(P. monodon)* and the Indian banana prawn *(P. indicus)* and even smaller catches of endeavour prawns (*Metapenaeus* sps.). Trawling only occurs in the day time as fewer prawns are caught at night. Prawns are sorted on the boat and are weighed head-on. After weighting, they are deheaded, cleaned with cold fresh seawater and placed in a chilled brine holding tank.

The catch was traditionally transported by sea to Alotau, but from 1994 the two licensed fishing trawlers have unloaded their catch at Bona Bona Island, near the entrance to Mullins Harbour (Figure 1). This has increased the efficiency of operation and therefore potential fishing effort. From there the catch is transported by a dory for 4 hours along the southern shore of Mullins Harbour and up the Sagarai River to the landing stage at Tamanai, where it is offloaded and taken to *Nako Fisheries* Alotau processing plant.

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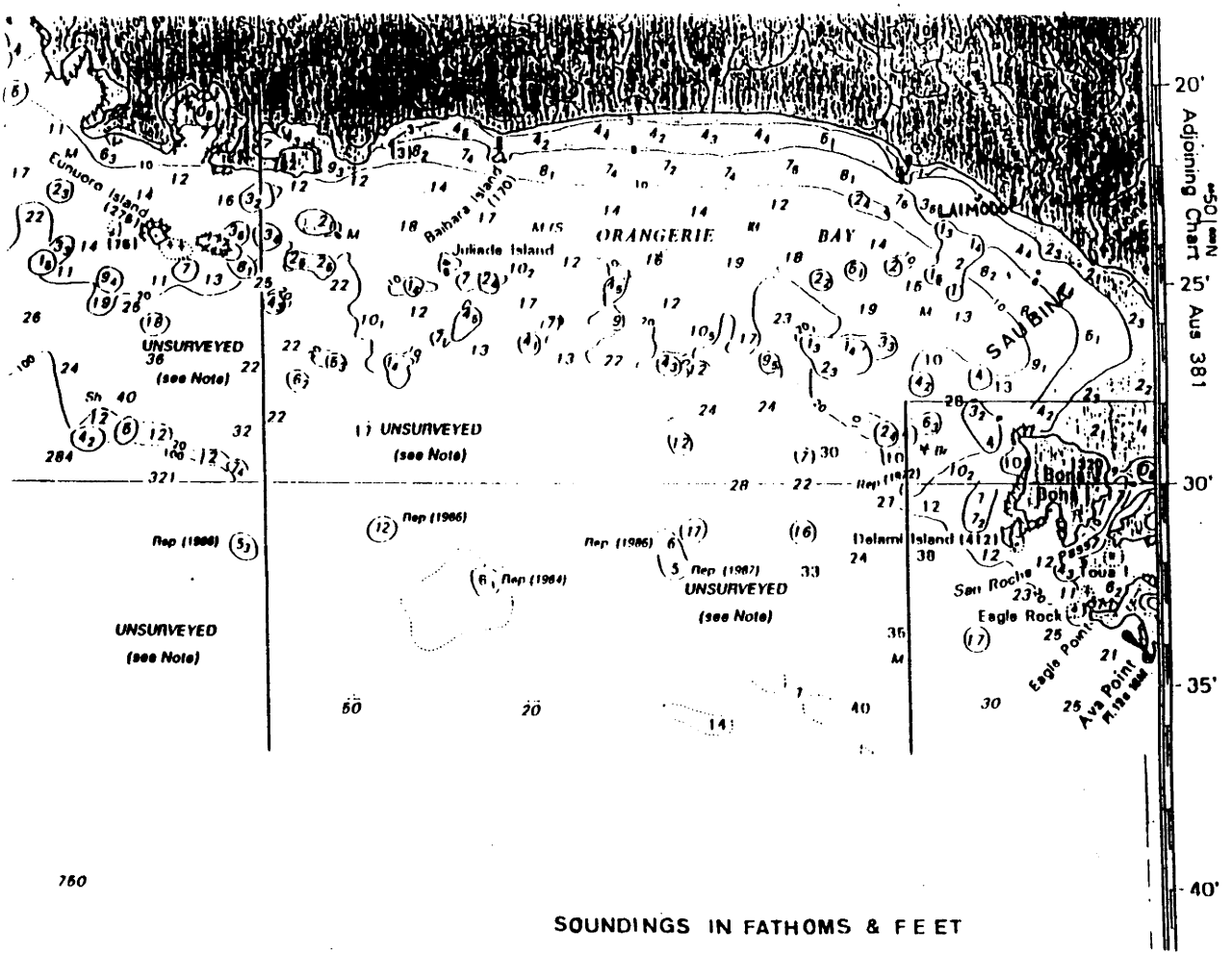
Figure 1: **Showing the Orangerie Bay Prawn Trawl Grounds (Chiefly Saubina to Laimoda).**



An interim management plan for the Orangerie Bay prawn fishery was gazetted in April 1995 and set out the agreed management measures based upon the results and recommendations of the Evans and Opnai (1994) study, and upon earlier consultations with *Nako Fisheries*.

The sustainable yield was initially estimated to be approximately 35-45 t from historical data on catch in the developing phase of the fishery. The research of Evans and Opnai (1994, 1995) indicated a somewhat lower maximum sustainable average yield in the region of 30 t.

A survey of the Orangerie Bay prawn resource was requested by the Milne Bay Provincial Fisheries Department during consultations in October 1995, and was already targeted by the National Fisheries Authority. This was with a view to the development of a more comprehensive management plan for the small, but valuable, resource. The purpose of the present study was to refine the earlier stock assessment of Evans and Opnai (1994, 1995) and to give accurate estimates with standard error, of the maximum sustainable average yield (MSY) and the optimum effort, also the equation of yield for a given effort.

In 1997, a TAC of 35 t was introduced based upon the stock assessment of the present study, together with a closed fishing season from 1st December to 30th April, to allow young prawns recruiting to the fishery in the first quarter of the year to grow and realise their growth potential. These management measures, and related measures limiting the number of vessels to 2 and their size to 14 m overall

Table 1: **Orangerie Bay Multi-species Prawn Fishery Catch and Effort Data.**

Year	Total Effort (trawl-hours)	Total Catch (metric tonnes)	Mean CPUE (kg/trawl-hour)
1981	169	4.9	29.0
1982	151	5.3	35
1983	1393	39	28.1
1984	195	10.3	53
1985	1793	25.8	14
1986	no records available		
1987	214*	1.8*	8.4*
1988	2134	9.6	4.5
1989	279	9.4	34
1990	439	16.7	38.1
1991	1252	16.2	12.9
1992	825	25.4	31
1993	600	21.5	35.8
1994	587.9	24.3	41.3
1995	records unprocessed		

*Suspected aberrant data: 1) 1.8 t catch is unusually low and may have resulted from incomplete reporting or incomplete records (personal communication, Mr Neil Stanton, *Nako Fisheries*, 1996) and 2) 1987 was a year with a pronounced El Nino effect. The availability of prawns for capture may have been excessively reduced as a result of insufficient rainfall for offshore emigration and/or reduced extent of suitable mangrove nursery habitat (at intermediate salinity levels).

Sources:
(1) Fisheries Annual Report 1985-91;
(2) Prawn Database Management System 1990-93;
The data in this table was sourced primarily from logbook data sheets and secondarily from data in Doulman and Kolkolo (1985).

length, and restricting fishing to the day-time, were formalised under a new management plan agreed with the prawn operators *Nako Fisheires* in September 1996 and approved by the National Fisheries Authority Board on 21st October 1996.

MATERIALS AND METHODS

Data

Catch and effort data from the log-book sheets were the primary source of the data. Information reported in Doulman and Kolkolo (1985) was a secondary source, as was the DFMR Annual Report for the years 1985-1991.

The fishery is a multi-species fishery and the catch data used in the analyses (Table 1) is for all species combined, in aggregated biomass (the total weight of whole prawns caught).

Data for the year 1987 have been left out of the analyses of the present study. There was exceptionally low catch (1.8 t) and CPUE during this year, which may have arisen due to incomplete reporting (personal communication, Neil Stanton, *Nako Fisheries,* 1996). 1987 was also one of exceptionally high temperatures in the eastern Pacific and Caribbean with a pronounced El Nino effect and concomitant reduced rainfall in the Western Pacific which could have caused very low annual catch in Orangerie Bay. The availability of prawns for capture may have been excessively reduced as a result of insufficient rainfall for offshore emigration and/or reduced extent of suitable mangrove nursery habitat (at intermediate salinity levels).

Quadratic regression

Annual yield (in metric tonnes, t) was plotted on annual fishing effort (in trawl-hours), since there were plots on the right hand side of the parabola (at the higher levels of fishing effort) which could help to identify where the curve peaked, thereby giving estimates of maximum sustainable average yield (MSY) and optimum effort (f_{msy}).

Correlation/Regression

Catch per unit of fishing effort (CPUE) was plotted on the total effort by linear regression. The maximum sustainable average yield (MSY) in the multi-species fishery was estimated from the Schaeffer (1954) model, using aggregated biomass, by the equations outlined in Pauly (1983):

$[MSY] = a^2/4b$ (1)

where a = the y-intercept and b = the slope (with the sign of the slope changed from negative to positive). Optimum effort (f_{msy}) was estimated from the Schaeffer (1954) model using Equation 2 (Pauly 1983):

$f_{msy} = a/2b$ (2)

The yield for a given effort C_f is similarly given by the Schaeffer (1954) model using Equation 3 (Pauly 1983):

$C_f = a.f - b.f^2$ (3)

The correlation/regression analysis and estimation of the standard error of a and b were carried out using the 'C-Stat for Windows' programme, and the estimates of s.e. generated were used in the estimation of the MSY +/- s.e. The method of estimation of MSY and f_{msy} consists of (a) substituting the sets of maximum slope and intercept values (i.e. slope+s.e., intercept +s.e.) in equations 1 and 2, to obtain minimum estimates of MSY and fmsy; and (b) substituting the sets of minimum slope and intercept values (i.e. slope-s.e., intercept-s.e.) in equations 1 and 2, to obtain maximum estimates of MSY and f_{msy}. The estimates are then taken as the median of the minimum and maximum.

RESULTS

The curve of catch on effort (Figure 2) indicated a maximum sustainable average yield (MSY) of approximately 29 t and an f_{msy} of approximately 1 250 trawl-hours. Linear regression of CPUE on effort (Fig. 3), and the related correlation/regression analyses (Table 2), resulted in an estimate of MSY at 28.6 +/-s.e. 1.2 t per year. The optimum effort was similarly estimated at 1329 t /-s.e. 165 trawl-hours per year. The yield (C_f) for a given effort (f) was as follows:

$C_f = 43.5f - 0.0168f^2$

Table 2: **Correlation-regression analysis for Orangerie Bay multi-species prawn resources: regression of CPUE on effort (data from Table 1, excluding 1987).**

	Value	s.e.	95% CI
Slope	- 1.68E-02	3.45E-03	-245E-02 to -9.10E-03
Intercept	43.5	3.6	35.4 to 51.5

Correlation coefficient = -0.8384
Degrees of freedom = 10
p = 0.0007

Figure 2: **Curve of catch on effort for Orangerie Bay prawn, all species.**

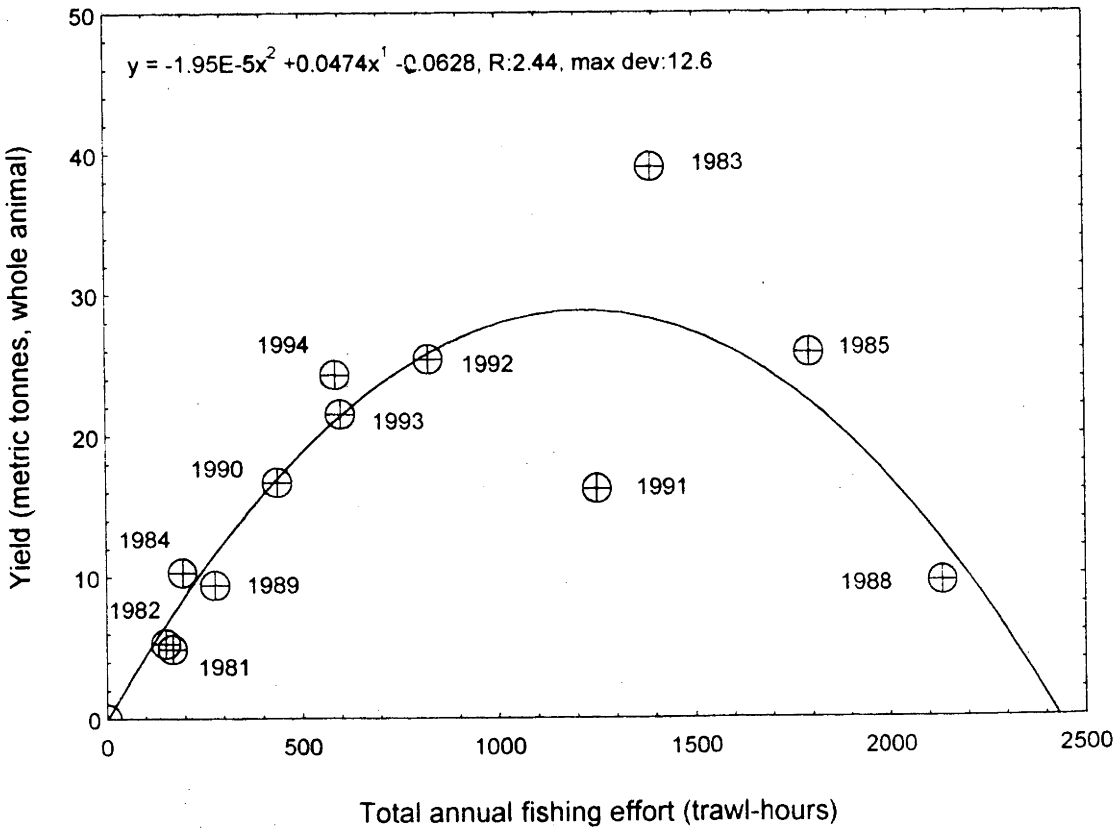
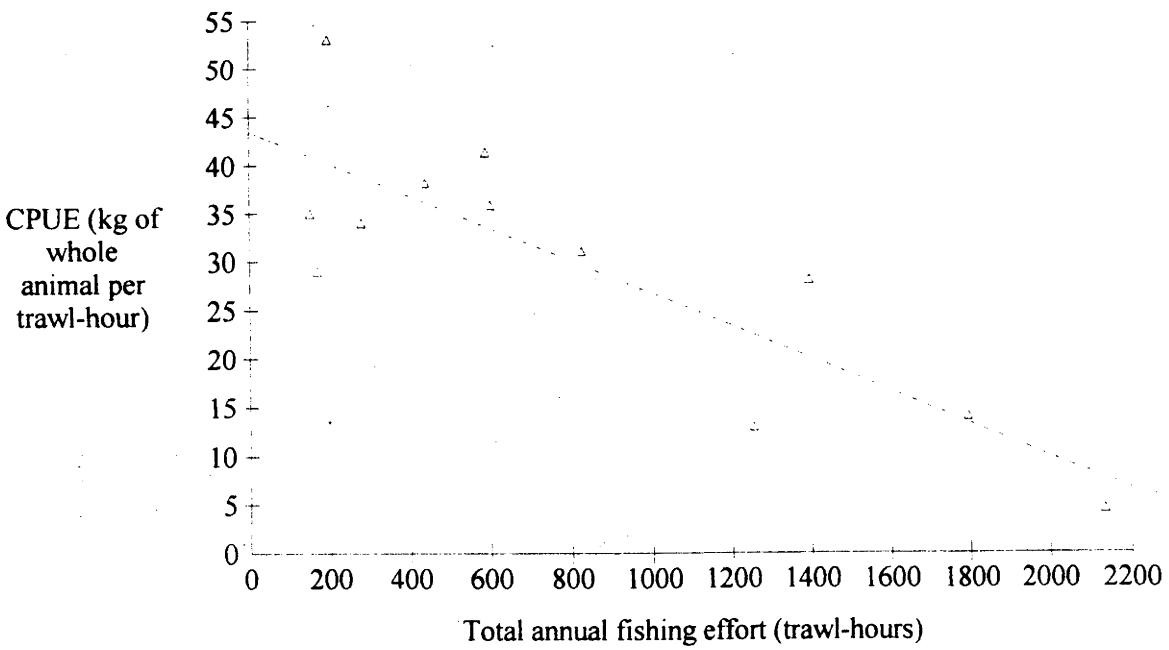


Figure 3: **Linear regression of CPUE on effort, Orangerie Bay prawn.**



DISCUSSION

Multi-species analysis using aggregated biomass is an acceptable method of stock assessment of species groups. Ralston and Polovina (1982) carried out multi-species analysis of the commercial deep-sea hand-line fishery of Hawaii, and were able thereby to determine the fishery dynamics when single species analysis revealed little of what was happening in that fishery.

Linear regression of CPUE on fishing effort is one of the most accurate ways of estimating maximum sustainable average yield (MSY) and f_{msy} with s.e. when data are available from both the developing phase and over-exploited phases of a fishery (Hillborn and Walters, 1992). This method has been used by Evans and Evans (1995), Evans *et al* (1996) and Evans *et al* (1997).

In the present study, estimates of MSY and f_{msy} by quadratic regression offer a comparison because there are data in the far right, on the decreasing leg of the curve (in the over-exploited phase), and estimates are likely to be accurate. The estimates from quadratic regression fall within the standard error margins of the estimates from linear regression.

The omission of the 1987 data from the analyses slightly increased the MSY estimates resulting from the Evans and Opnai (1994 and 1995) studies (which were 27.5 t from quadratic regression and 26.6 t from linear regression).

The sustainable yield was initially estimated to be around 35-45 t (personal communication, Mr. Joel Opnai, National Fisheries Authority, 1995) from data on catch and effort in the developing phase of the fishery. During the developing phase of a fishery, catches and CPUE can frequently be higher than can be sustained in the long-term, since most fisheries have an inherent lagged response towards the equilibrium state (Hillborn and Walters, 1992). Thus the present study, including additional data from the over-exploited phase), provides a more reliable estimate of the maximum sustainable average yield (MSY) than the earlier approximation.

CONCLUSIONS

The maximum sustainable average yield for the multi-species prawn resources at Orangerie Bay is 28.6 +/- s.e. 1.2 t per year ($p = 0.0007$). The Optimum effort was similarly estimated to be 1 329 +/- s.e. 165 trawl-hours per year, and the yield (C_f) for a given effort (f) was as follows: $C_f = 43.5f - 0.0168f^2$.

The maximum sustainable average yield is therefore relatively small at 26 to 31t (95% confidence limits) and will be lower if unfavourable environmental conditions occur, such as exceptionally low levels of rainfall.

RECOMMENDATIONS

1. Because of the relatively small maximum sustainable average yield of 26-31 t (95% confidence limits), only two trawlers of less than 14 m overall length should be allowed to operate in the fishery, based on the number and size of vessels operated by *Nako Fisheries* since 1992 (during 1992 to 1994): annual catches of 21.5 to 25.4 t were caught by this fleet (of 2 vessels) during 1992-94.

2. A total allowable catch (TAC) in the region of 30-35 t per year (multi-species, whole weight) is recommended, based upon the upper limit of the 95% confidence limits of the estimate of maximum sustainable average yield. The TAC should be set at lower levels if unfavourable environmental circumstances occur, such as exceptionally low levels of rainfall in the wet season: should unfavourable environmental conditions become established, there should be in-season revision of the TAC.

ACKNOWLEDGEMENTS

We would like to thank *Nako Fisheries* staff, the Director Mr Neil Stanton, the Manager Mr. Reuben Ngu, and the skipper and crew of the Trekka, and the skipper of the Streaker for all their kind help during the survey, the same to Mr. Peter (who participated in the parallel field studies of size and spatial distribution patterns) and Mr Kelo Kelo of the Provincial Fisheries Office (who approved and facilitated the survey), also many thanks to Mr Chris Able of Masuarina who assisted with transport. Grateful thanks also to our NFA colleagues Mr Barre Kare, Mr Lester Baule and Mr Mishak Tatamasi, for their laborious and fine work on the parallel field

studies, and NFA Divisional Executive Manager Mr Joel Opinai, for approving and facilitating the programme of stock asssessment and parallel studies, despite a lack of funding at the provincial level.

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