ANALYSIS OF CATCH DATA FROM AN ARTISANAL CORAL REEF FISHERY IN THE TIGAK ISLANDS, PAPUA NEW GUINEA

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ABSTRACT

For the period 1970–1982, landing records from a small-scale coral reef fishery in the Tigak Islands, northern Papua New Guinea (PNG), are summarised and analysed. Fishermen in the Tigak Islands spear, net, or handline the majority of the catch. Mugilids, carangids, lutjanids, letherinids, serranids and scarids comprise 76 percent of the total weight of the fish caught in these islands. From 1970 to 1982, 303 tonnes of reef fish caught by island fishermen were landed at a government fisheries station in Kavieng. This involved 9,131 beachside transactions. Landings of fish from the Tigak Islands increased between 1976 and 1982 and the possible reasons for this are discussed. Population size and annual rainfall did not have a significant affect on fish landings, but fish landings in two villages which owned copra plantations were negatively correlated with the mean annual copra price. As the distance from Kavieng increased, the incentive to fish decreased; more than 30 percent of the total landings for the period originated from within two kilometres of the government fisheries station. However, mean weight of landings increased with increasing distance of the source of the catch from the fisheries station. The implications of this analysis for fisheries development planning are discussed.

INTRODUCTION

The northern and eastern coasts of the main eastern and northern islands of Papua New Guinea (PNG) support extensive coral reefs. The majority of these reefs are fringing or barrier types and are among the most diverse in the world for coral species (Kojis *et al.* 1985). Associated with these reefs and the adjacent shallow water environments, which includes lagoons, seagrass beds and mangrove forests, is a rich fish fauna represented by species found throughout most of the tropical Indo-Pacific (Wright and Richards 1985). In PNG, components of this fauna have been harvested by man since pre-history (White and O'Connell 1982).

The present harvest from PNG's coral reefs has been estimated to be between 10,000 and 15,000 tonnes annually (Kearney 1975; Densely *et al.* 1977; Frielink 1983). The factors affecting fisheries production are generally unknown. Lock (1986a, b, c, d) analysed catch and effort data from the Port Moresby artisanal reef fishery and has shown that the harvest and

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catch per unit effort is inversely correlated with total fishing effort. Wright and Richards (1985) have described the catch composition and the catch rates of the Tigak Islands reef fishery in New Ireland Province and suggested that the present yields were effort limited rather than resource limited.

Wright and Richards (1985) recorded the methods of fish capture for landings of reef fish from the Tigak Islands at the Kavieng Government Fish Purchasing Centre (GFPC) during 1980–1981. A summary of these data is presented in Table 1. Fishing with nets is the most common method of fish capture in the Tigak Islands and accounts for about one-third of the total catch weight. The miscellaneous classification in Table 1 refers to fishing trips where combinations of fishing methods were used and for which detailed catch information was rarely available. The use of explosives is also common in the Tigak Islands but as this method is illegal, few fishermen attempt to sell fish obtained by bombing to the GFPC.

The composition of the artisanal catch landed at the Kavieng GFPC during 1980–1981 is given in Table 2. Wright and Richards (1985) recorded a total of 253 species of teleost fishes, representing 43 families, during this period. The catch was dominated by Mugilide which accounted for about one fifth (in weight) of the total. A further five families (Carangidae, Lutjanidae, Lethrinidae, Serranidae and Scaridae) comprised 76.1 percent of the total landed catch.

The principal method of transport from the outlying islands in the Tigak Group to Kavieng, the urban center in New Ireland, is by canoe or dinghy powered by outboard motors. These vessels are also used to transport copra from the Tigak Islands to the exporting port at Kavieng. Plantations are owned by many of the local village groups and copra has offered a regular source of cash to the island communities in the recent past.

In this paper, we examine a time series of fish landing data at a GFPC at Kavieng for the period between 1970 and 1982. The majority of the fish landed at the Kavieng GFPC

Table 1.–**Contribution by various fishing methods to the artisanal fishery in the Tigak Islands [adapted from Wright and Richards (1985)].**

Fishing Method	Percentage contribution (by weight) to the artisanal fishery
Gill netting & Beach seining	35.2
Miscellaneous (e.g. derris root poisoning or combination of methods)	31.2
Hand-lining	21.6
Spearing	6.1
Trolling	5.9

are caught in the Tigak Islands. The receipts for fish purchased by the GFPC are not designed to monitor fish landings to provide biological information relating to the dynamics of the fishery operating to the Centre, but rather to provide an economic record of the GFPC transactions. These receipts have until now been largely ignored as a useful source of information on the dynamics of small-scale fisheries in PNG. This paper presents the first attempt to use the records of a fish purchasing Center to provide information that may be useful for planning future development of PNG's coastal fisheries.

MATERIALS AND METHODS

The Study Site

The Tigak Islands (Fig. 1 and Fig. 2) lie to the west of the New Ireland mainland in the Bismarck Archipelago, between 2 ° 32 ′ S and 2° 47′ S, and 150° 30′ E and 150° 47′ E. The total population of the 24 islands in the group at the 1980 census was 1,481 (Anonymous 1983).

Many of the Tigak Islands are raised reefal limestone, whereas others consist of an atoll of reef-derived beach rock and coralline sand. The climate is tropical-monsoonal with an average annual rainfall of 3,300 mm. The average sea surface temperature is 30° centigrade with a mean salinity of 33.5 parts per thousand (Wright *et al.* 1983). The coastal vegetation fringing these islands consists of mangrove swamps bordered by either rainforest or coconut plantation.

Catch Data

Residents in the Tigak Islands catch fish which are either sold in the provincial centre of Kavieng or consumed

Table 2.–**Family composition (by weight) of Tigak Islands artisanal reef fish catch at Kavieng GFPC [adapted from Wright and Richards (1985)].**

Family	Common Name	% of Tigak Islands Catch
Mugilidae	Mullet	21.2
Carangidae	Trevally	14.0
Lutjanidae	Snapper	13.3
Lethrinidae	Emperor	10.4
Serranidae	Rock cod	9.1
Scaridae	Parrot fish	8.1
Acanthuridae	Surgeon fish	4.7
Haemulidae	Sweetlip	3.3
Scomberomoridae	Mackerel	2.7
Chanidae	Milk fish	2.3
Balistidae	Trigger fish	1.6
Siganidae	Rabbit fish	1.3
Albulidae	Bone fish	1.0
Hermiramphidae	Gar-fish	1.0
Belonidae	Needle fish	1.0
Gerridae	Biddies	1.0
Mullidae	Goat fish	1.0
Other Families		7.0

in the local villages. Fish sales in Kavieng occur through street sales, sales through the general produce market, or trade stores, or sales to the GFPC. Sales other than through the GFPC are difficult to monitor and are not considered here.

Since 1968, the government has maintained the fish purchasing facility on the Kavieng water-front. Finfish are transported to this facility from the islands by fishermen or are bought from island fishermen by GFPC staff on a collection vessel. Each purchase of fish is recorded on a produce purchase docket (PPD) which forms the basis of the GFPC accounts.

The PPDs from 1970–1982 were analyzed in an attempt to describe the history of fishing for reef fishes in the Kavieng area. The volume of catch sold to the GFPC is referred to here as the landed catch. This distinguishes it from the total catch which comprises the landed catch, and fish which are kept by the fishermen for sale elsewhere or for subsistence purposes.

As there were no data or direct measures of fishing effort, the frequency of landings were summarized by village or island with the corresponding landed catch. These summaries formed the basic data set for analysis. A data subset was selected

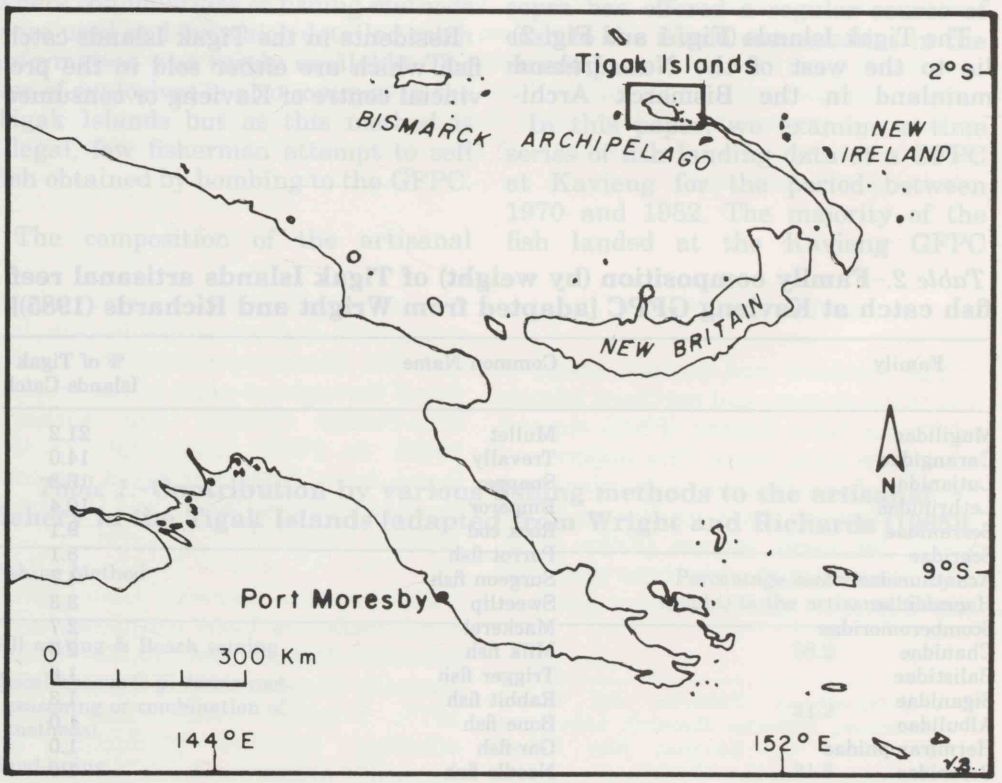

Figure 1.–**Map showing the location of the Tigak Islands in Papua New Guinea.**

for ten villages or islands that had contributed to the catch total for all years of the thirteen year study period.

RESULTS

Total Production

The total annual landed catch, number of landings and the mean weight for landings each year from the Tigak Islands between 1970–1982 are given in Table 3. Over this period, the mean annual number of landings of fish at the Kavieng GFPC was 702 landings (s.e.m. 195 landings). The mean annual landed catch between 1970–1982 was 23.3 tonnes (s.e.m. 3.0 tonnes). The average weight of the catch at each landing was 33.2 kilogrammes.

The data show that there was a considerable increase in the size of the annual landed catch in 1976 and it remained relatively constant thereafter. The average size of the annual landed catch from 1970–1975 was 14.4 t (s.e.m. 2.4 t) compared with 30.9 t (s.e.m. 3.1 t) between 1976 to 1982. Apart from 1976 when the number of landings was markedly higher, there was no corresponding rise in the number of landings after 1975. Thus after 1975 the mean size of the catch in each landing increased.

Fish production by village or island

Twenty villages or islands contributed to the total landed catch at the Kavieng GFPC between 1970 and 1982. The details of landings by

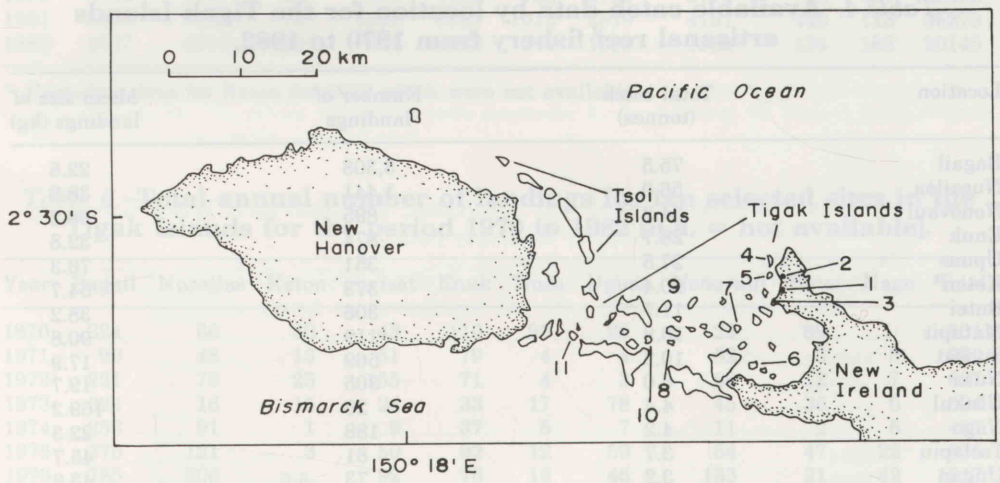

Figure 2.–**Map of the Tigak Islands and environs showing the ten villages and islands that landed fish at the Kavieng GFPC on a regular basis throughout the ten year study period. Key: 1. Kavieng GFPC, 2. Bagail, 3. Sivisat, 4. Nusa, 5. Nago, 6. Nusailas, 7. Enuk, 8. Nonovaul, 9. Butei, 10. Keton, 11. Upuas.**

Table 3.–**Total recorded annual weight of landed catch and total recorded number of landings at the Kavieng GFPC from the Tigak Islands artisanal fishery from 1970 to 1982.**

Year	Annual weight of landings (tonnes)	Annual number of landings	Mean weight of landings (kg)
1970	23.7	890	26.6
1971	7.6	387	19.7
1972	13.5	729	18.5
1973	16.8	610	27.5
1974	8.6	434	19.8
1975	16.3	869	18.7
1976*	31.4	1,522	20.6
1977	33.7	763	44.1
1978	32.8	642	51.1
1979	26.5	541	49.0
1980	22.1	447	49.4
1981	46.5	844	55.1
1982	23.3	453	51.5
Total	302.8	9,131	–
Mean	23.3	702	33.2

* Excludes data for Keton which were not available.

Table 4.–**Available catch data by location for the Tigak Islands artisanal reef fishery from 1970 to 1982.**

Location	Total catch (tonnes)	Number of landings	Mean size of landings (kg)
Bagail	75.5	3,308	22.8
Nusailas	56.0	1,441	38.9
Nonovaul	34.2	895	38.2
Enuk	28.7	874	32.8
Upuas	27.5	351	78.3
Keton*	20.4	373	54.7
Butei	11.7	306	38.2
Matupit	10.8	119	90.8
Sivisat	10.2	569	17.9
Nusa	6.0	305	19.7
Utukul	4.4	26	169.2
Nago	4.2	188	22.3
Tselapiu	3.7	81	45.7
Ungan	3.2	73	43.8
Tome	2.0	90	22.2
Nusalomen	1.9	61	31.1
Bangatang	1.0	35	28.6
Nusalik	0.9	50	18.0
Noipos	0.2	8	25.0
Limalon	0.05	5	10.0

* Excluding data for 1976 which are not available.

location are given in Table 4. The landings are ranked from Bagail, with a total catch of 75.5 t for the thirteen year period, to Limallon with a total catch of 0.05 t for the same period. The correlation between number of landings and total annual catch is significant ($r = 0.94$, $P < 0.05$).

Factors affecting fish production in the Tigak Islands were examined using the data subset of the ten villages and islands that consistently contributed to the landed catch between 1970 and 1982 (Table 5 and Table 6). The catches from Nusailas, Nusa and Nonovaul followed the general trend for the fishery as a whole, with increased production after 1975. There were, however, no obvious trends in total catch or number of landings over the thirteen year period within the data subset.

The possible affect of village population size, rainfall, mean annual

Table 5.–**Total recorded annual catch (kgs) for ten selected sites in the Tigak Islands for the period 1970 to 1982 [n.a. = not available].**

Year	Bagail	Nusailas	Keton	Sivisat	Enuk	Nusa	Upuas	Nonovaul	Butei	Nago	Total
1970	5959	1700	1142	600	3704	1106	3107	717	3750		21795
1971	1687	828	554	620	1608	36	317	1395	79	118	7242
1972	3298	1558	824	2106	2112	120	1217	372	372	105	12772
1973	5951	354	492	243	1163	360	5348	720	1114	190	15935
1974	3943	1673	5	139	1536	31	902	152	52	99	8532
1975	6612	1546	42	509	1367	195	3447	781	56	596	15656
1976	18638	3434	n.a.	1140	1346	174	3419	1419	243	864	30677*
1977	4485	10433	1875	339	2128	76	1750	9932	144	45	32512
1978	8149	10844	3283	711	1120	447	1812	4018	461	414	21259
1979	5032	8378	2992	405	812	1371	349	4069	76	167	23651
1980	3745	4747	287	525	1106	753	2780	3770	12	357	18082
1981	5202	5633	6197	1892	6094	1012	2579	4151	423	113	36278
1982	2837	4914	2687	972	4602	340	1608	1889	134	162	20145

* Excluding data for Keton for 1976 which were not available

Table 6.–**Total annual number of landings for ten selected sites in the Tigak Islands for the period 1970 to 1982 [n.a. = not available].**

Year	Bagail	Nusailas	Keton	Sivisat	Enuk	Nusa	Upuas	Nonovaul	Butei	Nago	Total
1970	324	60	30	43	110	93	29	23	89		801
1971	99	48	13	51	79	4	4	62	5	5	370
1972	221	76	23	155	71	4	3	60	12	7	697
1973	324	16	15	24	33	17	78	45	36	6	594
1974	258	91	1	9	37	5	7	11	2	6	427
1975	375	121	3	50	92	12	59	54	47	22	835
1976	785	306	n.a.	92	76	16	46	133	21	42	1517*
1977	192	215	17	16	59	2	24	158	37	1	721
1978	227	143	69	25	27	18	25	55	15	13	617
1979	137	94	71	14	23	48	5	79	3	5	479
1980	114	83	7	17	38	27	31	82	3	8	410
1981	147	99	80	57	136	46	23	95	34	4	721
1982	105	89	44	16	93	13	17	38	2	2	421

* Excluding data for Keton for 1976 which were not available.

copra price and the distance of the village from the Kavieng GFPC on the catch of fish from the Tigak Islands was examined. The population figures for each village or island (Table 7) were obtained from the 1971 and 1980 Government census (Anonymous 1983). There was no significant correlation between total catch or number of landings and mean population size ($P > 0.05$) for the ten locations in the subset.

Annual rainfall figures for the years 1970 to 1982 were obtained from the Kavieng Weather Station, which is adjacent to the airport and about 1.5km from the town (Table 8). There was no significant correlation between rainfall and total number of landings for the 20 locations ($P > 0.05$).

The mean annual purchase price for copra between 1970–1972 was obtained from Copra Marketing Board

Table 7.–**Population census figures for ten locations in the Tigak Islands used as data subset [source: PNG Government Bureau of Statistics, Port Moresby].**

Location	Population	
	1971	1980
Bagail	119	127
Nusailas	80	102
Nonovaul	126	157
Enuk	97	123
Upuas	214	213
Keton	110	86
Butei	179	199
Nusa	101	110
Sivisat	30	40
Nago	5	5
Total	1,061	1,162

Table 8.–**Total annual rainfall for Kavieng, summarized from Kavieng Weather Station records.**

Year	Rainfall (mm)
1970	3,150
1971	3,014
1972	2,606
1973	3,825
1974	2,570
1975	2,756
1976	2,990
1977	3,447
1978	3,315
1979	3,147
1980	3,734
1981	3,606
1982	2,686

(CMB) records (Table 9). Two locations in the Tigak Islands, Enuk and Sivisat, are almost entirely planted with coconut. Plots of the natural logarithm of the annual number of landings against copra price for these two locations (Fig. 3) had negative slopes and both the r values are highly significant ($P < 0.005$).

The distances between Kavieng and the ten locations in the data subset were estimated from Australian Admiralty charts (Table 10). The landed catch data for Bagail, Nusa, Nago and Sivisat were grouped under the one heading of Kavieng Harbour, with a mean distance from Kavieng GFPC of 2km. There was a significant ($P > 0.05$) negative correlation between the natural logarithm of the total number of landings with distance

Table 9.–**The buying price for copra (in standard units). [source: PNG Copra Marketing Board, Port Moresby.]**

Year	Annual Copra price* (standard units)
1970	1.00
1971	0.86
1972	0.49
1973	1.20
1974	2.44
1975	0.72
1976	0.91
1977	1.49
1978	1.62
1979	2.43
1980	1.40
1981	1.09
1982	0.87

* Between 1970 and 1974 the copra price was in Australian dollars. It was changed to Kina with the introduction of the new currency in 1975. The copra price was converted to standard units based on 1.00 for 1970. The effects of inflation were accounted for by deflating the annual copra price by the consumer price index for each year.

Table 10.–**Distance (km) from Kavieng of ten locations in the Tigak Islands used as a subset for the fishery catch data.**

Location	Distance from Kavieng (km)
Kavieng Harbour (Bagail, Sivisat Nago, Nusa)	2
Enuk	11
Nusailas	12
Butei	20
Nonovaul	21
Keton	22
Upuas	32

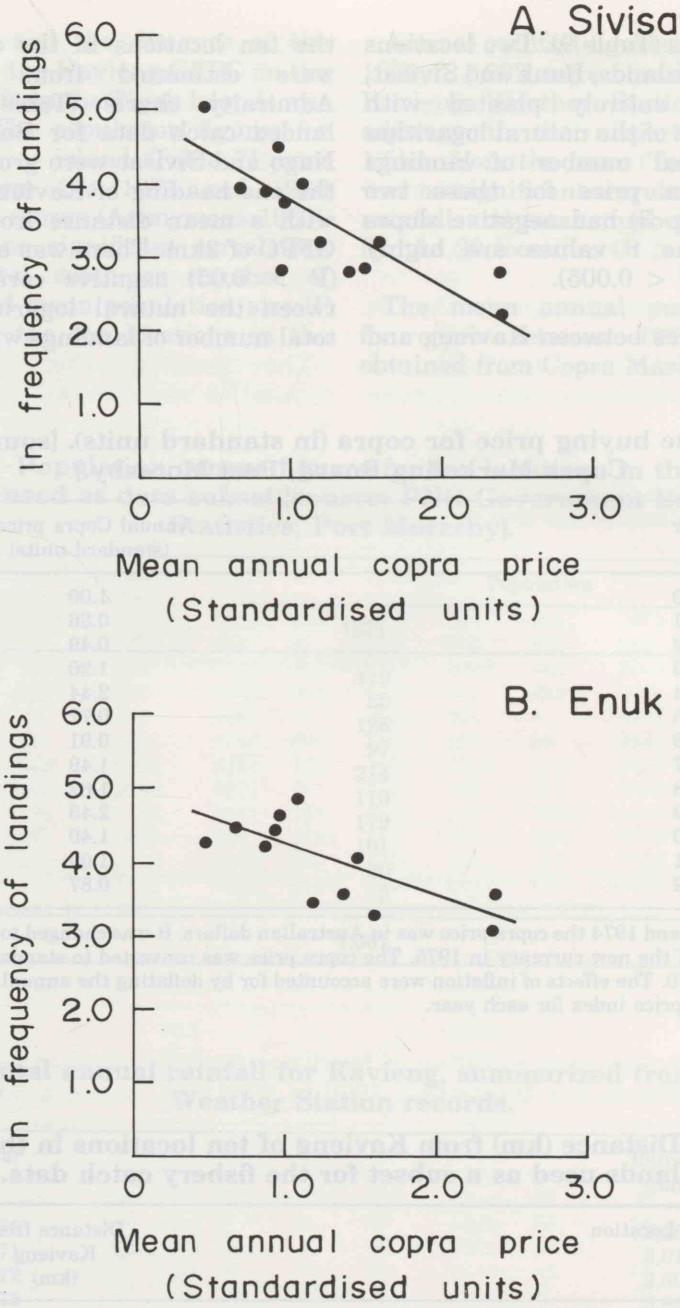

Figure 3.–**Plots showing the relationship between the annual number of landings of fish from (A) Sivisat Island and (B) Enuk Island at the Kavieng GFPC and the mean annual copra price. The copra price was converted to standard units based on 1.00 for 1970. The effects of inflation were accounted for by deflating the annual copra price by the consumer price index for each year. The regression equation for Sivisat is $y = 4.81 - 1.08x$, $r^2 = 0.62$, $P < 0.05$. For Enuk Island the equation is $y = 4.96 - 0.70x$, $r^2 = 0.55$, $P < 0.05$.**

from Kavieng (Fig. 4). A plot of the natural logarithm of the mean weight of the landed catch against distance from Kavieng is shown in Fig. 5. A significant positive correlation was obtained ($P < 0.05$).

DISCUSSION

The reasons for increased fish production after 1975 are not clear. One possibility is that the increase in buying price of fish catches at the Kavieng GFPC from 0.21 Kina/kg (Aust. $0.21 prior to 1975) to 0.45 Kina/kg in 1975 stimulated greater interest in catching and selling fish as a source of cash. As a consequence during 1976 the number of landings reached the maximum for the 1970–1982 period. Landings remained at normal levels from 1977 to 1982.

There is no evidence that fishing methods changed during the period so an apparent increase in the average weight of each unit sale from 1977 onwards could only be explained by fishermen exerting greater effort. The main motivation for this is probably related to the attractiveness of fishing for cash compared with other means of generating a cash income.

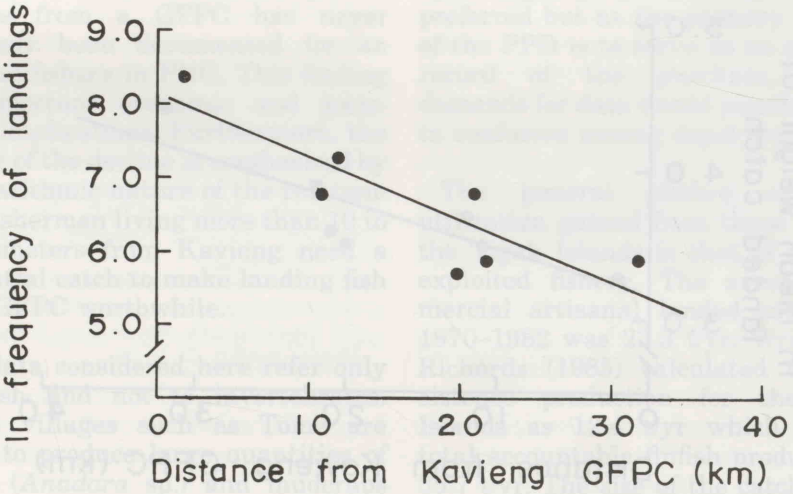

Figure 4.–**A plot showing the relationship between the number of landings of fish for the period 1970 to 1982 and the distance of the producing village from the Kavieng GFPC. The equation for the relationship is $y = 8.14 - 0.085x$, $r^2 = 0.72$, $P < 0.05$.**

Events outside the artisanal fishery may also have affected fish production from the Tigak Islands. The data relating to copra price and number of landings of fish (Fig. 3) by Sivisat and Enuk villagers at the GPFC suggest that when the price of copra is low more effort is put into fishing. Other villages also have access to large plantings of copra but the same relationship between copra price and fish landings is not evident. However, these other villages also benefit from a number of other income sources including fertile vegetable producing land and royalty payments for timber logging operations. These may also influence fishing effort.

In June 1975 royalty payments were commenced to Tigak Islands' residents for the use of traditional fishing areas as a source of live bait, by the domestic pole-and-line tuna fleet. Royalty payments were based on 2.5 percent of the value of the tuna catch taken by the tuna boats which baited in the traditionally-claimed shallow reef-associated lagoons throughout the Tigak Group.

Unfortunately, accurate records of royalty payments were not kept, but it is estimated that they amounted to between 25,000 and 30,000 Kina/yr. The influx of this money into the Tigak Islands between 1975 and 1981 may

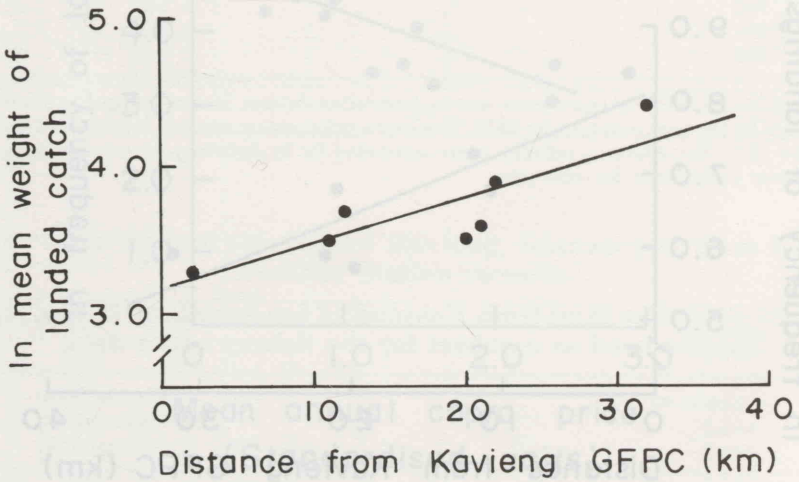

Figure 5.–**A plot showing the relationship between the mean weight of the catch per landing at the Kavieng GFPC and the distance of the producing village from the GFPC. The equation for the relationship is $y = 3.16 + 0.032x$, $r^2 = 0.72$, $P < 0.05$.**

have permitted the acquisition of more outboard motors and fishing equipment which led to increased fish production after 1975, although this reason for increased fish production cannot be substantiated.

As they are, the PPD records are useful and can provide an insight into the dynamics of an artisanal fishery. Within the Tigak Islands reef fishery, several factors have affected fish production between 1970 and 1982. Approximately one third of the total landings of the Tigak Islands fishery come from the immediate proximity of the Kavieng GFPC. Fishing effort, at the least that directed to commercial fishing, declines markedly within the 2–10 km distance from Kavieng GFPC. For a fisherman living far from Kavieng to journey to Kavieng to sell fish, it is expedient for him to bring a substantial catch.

The logical conclusion that fish production declines substantially with distance from a GFPC has never previously been documented for an artisanal fishery in PNG. This finding has important economic and sociological implications. Furthermore, the severity of the decline is emphasized by the logarithmic nature of the relationship. Fishermen living more than 10 to 15 kilometers from Kavieng need a substantial catch to make landing fish at the GFPC worthwhile.

The data considered here refer only to finfish and not to invertebrates. Certain villages such as Tome are known to produce large quantities of cockles (*Anadara* sp.) and mudcrabs (*Scylla serrata*), although they produce very little finfish (Table 4). Wright *et al.* (1983) estimated that 8.4 t of spiny lobster (*Panulirus* spp.) and 7.6 t of mudcrab are harvested annually from the reefs and mangrove areas adjacent to Kavieng. Fish production may therefore be affected by the harvesting of other marine resources which offer a better economic return.

A major problem with a study of an artisanal reef fishery is the lack of estimates of catch per unit of effort (CPUE). Average CPUEs for various gears used in the Tigak Islands have been estimated independently by Wright and Richards (1985). Station records do not detail the number of fishermen contributing to the catch, the period spent fishing or the fishing gear used.

For fisheries analysis, catch per unit effort (CPUE) would be a much more appropriate statistic than the size of the landed catch for assessing changes within the fishery. Collection of these data, therefore, would mean adopting a more suitably designed receipt book that would include a measure of the weight contributed by the 5 main fish families in the catch and the number of fish contributing to each family group. Species groupings obviously would be preferred but as the primary function of the PPD is to serve as an economic record of the purchase, further demands for data would possibly result in confusion among depot staff.

The general picture of finfish utilization gained from these data for the Tigak Islands is that of a lightly exploited fishery. The average commercial artisanal landed catch from 1970–1982 was 23.3 t/yr. Wright and Richards (1985) calculated the subsistence production for the Tigak Islands as 12.4 t/yr which gives a total accountable finfish production of 35.7 t/yr. The size of the catch sold at the Kavieng Market or trade stores is unknown. The total reef area of the Tigak Islands to a depth 30 m is 20,765 hectares and virtually the entire artisanal and subsistence catch comes from within these depths (Wright *et al.* 1983; Wright and Richards 1985). The yield of finfish during the years 1970 to

1982 was approximately 1.72 kg/ha. This is very small when compared with the Daugo Island reef fishery in Port Moresby where yields approach 80 kg/ha (Lock 1986a, b and c).

However, the present yields from the Tigak Islands fishery are likely to be more typical of reef fisheries throughout PNG. The observed generally large size of fish in all species groups and the high proportion of predators in the catch suggests that the fishery is still exploited at low levels and that production from the Tigak Islands is effort limited rather than resource limited.

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