Recent Developments in Papua New Guinea's Tuna Fishery

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Introduction

Like most island states in the central and western Pacific regions, the tuna resources found within the Papua New Guinea (PNG) 200-mile Declared Fisheries Zone (DFZ) represent an important resource. In PNG's case, its tuna resources, if fully developed, could be one of the nation's most valuable export industries.

The results of the recently completed Skipjack Tuna Assessment Programme conducted by the South Pacific Commission (SPC) infer that 180,000 metric tons (t) of skipjack tuna, *Katsuwonus pelamis*, can be taken annually from PNG's DFZ on a sustainable basis[1]. Total reported landings of skipjack tuna within PNG waters were approximately 42,000 t in 1980 and 31,000 t in 1981 which represent 23 percent and 17 percent, respectively, of the possible skipjack yield from the zone.

This paper reports and analyzes developments in PNG's tuna fishery from 1979 to 1982. In so doing, papers by Kearney (1975), Lewis and Smith (1977), Lewis[2], Wilson and Lindholm[3], and Wankowski and Lindholm[4] are updated. However, this paper represents the first attempt to relate economic and biological aspects of the fishery; previous authors dealt with biological aspects only.

PNG's tuna fishery has two components: The domestic fishery and the distant-water fishery. We begin with an analysis of the domestic fishery (including a production data review), the baitfishery, economic considerations, and reasons for the closure of the fishery at the end of the 1981 season.

Discussion of the distant-water fishery summarizes PNG's access arrangements with distant-water fishing nations (DWFN) since Independence in 1975. Fishery analysis focuses on the three fishing methods: Purse-seining, longlining, and pole-and-lining. Each method is reviewed in terms of available catch/effort and economic data. These data are in turn combined with data from the domestic fishery to provide an overview of PNG's tuna fishery as a whole.

The paper concludes by outlining PNG's view of the need for regional cooperation in the management of tuna stocks in the western Pacific and by commenting on future prospects for PNG's tuna fishery.

[1] DPI. 1982. Papua New Guinea's tuna fishery. Fish. Div., Dep. Primary Industry, Port Moresby, (mimeo), 16 p.

[2] Lewis, A. D. 1976. Features of the Papua New Guinea tuna fishery 1970-75. Fish. Div., PNG Dep. Primary Industry, Port Moresby, (mimeo), 9 p.

[3] Wilson, M. A., and R. Y. Lindholm. 1978. Papua New Guinea tuna and baitfish fishery: 1977. Fish. Div., PNG Dep. Primary Industry, Port Moresby, (mimeo), 12 p.

[4] Wankowski, J. W. J., and R. Y. Lindholm. 1980. The Papua New Guinea tuna and bait fisheries in 1978 and 1979. Fish. Div. Dep. Primary Industry, Port Moresby, (mimeo), 11 p.

ABSTRACT—This paper reviews Papua New Guinea's (PNG's) domestic (pole-and-line) and distant-water (purse-seine, longline, and pole-and-line) tuna fisheries from 1979 to 1982 and updates previously published works. The live-bait dependent domestic fishery, PNG's sixth largest export earner, landed 26,944 t of predominantly skipjack tuna, Katsuwonus pelamis, *during 1979, 34,099 t during 1980, and 24,029 t in 1981. The average annual value of these exports was $28.2 million. The reasons for the closure of the domestic fishery at the end of 1981 and its implications for future development are discussed.*

Distant-water fishing nation vessels operate in PNG's Declared Fishing Zone under negotiated Access Agreements. Japanese-based purse-seiners landed 12,906 t of tuna valued at $17.5 million during 1980 and 14,938 t valued at $18.0 million during 1981. Longliners landed 14,557 t valued at $31.0 million on the Japanese sashimi market during 1980 and 17,613 t valued at $35.0 million during 1981. Japanese long-distance pole-and-line vessels landed 503 t of tuna during 1979, 99 t during 1980, and only 16 t during 1981. These catches were valued at $134,177 in 1980 and $20,698 in 1981. The benefit PNG receives from these fisheries is analyzed and the likely future developments discussed, particularly with respect to regional cooperation through the Nauru Agreement.

Domestic Fishery

Background

PNG's domestic commercial tuna fishery began in March 1970. This was after initial baitfish and tuna surveys in

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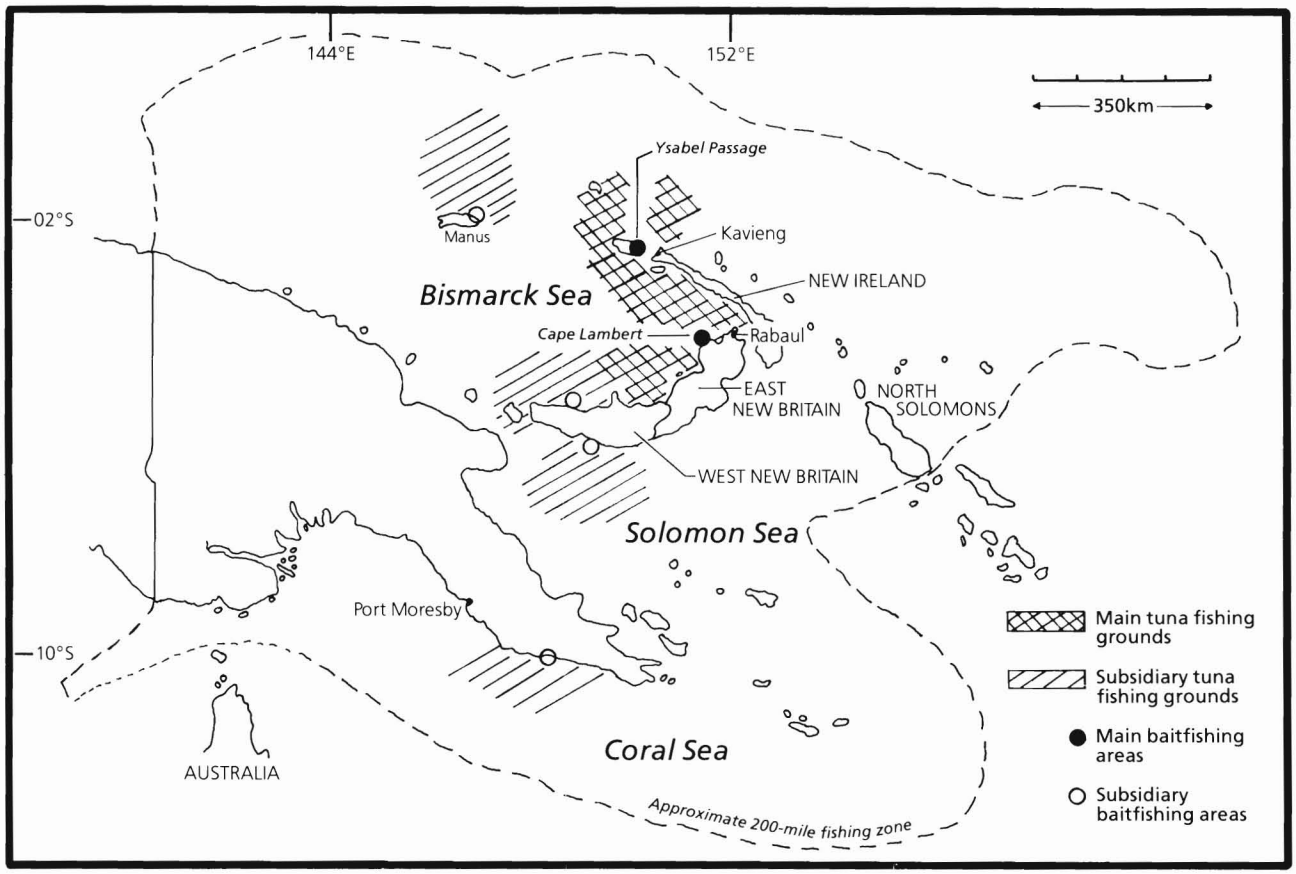

Figure 1. — Papua New Guinea baitfish and domestic tuna grounds.

the late 1960's indicated the existence of bait and tuna stocks capable of sustaining commercial exploitation (Anonymous, 1968; Nakamura, 1969). Two companies operated in the fishery in 1970, three in 1971, and four in 1972. However, by 1979 only two companies remained. These companies were Star-Kist (PNG) Pty. Ltd.[5] and New Britain Fishing Industries Pty. Ltd. (NBFI). Both companies operated through 1981, but as a result of deteriorating world tuna market conditions they did not start fishing in 1982. NBFI announced its intention to terminate operations in PNG due to losses incurred in 1981 and because of corporate reorganization plans by its parent company. Likewise, Star-Kist terminated its operations in PNG in early 1983.

Since the start, fishing operations have been primarily based around Kavieng in the New Ireland Province and more recently in the East New Britain Province adjacent to Cape Lambert because both areas have reliable supplies of good quality bait and are close to good tuna fishing areas. Other areas of PNG are also known to have good quality baitfish grounds but they have not been exploited extensively, either because there have been political problems over the opening of baitfish grounds to commercial exploitation or because the presence of tuna in these areas tends to be seasonal. Figure 1 shows PNG's proven tuna and baitfish grounds.

The pole-and-line method of fishing has been used exclusively in the fishery since 1970[6]. The boats employed were of the traditional Okinawan type. Most were 59 GRT class vessels, about 12 m long. Steel has replaced wood as the main hull material in more recent vessels. The main engines of these boats range from 350 to 600 hp with 50-150 hp auxiliary power units.

Despite attempts to establish shore bases, including a cannery, catcher boat

[5]Star-Kist (PNG) Pty. Ltd, is a wholly owned subsidiary of Star-Kist (California) Pty. Ltd, and part of the Heinz Group. New Britain Fishing Industries Pty. Ltd, is a subsidiary of Kaigai Gyogyo K.K. which in turn is owned by the Mitsubishi Corporation. Mention of trade names or commercial firms does not imply endorsement by the authors or by the National Marine Fisheries Service, NOAA.

[6]NBFI introduced a 400 GRT purse-seiner in late 1980 on a trial basis. The seiner made exceptionally good catches, but its operations were discontinued in mid-1982 because it proved uneconomic to operate a single seiner of this capacity.

operations from 1970 to 1981 used anchored motherships of 1,000-4,000 GRT. These vessels were moored close to the baiting grounds so that catcher boats could take on supplies and discharge their catch at the end of a day's fishing and prior to taking bait the same night. High mortality of bait in the catcher boats' holding tanks requires fresh supplies of bait to be obtained each night. Because of this, the operations of the domestic fishery have been highly localized as catcher boats were unable to fish more than 100 km away from motherships and baiting grounds.

About 10-12 catcher boats operate off each mothership. This constitutes one fishing unit. The four units that operated in 1981 were each valued at between $8 and $10 million[7], depending on the number of vessels, their age, and other considerations.

After the catch is transferred from the catcher boats to the mothership, it is brine frozen and stored below deck until sufficient supply has accumulated to require transshipment to a refrigerated carrier vessel. These carrier vessels call on demand to transport the catch to overseas markets. Almost the entire PNG catch since 1970 has been exported without being landed within the country[8].

Production

PNG ranked third as a world producer of skipjack tuna from 1971 to 1979, though on average the domestic fishery only produced 5 percent of the total world production each year (FAO, 1972-80). In the western Pacific region, as defined by FAO, PNG is by far the largest producer of skipjack tuna. The highest annual catch taken in the domestic fishery was 48,000 t in 1978. In 1979 the catch decreased to 26,944 t and averaged 28,357 t per year over the review period (Table 1). Fluctuations in resource availability, rather than changes in fishing effort or other factors, have resulted in the catch variation from year to year[9]. Fluctuations of this type are typical of all skipjack fisheries. However, they tend to be more pronounced at higher latitudes[10].

Catch per fishing day (cpue) in the fishery over the period under review ranged from 3.6 t on average per day in 1980 to 3.3 t in 1979 and 1981. The mean catch for this period was 3.4 t per day (Table 1). Catch rates, while fluctuating, have shown no tendency to decline since 1970. Consequently biologists believe these tuna stocks can sustain a higher level of fishing pressure than has been exerted in the past.

Between 1979 and 1981, an average of 41 boats operated on a full-time basis during each fishing season. Most boats do not fish during rough weather associated with the annual northwest monsoon season between December and March, although some NBFI boats did transfer their fishing operations to the relatively sheltered Papuan south coast during these months. The number of boats operating full time does not vary greatly from year to year (Table 1). However, there is a high degree of variation in the individual performance of boats within the fishery, in spite of all boats having access to the same or similar fishing grounds. Performance of boats is closely related to the fishing skills of the skipper, and in particular to the skills of the "mengane" (fish spotter) who directs the boat on the fishing grounds. It is also apparent from catch data that the performance of company-owned boats is inferior to skipper-owned and operated boats which are contracted by the companies[11].

The distribution of catcher boat landings between 1979 and 1981 shows that on average 20 percent of the fleet took less than 499 t of tuna per year, while 49 percent landed less than 699 t (Table 2). Economic investigations have revealed that catcher boats need to take 800-850 t of tuna per annum at long-term average prices to operate at a break-even position. Thus the data contained in Table 2 shows that at least 50 percent of PNG's domestic fleet over the review period operated at a loss. This problem is exacerbated in years when prices fall below their long-term average trend. In the past, Star-Kist and NBFI have provided financial support to boats that were nonprofit operators with the result that some owners have become highly indebted to them. Only 10 percent of the catcher boats, on average, caught more than 1,100 t per year between 1979 and 1981[12]. Catches of more than 1,000 t per annum are required to ensure that a boat

Table 1. — Total catch, catch per fishing day, and number of boats in PNG's domestic tuna fishery, 1979-81.

Year	Catch (t) Total	Catch (t) Daily	No. of Boats[1]
1979	26,944	3.3	41
1980	34,099	3.6	43
1981	24,029	3.3	40
Mean	28,357	3.4	41

[1]Only vessels fishing for more than 50 days/year are included.
Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

Table 2. — Distribution of catcher boat landings in PNG's domestic tuna fishery, 1979-81.

Catch per boat (t)	Number of boats 1979	1980	1981	Mean	Cumulative distribution (%)
<499	9	9	6	8	20
500 - 699	19	6	12	12	49
700 - 899	9	17	13	13	80
900 - 1,099	2	5	5	4	90
1,100 - 1,299	2	6	4	4	100
Total boats	41	43	40	41	

Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

[7]All values are expressed in U.S. dollars.
[8]Between 1971 and 1978 Gollin Kyokuyo Pty. Ltd, operated a katsuobushi plant at Kavieng. The plant produced an average of 203 t of smoked tuna valued at $730,000/year for the Japanese market. The plant ceased operations in 1978 when the company terminated its involvement in the fishery.

[9]Our analysis of PNG catch data (unpubl.), supported by observations of fishing masters, indicates that good and bad fishing years alternate. The reasons for this are not known.
[10]Because of its proximity to the Equator, PNG is unique in that it has a year-round fishery. This is in contrast to Hawaii, Fiji, and New Zealand which have pronounced skipjack fishing seasons which usually coincide with summer months.

[11]Star-Kist owns the Star of the Pacific fleet which in 1981 consisted of eight boats.
[12]The quality and adequacy of baitfish directly affects a boat's ability to catch tuna. If a boat is forced to take weak or unattractive bait, or is unable to secure sufficient quantities, it can be expected that its tuna catch rates will be below average. However, between 1979 and 1981 there is no evidence to suggest that some boats were unable to obtain sufficient supplies of good quality bait. Consequently, the variations in annual catches between boats appear unrelated to these factors.

Table 3. — Percent composition of catch in PNG's domestic tuna fishery, 1979-81.

Species	Catch composition (%)			
	1979	1980	1981	Mean
Skipjack tuna	89.0	90.8	85.4	88.4
Yellowfin tuna	10.7	8.9	14.6	11.4
Other	0.3	0.3	0	0.2
Total	100.0	100.0	100.0	100.0

Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

Table 4. — Baitfish landings per day and bait-use effectiveness ratio in PNG's domestic tuna fishery, 1979-81.

Year	Bait (t)	Catch per day/ boat (buckets)[1]	Bait effectiveness (bait:tuna)
1979	1,424	69.6	1:18.9
1980	1,703	67.0	1:20.3
1981	1,473	70.0	1:16.3
Mean	1,533	68.9	1:18.5

[1]One bucket of bait equals 2.5 kg of fish.
Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

is a nonmarginal operator.

The average operating cost of a typical 59 GRT pole-and-line boat in PNG's domestic fishery in 1981 was $565,000, though costs ranged from $384,000 to $728,000 for individual boats across the fleet. The major cost item for these boats was fuel which accounted for approximately 35 percent of the total operating costs. Crew costs (wages, travel, food, insurance, etc.) averaged 38 percent of total costs, and vessel costs (fuel, oil, maintenance, fishing gear, management fees, etc.) comprised the remaining 62 percent.

The total operating costs of the four motherships (NBFI = 1; Star-Kist = 3) were estimated to be $7.3 million. Costs ranged from $1.2 million to $2.3 million depending on the size of each vessel. Crew costs accounted for approximately 26 percent of total operating costs for each mothership while vessel costs were 74 percent of the total.

Average production costs for tuna in PNG's domestic fishery in 1981 were $1,148 per t. Of this amount, catcher boat costs represented 63 percent ($725/t), mothership costs 26 percent ($302/t), and shore-side costs 4 percent ($43/t). The remaining 7 percent ($78/t) was attributable to baitfish royalty payments, export tax, and other minor statutory charges. With a mean annual FOB price in 1981 of $1,040 (Table 6), it is estimated that an average of $108 was lost by the pole-and-line fleet for each metric ton of tuna landed.

The composition of the catch of the domestic tuna fishery for 1979-81 is shown in Table 3. Between these years skipjack tuna accounted for an average of 88.4 percent of the catch per year, yellowfin tuna, *Thunnus albacares*, 11.4 percent, and other species of tuna 0.2 percent. Skipjack tuna taken are in the 2-4 kg weight range and most yellowfin tuna weigh 6-9 kg.

Fish aggregating devices (FAD's) were introduced commercially in PNG's domestic fishery in 1981 by NBFI. A total of 56 devices were deployed, but losses were high due to devices breaking moorings in bad weather (DPI, 1982). Information gathered from tuna boat catch record data sheets about the use of FAD's in 1981 indicate that:

1) They are useful when tuna are scarce as there are always some fish available around them;

2) they are very productive when new schools of tuna are moving into the area where FAD's are anchored;

3) in general, the biting response of tuna around FAD's is best during the first hour after dawn; and

4) pole-and-line boats, due to their method of fishing, do not seriously deplete accumulated stocks of tuna under FAD's, which remain continuously productive. However, fishermen have indicated that purse-seining destroys tuna aggregations so that devices that have been fished by purse-seiners are usually left for about 1 month before being fished again.

Baitfishery

Unlike some states in the western Pacific, PNG has ample supplies of baitfish suitable for pole-and-line fishing[13]. The dominant species used are anchovies, *Stolephorus devisi* and *S. heterolobus*, and a sprat, *Spratelloides gracilis*. Biological aspects of PNG's baitfishery have been analyzed by Kearney (1977), Lewis (1977), Smith (1977), and Dalzell and Wankowski (1980).

Baiting is generally confined to two bait grounds, Ysabel Passage in New Ireland and Cape Lambert in East New Britain (Fig. 1). Baitfish landings from 1979 to 1981 averaged 1,533 t per year (Table 4). This represents a mean daily catch rate of 68.9 buckets of bait per boat per fishing day. Daily landings of bait at this rate probably exceed requirements for a normal day of fishing.

Fishermen tend to take excessive quantities of bait because the method of charging for it is not related to the quantity actually taken, but rather is tied to a fixed proportion of the value of tuna exports. Although this method of collecting payment for baitfish is administratively simple, it is fundamentally inadequate from a bait resource management point of view. PNG is currently reviewing its baitfishery policy and this aspect is being closely scrutinized.

Table 4 also shows a bait-use effectiveness ratio for the review period. The ratio (bait:tuna) ranged from 1:20.0 in 1980 to 1:16.3 in 1981 with a mean for the 3-year period of 1:18.5. As might be expected, bait tends to be used more effectively (i.e., tuna catches per unit of bait are higher) in good fishing years and less effectively in poorer fishing years. It is principally for this reason that the bait-use ratios in 1979 and 1981 are lower than in 1980.

While the relatively abundant supply of baitfish contributed to the rapid expansion of PNG's domestic tuna fishery in the early years of its development, the availability of bait rather than tuna is the limiting resource factor for the expansion of the domestic pole-and-line tuna fishery. The baitfishery has also proven to be a valuable management tool for the tuna fishery. In regulating the exploitation of the baitfishery through the control of access to baiting grounds, it has been possible to regulate indirectly and spatially distribute fishing effort within the tuna fishery.

Economic Considerations

The employment of nationals on catcher boats, motherships, and in

[13]This is partially due to PNG's large land masses and extensive river systems which together provide a constant supply of nutrients for baitfish in the sheltered waters adjacent to fishing grounds.

shoreside activities provides significant direct socioeconomic benefits to PNG. During 1979, 1,234 nationals were employed in all aspects of the fishery, 1,381 in 1980, and 1,202 in 1981 (Table 5). This represents a mean yearly employment figure for this period of 1,257. Of this total, 81.1 percent of nationals were employed on catcher boats, 14.8 percent on motherships, and 4.1 percent on shoreside activities. Overall, employment of nationals accounted for an average of 63.3 percent of the total employment in the fishery between 1979 and 1981.

Employment of foreigners in the fishery is also substantial. Between 1979 and 1981, an average of 730 foreigners were employed each year, 86.3 percent of which were employed on catcher boats.

The overall foreign:national employment ratio over the review period was 1:1.7. The ratios on motherships and shoreside (1:2.3 and 1:2.6, respectively) were noticeably higher than for the catcher boat ratio (1:1.6), primarily reflecting a higher degree of unskilled work (i.e., fish handling) on motherships and shoreside. However, it has been suggested by industry that the rate of national employment on catcher boats could be increased without affecting established production levels. Indeed, industry claims that for each catcher boat crew of 24, only 8 need be foreigners. Had this crew ratio been achieved, it would have lifted the mean catcher boat employment ratio between 1979 and 1981 from 1:1.6 to 1:2.0.

An increased Papua New Guinea crew component could be expected to produce considerable savings for boat owners because of their lower rates of pay and bonuses. During 1981, the mean annual wage paid to nationals employed on catcher boats was $3,200, including bonuses. In comparison, mean wages and bonuses paid to Okinawans and Koreans employed in similar capacities were approximately $14,000 and $13,000, respectively. If an additional four positions on catcher boats are localized, wages and bonus savings per boat could be as high as $43,000 per year. Across a fleet of 40 boats these savings would exceed $1.7 million annually. Apart from the direct financial benefits to industry, the creation of additional employment opportunities for nationals would be viewed favorably by the PNG Government.

Table 5. — National and foreign employment in PNG's domestic tuna fishery, 1979-81.

	1979		1980		1981		Mean			Mean ratio
Category	Natl.	For.	Natl.	For.	Natl.	For.	Natl.	For.	Total	For.:Natl.
Catcherboats	943	574	1,150	700	1,012	616	1,020	630	1,650	1:1.6
Motherships	245	105	174	75	140	60	186	80	266	1:2.3
Shoreside	46	18	57	23	50	20	51	20	71	1:2.6
Total	1,234	697	1,381	798	1,202	696	1,257	730	1,987	1:1.7

Source: Star-Kist (PNG) Pty. Ltd. and New Britain Fishing Industries Pty. Ltd.

PNG's domestic tuna fishery ranks sixth as an export earner. Between 1979 and 1981 the value of these exports averaged $28.2 million (Table 6). This represents 74 percent of the value of PNG's fisheries exports over this period, 3 percent of the total value of exports and 2 percent of Gross Domestic Product. The highest value of exports from the domestic fishery in any year was $37.3 million in 1980.

Table 6 also compares PNG's mean annual FOB tuna price and the U.S. west coast mean annual skipjack tuna price. PNG's price rose from $786 in 1979 to $1,080 in 1980, easing to $1,040 in 1981. Over the period a mean price of $969 was recorded. A similar movement was registered in the U.S. west coast skipjack tuna price between 1979 and 1980, but the extent of the rise (55.8 percent) exceeded the increase in the PNG FOB price between these years (37.4 percent).

The U.S. market has traditionally been the largest market for PNG's tuna, followed by Japan. This is primarily because skipjack and smaller yellowfin tuna are most suitable for canning and the major canned tuna market is the United States. In 1979, 92.0 percent of PNG's domestic tuna catch was exported to the United States, either to the west coast, Puerto Rico, or American Samoa (Table 7). The proportion rose to 96.0 percent in 1980 but declined to 74.0 percent in 1981. This drop reflected the weakening U.S. market for tuna in 1981 combined with strengthening demand for good quality skipjack tuna in Japan.

While it is recognized that skipjack tuna is an inferior sashimi fish compared with other tunas, Japanese industry officials have noted that its demand is rising because of its assured supply throughout the year and its predictable quality.

The market demand for canned tuna in Japan is also rising. This is reflected in the fact that exports of skipjack tuna from Japan to the United States were negligible in 1981 compared with the volume of exports in 1980. Between 1979 and 1981, the mean proportion of PNG's catch exported to the United States was 87.3 percent while the proportion going to Japan was 11.3 percent. Other destinations such as Australia, Singapore, and Mauritius took 1.3 percent.

Financial benefits accruing to the PNG Government through taxation and royalty payments to the baitfish owners

Table 6. — Value of PNG's domestic tuna exports and mean FOB price per metric ton, 1979-81.

Year	Value of exports (10^6)	Mean FOB price per ton ($)	U.S. west coast FOB price (all nations) ($)
1979	22.3	786	746
1980	37.3	1,080	1,162
1981	24.9	1,040	n.a.
Mean	28.2	969	954

Source: Bank of PNG, "Quarterly economic review," Port Moresby, and U.S. Department of Commerce, Washington, D.C.

Table 7. — Destination of exports from PNG's domestic tuna fishery, 1979-81.

Year	United States	Japan	Other
1979	92.0%	8.0%	
1980	96.0	4.0	
1981	74.0	22.0	4.0%
Mean	87.3	11.3	1.3

Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

are detailed in Table 8. Export taxation payments between 1979 and 1981 averaged $1.4 million per year or 64 percent of total tax payments by the domestic tuna industry. Baitfish royalty payments averaged 29 percent of total payments or $616,611 per year. Total payments by industry to government and baitfish owners averaged $2.1 million per year over the review period.

Since the establishment of the domestic tuna fishery, no corporate income tax has been paid by any company. In addition, the two companies that operated in 1981 carried forward losses that would preclude the payment of corporate income tax even if profits were made in subsequent years. Consequently the main source of revenue for the national government was export tax. This tax is set at 5 percent ad valorem of tuna exports and does not apply to exports of processed tuna. The baitfish royalty is linked to the value of exports at the rate of 2.5 percent ad valorem.

Apart from direct financial benefits flowing from the domestic tuna fishery, indirect benefits accruing through linked industries were also substantial. Such expenditures by Star-Kist and NBFI in Rabaul amounted to $12-15 million yearly between 1979 and 1981[14].

Table 8. — Direct PNG National Government revenue and baitfish royalty payments from the domestic tuna fishery, 1979-81.

Revenue source	National Government revenue ($)				Percent
	1979	1980	1981	Mean	
Taxation					
Wages and salaries	94,315	91,708	103,963	96,662	5
Export	1,025,392	1,841,318	1,245,000	1,370,570	64
License fees	49,696	31,672	64,194	42,521	2
Subtotal	1,169,403	1,964,698	1,395,157	1,509,753	71
Baitfish royalties	512,568	920,659	416,608	616,611	29
Total revenue	1,681,971	2,885,357	1,811,765	2,126,364	100

Sources: Annual corporate statements of Star-Kist (PNG) Pty. Ltd. and New Britain Fishing Industries Pty. Ltd.

Closure in 1982

In early 1982 both Star-Kist and NBFI announced that their fishing operations would be suspended until the world tuna market improved. The closure of the fishery, which was not fully anticipated by the PNG Government, caused widespread unemployment and loss of foreign exchange, baitfish royalties, and taxation. The impact on linked industries (i.e., shipyards, merchants, and local farmers) has been dramatic. In most cases these industries have been forced to lay off workers either permanently or on a rotating basis. In 1982, the two Rabaul-based shipyards were operating with skeleton staff, approximately 80 percent below their scale of operations in 1981. These yards are so dependent on servicing the domestic tuna fleet that their survival has been jeopardized.

Doulman (1982) has summarized the reasons underlying the closure of the fishery. While world tuna production has risen significantly in recent years, principally from purse-seine operations in the western Pacific, the cyclical downturn in the tuna market which occurs every 3-4 years, has been exacerbated by the U.S. recession and prevailing high interest rates. The latter factor has forced canners to reduce inventories, thereby inflating supply at a time of flagging demand. Competition from such quasi-substitutes as hamburger, poultry, and other fishes, as well as cheap canned tuna from the Philippines, Taiwan, and Thailand, has dampened demand for tuna by U.S. processors.

The closure of the PNG fishery is also related in some degree to a movement by canners to disengage from fishing operations. With the contractual arrangements that have developed in recent years between fishermen and canners, especially in the United States, and the availability of fish on the world market, processors no longer require their own fleets to acquire fish for their canneries.

Distant-Water Fishery

Foreign vessels use three methods to exploit tuna within PNG's DFZ: Purse-seining, longlining, and pole-and-lining. PNG benefits from these operations only through the payment of access fees. These vessels do not enter PNG ports for provisions or to off-load their catch. This means that no PNG nationals are employed directly or indirectly in these fisheries. However, an intermediate goal of the PNG Government is to develop shore facilities to encourage foreign vessels to transship their catch at PNG ports. This would generate employment and related benefits.

Access Arrangements

Prior to PNG's independence, Australia was responsible for all foreign policy matters affecting PNG, including fisheries arrangements with DWFN's. Consequently, at Independence PNG inherited an access arrangement negotiated under a 1968 Australia-Japan Fisheries Agreement that gave Japanese vessels almost exclusive access to PNG waters. Under this pact, vessels were permitted to fish to within 3 miles of PNG's coastline. However, in 1976 PNG terminated this agreement and entered into a series of short-term ad hoc fisheries arrangements with the Government of Japan. These arrangements continued for varying periods until 1978.

In March 1978, PNG declared its 200-mile DFZ and the Governments of PNG and Japan formalized an Interim Fisheries Agreement for 9 months (May 1978-January 1979). Under this agreement, Japanese vessels wanting to operate in PNG waters paid annual vessel and fisherman fees of $43.50/m of vessel and $1.45 per crew member. These charges were made on a 3-month pro rata basis, the duration of each license period. In addition, a lump sum operational fee of $1.45 million was charged for all vessels. This fee was linked to the potential catching capacity of the vessels to be licensed under the agreement. The payment of the operational fee exempted Japanese fishermen from payment of PNG's statutory 5 percent export tax.

[14] Information supplied by the management of Star-Kist (PNG) Pty. Ltd, and New Britain Fishing Industries Pty. Ltd, Rabaul, 1982.

In determining the $1.45 million access fee payment for Japanese vessels, the PNG Government's policy was that domestic fishermen should not be required to pay a higher rate of tax on their fish than foreign fishermen. Thus the $1.45 million was estimated to be 5 percent ad valorem of the fish landed by the Japanese vessels over the 9-month period of the agreement.

As part of the agreement, the Japanese Government agreed to remove export restrictions on any fishing vessel the PNG Government wished to purchase from Japan. However, this option was never exercised. The agreement also provided for access to Japanese concessional loan finance and technical assistance, specifically for site surveys for tuna bases in Manus and East New Britain (Fig. 1), and design work for a new pole-and-line vessel for the domestic fishery.

A protracted series of negotiations to extend the 1978 Interim Agreement broke down when the PNG Government insisted on a $1.16 million lump-sum payment for a 1-year extension of the agreement. The Japanese fishing industry, facing a serious recession, was convinced that it had paid dearly for access under the 1978 agreement. It therefore found PNG's financial demands for the extension of the agreement unacceptable. To try to prevent an impasse, the Japanese Government offered aid as part of an access fee payment, but this was rejected by PNG on the basis that such aid should be obtained independently of a fisheries agreement and that such agreements should be negotiated on strictly commercial terms.

With the termination of the 1978 Interim Agreement, no Japanese vessels operated legally within PNG's DFZ from February to June 1979. However, following consultations with four Japanese tuna fishing associations, the PNG Government reached an understanding with them and agreed to license individual vessels on a per-trip basis. In most cases, licenses were based on the estimated catch by vessel class sizes and the anticipated Yaizu market value of fish caught. This understanding between the PNG Government and the Japanese fishing associations extended from July 1979 to December 1980, with 357 Japanese vessels fishing within PNG's DFZ.

Although this understanding worked satisfactorily, Japanese industry requested its review and the establishment of a formal agreement based on similar terms and conditions. Discussions began in Japan in 1980 and an agreement was signed in PNG in August 1981. Fee payments under this agreement were premised on an operational fee of 5 percent of the FOB value of the catch valued at average Yaizu prices, a boat license fee of $43.50/m of vessel per year and an annual fisherman fee of $1.45 for each crew member.

Purse-seine, longline, and pole-and-line vessels were granted 2-month trip licenses, while group seiners could obtain 2- or 4-month licenses. The fishing operations of these vessels are described below. The arrangement was negotiated for 1 year (until August 1982) but would remain in force beyond that time until either the PNG Government or the Japanese associations gave a 3-month notice of termination.

During 1981 PNG collected $1,222,722 for 377 licenses issued between January and August and a further $1,181,272 for 240 licenses after the introduction of the arrangement. This resulted in a total payment of $2.4 million for 1981, a total that the Japanese industry would never have agreed to under a lump-sum payment system. In 1982 the Japanese arrangement yielded PNG $3.4 million.

In August 1982, representatives from the Governments of PNG and Japan and the Japanese fishing associations met to review the operation of the arrangement. Parties to the arrangement acknowledged that it was operating satisfactorily and it was mutually agreed that it continue.

In 1980 the Government of PNG initiated discussions with the Government of the Republic of Korea on the possible implementation of a fisheries agreement between the two Governments. It is anticipated that this agreement will be concluded before the end of 1983 and will permit Korean longline and purse-seine vessels to operate within PNG's DFZ under similar terms and conditions to the current Japanese agreement[15].

An Interim Agreement was also reached in April 1982 with the American Tunaboat Association (ATA) to permit American seiners to fish PNG's DFZ until the end of 1982. This agreement resulted from seizure of the U.S. seiner *Danica*. The captain of the vessel was tried and convicted under PNG law for unlicensed fishing within PNG's DFZ. The mandatory penalty for such an offense is confiscation of the vessel and catch. However, to avoid an embargo on PNG exports of tuna and other seafood products to the United States as provided for under the Magnuson Act, PNG was required to release the *Danica* on nondiscriminatory terms and to accept an Interim Agreement under terms basically determined by the ATA. The conditions of this agreement required PNG to license U.S. seiners at considerably lower rates than those charged Japanese seiners. The ATA agreement yielded PNG $454,000 during 1982 but was not renewed in 1983[16].

Although the PNG-ATA agreement favored U.S. vessels in financial terms, it should be noted the ATA concluded an agreement with a single state. This represents de facto recognition by ATA of PNG's fisheries laws and jurisdiction over its tuna stocks.

Purse-Seine Fishery

Most vessels operating in the purse-seine fishery in PNG prior to 1982 were Japanese, although unlicensed vessels from Korea, Philippines, Indonesia, U.S.S.R., Taiwan, and the United States were suspected to have fished within PNG waters. In 1982, Japanese and U.S. vessels operated under agreement within this area. A small number of seiners from other countries also operated under special arrangements.

Japanese and American single seiners operating in the western Pacific are of

[15] Some Korean and Taiwanese purse seiners are already licensed under terms and conditions of the Japanese Agreement.

[16] U.S. seiners were licensed at the rate of $35/NRT of vessel for the period of the agreement. This meant that most seiners paid between $18,000 and $22,000 for the 9-month period for their license.

similar design with a forward superstructure, aft seining, and equivalent sized nets (1,700-2,400 m long, 240 m deep, and 120 mm mesh) (Wankowski, 1980). The U.S. seiners, commonly known as "superseiners," are generally 1,000-1,700 GRT and frequently use helicopters to locate schools of fish. They have a crew of 22, including the aircraft pilot. Japanese single seiners are usually in the 500-750 GRT range with a crew of between 18 and 24 men. Japanese vessels make 5-7 trips to PNG waters each year where they tend to operate as a fleet in the northwest sector of the DFZ.

When U.S. seiners first entered the western Pacific in the late 1970's, catches were not encouraging due to major differences in fishing conditions in the eastern Pacific. In particular, the western Pacific has a deeper thermocline, so fishing techniques had to be adjusted. In 1982, 22 U.S. vessels were licensed to fish in PNG's DFZ. The expected annual catch of each of these vessels in the western Pacific is about 6,000 t/year as opposed to 3,000 t in the eastern Pacific. Many U.S. seiners are now basing their operations in New Zealand, American Samoa, and Guam to maximize catch in the region and minimize costs.

In 1980, group purse-seiners, which usually fish Japan's near-water tuna fishery, extended their operations as far south as PNG. Group seine operations usually involve three vessels, a seiner of about 116 GRT, one or two carrier vessels of 325 GRT, and an anchor vessel of 45 GRT. The vessels are crewed by 23, 15, and 7 workers, respectively. During fishing operations, the anchor vessel attaches itself to the seiner and keeps the seiner from drifting onto the net while it is being pursed. The anchor vessel also prevents the carrier vessel and seiner from drifting together while transferring the catch from the net. The anticipated catch/fishing day for these vessels operating in the western Pacific is 17 t[17].

[17]DPI. 1982. Record of discussion between the Government of Papua New Guinea, the Government of Japan, and the Japanese Fishing Associations. Fish. Div., PNG Dep. Primary Industry, Port Moresby, (mimeo), 32 p.

Table 9. — Species composition of nominal reported catch of single purse-seine vessels operating in PNG's DFZ, 1980-81[1].

	Skipjack tuna			Yellowfin tuna			Bigeye tuna			
Year	t	Percent occurrence	Percent dominance	t	Percent occurrence	Percent dominance	t	Percent occurrence	Percent dominance	Total (t)
1980	10,367	95.7	81.0	2,459	79.7	12.0	80	5.9	0	12,906
1981	10,393	93.8	70.0	4,431	90.8	22.0	114	7.2	0	14,938
Mean	10,380	94.8	75.5	3,445	85.3	17.0	97	6.6	0	13,922

[1]1979 data not available.
Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

Table 10. — Summary of single purse-seine reported operational data from PNG's DFZ, 1979-81.

Total	Licenses issued	No. of vessels	Total sets	Successful sets as % of total	Catch per set (t)	Total catch (t)	Est. value of catch[1] (10^6)
1979[2]	n.a.	11	n.a.	n.a.	n.a.	1,555	n.a.
1980	63	12	555	89	23.3	12,906	17.5
1981	103	23	664	92	22.5	14,938	18.0
Mean 1980-81	83	18	610	91	22.9	13,922	17.8

[1]Estimates based on mean annual Yaizu price.
[2]Data available from July only.
Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

This is based on the operations of five group seiners in Micronesian waters that landed 12,000 t of fish between February and May 1981, the period that these vessels operate in equatorial waters. Three group seiners were licensed to fish in PNG's DFZ in 1981 but no catch/effort data is available for their operations.

Purse-seining in the western Pacific usually takes place on schools of tuna associated with logs or other floating debris, whales, and sharks. During 1981, 85 percent of schools fished by Japanese single seiners operating within PNG waters, and 68 percent of those fished by group seiners, were log-associated schools. Free-moving tuna schools can yield exceptional catches, but sets on these schools are not always successful as the fish often escape through the bottom of the net before it is pursed. Of 961 sets analyzed for 1980 and 1981 purse-seine operations in PNG's DFZ, 68 percent began between 0400 and 0600 hours.

Target species for the tropical purse-seine fishery are skipjack and yellowfin tuna, which together composed 99.3 percent and 99.2 percent of the catch of Japanese seiners operating within PNG's waters during 1980 and 1981 (Table 9). Fishing operations in 1979 were limited due to delays in finalizing an access agreement. However, during 1980 and 1981 there were successive record catches reported of 12,906 t and 14,938 t, respectively, by the Japanese purse-seine fleet within PNG waters. Twelve vessels were granted 63 trip licenses during 1980 to fish within PNG's DFZ, while 23 vessels purchased 103 licenses in 1981 (Table 10). The average catch per set increased from 17.0 t in both 1977 and 1978 (Wankowski, 1980), to 23.3 t in 1980 and 22.5 t in 1981 (Table 10). This reflects, among other factors, an improvement in techniques with increased familiarity of the fishery.

The estimated market value of the purse-seine catch was $17.5 million in 1980 and $18.0 million in 1981 (Table 10). These figures are based on average Yaizu prices for skipjack of $1.35/kg and $1.29/kg during 1980 and 1981, respectively. The financial yield to PNG from the sale of purse-seine licenses was $365,104 in 1980 and $856,668 in 1981 (Table 11).

Longline Fishery

Apart from about 50 vessels based in the Solomon Islands, Fiji, New Cale-

Table 11. — PNG Government receipts and estimated value of catch for the tuna fishery, 1980-81 (Sources: Tables 6, 8, 10, 14, and 16).

Fishery	Receipts and estimated values (10^6) 1980	1981
Domestic		
Receipts	1.8	1.2
Value of fish	37.3	24.9
Receipts as percent of value of fish	4.9	5.0
Foreign		
Purse-seine		
Receipts	0.4	0.9
Value of fish	17.5	18.0
Receipts as percent of value of fish	2.3	5.0
Longline		
Receipts	0.7	1.2
Value of fish	31.0	35.0
Receipts as percent of value of fish	2.3	3.4
Pole-and-line		
Receipts	0.05	0.01
Value of fish	0.1	0.02
Receipts as percent of value of fish	50.0	50.0
Summary		
Total receipts	3.1	3.4
Total value of fish	85.9	77.9
Receipts as percent of value of fish	3.6	4.4
Domestic receipts as percent of total receipts	61.3	38.2

Table 12. — Reported fishing effort by longline vessels licensed to operate in PNG's DFZ, 1979-81.

Year	Vessels licensed	Licenses issued	Total boat days	Thousands of hooks set
1979[1]	180	n.a.	1,110	1,863
1980	123	312	11,090	17,278
1981[2]	151	507	12,675	19,947
Mean 1980-81	137	410	11,883	18,613

[1]Data available from July only.
[2]Estimated from data reported by Japanese industry and catch returns analyzed at time of writing which accounted for 48 percent of total reported catch.
Source: Fisheries Division, Department of Primary Industry, Port Moresby.

donia, and American Samoa, the western Pacific longline fleet operates from ports in Japan, Korea, and Taiwan. In total there are 2,700 longliners in the Japanese fleet of which an estimated 700 are licensed by the Japanese Government to fish in the western Pacific region. Based on average catch figures for 1976-80, these longliners are estimated to have caught 40,000 t of tuna and billfish annually from the combined fisheries zones of countries in the region.

Distant-water longline operations have been analyzed in detail for the Atlantic and Pacific Oceans (Beare et al., 1963; Kume, 1974; Honma, 1975; Klawe, 1978; Wright, 1980). Most vessels operating within PNG waters are 59 GRT class vessels and have a crew of 10. They average between 4 and 7 fishing trips to PNG each year with each trip being of about 50 days duration. Only about half of each trip is spent actually fishing, the remainder being devoted to traveling to and from the fishing grounds. In a typical fishing day, each vessel sets 2,000 hooks for target yellowfin tuna and bigeye tuna, *Thunnus obesus*, as well as billfish. Wright (1980) estimated that 22 percent of all whole tunas hauled in PNG are discarded because they are too small for the sashimi market and an additional 10 percent are discarded because they are shark-mauled.

During 1980, 123 longliners were issued 312 trip licenses for operation in PNG waters. In 1981, the number of vessels increased to 151 and the number of licenses to 507 (Table 12). In 1980, longliners landed 14,557 t of fish while in 1981 the catch increased by 21 percent to 17,613 t (Table 13). Yellowfin tuna formed 78.9 percent of total catch in 1980 and 74.2 percent in 1981, while bigeye tuna accounted for 13.6 and 11.6 percent, respectively (Table 13).

The estimated market value of the longline catch from PNG waters during 1980 and 1981 was $31 million and $35 million, respectively (Table 14). The financial benefit to PNG from the sale of licenses for this fishery totaled $726,663 in 1980 and $1,185,002 during 1981 (Table 11).

Table 13. — Reported species composition of longline catch landed in PNG's DFZ, 1979-81.

Species	Catch 1979[1] t	Percent	1980[2] t	Percent	1981[3] t	Percent
Yellowfin tuna	1,375	82.5	11,484	78.9	13,076	74.3
Albacore	2	0.1	323	2.2	1,268	7.2
Bigeye tuna	211	12.7	1,973	13.6	2,050	11.6
Swordfish	10	0.6	93	0.6	123	0.7
Blue marlin	41	2.5	404	2.8	482	2.7
Striped marlin	1	0.1	7	0.0	10	0.1
Black marlin	14	0.8	101	0.7	163	0.9
Sailfish	8	0.5	85	0.6	195	1.1
Other[4]	4	0.2	87	0.6	246	1.4
Total	1,666	100.0	14,557	100.0	17,613	100.0

[1]Data available from July only.
[2]Data based on analysis of 90 percent of the total catch reported by Japanese industry.
[3]Composition estimated from data reported by Japanese industry and catch returns analyzed at time of writing which accounted for 48 percent of total reported catch.
[4]Includes sharks and other less valuable species.
Source: Fisheries Division, Department of Primary Industry, Port Moresby.

Table 14. — Estimated market value of reported longline catch landed in PNG's DFZ, 1980-81[1].

Species	Market value (10^6) 1980	1981
Yellowfin tuna	23.3	25.3
Albacore	0.6	0.3
Bigeye tuna	6.3	7.6
Other	0.8	1.8
Total	31.0	35.0

[1]Estimates based on reported catch and mean annual Yaizu prices for each species.
Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

Pole-and-Line-Fishery

In 1973 Japan had almost 500 distant-water pole-and-line vessels of less than 500 GRT operating in the western Pacific (Ishida, 1975). In 1979 the size of the fleet had dropped to 300 vessels and by 1981 only 120 vessels remained[18]. Part of the reason for this was the Japanese policy, begun in the late 1970's but discontinued in 1982, of reducing distant-water pole-and-line fishing effort by 20 percent. This was achieved through a Government-supervised license buy-back scheme. The maximum number of pole-and-line licenses was fixed by the Japanese Government, and fishermen wanting to re-

[18]DPI. 1982. Papua New Guinea's tuna fishery. Fish. Div., PNG Dep. Primary Industry, Port Moresby, (mimeo), 16 p.

Table 15. — Species composition of nominal reported catch by pole-and-line vessels in PNG's DFZ, 1979-81[1].

	Catch					
	1979		1980		1981	
Species	t	%	t	%	t	%
Skipjack tuna	479	95.2	94	94.9	15	93.8
Yellowfin tuna	15	3.0	3	3.0	1	6.2
Other	9	1.8	2	2.1	0	0
Total	503	100.0	99	100.0	16	100.0

[1]Composition of catch extrapolated from mean composition between 1973 and 1977 as reported by Wankowski (1980).
Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

Table 16. — Reported fishing effort by pole-and-line vessels licensed to operate in PNG's DFZ, 1979-81.

	Fishing effort		
Item	1979	1980	1981
Total vessels	24	7	5
Catch (t)	503	99	16
Estimated catch value ($)[1]	n.a.	134,177	20,698

[1]Estimates based on mean annual Yaizu prices.
Source: Fisheries Division, PNG Department of Primary Industry, Port Moresby.

Table 17. — Summary of catch by fishery and species in 1980-81. (Sources: Tables 1, 9, 13, and 15.)

	Catch (t)	
Fishery	1980	1981
Domestic		
Skipjack tuna	30,962	20,521
Yellowfin tuna	3,035	3,508
Other	102	0
Subtotal	34,099	24,029
Foreign		
Purse-seine		
Skipjack tuna	10,367	10,393
Yellowfin tuna	2,459	4,431
Other	80	114
Subtotal	12,906	14,938
Longline		
Skipjack tuna	0	0
Yellowfin tuna	11,484	13,076
Other	3,073	4,537
Subtotal	14,557	17,613
Pole-and-line		
Skipjack tuna	94	15
Yellowfin tuna	3	1
Other	2	0
Subtotal	99	16
Subtotals		
Skipjack tuna	41,423	30,929
Yellowfin tuna	16,981	21,016
Other	3,257	4,651
Grand total	61,661	56,596

main in the fishery collectively compensated those who wished to leave it. Licenses purchased in this way were not reissued so that there was a permanent reduction in the number of fishing vessels licensed to operate in the fishery.

The Japanese Government also instituted a replacement program in the distant-water pole-and-line fishery whereby five licensed pole-and-line boats could be replaced by one seiner, thus reducing the absolute number of vessels without any appreciable loss of fishing capacity. The trend toward replacement of pole-and-line vessels with purse-seiners was encouraged principally because seiners are more efficient and less costly to operate per unit of output.

The literature contains descriptions of the functional aspects of pole-and-line tuna fishing (Tomiyama, 1975) and the geographical expansion of this fishery (Bour and Galenon, 1979). Fewer pole-and-line vessels have fished PNG waters in recent years because there is reportedly less bait mortality and similar fishing grounds closer to Japan around the Marshall Islands and Kiribati. Consequently, fishing effort by Japanese pole-and-line vessels in PNG's DFZ has dropped dramatically in recent years[19].

Most distant-water fishing by Japanese pole-and-line vessels occurs between October and March each year because a near-water fishery exists during the northern summer months. A typical 35 GRT pole-and-line vessel that fishes PNG waters has a crew of between 18 and 24 men and carries about 1.5 t of live bait (Wankowski, 1980).

From 1972 to 1978, pole-and-line vessels operating in the western Pacific took an average of 5.1 t of tuna per fishing day (Wankowski, 1980). Data from catch returns for PNG are not available for 1979, 1980, and 1981, but based on information supplied by Japanese industry, skipjack tuna averaged 93.8 percent and yellowfin tuna 6.3 percent of the pole-and-line catch taken in PNG's DFZ in these years (Table 15). During 1979, 24 vessels caught 503 t of tuna, while in 1980, seven vessels purchased 14 trip licenses for a total catch of 99 t. In 1981, effort was further reduced when only five vessels entered PNG waters on seven trip licenses for a total catch of 16 t (Table 16).

Most tuna caught by distant-water pole-and-line vessels is canned. Based on average Yaizu prices for 1980 and 1981, the annual market value of the PNG catch is estimated to be $134,117 and $20,698, respectively.

The financial benefit to PNG from the sale of licenses in the pole-and-line fishery was $50,586 in 1980 and $15,668 in 1981 (Table 11). These figures highlight the practice of Japanese fishermen purchasing PNG licenses as insurance against the possibility of apprehension for illegal fishing should they stray into PNG's DFZ from adjoining zones in pursuit of moving concentrations of fish.

Fisheries Data Consolidation

Table 17 shows a consolidation of catch data for the domestic and distant-water fisheries for 1980 and 1981. In total, 61,661 t of tuna were reportedly harvested in PNG's DFZ in 1980 and 56,596 t in 1981, and the difference was due almost entirely to a lower domestic catch in 1981. The domestic fishery accounted for 55 percent and 42 percent, respectively, of total tuna landings in 1980 and 1981.

As a proportion of total landings, skipjack tuna was the dominant species harvested, representing 67 percent of the total in 1980 and 55 percent in 1981. On the basis of an estimated annual skipjack tuna maximum sustainable yield (MSY) of 180,000 t for PNG's DFZ, reported skipjack tuna landings in 1980 and 1981 accounted for 23 percent and 17 percent, respectively, of this estimated yield. These results indicate that, provided purse-seine and pole-and-line fishing effort can be spatially distributed optimally within the DFZ, it should be possible to at least double effort over 1980 and 1981 levels without jeopardizing the resource.

Landings of yellowfin tuna as a proportion of total landings were relatively more important in 1981 than in 1980 (37 percent vs. 28 percent), principally because of higher purse-seine and longline

[19]In 1974, 289 Japanese pole-and-line vessels took 57,000 t of tuna in PNG's DFZ (Wankowski, 1980).

catches of this species in 1981.

Government revenue and the estimated value of total tuna landings from PNG's DFZ for 1980 and 1981 are consolidated in Table 11. Total Government receipts from the domestic and distant-water fisheries were $3.1 million in 1980 and $3.4 million in 1981. The drop in receipts in the domestic fishery in 1981 was more than compensated for by increase in revenue from the purse-seine and longline fisheries.

Total Government receipts as a proportion of the estimated value of fish landed in PNG waters was 3.6 percent in 1980 and 4.4 percent in 1981. In both the domestic and distant-water fisheries, the Government aims to appropriate 5 percent of the value of the catch through the imposition of export tax and license fees. In the domestic fishery this goal was achieved in 1980 and 1981. However, ignoring the distant-water pole-and-line fishery because its results are atypical, the 5 percent objective was achieved only in the purse-seine fishery in 1981. In the longline fishery, Government receipts as a proportion of the value of the catch were significantly less than the 5 percent target in both 1980 and 1981. Analysis of Japanese tuna landings and prices undertaken by the Forum Fisheries Agency (FFA) in 1982 implies that PNG's longline catch since 1980 has been undervalued each year by approximately 40 percent[20]. Consequently, if the value of PNG's longline catch is revised upward to reflect its real market value, Government revenue as a percentage of the revised valuation falls markedly. A similar problem does not arise in evaluating the purse-seine catch.

In terms of the accuracy and completeness of PNG's 1980 and 1981 catch data, a word of caution is necessary. While data for the domestic fishery are accurate and reliable because of the established reporting system, the same degree of confidence cannot be placed in data for the distant-water fishery. Consequently, data presented in Table 17 represent minimum catch aggregates only.

[20]FFA. 1982. Skipjack tuna price data for 1982. Paper prepared for the Workshop on Access Negotiations, Vanuatu (23 September-1 October 1982), (mimeo), Econ. Unit, Forum Fish. Agency, 27 p.

The reliability of PNG's distant-water fishery data is affected by three types of underreporting:

1) Failure of licensed vessels to file catch returns. Some vessels licensed to operate in the DFZ fail to complete and file catch returns as required under the terms and conditions of their license. This particularly applies to non-Japanese vessels that operate within PNG waters on an irregular basis. Vessel operators violating this requirement are not usually granted subsequent licenses. Data presented in this paper cover only about 90 percent of trip licenses issued each year.

2) Underreporting of catch by licensed vessels. Because the PNG formulae for determining license fees are linked to catch rates on a historical basis, there is a strong incentive for fishermen to underreport catch/effort data as a means of trying to ensure that fee levels are not adjusted upwards in subsequent access negotiations. It is believed that underreporting is common among purse-seine operators fishing within PNG's DFZ. According to an independent Japanese source, purse-seine catch rates and the time actually spent fishing in PNG waters are higher than is being officially reported.

3) Unlicensed fishing. It is known that unlicensed vessels operate in the DFZ, though the incidence of this type of operation has probably declined following the apprehension of several vessels by PNG naval boats on routine patrols. However, with such an extensive DFZ (approximately 3,120,000 km^2) it is expected that illegal fishing operations will continue but probably not on a regular basis by particular vessels. Given the lack of information on the operations of unlicensed vessels within PNG waters, no reliable estimate of landings by these vessels is currently available.

These types of underreporting show the need for PNG to negotiate future access agreements with DWFN's on a government-to-government basis rather than with industry. With government-to-government agreements, diplomatic pressure can be exerted to ensure that terms and conditions of access are fulfilled. This same degree of influence cannot be so readily exercised by the PNG Government over industry in DWFN's. Regionally, the initiation of the Regional Vessel Register by the FFA and the tracking of voyages for individual vessels within the western Pacific region should make it more difficult for vessel operators to underreport catch/effort data or to fish illegally.

Management

Recognizing the highly migratory nature of tuna and the implications this has for effective resource management, PNG acknowledges that management of tuna stocks in the western Pacific must necessarily be undertaken on a regional basis. It is primarily for this reason that PNG staunchly supported the establishment of the FFA in 1979. More recently, PNG was the prime mover behind the formation of the Nauru Group, seven states in the western Pacific that have shared tuna fisheries and contiguous fisheries zones. This is a subgroup of the FFA[21]. Through consultation and in close cooperation with each other, parties to the Nauru Agreement aim to harmonize and coordinate fisheries policies. This is particularly the case in relation to resource management and terms and conditions of access to the tuna resources of the region by DWFN's.

Quite apart from the legal aspects of the Convention on the Law of the Sea (United Nations, 1980) relating to the management of highly migratory species of fish, the economic and political reasons underlying regional cooperation among the small island states in the western Pacific are compelling. The case for such a management approach has been stated by Kearney (1976), Lawson (1979), and Doulman (1981). From an economic point of view these writers argue that regional management fosters efficiency in resource utilization and that effective regional planning should prevent problems of overcapitalization in the fishery.

Standardized region-wide data collection and centralized analysis by SPC and

[21]The member states are Palau, Federated States of Micronesia, Marshall Islands, PNG, Solomon Islands, Nauru, and Kiribati.

FFA provide basic biological and socioeconomic information necessary for informed management decisions. The costs of regional surveillance and enforcement of fishing agreements should also be lower. This is an important consideration, as costs of this nature can easily whittle away financial gains received from the exploitation of tuna stocks.

In the absence of effective regional cooperation, countries reliant on DWFN's for the exploitation of their tuna stocks will be forced into competition with each other for resource development, thus dissipating part of their resource rent and fostering irrational resource use. The small size of most of the island states in the western Pacific, and their present dependence on DWFN's for harvesting tuna stocks, makes them vulnerable to economic exploitation by DWFN's and their experienced multinational agents. These issues have recently been analyzed by King and Galloway[22].

Future Outlook

Immediate prospects for the domestic fishery are uncertain. While the potential exists for a robust pole-and-line and purse-seine fishery, it appears unlikely that the past pattern of corporate exploitation will be maintained. Future operations will probably directly involve the Government of PNG, Okinawan fishermen, and possibly a European and/or U.S. partner in joint venture arrangements. It is envisaged that part of the domestic catch would be processed within PNG for export (loined and/or canned) and part sold under marketing agreements at world market prices.

An anticipated development in the domestic fishery, if it recommences, will be diversification of fishing operations away from a fleet consisting solely of pole-and-line boats to one composed of both pole-and-line and small (500 GRT class) purse-seine vessels. While significant socioeconomic benefits result from the operation of pole-and-line boats, particularly through employment of PNG nationals, unit production costs by these boats are considerably higher than for purse-seine caught fish. It is estimated that production costs for tuna landed by purse-seiners in PNG are about $150/t less than for fish caught by pole-and-line boats. Consequently, to contain costs and maintain a competitive position, fishing costs in the domestic fishery must be reduced where possible or at least kept at current levels. However, determining the required mix of vessels in the fleet will necessarily involve a trade-off between socioeconomic considerations and those of a strictly financial nature. These decisions must also be made within the guidelines of existing Government policy on industrial development which clearly states that subsidies of any type will not be given to commercial undertakings.

As for the distant-water fishery, it is expected that the rapid build-up in purse-seine activity within PNG's DFZ since 1980 will be maintained, though a lower rate of expansion is anticipated over the next few years. Almost the entire increase in capacity will come from U.S. seiners, though it is expected that additional purse-seine vessels from Korea, Taiwan, and especially the Philippines will enter the western Pacific tuna fishery. The build up in purse-seine fishing effort in PNG's DFZ by U.S. vessels will probably be tempered in some degree by the recent discovery of rich fishing grounds around Kiribati. Operations in this area are preferred by American fishermen because of its proximity to transshipment and processing facilities in American Samoa. However, because of the high catch rates in the western Pacific compared with those in the eastern Pacific, interest by U.S. seiner operators in the western Pacific will certainly remain keen.

The distant-water longline fishery operating within PNG's DFZ is anticipated to continue at current levels of operation over the medium term. A build-up in activity can be expected if fishing areas are closed off to part of the Japanese fleet, as was the case in September 1982 when access negotiations were suspended between the Japanese fishing associations and the Solomon Islands Government. Many of the vessels that had been previously licensed in the Solomon Islands immediately applied for licenses to fish in PNG waters.

A similar situation resulted in early 1982 when the Japanese fishing associations and the Federated States of Micronesia failed to reach agreement on the level of access fee payments. When situations of this type arise, there is a movement of vessels into zones where agreements exist between Japanese industry and coastal states. In the longer term, the number of longline vessels operating in the western Pacific will probably decline because of the effects of rising production costs and flagging demand in Japan.

Recent trends in the distant-water pole-and-line fishery should continue, and in fact it is expected to disappear completely from PNG's DFZ.

In the intermediate term, PNG will attempt to develop shore bases for the transshipment of purse-seine and longline caught fish. Transshipment of longline fish should enhance the profitability of individual operators because expensive and unproductive travel time to and from Japan would be eliminated. However, it appears that the Japanese Government does not favor the development of such overseas bases because the present mode of operation serves to regulate the supply of fish to the Japanese market and thereby support prices[23]. However, provided that restrictions are not placed on transshipment of longline caught fish either by the Japanese Government or industry, the existence of shore bases in PNG capable of handling fish for the sashimi market should encourage fishermen to offload at least part of their catch within the country. The PNG Government could enforce Article 62(4e) of the Convention on the Law of the Sea (United Nations, 1980), which requires fishermen to offload part or all of their catch taken in PNG waters at that nation's ports. But the enforce-

[22] King, D. M., and F. J. Galloway. 1981. A game-theoretic bargaining model of tuna fishing in the South Pacific: Island nations vs. multinational corporations. Paper presented at Western Economic Association Annual Meeting, San Francisco, 24 p.

[23] DPI. 1982. Record of discussion between the Government of Papua New Guinea, the Government of Japan, and the Japanese Fishing Associations. Fish. Div., PNG Dep. Primary Industry, Port Moresby, (mimeo), 32 p.

ment of this provision should not be necessary if it is economically advantageous for fishermen to transship their catch in PNG. It is estimated that longline vessels currently fishing in PNG could increase their fishing time 30 percent by transshipping their catch in the country.

Without the establishment of shore facilities (transshipment and processing), PNG will not be in a position to achieve maximum benefit from the exploitation of its tuna resources. It is recognized that direct financial, employment, and other benefits in the fishing industry are substantial, although these are outweighed by the magnitude of indirect benefits of a similar nature in linked industries. Until strong backward and forward linkages are forged, the full potential of the industry's contribution to the economic development of PNG will not be realized. Thus, the Government intends to press for the establishment of shore-based processing and transshipment facilities as a matter of priority.

At the regional level, cooperation among parties to the Nauru Agreement should improve. Steps are being taken to harmonize fisheries policies between these countries so regional licensing on common terms and conditions for all DWFN vessels can be introduced. This method of licensing will initially be introduced for purse-seiners because of the small number of vessels involved, and will be progressively extended to pole-and-line and longline vessels. Apart from the inherent financial and management advantages for the coastal states in the region from such an arrangement, DWFN vessels will also benefit from having access to a rich resource over a wide area. It will also be administratively simpler for these vessels to operate within the region as many of the restrictions currently in force, through individual states having their own licensing arrangements, will be minimized or removed completely.

Acknowledgments

The writers acknowledge valuable comments made on a draft of this paper by Peter T. Wilson, former FAO Fisheries Advisor to the PNG Department of Primary Industry. However, the authors alone are responsible for the final version of the paper which does not necessarily reflect the views or position of their employer or of the National Marine Fisheries Service, NOAA.

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