ECONOMIC APPRAISAL OF SMALL SCALE FISHING VESSELS USED FOR THE DEEP WATER ARTISANAL FISHERY IN EAST SEPIK PROVINCE

by

MOLEAN R. CHAPAU[1]

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1. FISHERIES RESEARCH AND SURVEYS BRANCH,
DEPARTMENT OF FISHERIES AND MARINE RESOURCES
P O BOX 165 KONEDOBU, PORT MORESBY
PAPUA NEW GUINEA.

ABSTRACT

An economic appraisal of six small scale fishing vessels was conducted over period of 2 years in the East Sepik Province of Papua New Guinea. Comparisons were made between the fuel consumption and running costs of a locally made outrigger canoe, a plywood outrigger canoe, a Samoan type 'Alia' catamaran, a 'Sandskipper' catamaran and an aluminium dinghy. All vessels were tested using 15 and 25 hp engines and a 13 hp diesel long tail engine. The economic viability of each vessel and engine combination were compared when used as a fishing platforms for deep reef slope artisanal handline fishing.

INTRODUCTION

During the early 1980s Papua New Guinea (PNG) started to place strong emphasis on developing indigenous artisanal fisheries. This was aimed at increasing domestic fish production and reducing reliance on imported fish. To achieve this, the Fisheries Research and Survey Branch of the Fisheries Division established a Gear and Vessel Appraisal Unit in 1983 to investigate methods of improving fishing techniques, fishing gear and vessels. At the same time resources not traditionally fished by indigenous fishermen were being surveyed, with particular attention given to the demersal stocks of the outer reef slope.

From 1980 to 1982 the P.N.G. Government requested the assistance of the South Pacific Commission Deep Sea Fisheries Development Project (SPC - DSFDP) to carry out a number of short term surveys with the objective of determining the availability and extent of the fisheries resources of PNG's outer reef slope. As a result of these surveys, recommendations were put to the Fisheries Division to set up a research programme aimed at assessing the size of the resource, and to determine if it could be harvested economically. Fisheries Research Branch undertook three major tasks as a response to these recommendations. The tasks were fishery and biological investigations based at Kavieng (New Ireland Province), gear and vessel appraisal based at Port Moresby and a pilot study of a small scale artisanal deep water fishery based at Wewak (East Sepik Province).

The objective of the pilot study at Wewak were the integration of the results of both the fishery and biological investigations with those of the gear and vessel appraisal task to achieve an economic harvest of the deep slope resources of East Sepik Coast and offshore islands. Part of this project was investigation of the economic performance of several small scale artisanal fishing craft and methods of propulsion. In this report, data are summarised on the economic performance of five vessel types used as fishing platforms for fishing the outer reef slope demersal stocks in the East Sepik Province.

BACKGROUND

The history of fisheries development in the East Sepik Province commenced in the 1980s with serious efforts to develop the fisheries resources of the outer reef slope (Chapau 1986), the coastal pelagic fishes (Anon 1985) and the estuarine fisheries resources of the Murik Lakes (Chapau 1991). In order to economically harvest, transport, process and market these resources, suitable fishing gear techniques and vessels had to be appraised. As all these resources will require some form of vessel either for harvesting or transporting the catch to an urban area. It thus became important to assess both the local fishing vessels and other introduced designs that might improve on locally available craft.

Of the three fisheries development initiatives, the most immediately successful was the expansion of fishing on the outer reef slope. A full account of the development of this fishery is given by Chapau (1986, 1988). Fishing for deep water snappers requires both a good sea worthy vessel that can be operated economically by artisanal fishermen. Further, it was recognised that engine powered craft would be necessary for the prosecution of deep slope fishing, thus the most fuel efficient combination of vessel and motor would be required as fuel costs are often a major constraint to fisheries development.One of the major objectives of the vessel appraisal study was to make a comparative study of the fuel consumption used by different vessel and engine combinations, and in particular the performance of introduced and improved vessels versus those of local outrigger canoes. Another important factor in this study was the sea worthiness of the different vessels in varying wind conditions.

The most common fishing vessel and presently the most important with respect to deep slope fishing is the motorized local outrigger canoe. In 1984 to 1985 74.4% by weight of the deep water fish landed were caught using this type of vessel. Cook (1984) argued that local outrigger canoes have the following disadvantages.

1. Comparatively unseaworthy except in relatively calm conditions.

2. Relatively low carrying capacity.

3. High rate of fuel consumption.

4. Short life span.

As a results of these factors , Fisheries Division commissioned an FAO designed 11 meter plywood outrigger canoe[1] (PNG 1) to be built at Wewak and designed to be powered by a 15 hp petrol outboard motor. Besides this canoe, 2 types of twin hulled vessels, an 'Alia' catamaran[2] by a 25 hp outboard motor and a 'Sandskipper' catamaran[3] powered by Yanmar TS-130 long tail diesel engine were included in the appraisal study. Imported aluminium and fibreglass dinghies were also included in this study because these vessels are widely used for the troll fishing as well as a platform for deep slope fishing.

STUDY AREA

The major fishing villages in the East Sepik Province are shown in Figure 1 in relation to the deep slope fishing grounds (indicated by the 200m isobath) and to the main market in Wewak. The major fishing villages for the deep water fishery are Kep, Turubu, Seir, Suanum and Samap. Recently the villages of Sup, Shagur, Karasau, and Yuo in the island region to the west of Wewak have also begun started to participate in deep slope fishing.

Generally, the East Sepik coastline is either made up of long sandy beaches or steep lime stone cliffs. Normally these areas have very little or no fringing reefs. The East Sepik coast faces northward and therefore is directly exposed the prevailing winds during the North West Monsoon season. During the North West Monsoon, the East Sepik coast experiences high swells and surf that continuously pounds the shores of the major fishing villages. In the Turubu area, most of the beaches are steep and narrow, making it difficult to beach large canoes during N.W season. Beaching also becomes impossible when surf continually breaks onto the shore. Local knowledge has helped fishermen to operate their canoes in and out of the surf but serious accidents have occurred.

The situation is different in the islands area. Most of the islands have fringing reefs and do not

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[1]. The design of the plywood canoe is based on work carried out by the Food and Agriculture Organisation (FAO) of the United Nations in Kiribati

[2] The Alia catamaran is design originating from work carried out in Samoa by the Food and Agriculture Organisation of the United Nations.

[3]. The Sandskipper catamaran is a design produced by the Overseas Development Administration of Great Britain based on studies carried out in the Carribean.

have from islands Shouten fishes
Wewak.

ave the same anchorage and beaching problems as experienced on the coastal areas. Apart rom Sup village (East Muschu) and Shagur on the north side of Kairiru islands, the other are a long way from Wewak thus handicapped by their geographical location. The houten islands, Tarawai and Walis have potential for deep water snappers and large pelagic (Chapman 1988) but are difficult to develop without suitable transport to markets in ewak.

AND METHODS

In the economic analysis five different types of vessel, 2 engine types of 3 different horse powers were tested. The vessels used in the study were the local outrigger canoe (8.5 to 10.9 m), an 11 m plywood canoe (P.N.G. 1), an 8.5 m FAO Samoan alia-catamaran (Akule), a 7 m ODA sandskipper catamaran and 4.9 to 5.8m fibreglass and aluminium dinghies. It was not practical to test in combination all vessels and all motors. The sandskipper catamaran was designed specifically for use with a Yanmar TS-130 long tail diesel engine and this engine was employed only in conjunction with this vessel. Both 15 hp and 25 hp outboard motors were tested in conjunction with the two types of canoe, whilst only the 25 hp engine was used with the alia catamaran and the different dinghies. In the case of the alia catamaran the 15 hp motor would simply have been to small to use effectively in conjunction with type of craft. The 25 hp motor-dingy combination is favoured by fishermen who catch coastal tunas by trolling. The power and peed of the 25 hp engine is essential for maintaining contact with tuna schools and it is assessed here for practicability as a bottom fishing platform.

Over a two year period records were kept on each fishing trip made by the different vessels. The total distance travelled and fuel consumption per trip for each vessel were recorded along with revenues from fishing and other costs incurred. To analyze the ability of the local outrigger canoe to fish in relatively rough sea conditions, the weather conditions when fishing trips were made were recorded and compared to the maximum daily wind strength recorded each day per month from January 1st to October 27th 1985. Wind strength data was obtained from the meterological station at Boram airport on the outskirts of Wewak.

WEATHER AND WIND CONDITIONS

The East Sepik area normally experiences between 4 to 5 months (November-March) when the prevailing winds blow from north west. This makes the coastal waters along most of the unsheltered coast very rough for the operation of small vessels. Maximum wind speeds during the north west season often exceed 25 knots, although in the last three years (since 1983) only winds strength up to 18 knots have been recorded. The region where the wind speed is measured is sheltered by morphology of the surrounding country side and tall buildings near the beach hence the results are considered under estimates. There is no data presently available to measure the degree of this under estimation. The pattern of wind during the north west season in 1985 was characterized by fortnightly periods of strong winds (in excess of 10 knots) being followed by a fortnight of relatively calm sea conditions.

VESSEL CHARACTERISTICS

Table 1 shows a comparison of the main descriptions of the five small-scale fishing vessels used in this study and basic plans for the catamarans and the canoes are shown in Figures 2 to 5. Detailed descriptions of these vessels can be found in Cook (1984). All five vessels were rigged to undertake both handreel fishing and trolling for large pelagics (ie Spanish mackerel, trevallies, tunas etc) in open water and around two floating fish aggregating devices deployed off Wewak.

Table 1. The main features of 5 different craft included in the vessel appraisal study

Vessel specifications	Local canoe	Plywood canoe	Alia catamaran	Sandskipper catamaran	Dinghy
Length (m)	9.6	11.0	8.5	7.3	5.4
Shelter	nil	nil	available	available	nil
Platform area (m^2)	3.7	5.1	15.0	16.6	5.6

RESULTS

Fuel consumption

A summary of results of the performance of the different vessel-engine combinations with respect to fuel consumption is given in Table 2. Fuel consumption ranged from a minimum of 0.18 l/km

Table 2. Summary of data used to estimate fuel consumption for the five vessel types and engine combinations used for deep bottom fishing.

Vessel & engine	No of trips	Distance travelled (km)	Total fuel consumed (l)	Consumption rate (l/km)
Local canoe & 25 hp petrol o/b motor	32	3,283	1,902	0.58
Local canoe & 15 hp petrol o/b motor	16	1,568	731	0.47
Plywood canoe & 25 hp petrol o/b motor	15	1,364	1,042	0.76
Plywood canoe & 15 hp petrol o/b motor	17	1,045	372	0.36
Alia catamaran & 25 hp outboard motor	15	1,376	1,132	0.82
Sandskipper catamaran & 13 hp longtail diesel motor	11	722	125	0.17
Dinghy & 25 hp petrol outboard motor	16	640	390	0.61

a. Fuel costs at the time of the study were K 0.57/l for petrol and K 0.4/l for diesel fuel.

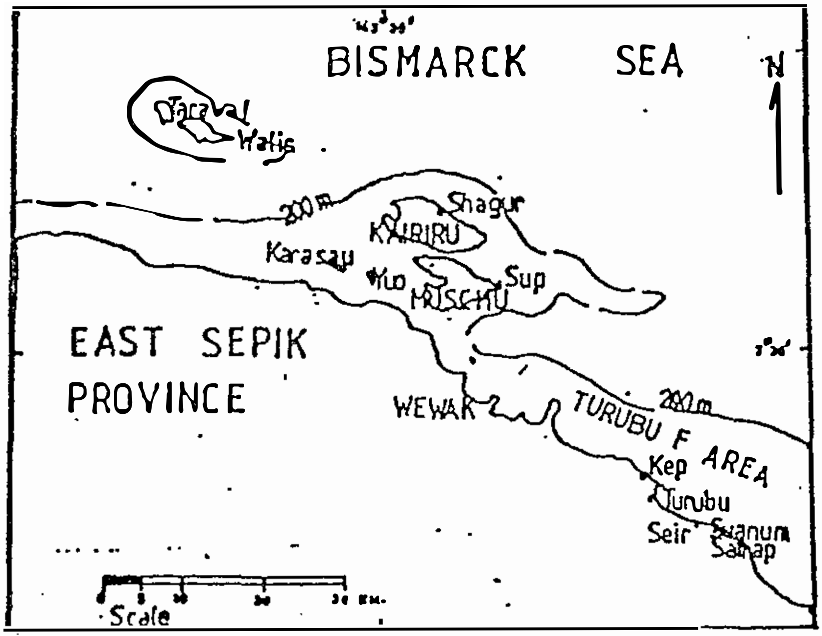

Fig.1. Sketch map of part of the East Sepik Province showing the deep reef slope fishing grounds and the 200m depth contour.

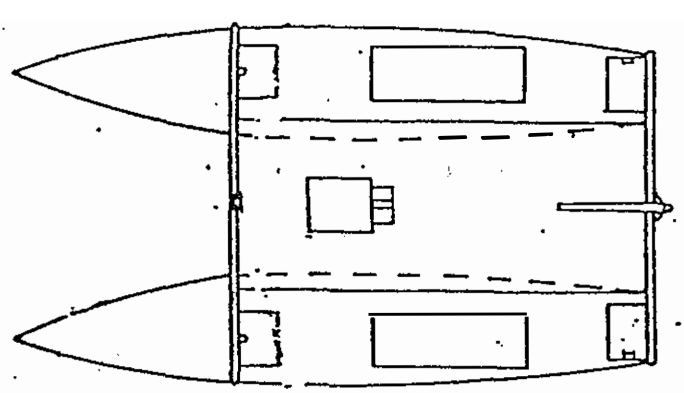

Fig.2. The 7.3m ODA designed Sandskipper catamaran used for deep reef slope fishing. The 13hp Yanmar longshaft diesel engine is mounted towards the centre of the vessel

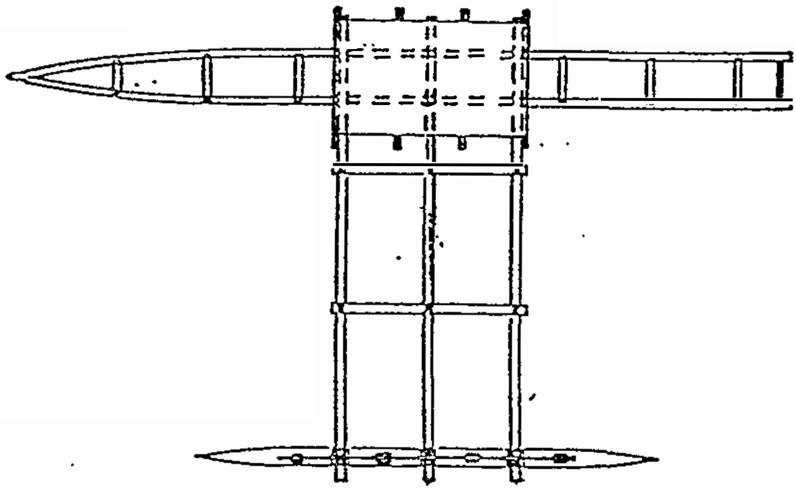

Fig.3. The 8.5m locally built canoe used for deep reef slope fishing. The outboard motor was mounted at the stern.

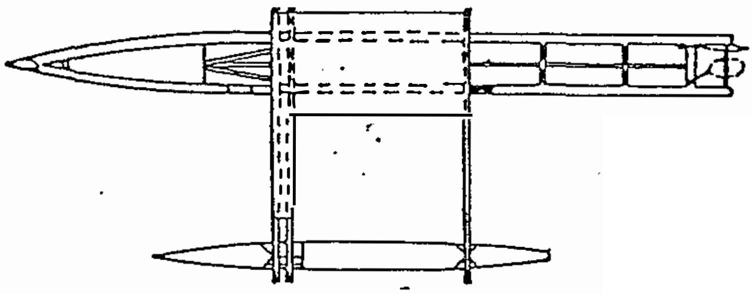

Fig.4. The 11m FAO designed plywood canoe used for deep reef slope fishing. The outboard motor was mounted at the stern.

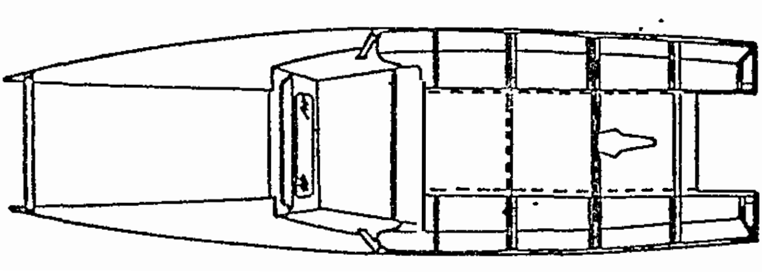

Fig.5. The 8.3m Alia catamaran used for deep reef slope fishing. The outboard motor was mounted about 1.5m in front of the stern.

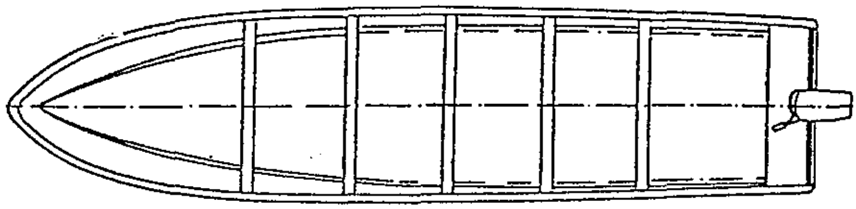

Fig.6. A 6.3m fibreglass dinghy of the type used for deep reef slope fishing and trolling.

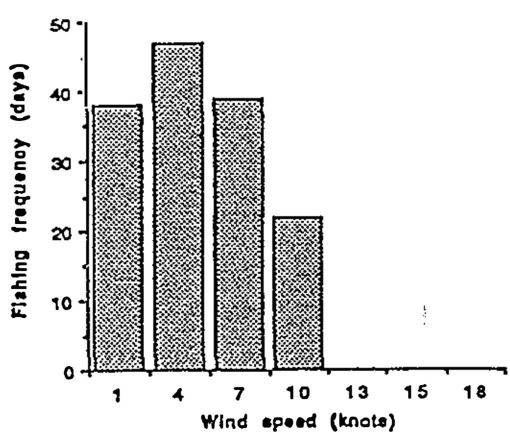

Fig.7.Frequency distribution of fishing days versus wind speed. The data were aggregated into wind speed classes of 3 knot intervals.

for Sandskipper-13 hp longtail diesel combination to a maximum of o.83 l/km for the Alia catamaran equipped with a 25 hp outboard. The overall average fuel consumption was 0.54 l/km. There was only an 11% reduction in fuel consumption of the local canoe with a 15 hp outboard motor, compared to the performance with the 25 hp motor. By contrast there was a 50% reduction in fuel consumption with the 15 hp engine relative to the 25 hp motor. The fuel consumption of the dinghies is similar to that of the local canoes in conjunction with the 25 hp outboard, but considerably lower than the combination of the plywood canoe with the same engine.

The data in Table 2 permits only simple comparisons of overall averages, without taking into account the variances of the fuel consumption on a per trip basis. These are compared between the different vessel-engine combinations through the analysis of variance (ANOVA) and the results presented in Table 3.

Table 3. Summary of the results of ANOVA testing between the variances of fuel consumption rates (l/km) for the different vessel-engine combinations used for deep bottom fishing

Vessel & engine	Local canoe & 25 hp o/b	Local canoe & 15 hp o/b	Plywood canoe & 25 hp o/b	Plywood canoe & 15 hp o/b	Alia ctmn & 25 hp o/b	S'skip ctmn & 13 hp dsl	Dinghy & 25 hp o/b
Local canoe & 25 hp o/b	-	*	0	**	**	**	0
Local canoe & 15 hp o/b		-	*	0	**	**	*
Plywood canoe & 25 hp o/b			-	**	*	**	0
Plywood canoe & 15 hp o/b				-	**	**	*
Alia ctmn & 25 hp o/b					-	**	**
S'skip ctmn & 13 hp dsl						-	**
Dinghy & 25 hp o/b							-

NOTE 0 - Non significant at $p > 0.05$

* - Significant at $p < 0.05$
** - Highly significant at $p < 0.01$

The results from this more rigorous analysis do not alter the conclusions drawn form the data presented in Table 2. As might be expected the two catamarans, representing the highest and lowest fuel consumptions have variances that differ significantly from all the other vessel-engine combinations. There were no significant differences between the combination of a 25 hp engine and the two canoe types and the dinghies. Further, differences between the performance of the 15 hp engine on the local and plywood canoes was again not significant.

Controlled tests were carried by Cook (1984) out on the plywood canoe using 15 and 25hp outboard engines. Cook recorded average fuel consumption rates with 15 and 25hp outboard motors of 0.54 and 0.96 l/km respectively when the vessel was operated in the coastal waters of Central Province. These results presented here and those of Cook (1984) confirm that a small horse power engine, when used correctly on a canoe, should result in substantial savings on fuel expenditure. Cook (1984) also argued that local outrigger canoes are a lot heavier then the introduced plywood canoe and hence would incur relatively greater fuel expenses. This study shows that there is no significant different in fuel consumption between local outrigger canoes and plywood canoes using outboard motors of equal horse power.

One of the main reasons for this is that local fishermen are becoming aware of fuel cost and hence the need to operate their engine at economical speeds. Local vessels are relatively smaller and therefore are much lighter than the plywood canoe. It is interesting to note that the local fishermen from the village of Turubu (Fig. 1) are starting to build smaller size canoes and are tending to employ 15 hp rather than 25 hp outboard motors. These changes are directly related to the high cost of fuel and other overheard for fishing, and the ability to beach their canoes with relatively less effort.

Effect of wind strength on fishing

The frequency distributions of the average daily maximum wind speed and deep bottom fishing trips made by local fishermen between January to October 1985 are given in Table 4. Deep slope handline fishing activity ceased entirely after October as fishermen beach their craft during the north west monsoon period. These data were aggregated in 3 knot class intervals and are shown in Fig. 7. Fishing activity does not decline greatly between 0 to 10 knots, however, beyond the 10 knot threshold fishing activity almost entirely ceases.

These data do not necessarily reflect the unseaworthiness of local vessels when wind speed are greater then 10 knots. A number of other variables such as rainfall and the build up of surf, associated with strong winds, will affect the motivation of fishermen. The effects of rainfall are particularly acute as the local fishing canoes have no shelter. There is very little data available to demonstrate which of these variables contribute most to explaining why fishing trips are not observed on days when winds are greater then 10 knots. Ten full time and part time fishermen were interviewed and preliminary results indicated that two main reasons that prevent fishermen going out fishing when winds are greater than 10 knots, namely:

1. the build up of surf on the village coast and the difficulty of launching a canoe.

2. the construction of the outrigger stem is often weak. Any vigorous wave action could

dislodge the outrigger causing the canoe to capsize.

Table 4. Daily windspeed frequency versus daily fishing trip frequency for deep bottom fishing in the East Sepik Province

Wind speed (knots)	Frequency (days)	%	Fishing trip frequency (days)	%
0	21	7.0	16	10.9
1	3	1.0	2	1.4
2	38	12.6	20	13.6
3	15	5.0	6	4.1
4	58	19.3	33	22.4
5	12	4.0	8	5.4
6	36	12.0	18	12.2
7	2	0.7	1	0.7
8	40	13.3	20	13.6
9	1	0.3	19	12.9
10	41	13.6	0	0.0
11	0	0.0	3	2.0
12	16	5.3	0	0.0
13	2	0.7	0	0.0
14	9	3.0	0	0.0
15	4	1.3	0	0.0
16	1	0.3	0	0.0
17	0	0.0	0	0.0
18	2	0.7	0	0.0
Total	301		147	

Based on a long time series of weather recordings for the coastal region of the East Sepik Province (PNG National Weather Service, unpub. data) wind speeds in excess of 10 knots occur on only 10 to 15% of the days in the year. This generally benevolent pattern of the prevailing winds creates a favourable condition for fishermen operating local out-rigger canoes. Fyson (1978) classified part time fishermen as those who fish ≤100 days a year and full time fishermen as those fishing fish for ≥200 days. Fishermen have much more then 200 potential fishable days available to them as suggested by the wind strength data, however, other village activities and obligations also limit fishing activity. As such part time fishermen form comprise the majority of the fishery although there are about 7 individuals practising full time bottom fishing in the region.

ESTIMATED ECONOMIC RETURNS FROM FISHING

Based on the information on fuel consumption of the different vessel-motor combinations, and on the observations of the bottom fishery over a two year period, it is possible to estimate the economic returns from fishing using various craft and propulsion units. The computations were based around the activities of the part time fishermen as they are more representative of persons involved in the bottom fishery.

It was assumed that ideal fishing conditions persisted for about seven months of the year and that two fishing trips were made each week. For ease of calculation the total trip number was set at 50 per year. The capital costs of each vessel, the operational costs, returns from fishing and projected revenues are shown in Tables 5 to 9. Catch rates in the fishery were set at 3.7. kg/line hr based on detailed records for the area summarised in Chapau 1986. Extensive records on deep bottom fishing in PNG suggests that catch rates usually range between 3 to 4 kg.line hr (Chapau 1988). About 80% of the species caught are classed as grade A fish and commands a higher price than the remainder of the catch.

Table 5. Capital costs (in Kina) of five vessel types rigged for deep sea fishing.

Item	Local canoe	Plywood canoe	Alia catamaran	Sandskipper catamaran	Dinghy
Hull	400	1,500	2,500	6,000	3,000
Engine[1]	1200	1,200	1,200	4,000	1,200
Fish Finder	nil	800	800	800	800
Fishing gear	200	250	300	300	300
Ice box	400	500	500	600	500
Total	2,200	4,150	5,300	11,700	5,800

1. The two canoes were assumed to use 15 rather than 25 hp engines that are used on the Alia catamaran and the dinghies. The costs for the Sandskipper assume a 13 hp Yanmar diesel longshaft motor.

The net revenues after costs by fishing with the five vessel-motor types are shown in Table 9.

Theoretically all combinations should generate a profit, even after crew incomes are deducted from gross returns from the catch. Clearly, however, fishing with both the dinghy-25 hp and plywood-canoe-15hp combinations does not generate any substantial extra income. Both types of catamaran would generate quite substantial revenues above total costs, although the higher depreciation costs of the expensive Sandskipper diesel engine offsets the cheaper fuel consumption and means that net profits are about the same.

Table 6. Operating costs (in Kina) of five vessel types employed in deep bottom fishing.

Item	Local canoe	Plywood canoe	Alia catamaran	Sandskipper catamaran	Dinghy
Fuel[1]	840	720	1,640	340	1,140
Wages[2]	2,016	2,016	2,520	2,520	2,016
Ice[3]	750	1,500	1,500	1,500	750
Victualling[4]	1,200	1,200	2,250	2,250	1,200
Maintenance[5]	250	600	710	890	700
Fishing gear[6]	100	100	150	150	150
Miscellaneous[7]	150	300	360	450	300
Total	5,306	6,436	9,130	8,100	6,256

1. Estimated for the canoes using 15 hp outboards, Alia catamaran and dinghy with 25 hp outboards and Sandskipper catamaran with 13 hp long shaft diesel. Number of trips per year = 50, with average length of 40 km.

2. Computed from 1985 rural minimum wage of K 36 per fortnight, working for 7 months of year (50 fishing trips). Crew size on canoes and dinghies = 4 persons and on catamarans = 5 persons.

3. Ice block capacity of local canoes and dinghies is 10 blocks per trip and for other vessels 20 blocks per trip. Cost of ice is computed from product of unit cost K 1.50/block and 50 trips per year.

4. Computed from daily allowance K 3.00 per man. Trip length of canoes and dinghies was 2 days and for the catamarans 3 days.

5,6,7. Estimated based on actual costs over 24 month period for different vessels and adjusted to one year

Table 7. Catch revenues of five vessel types employed in deep bottom fishing.

Fish grade	Local canoe	Plywood canoe	Alia catamaran	Sandskipper catamaran	Dinghy
A[1]	6,660	6,660	13,320	13,320	6,660
B	1,332	1,332	2,664	2,664	1,332
Total	7,992	7,992	15,984	15,984	7,992

1. Assumes average catch rate of 3.7 kg/line hr for bottom fishing and 3 lines in operation during each fishing trip. Fishing time for canoes estimated at 10 hrs/trip and for catamarans at 20 hrs/trip. Grade A species are all snappers (Lutjanidae), emperors (Lethrinidae) and Spanish mackerel (*Scomberomorus commerson*)

Table 8. Projected expenditures of five vessel types employed in deep bottom fishing.

Total expenditure	Local canoe	Plywood canoe	Alia catamaran	Sandskipper catamaran	Dinghy
Replacement costs	550	1,038	1,325	2,925	1,450
Running costs	5,306	6,436	9,130	8,100	6,256
Total	5,856	7,474	10,455	11,025	7,706

1. Replacement costs are set at 25% of the capital investment costs.

Table 9. Annual projected income versus costs for five vessel types employed in bottom fishing

Costs & revenues	Local canoe	Plywood canoe	Alia catamaran	Sandskipper catamaran	Dinghy
Gross income	7,992	7,992	15,984	15,984	7,992
Costs	5,856	7,474	10,455	11,025	7,706
Net income	2,136	518	5,529	4,959	286

DISCUSSION

be an effective deep bottom fishing unit capable of generating an income equivalent to the minimum rural wage and a substantial surplus profit for four fishermen. The plywood canoe and dinghy are more seaworthy craft, but because they are made from processed or man made materials, rather than from raw materials they incur more maintenance costs. The main advantage of the dinghy is the potential for trolling for bait for bottom fishing, and to supplement incomes from sale of troll caught fish. However, the dinghy is not a particularly suitable bottom fishing platform in comparison with the other vessels in this study.

Both the plywood canoe and the dinghies can fish for longer periods of the year and are not so constrained by bad weather. The seaworthiness of the plywood canoe may make this vessel more attractive to local fishermen. A slightly smaller 8.5m version of the plywood canoe used here has been profitably used for outer reef slope fishing in the Central Province (David Cook, Fisheries Research, Kanudi *pers comm*). Interestingly, Turubu fishermen have been scaling down their locally built canoes to effect greater fuel economy. For the coastal villagers in the East Sepik, with limited capital resources, the combination of local canoe and 15 hp motor will probably continue to be the most economically viable fishing unit.

The foregoing assumes that the expectations of the villagers are rewarded by the earning for seven months of the year by a wage equivalent to the official rural minimum and by the extra income of about K 2000 after all costs. In the rural communities of the East Sepik coast as in much of Papua New Guinea, employment opportunities are limited. Further, returns on capital investment in PNG through bank deposits are poor. Better capital returns might be experienced through financial investment overseas but such activity is generally beyond the scope of rural villagers where communications are poor.

Larger fishing units in the form of catamarans appear to offer quite substantial profits after costs and a living wage are deducted from the gross catch income. The similarities of the profit, approximately K 5000, are due to using a 25% annual replacement cost for each vessel. As the cost of the Yanmar diesel engine is almost three times that of a 25 hp outboard motor then this offsets the savings in lower fuel consumption with the diesel engine. This may be realistic as a diesel engine should be more reliable and have a longer lifespan than a petrol driven outboard motor. Further, unlike the Alia catamaran, the broader beam of the Sandskipper means that four reels can be deployed without tangling the fishing lines. alone would increase the pure profit of the Sandskipper to about K 8,800 per year under average fishing conditions.

The two main conclusions from this study are that:

1. local canoes employed in deep bottom fishing should be used in conjunction with 15 hp outboard engines.

2. if sufficient capital is available for investment in fishing then the Sandskipper catamaran and diesel engine combination should be chosen in favour of the Alia catamaran and outboard motor

However, these recommendations assume that expansion of the fishery will continue to supply a domestic demand for fish in Wewak and environs. A note of caution should be sounded that continued expansion of the fishery might lead to market saturation and that development of markets (eg disposal of catch to other provinces) should take place in conjunction with development of the fishery so as to generate the level of incomes suggested by these analyses.

I would like to acknowledge the work of Mr. O. Gulbrandsen (FAO Consultant) for the design of the plywood canoe (the PNG 1), Mr. B. Alexander (U.S.A. - Peace Corps) for his tremendous effort in constructing both the Alia catamaran and plywood canoe. I thank Mr David Cook of Fisheries Division who made available the Sandskipper catamaran. Thanks are due to the local fishermen particularly those in the Turubu area for their generous attitude to making the economic data for local canoes available. The Staff of Marine Fisheries (Provincial D.P.I.) and Fisheries Research, and in particular, Mr. Emmanuel Tamba, Alea Saiga and Tapas Potuku for the collection of data and assisting local fishermen. I am indebted to my colleague Mr. S. Frusher for his advice and guidance during the two years to complete this study. Finally, I thank the Fisheries Programme of the South Pacific Commission and Inshore Fisheries Scientist, Mr P. Dalzell, for editorial assistance with this report.

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Fig.1. Sketch map of part of the East Sepik Province showing the deep reef slope fishing grounds and the 200m depth contour.

Fig.2. The 7.3m ODA designed Sandskipper catamaran used for deep reef slope fishing. The 13hp Yanmar longshaft diesel engine is mounted towards the centre of the vessel

Fig.3. The 8.5m locally built canoe used for deep reef slope fishing. The outboard motor was mounted at the stern.

Fig.4. The 11m FAO-designed plywood canoe used for deep reef slope fishing. The outboard motor was mounted at the stern.

Fig.5. The 8.3m Alia catamaran used for deep reef slope fishing. The outboard motor was mounted about 1.5m in front of the stern.

Fig.6. A 6.3m fibreglass dinghy of the type used for deep reef slope fishing and trolling.

Fig.7.Frequency distribution of fishing days versus wind speed. The data were aggregated into wind speed classes of 3 knot intervals.