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THE COMMERCIAL FEASIBILITY OF BOTTOMFISHING IN TUVALU: FINAL ECONOMIC EVALUATION

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2

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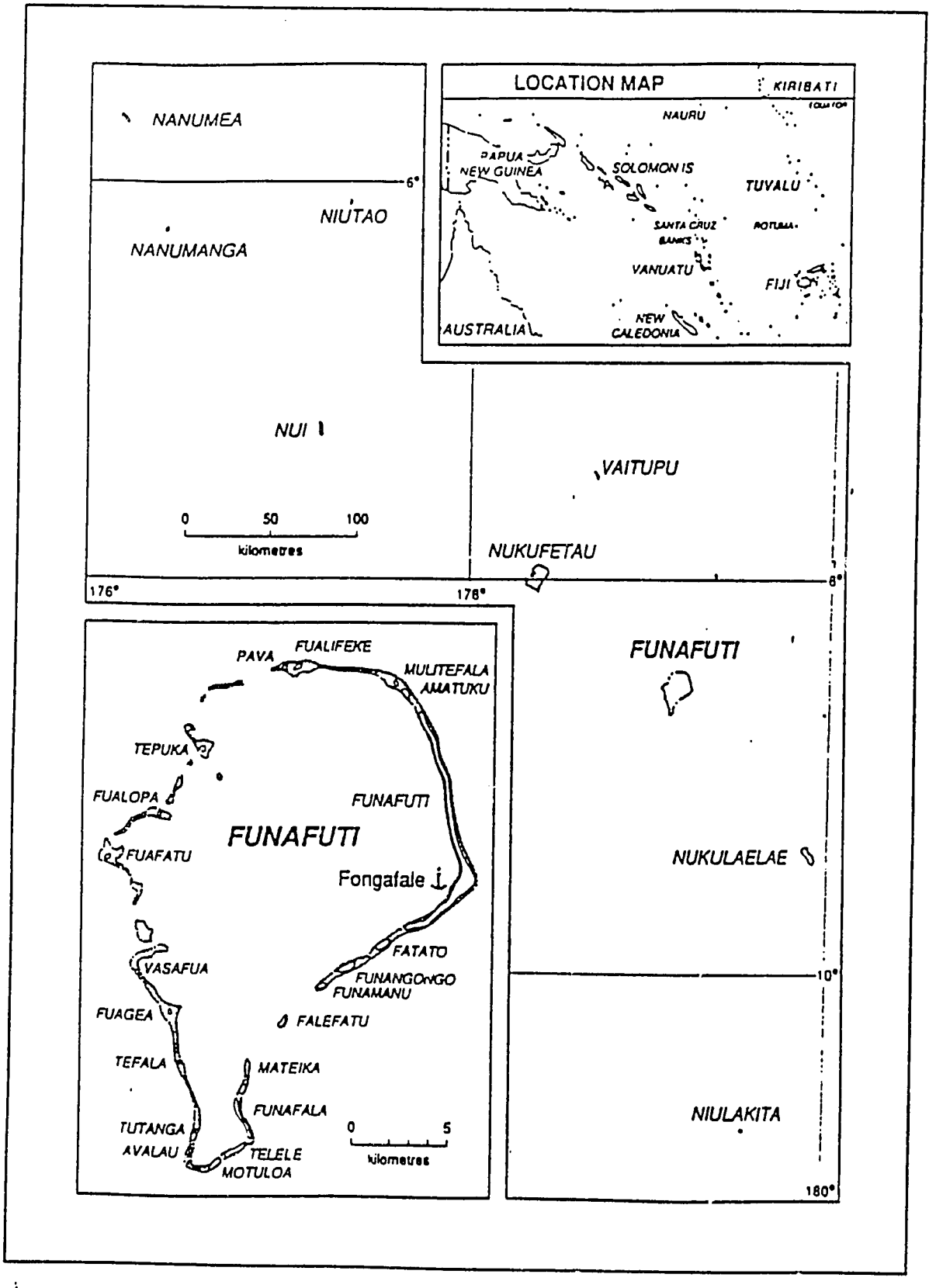

Figure 1. Tuvalu

ABBREVIATIONS

A$	Australian dollar
C	Centigrade
CPUE	Catch per unit effort
GOT	Government of Tuvalu
IRR	Internal rate of return
kg	Kilogram
km	Kilometer
l	Liter
m	Meter
MSY	Maximum sustainable yield
mt	Metric ton
NAFICOT	National Fishing Corporation of Tuvalu
nm	Nautical mile
	Degree
PIMAR	Pacific Islands Marine Resource
RDA	RDA International, Inc.
RDO	Regional Development Office
SP	South Pacific
SPC	South Pacific Commission
USAID	United States Agency for International Development
US$	United States dollar

CURRENCY EQUIVALENTS

Tuvalu currency unit = A$

A$1.00	=	US$0.74
US$1.00	=	A$1.35

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 1-1

2.0 INTRODUCTION 2-1

3.0 RESOURCES, CATCH PROJECTIONS AND FISHING COSTS 3-1
- 3.1 Bottomfish resources 3-1
- 3.2 Catch projections 3-7
- 3.3 Fishing Costs 3-8
  - 3.3.1 Vessel considerations 3-8
  - 3.3.2 Fuel Cost 3-9
  - 3.3.3 Ice 3-11
  - 3.3.4 Bait 3-13
  - 3.3.5 Crew provisions 3-14
  - 3.3.6 Crew wages 3-14
  - 3.3.7 Gear replacement and miscellaneous costs 3-18
  - 3.3.8 Summary running costs for a representative fishing trip 3-18
- 3.4 Summary of resources, catch projections and fishing costs 3-19

4.0 MARKETING POTENTIALS, REVENUES AND COSTS 4-1
- 4.1 Exportable and locally marketable fish catches 4-1
- 4.2 Local marketing and expected prices 4-1
- 4.3 Export marketing and expected prices 4-2
- 4.4 Marketing costs 4-6
  - 4.4.1 Local marketing costs 4-6
  - 4.4.2 Export marketing costs 4-6
    - 4.4.2.1 Packing costs 4-7
    - 4.4.2.2 Shipping costs 4-7
    - 4.4.2.3 Other marketing costs 4-8
    - 4.4.2.4 Summary of export marketing costs 4-8
- 4.5 Summary of marketing revenues and costs 4-9

5.0 COMMERCIAL FEASIBILITY OF BOTTOMFISHING IN TUVALU 5-1
- 5.1 Investment and fixed costs of bottomfishing in Tuvalu 5-1
- 5.2 Profitability of bottomfishing in Tuvalu 5-3
- 5.3 Summary 5-10

6.0 DEVELOPMENT CONSIDERATIONS AND CONCLUSIONS 6-1
- 6.1 Development considerations 6-1
- 6.2 Conclusions 6-5

7.0 References 7-1

7

LIST OF TABLES

Table 3-1	The islands and seamounts of Tuvalu and their respective distances and steaming times from Funafuti, and the 200m isobaths and MSY's of the seamounts	3-3
Table 3-2	Fuel use and cost for an average bottomfishing trip	3-11
Table 3-3	Standard *Manaui* crew wages	3-15
Table 3-4	Fishing cruise wages on the *Manaui*	3-16
Table 3-5	Summary running costs for a typical 5-day fishing trip	3-18
Table 4-1	Names, marketability, and expected prices of bottomfish species in the Hawaii market	4-4
Table 4-2	Expected fish prices for export shipments with a higher and lower proportion of higher-valued species	4-5
Table 4-3	Export marketing costs	4-9
Table 5-1	Initial investment costs for a bottomfishing operation in Tuvalu	5-2
Table 5-2	Annual fixed costs	5-3
Table 5-3	Rates of return on investment in bottomfishing in Tuvalu	5-5
Table 5-4	The sensitivity of rates of return on investment in bottomfishing in Tuvalu	5-8

LIST OF FIGURES

Figure 1.	Map of Tuvalu's EEZ	v
Figure 3-1.	Map of the islands and seamounts of Tuvalu	3-3

8

THE COMMERCIAL FEASIBILITY OF BOTTOMFISHING IN TUVALU: FINAL ECONOMIC EVALUATION

1.0 EXECUTIVE SUMMARY

This report provides a final detailed economic evaluation of the commercial feasibility of developing a bottomfishing industry in Tuvalu. The industry would be based on fishing Tuvalu's unexploited distant seamounts and selling the higher-valued export species in international markets. The report has been prepared by RDA International, Inc. (RDA), as part of the Tuvalu Component of the Pacific Islands Marine Resource (PIMAR) Project, Project No. AID 879-0020-C-00-1231-00, funded by the United States Agency for International Development (USAID/RDO/SP/Suva).

Tuvalu has a promising opportunity to develop a small but profitable and sustainable export-oriented bottomfishing industry. Successful exploitation of this opportunity will require a high degree of cooperation between the GOT and the private bottomfishing operators.

Tuvalu has small but commercially exploitable bottomfish resources available on the deep submarine slopes of its atolls and distant seamounts. A commercial bottomfishing operation fishing on Tuvalu's distant seamounts can expect to generate an internal rate of return on investment over cost of 20% to 25%. This is sufficient to justify an investment in a bottomfishing operation since the current rate of interest on development loans charged by the Tuvalu Development Bank is only 8%. However, high fishing costs, because of the long distances to the fishing grounds, and high marketing costs, because of the required transhipment of exports through Fiji enroute to the Hawaii market, both constrain the profitability of this very high-valued export. Accordingly, sustained profitability of commercial bottomfishing on Tuvalu's distant seamounts will require that the number of fishing vessels be limited and fishing effort be carefully monitored to ensure that catch rates remain relatively high. Tuvalu's distant seamount bottomfish resources are sufficiently modest that the number of commercial vessels allowed into the fishery should be limited to 3 or 4 until it is proven that catch rates can remain high at that level of exploitation. Too great an expansion of the fishery will reduce catch rates and undermine the profitability for all bottomfishing operations, forcing some or all into bankruptcy.

According to the project's resource assessment reports, the maximum sustainable yields (MSYs) of bottomfish on Tuvalu's distant seamounts are estimated at about 84 mt annually. More than three-quarters of these resources are located on two distant seamount areas, one about 130 miles and the other about 225 miles from Funafuti, the landing site for export quality bottomfish. If the fishery were optimally managed, the average or typical fishing trip would involve traveling 178.5 miles to and from the fishing grounds. Based on actual fishing experience by project trials, catch rates per

line hour of effort for high-valued export quality bottomfish range from 4 kg to 5 kg. While these catch rates are sufficient to warrant the development of a commercial bottomfishing industry in Tuvalu, the high running costs of commercial fishing operations constrain profitability and suggest that fishing vessels must be relatively small and fuel efficient.

Project trials demonstrate that Tuvalu can successfully export high quality bottomfish to the Hawaiian market and receive prices averaging between A$9.00 per kg and A$10.00 per kg. To insure these high prices, however, Tuvaluan fishermen must target the high-valued species, in particular, *Etelis coruscans* (onaga or longtail red snapper) and *Pristipomoides filamentosus* (opakapaka or ruby snapper), so that these make up a large proportion of the export shipments. Despite these high prices received in Hawaii, the net returns to a Tuvaluan commercial fishing operation will be modest due to the high marketing costs. The air freight costs are particularly high due to the fact that the exports must be transhipped through Nadi, Fiji enroute to Honolulu, Hawaii.

Due to the high fishing and marketing costs, the rates on return on investment in a commercial bottomfishing operation in Tuvalu are low but adequate to justify the investment. Unfortunately, maintaining profitability requires that the initial investment be kept low and that catch rates and the proportion of the higher valued bottomfish species in the catch be kept high.

The potential scale of a Tuvaluan bottomfishing industry is small in comparison to similar fisheries developed by several of Tuvalu's South Pacific neighbors. Careful fishery management will be required to insure that catch rates remain sufficiently high to justify the commercial investments. However, if a small fleet of 3-4 bottomfishing vessels are carefully monitored, Tuvalu can successfully develop an export oriented bottomfishing industry. The industry should be able to provide at least a dozen good paying jobs and additional support for a like number of industry-support jobs. In addition, the industry could generate A$150,000 to A$170,000 annually in foreign exchange earnings.

2.0 INTRODUCTION

This report provides a final detailed economic evaluation of the commercial feasibility of developing a bottomfishing industry in Tuvalu. The industry would be based on fishing Tuvalu's unexploited distant seamounts and selling the higher-valued export species in international markets. The report has been prepared by RDA International, Inc. (RDA), as part of the Tuvalu Component of the Pacific Islands Marine Resource (PIMAR) Project, Project No. AID 879-0020-C-00-1231-00, funded by the United States Agency for International Development (USAID/RDO/SP/Suva). (The USAID administration of the project has recently shifted to USAID/Manila.)

Among other research and training components of the project which began in September 1991, RDA, in cooperation with USAID and the Government of Tuvalu (GOT), conducted hydrographic surveys of and test fishing for bottomfish on Tuvalu's distant seamounts and undertook commercial bottomfishing and export marketing trials to assess the bottomfish resources and their catchability and marketability. A preliminary economic evaluation was prepared at the beginning of the project by RDA Socio-Economist P.W. Philipson. Now that the resources have been assessed, the test fishing and commercial fishing trials have been completed, and the results of the export marketing trials are known, this final economic evaluation will assess the commercial feasibility of developing a bottomfishing industry in Tuvalu.

Tuvalu's distant seamount bottomfish resources are modest by comparison with those of several of Tuvalu's South Pacific neighboring countries. This is due in part because of the shallow depths (100-200 m) of the seamount surfaces and the steep submarine slopes. Furthermore, the fishing grounds are long distances from the main landing site, so fishing costs are relatively high. In addition, even though Tuvalu can receive premium prices on its export quality bottomfish in the Hawaiian market, marketing costs are extremely high due to the necessity of transhipping the exported fish through Fiji enroute to Hawaii. Accordingly, catch rates of higher-valued export quality bottomfish species must remain high if adequate rates of return on investment in Tuvalu bottomfishing are to be maintained. Careful fishery management and a high degree of cooperation between the Government of Tuvalu and the commercial bottomfish operators will be required to assure the sustainability of Tuvalu's bottomfish resources.

Section 3.0 below reviews the resources, catch projections, and fishing costs. Section 4.0 explores marketing potentials, revenues, and costs. Section 5.0 examines the commercial feasibility of bottomfishing in Tuvalu. Section 6.0 discusses numerous development considerations and options and draws the final conclusions of this study.

3.0 RESOURCES, CATCH PROJECTIONS AND FISHING COSTS

3.1 Bottomfish resources

Tuvalu's bottomfish resources have been estimated in a resource assessment report prepared by RDA Marine Biologist W. Haight. The project conducted hydrographic surveys of and test fishing on Tuvalu's distant seamounts. Based on the measurements of the 200 m isobaths of the distant seamounts, the test fishing results, and information on catch and 200 m isobath information in other South Pacific fisheries, the unexploited biomass and Maximum Sustainable Yield (MSY) was calculated for each of Tuvalu's distant seamounts. These results are shown in Table 3-1 on page 3-3 and Figure 3-1 on page 3-5. The total MSY for all of Tuvalu's seamounts was estimated at 84 mt, ranging from a low estimate of 42 mt and a high estimate of 126 mt. Similar calculations for Tuvalu's islands suggest that an additional MSY of about 44 mt, ranging from a low of 22 mt to a high of 65 mt, is available around the country's atolls.

An examination of Table 3-1 and Figure 3-1 shows that 2 seamounts to the north of Funafuti are relatively small and have only about 2% of Tuvalu's estimated bottomfish MSY. Accordingly, Tuvalu's bottomfishing industry will concentrate fishing effort on the southern seamounts. To the south of Funafuti, there are 2 major fishing areas. The closer fishing area is around Kosciusko Bank, including Martha Bank. About 130 miles from Funafuti, the Kosciusko-Martha fishing grounds have an MSY of 31.8 mt, or about 37.9.% of Tuvalu's total bottomfishing MSY. The other major fishing area is further south at Bayonnaise Bank. Bayonnaise Bank is about 225 miles from Funafuti and has a bottomfish MSY of 32.4 mt, or about 38.6% of Tuvalu's total bottomfishing MSY.

As the Tuvaluan bottomfishing industry develops, commercial fishing will first concentrate on the Kosciusko-Martha area about 130 miles from Funafuti. This would require about 20 hours of steaming time to and from the fishing area. As the fishery expands to the optimum number of vessels, the more distant areas will also be exploited. If the fishery were optimally exploited, then the average fishing trip would be approximately 178.5 miles and would require 27.5 hours of steaming to and from the fishing grounds. (This average fishing trip was calculated by weighting the seamount distances from Funafuti by the seamount approximate MSY's; the steaming times were based on an assumed speed of 6.5 nm per hour.)

While the focus of the project was on evaluating Tuvalu's bottomfishing potential on its distant seamounts, some attention was also given to examining the bottomfish resources near Tuvalu's islands. As was noted above, the MSY of bottomfish on Tuvalu's islands is about half that on Tuvalu's distant seamounts. Because of the proximity of these near-island bottomfish resources to population centers, they are the most susceptible to over fishing and over exploitation. Since, as will be seen later in

this report, the value of the exportable bottomfish species averages about twice the value of the locally marketable fish, it would be represent a significant loss to Tuvalu if the near-island bottomfish resources were sold locally or depleted due to over fishing. The GOT will need to incorporate the near-island bottomfish resources into its overall resource management planning.

Figure 3-1. Map of the islands and seamounts of Tuvalu.

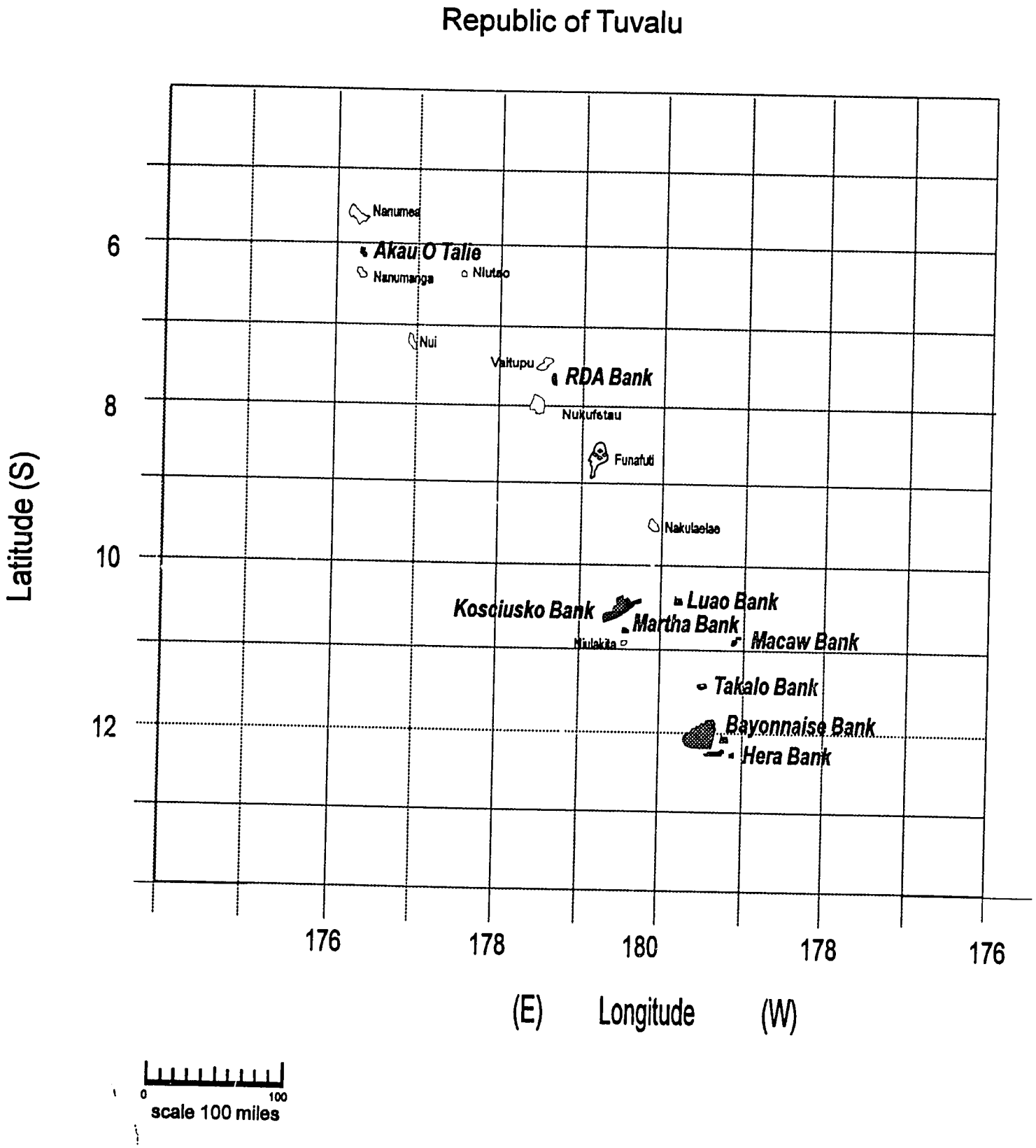

Table 3-1. The islands and seamounts of Tuvalu and their respective distances and steaming times from Funafuti, and the 200m isobaths and MSY's of the seamounts.

BASE ISLAND	DESTINATION	DISTANCE FROM FUNAFUTI IN MILES[1]	STEAMING TIME FROM FUNAFUTI IN HOURS[2]	200m ISOBATH IN MILES[3]	MSY (MT)[4]
	NANUMEA	250	38.5		
	***AKAU O TALIE**	**222**	**34.2**	**3.23**	**1.10**
	NANUMANGA	218	33.5		
	NIUTAO	184	28.3		
	NUI	145	22.3		
	VAITUPU	70	10.8		
↑	***RDA BANK**	**68**	**10.5**	**1.75**	**.59**
NORTH	NUKUFETAU	58	8.9		
FUNAFUTI					
SOUTH	NUKULAELAE	70	10.8		
↓	***LUAO BANK**	**116**	**17.8**	**6.72**	**2.28**
	***KOSCIUSKO & MARTHA BANKS**	**130**	**20.0**	**93.78**	**31.81**
	NIULAKITA	137	21.1		
	***MACAW BANK**	**165**	**25.4**	**24.79**	**8.41**
	***TAKALO BANK**	**205**	**31.5**	**12.12**	**4.11**
	***BAYONNAISE BANK**	**225**	**34.6**	**95.62**	**32.40**
	***HERA BANK**	**240**	**36.9**	**9.65**	**3.27**

* **SEAMOUNTS**

1. Distance measured in approximate nautical miles
2. Steaming time based on vessel speed of 6.5 nautical miles per hour
3. Approximate circumference of seamount at 200m depth in nautical miles
4. Maximum sustainable yield (MSY) in metric tons proportionate to 200m isobath

3.2 Catch projections

While the project conducted a total of 35 cruises, most of these were explicitly research cruises focused on measuring the 200 m isobaths of the distant seamounts, with only intermittent test fishing. Only the final 5 cruises were focused explicitly on "commercial-style fishing." Up through the final commercial fishing trial, the skipper and crews were learning how to locate the bottomfish with a bottom sounder, how to target the higher-valued species, and how to use the sea anchor for effective fishing. Accordingly, catch results exhibited high variability, and only the cruises with the highest catch rates approach the catch rates likely to be obtained by a commercial fishing operation.

The test fishing conducted in conjunction with the hydrographic surveys on the first 17 research cruises yielded CPUEs of 6.45 kg per line hour for all species and 5.55 kg per line hour for exportable species. By comparison, the final 5 commercial fishing trials yielded CPUEs of 4.85 kg per line hour for all species and 4.44 kg per line hour for exportable species. Due to mechanical problems, the lack of a sea anchor for all but the final three cruises, and malfunctioning of the echo-sounder which reduced the ability to target the higher-valued species, the CPUEs on even the final 5 cruises remained substantially below what is commercially feasible. Despite these shortcomings, CPUEs for marketable fish ranged from 5kg to 6 kg per line hour on several of the cruises and reached 6.88 kg per line hour on the final cruise. A more complete analysis of the expected catch rates is found in the project reports on resource assessment and fishery management.

Throughout this financial analysis, it will be assumed that a commercial bottomfishing operation will be able to sustain an average total CPUE of 6.0-7.5 kg per line hour, with an average CPUE for exportable species of 4-5 kg per line hour and an average CPUE for locally marketable species of 2.0-2.5 kg per line hour. Thus, 20 line hours of fishing per day would yield 80-100 kg of exportable bottomfish and 40-50 kg of locally marketable species. A fishing trip with 3 fishing days and 60 line hours of fishing would yield 240-300 kg of exportable bottomfish and 120-150 kg of locally marketable species. There is certainly a case to be made that a commercial bottomfishing operation might increase the number of line hours to compensate for lower CPUEs. In this base scenario, an operator would be able to maintain the same catch and export volume with CPUEs 20% lower (ranging from 4.8-6.0 kg per line hour) by increasing line hours by 25% (to 25 line hours per day or 75 line hours for 3 fishing days). As with many considerations throughout this report, there are many workable scenarios. Nonetheless, for our purposes, we will begin the analysis with the assumption of CPUEs of 6.0-7.5 kg per line hour and a typical fishing trip with 60 line hours of fishing effort.

A more elaborated discussion of the species composition of the catch is found below in section 4.0 which deals with marketing issues.

3.3 Fishing Costs

There are several difficulties in estimating fishing costs in a developing Tuvaluan bottomfishing industry, principally because of the lack of practical experience with this or other commercial fisheries. Prior to the project's bottomfish export marketing trials, there were no official fish exports from Tuvalu. There are only 3 or 4 Tuvaluans with training and credentials to act as skippers of an appropriate bottomfishing vessel, and only 2 of these currently reside in Tuvalu. Most Tuvaluan fishing has been subsistence reef and near-shore fishing, and only a small proportion of fish is actually marketed, even in Tuvalu. Prior to this year's brief experience with *beche de mer* harvesting, there has been little commercialization of any fishing activities. Up until only a few years ago, most vessels in Tuvalu's reef fishery were small canoes and skiffs. Japanese aid has provided Tuvalu with the *Manaui*, an 18.6 m fully equipped vessel that is too expensive to function appropriately as a commercial bottomfishing vessel, and four 9 m fishing vessels that are somewhat small and ill-designed to serve as distant seamount bottomfishing vessels. The *Manaui* has been used as a Department of Fisheries research vessel since 1988, and the 9 m vessels have been only partially employed as NAFICOT-sponsored reef and near-shore fishing vessels. Tuvalu's maritime school has trained many seamen who have worked on a variety of maritime vessels, but except for those trained in the bottomfishing project, Tuvalu does not have many trained commercial fishermen. Thus, all estimates of fishing costs, from the cost of provisions to crew wages, must be somewhat provisional.

3.3.1 Vessel considerations

One of the most serious difficulties in estimating fishing costs concerns the absence of an appropriate bottomfishing vessel. Furthermore, there is no readily available appropriate vessel, newly constructed within easy sailing distance from Funafuti, which meets the size, power, and safety requirements for regularly traveling to and from the distant seamounts, while having sufficiently low investment and operating costs to be economical given the expected catch rates and sales revenues. In the Preliminary Economic Evaluation report conducted at the initiation of this project, RDA Socio-Economist P.W. Philipson used 2 FAO vessel designs for reference purposes. These were the 10 m diesel VAN-1, only one of which was produced in Vanuatu, and the 8.6 m diesel FIJ-5, about 240 of which had been built in Western Somoa by the early 1990's. Neither vessel was designed for trips of the distance or duration required for exploitation of bottomfish on the Tuvaluan distant seamounts, and both vessels appear to be at the lower end of acceptability in terms of size, space, safety, speed, and economy considerations. Because of cost considerations, however, the project report prepared by Tuvalu's most experienced skipper on the desired vessel characteristics for bottomfishing in Tuvalu concluded that a vessel with many of the VAN-1 characteristics would provide an optimal balance among the constraints facing a bottomfishing operation in Tuvalu.

17

For purposes of conducting a financial feasibility analysis, however, the vessel investment and operating costs are more important than defining the particular vessel design characteristics. The general cost and revenue situation suggests that return projections should be based an overall commercial fishing operation investment of roughly A$50,000. This would be divided into approximately A$40,000 for a fully equipped fishing vessel and approximately A$10,000 in operating capital.

These hypothetical vessel costs of A$40,000 are based on a hull and engine similar to those recommended in the project vessel characteristics report. The hull is presumed to be approximately 10 m in length and to cost approximately A$20,000. A 20 hp Yanmar diesel engine, costing less than A$10,000, has been used rather than a 30 hp Yanmar diesel engine costing upwards of A$11,000, which was recommended in that report. Perhaps more important that the lower initial cost (up to 15% lower) of the smaller engine are the lower fuel requirements of the smaller engine. The 20 hp engine requires about 40% less fuel than a 30 hp engine, about 3 l/hr as opposed to about 5 l/hr at cruising speed. On the other hand, the hypothetical costs assumed here include 2 hydraulic reels at a cost approaching A$3,000 in Tuvalu, while the vessel characteristics report recommends the much less expensive Samoan hand reels. The limited living and work space available on a 10 m vessel that must be at sea at least 5 days a week for at least 30 weeks a year is sufficient reason to limit the crew to 3 rather than 4 persons which would probably be required using hand reels. Furthermore, the necessity of fishing up to 10 hours or more per day is sufficient justification for switching to the relatively inexpensive hydraulic reels rather than utilizing the more labor intensive hand reels. This discussion highlights some of the trade-offs which must be encountered in every beginning commercial bottomfishing operation in Tuvalu. There is no need to make a final decision regarding the precise configuration of the vessel, equipment, crew numbers, and so forth, for these will be worked out in practice as commercial bottomfishing begins. It is sufficient here simply to draw attention issues and concerns involved in estimating the costs and returns to bottomfishing in Tuvalu. (See Table 5-1 on page 5-2 below for a more detailed breakout of the vessel and equipment costs.)

3.3.2 Fuel Cost

Fuel cost is one of the most important considerations in determining the per fishing trip fishing costs, the optimum size vessel, and overall profitability. Most of the project's research cruises and commercial fishing trials were conducted using the *Manaui*, a fully equipped 18.6 m vessel with a 163 hp Yanmar diesel engine which consumes about 25 l/hr of fuel at cruising speed. While the *Manaui* can be used to continue conducting bottomfishing trials and training, it is far too expensive to operate as a business venture. However, since the *Manaui* is the only vessel currently available in Tuvalu that can travel the distances required to conduct bottomfishing on Tuvalu's distant seamounts, it is instructive to compare its fuel requirements with

those of a more suitable and more economically-powered vessel which can be supported by a commercial operation. It is assumed that a commercial vessel would consume about 3 l/hr at cruising speed.

Assuming a typical bottomfishing trip of 178.5 miles, the average distance to the distant seamount fishing grounds presuming a balanced or optimal exploitation of the bottomfishing resources in Tuvalu, Table 3-2 below compares the fuel costs of the *Manaui* with those of a more suitable commercial vessel. The typical fishing trip would include 1 day of cruising to and from the fishing grounds plus 3 days of fishing. Diesel fuel in Tuvalu currently costs A$0.5493/l.

Table 3-2 shows that the *Manaui* is extremely expensive to operate, costing approximately A$1,087 in diesel fuel for each typical fishing trip. By comparison, a more suitable commercial bottomfishing vessel would use approximately A$124 in diesel fuel for an equivalent bottomfishing trip.

19

Table 3-2. Fuel use and cost for an average bottomfishing trip

Item	*Manaui*	Commercial Vessel
Cruising Speed	8 kn/hr	6.5 kn/hr
Fuel Use, Cruising Speed	25 l/hr	3 l/hr
Fuel Use, Drift Fishing	15 l/hr	1 l/hr
Fuel Use, Anchor Fishing	6 l/hr	1 l/hr
Fuel Use, At Anchor	6 l/hr	0 l/hr
Cruising to Fishing Grounds, 178.5 nm	22.3 hrs	27.5 hrs
Searching/Day	2 hrs	2 hrs
Drift Fishing/Day	10 hrs	10 hrs
Anchor Fishing/Day	4 hrs	4 hrs
At Anchor/Day	8 hrs	8 hrs
Fuel Use, Cruising	1115 l	165 l
Fuel Use, Searching	150 l	18 l
Fuel Use, Drift Fishing	450 l	30 l
Fuel Use, Anchor Fishing	72 l	12 l
Fuel Use, At Anchor	192 l	0 l
Total Fuel Use	1,979 l	225 l
Fuel Cost/Fishing Trip	A$1,087	A$124

3.3.3 Ice

Ice is an essential input to the development of a distant seamount bottomfishing industry in Tuvalu. At the initiation of the project, Tuvalu did not have a proper ice-making machine. Ice was being frozen in blocks in NAFICOT deep freezers and then crushed for use by fishers. When the fish were kept onboard with this crushed ice, indentations in the fish skins developed which would have significantly reduced the value of the fresh fish in foreign markets. To avoid this problem and to assist the implementation of the project's export marketing trials, the Government of Tuvalu purchased a 1 mt/day capacity fractured ice-making machine. The ice-making

machine was placed under the jurisdiction of the Department of Fisheries. The fractured ice lies flat against the skin of the fish so that no indentations are created. No export marketing trials were undertaken until after the new ice-making machine was functioning. The Department of Fisheries has been selling ice to the public and to the project's bottomfishing operation for A$0.20/kg.

While the ice-making machine's capacity is 1 mt/day, in current use it is capable of producing only about 3 mt/week. There are several constraints on the ice-making capacity and the availability of ice required for supplying commercial fishing vessels. The machine has been subject to continual breakdowns and has been in need of repeated repair and maintenance. Commercial fishing trips will require precise departure schedules in order to return appropriately to meet the one available air carrier flight each week which makes good connections to Honolulu, Hawaii through Nadi, Fiji. In addition, the ice-making condenser is currently housed in a very hot room so that the ice begins to melt even before the storage unit is filled. During project trials, the *Manaui* typically carried 600-750 kg of ice at a cost of A$120-A$150 for each 6-7 day bottomfishing trip. It has taken about 1.5 days or more to produce this much ice. However, the *Manaui* had refrigerated storage compartments which are not likely to be available on the vessels affordable to commercial bottomfishing operations in Tuvalu. The limited ice-making capacity combined with the current availability of only one appropriate air carrier flight per week, puts an effective limit on the number of commercial bottomfishing vessels at 1 or 2 vessels. This limited ice-making capacity creates queuing problems. Due to scheduling constraints, even with only 2 commercial bottomfishing vessels operating out of Funafuti, there will need to be a high degree of cooperation between the operations on fishing trip departure times and how far from Funafuti each fishing trip will travel.

Ideally, a commercial vessel would carry about 2 kg of ice for each 1 kg of expected exportable fish catch. With careful handling and well-insulated ice boxes, the vessel could get by with about 1.5 kg of ice for each 1 kg of exportable fish. The operation should allow at least half the amount of ice for the locally marketable catch as it allows for the exportable catch. In addition, the vessel will need to carry 40-50 kg of ice per fishing day for the brining of fish, to rapidly reduce the core temperature of the fish before putting them into iced storage. Assuming that a commercial vessel had high quality ice boxes, then, a commercial fishing trip of 5 days, with 3 fishing days and an expected catch of 250+ kg of exportable fish and 100+ kg of locally marketable fish, will require approximately 625 kg of ice at a cost of A$125. In view of the highly valuable exportable fish catch, it would be highly risky for the vessel to carry less ice.

3.3.4 Bait

During the project, skipjack tuna has been used as the bottomfishing bait. The *Manaui* typically deployed a skiff with 3 men to spend about 3 hours to catch 80-100 kg of skipjack tuna, which was sufficient for about 2 days of fishing. This was usually done once enroute to the fishing grounds and once on day 3 of fishing, each bait fishing trip producing enough bait for about two days of bottomfishing. In the off-season for skipjack tuna, the crew might have to fish for bait every day. A commercial venture, using a vessel much smaller than the *Manaui*, would have to interrupt bottomfishing to conduct bait fishing. Since skipjack tuna and other suitable bait is readily available in Tuvaluan waters, and since during the project fishing activities it was common practice to utilize some of the crew's time to fish for bait, it is instructive to examine ways of estimating the real costs of such bait fishing as compared to importing bait.

Skipjack tuna can be sold to NAFICOT for A$1.40/kg. This means the opportunity cost of the bait for a fishing trip by the *Manaui* with 3 days of actual fishing comes to A$168-210. Alternatively, the cost of the bait can be estimated by adding the fuel and labor costs of catching the skipjack tuna. During the project, the skiff used about 25 liters of fuel, valued at A$13.73, to conduct the skipjack fishing on each fishing cruise. *Manaui* anchor time fuel costs came to approximately A$19.77 for the 6 hours, bringing total fuel costs to A$33.50. At actually paid fisher wages, the labor cost came to approximately A$57.33, bringing the total fuel plus labor cost of bait fishing to A$90.83. Presuming an additional A$9-10 of miscellaneous costs, this approach also suggests that the bait costs for the *Manaui* amount to approximately A$100, considerably less than the potential revenues foregone by using the skipjack as bait rather than selling it to NAFICOT.

The opportunity cost of fishing for bait would also be relatively high for a commercial venture in Tuvalu. To the extent that fishing for bait meant that bottomfishing time had to be reduced, then the true opportunity cost of bait fishing would be equivalent to the foregone value of potential bottomfish catch. Assuming a vessel with 2 reels, a CPUE of 4 kg of exportable fish and 2 kg of locally marketable fish per line hour, a net return over packing and shipping costs of A$4.50 per kg of exportable fish, and a return of A$1.40 on locally marketable fish, then each hour of bottomfishing time sacrificed to bait fishing is costing the operation A$41.60 in foregone income. So, according to the above assumptions, even if only 1-1/2 hours per day of bottomfishing were sacrificed to bait fishing, the opportunity cost of fishing for bait would amount to A$187.20 for each fishing trip with 3 fishing days. This suggests that it would be economically wise to import bait if it could be obtained for less than about A$5.20-A$6.24 per kg.

As the above calculations suggest, bait fishing is actually a relatively expensive way of obtaining bottomfishing bait. It is likely that frozen bait could be imported to Tuvalu for A$4.00-A$5.00/kg. However, because of other constraints, it is unlikely that substantial savings could be attributed to importing bait for bottomfishing purposes. Freezer capacity is quite limited in Tuvalu and the costs of electricity are extremely high, so despite the relatively high opportunity costs of using skipjack tuna for bait, it is likely that a commercial venture will continue the practice of fishing locally for bait or buying skipjack or other bait from local fishermen rather than importing bait.

3.3.5 Crew provisions

Crew provisions for 6-7 day bottomfishing trips on the *Manaui* during project fishing trials ranged from about A$4.50/day to about A$5.90/day, with the average being somewhat above A$5.00/day per person. Apparently, GOT regulations require a minimum of A$5.00/day per person be provided for crew provisions. Accordingly, the 7 person *Manaui* crew (including the captain, mate, engineer, bosun, 2 fishermen, and a cook) required a minimum of A$35/day, or A$210-245 per 6-7 day fishing trip, for provisions. A commercial operation, utilizing a more appropriate commercial bottomfishing vessel with a crew of 3 persons (including the skipper and 2 fishermen), would almost certainly offer less luxurious provisions. How much less luxurious is simply not known.

Since Tuvalu has no experience with fishing operations similar to that required by the potential commercial bottomfishing, there are few benchmarks by which to gauge what level of provisions would be viewed as satisfactory by a crew. The typical commercial operator in the somewhat similar Tongan bottomfishing industry spent the equivalent of about A$2.00-A$2.25 per day per crew member, but these provisions are also viewed as quite spartan, both by the outside observers and the fishermen themselves. Discussions with Tuvaluans with sea going experience and a good understanding of local conditions have led this author to the conclusion that approximately A$2.50-A$3.00 per day per crew member for provisions would be considered satisfactory by crew members and potential boat owners. For purposes of costing a typical commercial bottomfishing operation in Tuvalu, therefore, this study will use A$3.00/day per crew member for provisions. Provisions for a 3 person crew for a 5 day fishing trip would cost approximately A$45.

3.3.6 Crew wages

As in the case of estimating crew provisions, Tuvalu has no commercial fishing experience on which to base reliable estimates of wages or the method of sharing the fish catch between the owner, the skipper and the crew. In commercial bottomfishing, the hours are long, the work is risky and hard, the crew members are

away from home for long periods and for much of the year. These factors suggest that typical crew wages must be substantially higher than ordinary government wages in order to keep an experienced crew member throughout the fishing season. Furthermore, the absence of traditional methods of sharing the fish catch among the owner, the skipper, and the fishermen suggests that a newly developing commercial bottomfishing industry will have to experiment with sharing arrangements in order to adapt to local views regarding equity or fairness.

It is instructive to begin by examining crew wages paid by the Department of Fisheries to the crew of the *Manaui*. Current hourly wages for the standard 6 person crew of the *Manaui* are shown in Table 3-3 below.

Table 3-3. Standard *Manaui* crew wages

Crew Member	Standard Hourly Wage	Standard Weekly Wage (36 hrs)
Skipper	A$1.83/hr	A$65.75
Engineer	A$2.57/hr	A$92.50
Bosun	A$1.07/hr	A$57.60
Crew (3 persons)	A$1.01/hr	A$56.93

The standard hourly wages in Table 3-3 are those paid for the first 8 hours worked during Monday through Thursday and the first 4 hours worked on Friday. Overtime hours worked Monday through Saturday are paid at the rate of 1-1/2 times the base hourly wage. All hours worked on Sunday are compensated at 2 times the base hourly wage.

A fishing trip that departs for distant seamount bottomfishing on Friday morning can engage in fishing for 3 days, from Saturday through Monday, return to Funafuti on Tuesday, and pack and ship the fish on Wednesday morning. Such a fishing trip would include one 8-hour day of steaming each to and from the distant seamounts, three 12-hour days of fishing, and one 8-hour day landing, packing, and shipping the fish. Given the government overtime rules described above, crew members would deserve compensation for the equivalent of 82 hours at their regular hourly rate, or 2.28 times the crew's standard weekly wages for the regular 36-hour week. In practice the crew members may be discouraged from turning in requests for such large amounts of overtime, and it should be noted that the Department of Fisheries often gives compensatory time off rather than actually paying the crew the full amount of overtime. Nonetheless, this example shows the general range of compensation expected by Tuvaluan government fishermen and crew members for going out to sea. The *Manaui* crew wage bill for the above described fishing trip is summarized in Table 3-4 below.

Table 3-4. Fishing cruise wages on the *Manaui*

Crew Member	Crew Wages For Cruise (A$)
Skipper	$149.76
Engineer	$210.69
Bosun	$ 87.47
Crew Member #1	$ 86.43
Crew Member #2	$ 86.43
Crew Member #3	$ 86.43
Total Crew Wages	$707.18

By comparison, NAFICOT pays fishermen who take its 9 m vessels out for a day of fishing earn a base wage of A$0.80/hr, or A$28.80 for a 35 hr week, plus a bonus of $A1.80/kg for all fish caught beyond 50 kg per day. It has been reported that the NAFICOT payment method is not considered attractive to most fishermen and that fishermen seldom catch beyond the 50 kg per day required to earn the bonus.

Unfortunately, these government worker wages provide little guide to what a commercial bottomfishing operator would have to pay crew members, particularly in view of the government overtime payment policies. In view of the absence of experience with commercial bottomfishing or related activities, it is not possible to precisely estimate a reservation wage (i.e., the wage below which potential crew members would choose unemployment rather than work) for crew members engaged in distant seamount bottomfishing. However, based on discussions with local fishermen, it has been concluded that a commercial bottomfishing venture would be required to pay crew members approximately A$65-A$80 per weekly cruise to compensate the crew sufficiently for the difficult conditions to avoid rapid turnover of crew members. This suggests that, at 30 cruises per year, a typical crew member would earn A$1,950-A$2,400 per year to compensate for the difficult seagoing conditions of work and being away from home about 150 nights of the year.

It is common practice in the fishing industry to pay crew members in proportion to the catch, or its value. By tying wages to the value of the catch, the crew members have financial incentives to work hard, to catch more fish, and to handle high-valued marketable fish with proper care. Since the crew costs are one element of the overall costs, this means that costs and return are interdependent. The shares must be set appropriately to insure, simultaneously, that the crew receives a fair share and an adequate wage <u>and</u> that the vessel owner can pay off a loan on the vessel, maintain the vessel, and earn a fair and adequate rate of return. The determination of crew

shares cannot be calculated independently of the determination of the return to the owner. However, in order to indicate how crew shares may be determined in a Tuvalu commercial bottomfishing operation, the following example is presented.

A small commercial bottomfishing vessel with 20 line hours of bottomfishing on each of 3 fishing days with a CPUE of 4 kg for exportable species and a CPUE of 2 kg for locally marketable species would catch 240 kg of exportable fish and 120 kg of locally marketable fish. At sales revenues (net of marketing expenses) of A$1.40/kg for locally marketed fish and A$3.68/kg for exported fish, this catch would yield A$1,051.20. After deducting running costs of A$344 (based on the summary costs of a representative fishing trip in a small vessel, as described below), there would be A$707 available to share between the vessel owner and the crew. If the vessel owner received a 60% share and the crew received a 40% share of the returns net of running and marketing costs, the crew would receive A$282.88 per fishing trip. If the skipper received 50% of the crew wages and the 2 fishermen split the other 50% of crew wages, then the skipper would receive A$141.44 per fishing trip (or A$4,243 for 30 fishing trips per year) and each crew member would receive A$70.72 per fishing trip (or A$2,122 for 30 fishing trips per year).

Thus, a 60%-40% share of returns net of fishing and marketing expenses between the owner and the crew, with the skipper receiving 2 times the wage of each crew member, could reasonably assure the skipper and crew members of per cruise wages above the presumed minimum necessary to keep a trained crew steadily employed. The per cruise wages would also be slightly higher than the substantial "government" wages with overtime pay on a typical *Manaui* fishing trip. The vessel owner would receive A$424.32 per fishing trip, or $12,730 for 30 trips per year, an amount which, as will be discussed below, should be sufficient to cover the investment and fixed costs of the operation while yielding an acceptable rate of return. While this report treats the roles of skipper and vessel owner separately because of their different economic functions, in practice it is common for a vessel owner to also be a working skipper. Naturally, these projected returns and wages are based on the above assumed catches, costs, and revenues. The consequences for both crew wages and owner rate of return of modest variations in catches, costs, and returns will be explored in following sections.

The choice of a 60%-40% sharing of net sales revenues between owner and crew was an arbitrary one, but one which yielded acceptable levels of wages and returns on investment. Similarly, the 50%-50% sharing of wages between the skipper and the other crew members was also an arbitrary division. Such sharing arrangements vary from country to country and from fishery to fishery. The acceptability of the sharing arrangement depends on local custom and practice, reservation wages of crew members, views on profiting from commercial activities and income inequality, and a myriad of other factors. A fair and acceptable sharing arrangement will have to worked out in practice as the bottomfishing industry develops in Tuvalu.

3.3.7 Gear replacement and miscellaneous costs

In addition to the above discussed cost items, there are also two other minor items which must be included. First, there is the matter of gear replacement. While difficult to measure, based on project experience in the fishing trials, an allowance of A$25 per fishing trip has been made for gear replacement. In addition, there are a variety of miscellaneous costs which invariably arise. These have also been estimated at A$25 per fishing trip.

3.3.8 Summary running costs for a representative fishing trip

Based on the discussion above of each element in the running costs of a typical fishing trip, fishing costs are estimated for a typical 5-day fishing trip for both the government vessel, the *Manaui*, and a more suitable commercial bottomfishing vessel. These results are shown in Table 3-5 below.

Table 3-5. Summary running costs for a typical 5-day fishing trip

Cost Category	*Manaui* 6-person crew	Commercial Vessel 3-person crew
Fuel	A$1,087	A$124
Ice	A$ 125	A$125
Bait	A$ 0	A$ 0
Crew Provisions	A$ 150	A$ 45
Crew Wages	A$ 707	A$347
Gear Replacement	A$ 25	A$ 25
Miscellaneous	A$ 25	A$ 25
Total Cost Per Trip	A$2,119	A$691

The running costs of the "representative" commercial vessel will be used in later sections of this report in the calculations of rates of return on investment in commercial bottomfishing in Tuvalu. The running costs of the *Manaui* have been shown, by comparison, to highlight the inappropriateness of using the *Manaui* for commercial bottomfishing purposes. However, the GOT may want to continue using the *Manaui* for bottomfishing trials and training cruises until a commercial operator becomes established. In this event, as other sections will make clear, most of *Manaui's* high running costs could be covered by fish sales resulting from fishing trials, thereby making the training almost self-financing.

27

3.4 Summary of resources, catch projections and fishing costs

This section has shown that Tuvalu has modest distant seamount bottomfish resources which are indeed exploitable. It also has modest bottomfish resources near its atolls, but these resources have been treated separately, partly because assessing the feasibility of distant seamount bottomfishing was the principal objective of the project and partly because incorporating these near-atoll resources into the overall resource management plan raises special political and resource ownership issues. The catch projections are substantial enough to warrant an exploration of the potential returns from commercially fishing for bottomfish and exporting the higher valued species. A detailed discussion of projected fishing costs was presented in order to highlight the actual conditions which must be confronted by potential investors and commercial bottomfishing operators.

4.0 MARKETING POTENTIALS, REVENUES AND COSTS

This section reviews the marketing potentials, costs, and revenues of exporting bottomfish from Tuvalu to Hawaii. This discussion highlights the importance of maintaining high catch rates of the higher-valued exportable bottomfish species.

4.1 Exportable and locally marketable fish catches

During the bottomfishing trials, the catch included a wide range of species, some of which could not bring acceptable prices on the export market and were therefore marketed locally. The commercial fishing trips on which the 7 export marketing trials were based provided an average of 244 kg of exportable fish and 180 kg of locally marketable species. The final 3 commercial fishing cruises, on which the final 3 export marketing trials were based, provided 267 kg of exportable fish and 135 kg of locally marketable fish. Based on project catch and marketing experience by species, it can be assumed that a commercial operation targeting higher-valued exportable bottomfish will be able to export about two-thirds of its catch and to market locally the remaining one-third of its catch.

In conducting the commercial feasibility analysis of bottomfishing in Tuvalu, it has been assumed that a "typical" 5-day fishing cruise will contain 2 days of cruising to and from the fishing grounds and 3 days of fishing. Each fishing day consists of containing 20 line hours of fishing, so that each fish trip consists of 60 line hours of fishing. Assuming a CPUE of 4-5 kg per line hour for exportable species and 2.0-2.5 kg per line hour for locally marketable species, the total marketable catch will range from 360 kg, of which 240 kg are exportable and 120 kg are locally marketable, to 450 kg, of which 300 kg are exportable and 150 are locally marketable.

4.2 Local marketing and expected prices

The project sold all of its locally marketable fish catch through NAFICOT, the parastatal fish marketing company in Tuvalu. While virtually all fishing activity in Tuvalu is for subsistence purposes, there is some marketing of fish through NAFICOT, through a small private operation, by individuals selling their catch directly to neighbors and others, and by sales to the one hotel in Funafuti or to the maritime school. The current price of most fish in Tuvalu is approximately A$2.00/kg, regardless of species. NAFICOT pays fishermen, few of whom actually sell via this marketing channel, and paid to the project A$1.40/kg for its locally marketed fish. A commercial bottomfishing operation assuring regular supplies of high quality fish could probably arrange to sell its locally marketable catch to the maritime school or to the hotel for A$2.00/kg, while incurring very little extra marketing or delivery costs. If it were to sell directly to consumers, a commercial operation would probably be able to obtain A$1.70/kg-A$1.80/kg, net of marketing expenses. However, for purposes of conducting the commercial feasibility analysis, it has been assumed that commercial operations would sell their catches through NAFICOT for A$1.40/kg. Alternative local

marketing arrangements could perhaps yield an additional net revenue of A$40-A$60 per fishing trip, or A$1,200-A$1,800 per 30 fishing trips per year. Accordingly, a commercial operation can probably be expected to seek an alternative local marketing arrangement.

4.3 Export marketing and expected prices

The project conducted 7 export marketing trials during 1994. All of the shipments were air freighted on Air Marshall Islands from Funafuti, Tuvalu to Nadi, Fiji, and then transhipped on to Honolulu, Hawaii. The export marketing shipments contained mainly bottomfish, although some non-bottomfish, principally *Acanthocybium solandri*, more commonly known as "ono" Hawaiian or "wahoo" in English, were shipped. Also, export trials were principally to Honolulu, although there was one forward shipment of bottomfish on from Hawaii to Europe. While the marketability of various bottomfish species in international markets constantly varies according to specific supply and demand conditions, this project experience in exporting bottomfish to Hawaii provides a firm basis on which to evaluate the current marketability and expected price situation.

The marketability of the various exportable species is summarized below. The expected prices are comparable to project experience during the export marketing trials. However, these prices were confirmed in discussions with Hawaiian fish importers and can be viewed as "typical" prices obtainable by a Tuvaluan bottomfish exporter under current market conditions if export quality is maintained.

There are two primary market species (commonly caught on Tuvalu's distant seamounts) which have consistently received the highest prices in Hawaii, *Etelis coruscans* (longtail red snapper or onaga) and *Pristipomoides filamentosus* (ruby snapper or opakapaka). During the export marketing trials, these two species consistently received about A$10.40/kg and A$10.10/kg, respectively, in Hawaii. The *E. coruscans* received upwards of A$13.00/kg and the *P. filamentosus* received upwards of A$11.00/kg in some trials, but these high prices were not received consistently. The *Pristopomoides flavipinnis* (yelloweye snapper or yelloweye opakapaka) consistently received about A$8.90/kg in Hawaii, which is less than the two primary export species. The *Etilis carbunculus* (shorttail red snapper or ehu) is very common in the Tuvaluan fishery, but they are principally older, larger fish which do not receive high prices. These received about A$7.40/kg in Hawaii, but smaller fish (< 5 kg), particularly available after the stock of larger fish has been reduced in the fishery, could be expected to receive up to A$8.90/kg in Hawaii. Both the *Aprion virescens* (green jobfish or uku) and *Aphareus rutilans* (red jobfish or lehi) received about A$8.60/kg. At the lower end of marketability, the *Pristipomoides zonatus* (flower snapper or gindai) received about A$6.70/kg. There is an array of lower-valued bottomfish species, including *Etilis radiosus* and *Epinephelus morrhua*, which should be able to obtain from A$6.70/kg to A$8.60/kg, depending on the size and

30

condition of the fish as well as the current market conditions in Hawaii. This overview of bottomfish marketability in Hawaii is summarized in Table 4-1 below. (For more on marketability, see Bartram 1994b.)

Table 4-1. Names, marketability, and expected prices of bottomfish species in the Hawaii market

Scientific Name	English Name	Hawaiian Name	Tuvaluan Name	Marketability	Expected Price, A$/Kg
Etelis coruscans	Longtail red snapper	Onaga	Palu malau loa	Primary market species (>2.5 kg)	A$10.40
Pristipomoides filamentosus	Ruby snapper	Opakapaka	Palua sega	Primary market species (>2.5 kg)	A$10.10
Pristipomoides flavipinnis	Yelloweye snapper	Yelloweye opakapaka	Palu sega	Secondary market species	A$8.90
Aprion virescens	Green jobfish	Uku	Uta	Secondary market species	A$8.60
Aphareus rutilans	Red jobfish	Lehi	Palu sega	Secondary market species	A$8.60
Etelis carbunculus	Shorttail red snapper	Ehu	Palu malau	Secondary species, > 5kg; Primary species, < 5kg	A$7.40, >5kg; A$8.90, <5kg
Pristipomoides zonatus	Flower snapper	Gindai	Palu savane	Secondary market species	A$6.70
	Other bottomfish			Secondary market species	A$6.70 - A$8.60

While the project has been primarily concerned with bottomfish, during the fishing trials the crew trolled for *Acanthocybium solandri* (wahoo or ono), a pelagic species, which are abundant near several of the seamount areas, and successfully exported them to Hawaii. Although the during the export marketing trials, the wahoo were typically sold for A$7.40/kg to A$8.15/kg, fish importers in Hawaii suggested that wahoo should be able to obtain an average annual price as high as A$9.65/kg. A commercial bottomfishing operation would probably not devote extra time to searching for the wahoo, project but experience suggests that catch rates justify trolling for them as an alternative to bottomfishing when they are found in abundance.

The export marketing trials were undertaken during the project as the crews were mastering the techniques of bottomfishing and of targeting the higher-valued deep water species. As the targeting improved, the export marketing trials contained higher and higher proportions of higher-valued fish. For example, the average price received in the first 4 export marketing trials was only A$8.00/kg, while the average price received in the final 3 export marketing trials was A$8.74/kg. Based on CPUEs by species, however, a commercial bottomfishing operation should be able to increase the proportion of higher-valued species beyond that of even the final fishing trials. Accordingly, in order to estimate the average price of exportable fish, average values for high-, medium-, and low-valued fish were estimated at A$10.25/kg, A$8.61/kg, and A$6.68/kg, respectively. Then, 2 alternative species compositions of export shipments were assumed as follows. A relatively high-valued species composition is assumed to include 65% of high-valued fish, 25% of medium-valued fish, and 10% of low-valued fish, while a relatively low-valued species composition is assumed to include only 50% of high-valued fish, 30% of medium-valued fish, and 20% of low-valued fish. An export shipment with the higher-valued species composition would bring an average price of A$9.48/kg, while a lower-valued species composition would bring an average of A$9.04/kg. These values are summarized in Table 4-2 below.

Table 4-2. Expected fish prices for export shipments with a higher and lower proportion of higher-valued species

Relative Value	Expected Price (A$/kg)	Low % of High-Valued Fish	High % of High-Valued Fish
High	A$10.25	50%	0.65
Medium	A$ 8.61	30%	0.25
Low	A$ 6.68	20%	10%
Average Price for Export Shipment, A$/kg		A$9.04	A$9.48

This range of expected prices for bottomfish exported to Hawaii, from A$9.04/kg to A$9.48/kg, is higher than the A$8.74/kg actually received by the project during its commercial fishing and export marketing trials. However, a commercial bottomfishing operation is likely to be able to received higher prices once it establishes itself in the market, can assure regular shipments of high quality fish, is successful in targeting higher-valued species, and maintains high quality handling and shipping procedures. A survey of bottomfish landings from the Northwestern Hawaiian Islands showed that in 1993, all bottomfish species yielded the equivalent of A$9.65/kg (Hamilton 1994). This suggests that a commercial operation may be able to receive higher prices than those used here. In addition, the RDA Marketing Advisor, who has been involved in the project and is a long-time participant in and observer of the Hawaiian fish markets, believes that a Tuvaluan commercial operation, focusing on higher-valued species, should be able to obtain an annual average price on fish exported to Hawaii in excess of A$10.00/kg (Bartram, pers. comm., 1994a).

4.4 Marketing costs

This section will examine local and export marketing costs. The expected returns net of marketing costs are available to cover the fishing and investment costs. Section 3.3 above reviewed representative fishing costs of catching exportable bottomfish on Tuvalu's distant seamounts. The net return over marketing and fishing costs may then be balanced against initial investment and annual capital costs to determine the expected rate of return on commercial bottomfishing in Tuvalu.

4.4.1 Local marketing costs

As noted above in section 4.2, locally marketable fish currently sells for approximately A$2.00/kg. So when a commercial operator sells the locally marketable catch to NAFICOT for A$1.40/kg, local marketing costs amount to A$0.60/kg. These marketing costs can probably be reduced substantially by marketing through a private channel or by direct marketing to the hotel or the maritime school. Once several bottomfishing operators are landing their catch in Funafuti, however, the direct marketing option will not be readily available. Accordingly, commercial bottomfishing operators will need to incur some local marketing costs to dispose of their locally marketable catch. As suggested above in section 4.2, a commercial operator can probably reduce local marketing costs by 50% or more by going through a private channel rather than using the NAFICOT option.

4.4.2 Export marketing costs

Export marketing costs are extremely high principally due to the fact that there are no direct flights from Funafuti, Tuvalu to Honolulu, Hawaii. Shipments have to be shipped to Nadi, Fiji, and then transhipped onward to Honolulu, Hawaii. Thus, Tuvaluan bottomfish exported to Hawaii must incur the costs of two separate flights

as well as the extra handling costs at the transhipment location in Nadi, Fiji. In addition, of course, there are packing costs, customs and handling costs in Hawaii, and miscellaneous communications and related costs. While the project incurred several cost items which a commercial bottomfish exporter would not normally have to incur, these extra costs have been netted out of the data presented below in the review of export marketing costs.

4.4.2.1 Packing costs

Bottomfish are exported whole to Hawaii. Fish handling to maintain high quality begins onboard when the fish are killed quickly with a spike and are immediately chilled to about 0°C in an ice-sea water slurry that also contains some fish preservative. The head and eyes of each fish are then covered with green parchment paper and stored in ice. After the fish are landed, they are individually weighed and packed in a heavy-duty carton of wax-impregnated cardboard which is fitted with a layer of thermal barrier insulation, "insufoil," protecting the inner layer of fish enclosed in a plastic liner. Bags of frozen coolant separate layers of fish. See Bartram 1994 for more details on the handling and packing process.

The heavy-duty waxed cardboard boxes are the most expensive item involved in the packing for shipment. Boxes are available in Fiji at a cost ranging from about A$22.00 per box if purchased in lots of 350 boxes to about A$29.00 per box if purchased in lots of 1,000 boxes. While less expensive boxes may available, these were prices quoted by Golden Manufacturers Limited in Suva, Fiji, as this report was being drafted. Since approximately 40 kg of fish can be packed in each carton, the cost of the boxes amounts to about A$0.55/kg to A$0.73/kg of fish exported. During the project export marketing trials, the other export handling and packing materials, including the fish preservative, the green parchment paper, the "insufoil," the plastic sheeting, the plastic bags for freezing ice packs, and miscellaneous items such as tape added up to about A$0.10/kg to A$0.12/kg. In sum, the packing costs can be expected to range from about A$0.65/kg to about A$0.85/kg of fish. Accordingly, for the commercial feasibility analysis, packing costs will be assumed to amount to A$0.75/kg of exported fish.

4.4.2.2 Shipping costs

There is only one air carrier, Air Marshall Islands, serving the route from Funafuti, Tuvalu to Nadi, Fiji. Also, since Honolulu service from Nadi by Quantas has been discontinued, there is only one air carrier, Air New Zealand, serving the connecting flight enroute from Nadi, Fiji to Honolulu, Hawaii. Furthermore, there is only one flight from Tuvalu to Fiji, departing mid-day on Wednesdays, which makes a good connection with a flight onward from Fiji to Hawaii. Air freight costs are relatively high because of this lack of competition. Fortunately, however, the arriving Air Marshall Islands flight originates in Fiji so that only Tuvaluan passengers and freight

are on the departing flight from Funafuti. This means that there are no serious limitations on the size or weight of bottomfish export shipments. Furthermore, the competing connections between Nadi and Honolulu have only recently been discontinued, so it is not unlikely that air freight costs will increase over the next year.

Air freight costs on Air Marshall Islands from Funafuti to Nadi currently amount to A$1.25/kg. Packing materials added about 21% to 35% to the weight of the fish over the 7 export marketing trials, with greater economy in packing material weight resulting as the trials proceeded. While a commercial operation may be able to achieve greater economy, the project export trial average of 30% additional weight added to shipments by packing materials will be used in the following calculations. Air freight costs from Funafuti to Nadi per kg of fish are thus estimated at A$1.62/kg.

The project used a freight forwarder in Nadi to handle the export shipments at the Nadi airport, to put the cartons in refrigerated storage, and ensure that the cartons got on the connecting flight to Honolulu. The total transhipping costs averaged A$2.04/kg, with air freight charges from Nadi to Honolulu amounting to A$1.67/kg and customs, handling, refrigerated storage and related charges amounting to A$0.37/kg. Per kg of fish shipped, the transhipping costs averaged A$2.63/kg, divided between air freight (A$2.15/kg) and other charges (A$0.48/kg). Together, the shipping costs from Funafuti to Nadi (A$1.62/kg) and from Nadi to Honolulu (A$2.63/kg) amounted to A$4.25/kg of fish.

4.4.2.3 Other marketing costs

Customs and handling on entering Hawaii amounted to approximately A$0.60/kg of fish. Miscellaneous marketing costs, to cover such things as telephone and fax communications, wire transfers, and related items, were estimated at another A$0.20/kg of fish.

4.4.2.4 Summary of export marketing costs

Based on project experience, the total export marketing costs of Tuvaluan bottomfish sold in Honolulu can be expected to amount to A$5.80/kg of shipped fish. The detailed costs are summarized in Table 4-3 below.

Table 4-3. Export marketing costs

Item	Cost Per Kg of Fish, in A$
Packing materials	A$0.75
Shipping to Nadi	A$1.62
Transhipment to Honolulu	A$2.63
Customs and handling	A$0.60
Miscellaneous	A$0.20
Total export marketing costs	A$5.80

4.5 Summary of marketing revenues and costs

Locally marketed fish can be expected to receive A$1.40/kg, although a commercial operator might be able to sell the catch directly or through private marketing channels and receive up to A$1.70/kg or more.

Export prices were estimated to range from an average of A$9.04/kg to A$9.48/kg. After netting out the total export marketing costs of A$5.80/kg, the gross margin on export sales is estimated to range from about A$3.24/kg to A$3.68/kg, with an average of A$3.46/kg of fish. Even after absorbing the extremely high packing and shipping costs, the gross margin on exporting bottomfish, before accounting for fishing and capital costs, comes to roughly 2.5 times the margin on locally marketed fish.

5.0 COMMERCIAL FEASIBILITY OF BOTTOMFISHING IN TUVALU

Having reviewed prospective bottomfish fishing and export marketing costs and revenues, we are now in a position to draw the analysis together to determine the commercial feasibility of bottomfishing in Tuvalu.

5.1 Investment and fixed costs of bottomfishing in Tuvalu

As discussed in section 3.3.1 above, we will assume that an appropriate and fully equipped bottomfishing vessel can be obtained for an initial investment of A$40,000. The components of this A$40,000 are roughly divided as outlined in Table 5-1. A basic vessel is expected to cost approximately A$20,000 and a 20 hp Yanmar diesel inboard can be had new for approximately A$10,000. Equipment onboard is estimated at approximately A$7,500, including a radio (A$250), GPS (A$1,500), echo-sounder (A$1,800), auto-pilot system (A$700), a 2 hydraulic reel system (A$3,000), and miscellaneous items (A$250). Fishing gear (not including the hydraulic reel system) and miscellaneous items are estimated to cost A$2,500. This brings the total fully-equipped vessel cost to A$40,000. (It is recognized that there are many required items which have not been included here. For example, there are ice boxes for storing fish onboard, life preservers and safety equipment, mooring ropes, and other items which must be available as part of a bottomfishing operation. However, the presentation of the costs of a fully-equipped bottomfishing vessel are schematic; the important consideration is that the total investment in an equipped vessel is assumed to be available for A$40,000, regardless of the components which make up the total amount.)

An additional component of the initial investment cost is the required operating capital. It is assumed here that A$10,000 is an adequate amount to allow for operating capital. This is undoubtedly a very modest allowance for operating capital. In any commercial bottomfishing operation, there will be many requirements for operating capital. For example, supplies of spare fishing gear, miscellaneous tools and replacement parts, inventories of packing cartons and supplies, and related items can quickly add up to a substantial amount of investment. Crew provisions and wages must be paid for a considerable period before the sales revenues from export sales are available. Air freight costs must be paid in advance of receiving payment on the shipments, and there will undoubtedly be delays between the time the fish are sold in Honolulu and when the funds are available to the Tuvaluan bottomfishing operator. Thus, while an allowance of only A$10,000 is being made for operating capital, in practice, a beginning bottomfishing operator in Tuvalu will have to balance vessel and operating cost demands to fit within an initial investment budget of A$50,000. In the analysis below, the impact of increasing the initial investment cost on the projected rates of return will be examined.

These initial investment costs are summarized in Table 5-1 below.

Table 5-1. Initial investment costs for a bottomfishing operation in Tuvalu

Item		Cost, A$
Vessel, fully equipped		A$40,000
Vessel hull, 10+m	A$20,000	
Engine (20hp inboard diesel)	A$10,000	
Equipment (SSB, radio, GPS, echo-sounder, reels, etc.)	A$7,500	
Gear & miscellaneous	A$2,500	
Operating capital		A$10,000
TOTAL INITIAL INVESTMENT		A$50,000

This initial A$50,000 invested will need to earn an acceptable rate of return, whether it is put up by a private investor or borrowed from the Tuvalu Development Bank. Since the going rate of interest on Tuvalu Development Bank loans is 8%, this is a fair estimate of the opportunity cost of the capital required.

The annual fixed costs of a bottomfishing operation will also need to covered by the operating revenues before the net revenues can be compared to the initial investment to determine the projected rate of return on the investment. A commercial operator will need to allow for vessel and engine depreciation (estimated at 10% per year); vessel repair and maintenance (estimated at 5% per year); equipment repair, maintenance, and replacement (estimated at 20% per year); fishing gear repair, maintenance, and replacement (estimated at 33.3% per year); vessel insurance (estimated at 3% of the value of the vessel per year); and interest on invested capital (estimated at 8% annually). The annual fixed costs for the vessel described above are summarized in Table 5-2 below.

Table 5-2. Annual fixed costs

Item	A$
Vessel and engine depreciation (10% per year; 10-year straight-line depreciation)	$ 3,000
Vessel repair and maintenance (5% per year)	$ 1,500
Equipment repair, maintenance, and replacement (20% per year)	$ 1,500
Gear repair, maintenance, and replacement (33.3% per year)	$ 833
Vessel insurance (3% per year)	$ 1,200
Interest on invested capital (8% per year)	$ 4,000
TOTAL ANNUAL FIXED COSTS	$12,033

Only the vessel repair and maintenance; the equipment and gear repair, maintenance, and replacement; and the vessel insurance are included in the calculations of the rate of return on investment. The allowance for vessel depreciation in embedded in the rate of return calculation, and the interest on invested capital (or the opportunity cost of capital) is based on the interest rate which is compared with the calculated rate of return to determine if the investment is indeed a profitable one. There are also additional management costs of each bottomfishing operation which have not been included here. When examining the return on the investment and effort involved, the vessel owner, whether he is the skipper or not, will need to allow for this management element when examining whether or not the rate of return is adequate to justify the initial investment.

5.2 Profitability of bottomfishing in Tuvalu

We now have all the information required to calculate the prospective rate of return on investment in a bottomfishing operation in Tuvalu. Initially, we will examine 4 basic scenarios, with 2 alternative catch rates and 2 alternative species compositions in the catches. After the rates of return on these 4 scenarios have been calculated, the impact of changes in the level of the initial investment, in the assumed number fishing trips per year, in fuel costs, in the price received on locally marketed fish, and in the prices received on exported fish will be examined

The 4 scenarios which include 2 scenarios assuming overall CPUEs of 6 kg per line hour of fishing, one with a high proportion (66%) of high-valued export quality fish

and one with a lower proportion (50%) of high-valued export quality fish, and 2 scenarios assuming overall CPUEs of 7.5 kg per line hour of fishing, one with a high proportion of high-valued export quality fish and one with a lower proportion of high-valued export fish. (See Table 4-2 on page 4-5 above.)

The fishery is assumed to be fished optimally, so that the average fishing trip involves a steaming distance to the fishing grounds of 178.5 miles, as discussed above in section 2.0. The vessel is assumed to cruise at 6.5 knots per hour, using 3 liters of fuel per hour of cruising. Other running costs are comparable to those outlined in section 3.3 above. Marketing and shipping costs are assumed to be A$5.80/kg of fish exported, as outlined in section 4.4.2 above. Locally marketed fish are assumed to sell for A$1.40/kg. The crew is assumed to be receive 40% of the net revenues after fishing and marketing costs are deducted, as discussed above in section 3.3.6. The owner receives the other 60% of the net revenues after fishing and marketing costs are deducted. Each fishing trip is assumed to include 2 days of cruising to and from the seamount fishing area and 3 days of fishing. It is assumed that there are 60 line hours of fishing effort per fishing trip.

The initial investment is assumed to be A$50,000, as in Table 5-1. Annual fixed costs are assumed to be those presented in Table 5-2. The vessel is assumed to last for 10 years and be sold for 15% of its initial value at the end of the 10 year period. Fishing effort is assumed to be at half the normal level in the first year to allow for difficulties in starting up the operation.

The alternative fishing scenarios and the corresponding rates of return on investment are summarized in Table 5-3.

Table 5-3. Rates of return on investment in bottomfishing in Tuvalu

	Low Catch Rate	Low Catch Rate	High Catch Rate	High Catch Rate
	Low % of High Valued Species	High % of High Valued Species	Low % of High Valued Species	High % of High Valued Species
CPUE, kg/line hour	6	6	7.5	7.5
Total catch, kg	360 kg	360 kg	450 kg	450 kg
Export species	240 kg	240 kg	300 kg	300 kg
Local species	120 kg	120 kg	150 kg	150 kg
Export fish prices	A$9.04	A$9.48	A$9.04	A$9.48
Total export revenues	A$2,170	A$2,276	A$2,713	A$2,845
Marketing costs per kg	A$5.80	A$5.80	A$5.80	A$5.80
Total marketing costs	A$1,392	A$1,392	A$1,740	A$1,740
Margin on exports	A$778	A$884	A$973	A$1,105
Local fish prices	A$1.40	A$1.40	A$1.40	A$1.40
Total local sales revenues	A$168	A$168	A$210	A$210
Total sales revenues, net of shipping and marketing costs	A$946	A$1,052	A$1,183	A$1,315
Fishing costs, except for crew wages	A$344	A$344	A$344	A$344
Total sales revenues, net of shipping, marketing and fishing costs	A$602	A$708	A$839	A$971
Crew share per trip, 40% of net revenues	A$241	A$283	A$336	A$388
Skipper share	A$120	A$141	A$168	A$194
Fishermen share (for each of 2 crew members)	A$60	A$71	A$84	A$97
Owner share per trip, 60% of net revenues	A$361	A$425	A$503	A$582
Owner share on 30 fishing trips per year (except for only 15 trips in start up year 1)	A$10,845	A$12,737	A$15,104	A$17,469
Initial capital investment (assuming a vessel cost of A$40,000 and a 15% salvage value after 10 years)	A$50,000	A$50,000	A$50,000	A$50,000
Annual fixed costs	A$5,033	A$5,033	A$5,033	A$5,033
Annual net revenue over marketing and fishing costs	A$5,812	A$7,705	A$10,071	A$12,437
INTERNAL RATE OF RETURN	7.4%	12.3%	19.2%	26.1%
NET PRESENT VALUE	(A$6,280)	A$5,542	A$20,327	A$35,105

Given the various assumptions behind the calculations in Table 5-3, it can be seen that only 3 of the 4 fishing scenarios yields a rate of return over cost that exceeds the opportunity cost of capital, 8%. The first scenario, with a relatively low overall catch rate and a relatively low composition of high-valued export species, yields a rate of return of only 7.4%, which is below the 8% reference interest rate, and thus is not a favorable investment opportunity. The other three fishing scenarios do in fact yield rates of return which justify investing in this type of fishing enterprise. As one would expect, however, only the 2 scenarios with higher catch rates (CPUEs of 7.5 kg per line hour) yield rates of return, 19.2% and 26.1%, sufficient to justify the investment given the normal risks and uncertainties associated with commercial fishing opportunities.

The net present values of returns over costs for the 4 scenarios have also been calculated for reference. The net present value is calculated by subtracting the initial investment cost (A$50,000) away from the annual flow of net returns discounted by the appropriate rate of discount or opportunity cost of capital (which is 8% in this case). The net present value is negative in the first low catch rate scenario, and it is still quite low (A$5,542) in the low catch scenario with a higher proportion of high-valued species in the catch. However, both of the high catch rate scenarios yield net present values sufficiently high to warrant potential investments in the bottomfishing operation.

Turning attention to the rates of return, one of the key implications of these rates of return on investment is that investors need to be assured that the fishery will be well managed and that entry will be limited. Maintaining CPUEs of 7.5 kg per line hour of effort will be possible only if the number of vessels is limited and if fishing effort on the various fishing grounds is moderated. Tuvalu's distant seamounts, and most of the atolls' submarine slopes, are virgin bottomfishing grounds. It is not uncommon for the high CPUEs on virgin fishing grounds to fall steadily as fishing pressure continues. Therefore, the modest projected rates of return on investment in bottomfishing on Tuvalu's distant seamounts suggest that the size of the industry and the degree of exploitation of the fishery will always need to be kept small.

Another implication of these rates of return on investment is that targeting the higher-valued export species is a necessity. Whether the overall catch is relatively high or relatively low, the rate of return on investment increases substantially (4.9% for the lower CPUE case and 6.9% for the higher CPUE case) when the proportion of higher-valued export species in the catch increases from only 50% to 66.6% of the total catch. Improved targeting of high-valued species turns an unfavorable investment into a slightly favorable one in the low catch rate scenarios, and raises the net present value of the investment opportunity by 73% (from A$20,327 to A$35,105) in the high catch rate scenarios.

As noted in section 3.0 on page 3-7, by increasing effort (i.e., line hours) by 25%, to 75 rather than 60 line hours per fishing trip, a commercial operator could obtain the same total catch even if CPUEs were 20% lower than those assumed. The effort can be increased, even with the same 3-person crew, by fishing longer hours per day or by having the skipper operate a third reel part of the time. A 25% increase in effort would raise the rates of return on the 2 low catch rate scenarios up to those of the 2 high catch rate scenarios (19.2% and 26.1%) and raise the rates of return on the 2 high catch rate scenarios to 34.8% and 43.9%. This illustrates a key factor which will determine success or failure of a bottomfishing venture in Tuvalu, namely, hard work. With the same technology, knowledge, skill, and initial investment, working longer hours can turn a marginally profitable operation into a highly profitable one.

It is now appropriate to examine the sensitivity of the rates of return in Table 5-3 to changes in the assumptions. Table 5-4 below shows the calculated prospective rates of return on investment in Tuvaluan bottomfishing under various alternative assumptions.

Table 5-4. The sensitivity of rates of return on investment in bottomfishing in Tuvalu

	Base Scenarios (reproduced from Table 5-3 above)	10% reduction in initial investment, A$45,000 initial investment	10% increase in initial investment, A$55,000 initial investment	Increase in fishing trips per year to 35	Doubling of fuel costs	Local fish sales revenues increase to A$1.70/kg	10% decrease in price of exported fish	10% increase in price of exported fish
Low catch rate								
Low % of high-valued species	7.4%	10.2%	3.9%	13.1%	0.3%	9.4%	---	19.7%
High % of high-valued species	12.3%	16.2%	9.1%	18.5%	5.8%	14.2%	0.1%	24.2%
High catch rate								
Low % of high-valued species	19.2%	23.8%	15.4%	26.5%	12.7%	21.5%	4.9%	33.5%
High % of high-valued species	26.1%	31.5%	21.6%	34.7%	19.6%	28.4%	11.2%	41.4%

A brief review of the implications of the rates of return in Table 5-4 will assist in clarifying several key features of the commercial feasibility of bottomfishing on Tuvalu's distant seamounts.

The prospective rates of return on investment in bottomfishing in Tuvalu are quite sensitive to small increases or decreases in size of the initial investment in a commercial fishing operation. A 10% reduction in the initial investment, from A$50,000 to A$45,000, raises the rates of return from 7.4% to 10.2% on the lowest return fishing scenario and from 26.1% to 31.5% on the highest return fishing scenario. Similarly, a 10% increase in the initial investment, from A$50,000 to A$55,000, reduces the rates of return from 7.4% to 3.9% on the lowest return fishing scenario and from 26.1% to 21.6% on the highest return fishing scenario. In other words, a relatively small change of A$5,000 in the initial investment has a significant impact on the attractiveness of the investment. This sensitivity to small changes in the initial investment highlights the importance of employing a relatively small and inexpensive vessel.

The rates of return on investment are also quite sensitive to small changes in the number of fishing trips undertaken each year. For example, it can be seen in Table 5-4 that increasing the number of fishing trips from 30 to 35 trips per year increases all of the prospective rates of return. Increasing the number of fishing trips to 35 per year increases the range of rates of return from 7.4%-26.1% to 13.1%-34.7%.

The impact of a doubling of fuel costs is particularly strong. Fuel costs in the above scenarios were based on a relatively fuel efficient vessel, using 3 liters per hour while cruising at 6.5 knots per hour. On an average fishing trip, which involves 178.5 miles of cruising to and from the fishing grounds, the fuel costs amounted to A$124. A doubling of fuel costs could occur because of an increase in fuel prices, now lower in real terms than before the oil crisis in 1973, or because of an increase in the fuel requirements of the vessel and engine. Even increasing the size of the engine from a 20 hp to 30 hp diesel engine on the same 10 m vessel used in our base case would increase fuel use and fuel costs by 67%, to A$207 per trip. A doubling of fuel costs has a strong negative impact on the profitability of all scenarios, revealing the nature of the constraints on the future development of the fishery, both in terms of the size of the fishing vessel employed and of the importance of restraining the level of exploitation in order to maintain high catch rates.

Even though it has been assumed that one-third of the fish are sold locally in Tuvalu, because of the low domestic price of fish, the locally marketed fish produce only about 16%-18% of the total sales revenues net of shipping and marketing costs. Accordingly, small changes in the price of locally marketed fish have only a modest (2 to 3 percentage points) impact on the rates of return on investment in bottomfishing in Tuvalu.

Just as the profitability of bottomfishing on Tuvalu's distant seamounts is highly sensitive to the size and fuel efficiency of the vessel and to the catch rates of the relatively high-valued export species, so, too, is it highly sensitive to variations in the price received on exported fish. A 10% decrease in the price received on exported fish so significantly reduces the prospective rates of return on investment that the three lowest return scenarios become losing propositions and only the highest return scenario (with an overall CPUE of 7.5 kg per line hour and 67% of the catch being the highest valued export species) is still worth considering, and it becomes a marginal opportunity at best. On the other hand, a 10% increase in the price of exported fish dramatically improves the profitability in bottomfishing in each of the four scenarios. When such price changes of this magnitude (10%) are due to the vagaries of the supply and demand in the market, the individual fishing operation can do little to alter the situation. However, here again, successful targeting of higher valued species, careful handling, packing and shipping of the fish, and insuring regularity in timing, size, and quality of the shipments to the export market could probably increase the expected export prices by 10% under current market conditions. In other words, bottomfishing in Tuvalu can be quite economically successful if careful attention is paid to the technical side of catching and shipping high valued export species. Successful targeting of high-valued export quality bottomfish species can turn a marginal investment opportunity into a lucrative one.

5.3 Summary

This section has demonstrated that a commercial operation catching export quality bottomfish on Tuvalu's distant seamounts can yield a rate of return on investment that is satisfactory to justify making such an investment. However, this profitability is highly dependent on employing a relatively small fuel efficient vessel and maintaining high catch rates of the higher valued export species of bottomfish.

6.0 DEVELOPMENT CONSIDERATIONS AND CONCLUSIONS

This section draws all of the above discussed elements together to examine some of the socio-economic implications of creating an export-oriented, distant seamount bottomfishing industry in Tuvalu. The focus will be on laying out the development considerations of interest to and options open to the GOT, highlighting the opportunities for and constraints on the development of this new industry. Following a review of the development considerations, there will be a summary of recommendations and the conclusions of this final detailed economic analysis c. the Tuvalu's potential for developing a bottomfishing industry.

6.1 Development considerations

Tuvalu has 8 distinct distant seamount fishing areas, 2 of which are major fishing grounds. The total 200 m isobath length of the distant seamounts has been estimated at 247.66 miles, while the total 200 m isobath length of Tuvalu's islands is estimated at 128.20 miles, roughly half the isobath length of the distant seamounts. The maximum sustainable yield (MSY) of bottomfish from the seamounts has been estimated at 84 mt (ranging from a low estimate of 42 mt to a high estimate of 126 mt), while that from the islands has been estimated at 44 mt (ranging from a low of 22 mt to a high of 65 mt). More than 75% of the estimated MSY from the seamounts derives from two major southern seamount areas: the Kosciusko-Martha Banks located about 130 miles from Funafuti and the Bayonnaise Bank located about 225 miles from Funafuti. A balanced exploitation of Tuvalu's distant seamounts would involve an average fishing trip distance from Funafuti of 178.5 miles.

The project was charged with looking at development options for bottomfishing on Tuvalu's distant seamounts. However, the development of a distant seamount bottomfishing industry will need to be assessed in the context of the potential for bottomfishing around the islands. Funafuti itself may be able to sustain a deep-water bottomfish yield of about 8 mt annually. And Funafuti along with Nukufetau and Vaitupu within 70 miles to the north of Funafuti and Nukulaelae about 70 miles to the south, probably have more than half the MSY of Tuvalu's islands. The first bottomfishing vessel to enter the fishery may be able to harvest bottomfish near Funafuti and these nearby islands. However, introducing commercial export-oriented bottomfishing around the islands raises a host of socio-economic and political issues that will need to be resolved. Local fishermen around Funafuti are already beginning to employ the deep water (> 200 m depths) bottomfishing techniques, and resource ownership issues will need to be addressed to resolve conflicts and to ensure that the bottomfish resources near the islands are not rapidly over fished. Serious resource management concerns must be addressed, for there has been a common experience throughout the South Pacific of depleting the bottomfishing resources nearest to the

landing and export shipping sites. Either a poorly managed commercial bottomfishing operation, which fully exploits the nearby resources before making more distant and more costly fishing trips to the seamounts, or unmanaged island-based bottomfishing by local Tuvaluan fishermen could rather quickly deplete these nearby resources. Therefore, it is very important that the GOT incorporate the island-based bottomfishing into its management scheme for the distant seamount bottomfish fishery.

The first vessel that enters Tuvalu's distant seamount bottomfishing industry should be able to demonstrate commercial and economic success. In fact, at catch rates comparable to those discussed in section 5.0 above, a single vessel fishing solely on the Kosciusko-Martha Banks about 130 miles from Funafuti would catch only about 40% of the estimated MSY on those banks. However, there is insufficient evidence on which to evaluate just how rapidly these resources can be depleted, or, more immediately, how low and how rapidly CPUEs will fall as fishing intensity continues and increases. Constrained by the relatively high operating costs of commercial bottomfishing and the high shipping costs of getting high-valued product to the Hawaiian market, maintaining commercial viability will require managing the fishing effort so as to keep CPUEs high. As more vessels enter the fishery, it will become imperative that the GOT monitor fishing locations, catch rates, and species compositions in the catches of commercial operations. This will require a high degree of trust and cooperation between the commercial operators and the GOT officials. Lacking this cooperation, however, the initial bottomfishing operations could overfish the most accessible fishing areas rather quickly, thereby reducing CPUEs so that profitability of bottomfishing falls for all bottomfishers. Since, as has been noted, bottomfish are a slow growing species, once the CPUEs are reduced, it could take 6-8 years or more for yields and profitability to be restored.

It would take only about 6 bottomfishing vessels, each catching 450 kg on each of 30 fishing trips per year, to catch to entire estimated MSY of bottomfish on Tuvalu's distant seamounts. However, fishing at this intensity would be certain to reduce significantly the CPUEs obtained by each of the vessels within only a few years of fishing. In fact, an intuitive guide used by many fisheries scientists suggest that CPUEs on virgin fishing grounds for bottomfish can be expected to fall by about half as continued fishing pressure drives yields down to sustainable levels. In section 5.0 above, it was emphasized that CPUEs must be maintained at a relatively high level to sustain commercial profitability of the fishing operations. Thus, it will be important in the development of Tuvalu's distant seamount bottomfish fishery that the number of vessels be strictly limited from the beginning, so that CPUEs do not fall substantially. A cautious approach to the development of the fishery would limit the number of vessels to 3 or 4, while carefully monitoring catch rates in order that no particular fishing area becomes so severely depleted that it is no longer profitable to fish there.

49

A Tuvaluan bottomfishing industry with 4 vessels would create at least 12 good paying fishing jobs, generating local wages of A$44,500 to A$51,000 annually. In addition, there would be some additional jobs in support activities such as provisioning the crew; maintaining the vessels, engines, and gear; and shipping and marketing the fish. Four bottomfishing vessels with annual fish exports of about 42 mt would generate, at current shipping rates, annual air shipment revenues of A$68,000 for Air Marshall Islands. Aside from the local earnings on the air shipment of the fish to export markets, a 4-vessel bottomfishing fleet could generate foreign exchange earnings of about A$150,000 to A$170,000 annually. While the size of the fishery and its potential earnings are relatively small by international standards, and even by comparison with similar fisheries in places like Tonga and Western Samoa, they could make a substantial contribution to Tuvaluan employment, incomes, foreign exchange earnings, and marine resource and economic development.

Despite the modest size of a potential bottomfishing industry in Tuvalu, there are some serious constraints on the ability of Tuvalu to fully exploit its distant seamount bottomfishing opportunities. As noted earlier in this report, virtually all fishing in Tuvalu has been artisanal and subsistence in nature. A developing bottomfishing industry in Tuvalu would represent the first serious commercialization of Tuvalu's marine resources. Despite the bottomfishing training provided by the project, there are few Tuvaluans with the knowledge and experience to immediately take advantage of the bottomfishing opportunities. The GOT will need to continue to provide training to local fishermen if the country is to develop adequate fishing crews even for a small bottomfishing industry. Furthermore, even a single commercial bottomfishing operation will require an initial investment of at least A$50,000. There are few investors in Tuvalu who would be able to finance such an operation. While the Tuvalu Development Bank officials have expressed interest in developing a bottomfishing industry in Tuvalu, it warrants notice that the largest development loan previously made by the bank was for about A$30,000. So obtaining the finance for even a single bottomfishing vessel presents Tuvalu with a challenging situation.

There are also some international and industry considerations which may significantly affect the development of the local industry. On the positive side, there are industry developments which may well improve the returns to a Tuvaluan bottomfish exporter. First, Tuvalu is, among its South Pacific neighbors, a late-comer to the bottomfishing industry. Several competitors such as Tonga and Western Samoa have already exploited the bottomfishing development alternative and, due to mismanagement of the fishing effort on their bottomfishing resources, are suffering the consequences of overfishing. In particular, the CPUEs and fleet profitabilities have fallen to disastrously low levels in many of the South Pacific bottomfishing industries. Furthermore, as falling catch rates have undermined profitability, cost cutting efforts by fishermen have often reduced care in handling and packing which has thereby reduced average export quality and received prices. With the potential to export high quality bottomfish, Tuvalu is entering the market at a time when some competitors are already suffering

declines in fleet size. Second, due to overly heavy fishing pressure on some of the Hawaiian bottomfish stocks, Hawaii may impose a seasonal closing on onaga, the highest-valued long-tailed red snapper, in some areas during the Hawaiian summer and fall, the best period for bottomfishing in Tuvalu. This could lead to some strengthening of onaga prices, an occurrence which would provide additional justification for better targeting of higher-valued species by Tuvaluan bottomfishers.

On the negative side, new U.S. seafood safety regulations to be implemented in 1996 will require special attention to carefully handling of exported fish. This has particular implications for ensuring that the fish are quickly chilled in brine and put on ice, since a key issue of concern to the U.S. health authorities will be the maintenance of a low internal temperature of the fish. This consideration will require additional attention to assuring that adequate ice is available for vessels departing Funafuti for the fishing grounds and additional crew training in and attention paid to chilling and storing the fish onboard. In addition, Tuvaluan fishermen will need to target deepwater species because several shallower water species in Tuvalu's fishing areas are known to be at risk for ciguatera. However, an additional requirement of the new regulations is that the supplier-country may be responsible for inspecting the fish prior to export and for insuring that the product meets the U.S. standards at the time of import. This may require GOT involvement in the fish export inspection system. This will present the GOT with additional responsibilities and the logistics of fish inspections will need to be worked out so that no unwarranted delays in shipping are imposed on the commercial exporter.

The discussion up to now has focused on the opportunities for and constraints on the development of a distant seamount bottomfishing industry in Tuvalu. It is clearly economically and commercially feasible to develop such an industry. However, there are some additional problems involved in initiating or starting up such an industry which should be noted. One key problem is that Tuvaluan fishermen are not experienced in deep water bottomfishing techniques. The training that has been provided by the project in fishing and export marketing could well be lost if what has been learned is not applied practically in the near future. Accordingly, the GOT will need to consider continuing the commercial fishing and export marketing trials and training until private investors begin to enter the developing industry. Unfortunately, the *Manaui* is the only vessel available to the GOT for conducting the fishing trial training. As noted above, the *Manaui* is a very expensive vessel to operate as a commercial bottomfishing vessel. However, the proceeds from export marketing trials could cover most of the operational running costs of the *Manaui* during such training, making the training essentially self-financing.

The only other vessel options open to the GOT are the four (4) 9 m vessels under the control of NAFICOT. Unfortunately, these vessels are not suitable for traveling long sea going trips. While these vessels could fish for bottomfish near Funafuti, this kind of activity should be discouraged until the near-island bottomfish resources are

incorporated into an overall bottomfish management plan. It is also not unlikely that overseas aid could provide the GOT or NAFICOT with a vessel that is large enough to travel to the distant seamounts. At the same time, however, the fuel efficiency of such a vessel should be carefully examined before using it to undertake distant seamount bottomfishing expeditions. It would be foolish indeed to exploit these small, but valuable, and depletable bottomfish resources using an uneconomic vessel. Less fuel efficient vessels are likely to fish as close to Funafuti as feasible, tending to over exploit those nearby resources.

This section has reviewed a number of development constraints, options, and considerations which should be reviewed by the GOT in promoting the development of an export oriented distant seamount bottomfishing industry in Tuvalu.

6.2 Conclusions

Tuvalu has small but commercially exploitable bottomfish resources available on its distant seamounts. Fishing costs are high because of the long distances that must be traveled to reach the fishing grounds. Export marketing costs are high since there are no direct flights from Tuvalu to Hawaii and fish must be transhipped through Fiji. Furthermore, there is no airline competition on either flight to constrain air cargo rates. These high fishing and marketing costs are responsible for relatively modest returns projected for commercial bottomfishing in Tuvalu, despite relatively high catch rates and high prices received on high quality bottomfish exported to Hawaii.

A commercial bottomfishing operation fishing on Tuvalu's distant seamounts should be able to target the highest-valued export species and achieve catch rates high enough to generate an internal rate of return on investment over cost of 20% to 25%. These rates of return significantly exceed the 8% going rate of interest now being charged by the Tuvalu Development Bank, and, accordingly, provide adequate justification for investing in commercial bottomfishing in Tuvalu. These returns are based on a hypothetical initial investment of A$50,000 in a commercial operation. Such a modest initial investment will purchase a relatively small vessel, presenting each operator with difficult choices in balancing vessel work space, comfort, speed, fuel efficiency, safety, and so forth. However, the key factor in maintaining profitability will be keeping catch rates high and ensuring that high-valued export species make up a substantial portion of the catch. Presuming careful fish handling, packing, and shipping, a commercial operator who is successful at targeting high-valued export quality bottomfish and at maintaining high catch rates should make adequate financial returns.

Since catch rates of high-valued export species must be maintained in order to cover the high fishing and marketing costs, it is imperative that the GOT carefully manage the resources, limiting the number of bottomfishing vessels and continually monitoring fishing locations and catch rates. Significant cooperation between the GOT and the commercial bottomfishing operators will be required.

The total number of commercial bottomfishing vessels actively fishing on Tuvalu's distant seamounts should be limited to 3 or 4. More vessels should not be allowed in the fishery until after it has been demonstrated that this modest level of exploitation is not significantly reducing catch rates. Too great an expansion of the fishery will reduce catch rates and undermine the profitability for all bottomfishing operations, forcing some or all into bankruptcy.

Tuvalu has a promising opportunity to develop a small but profitable and sustainable export-oriented bottomfishing industry. Successful exploitation of this opportunity will require a high degree of cooperation between the GOT and the private bottomfishing operators.

7.0 References

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