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FINAL REPORT:
TUVALU BOTTOMFISH PROJECT

Pacific Islands Marine Resource Project
Tuvalu Component
Project No. 879-0020

Prepared by RDA International, Inc.
under Contract No. 879-0020-C-00-1231-00
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This report was prepared for the Government of Tuvalu and the United States Agency for International Development (USAID) under terms of Contract No. AID-0020-C-00-1231-00. The views, expressions, opinions, and conclusions contained in this report are not intended nor should they be construed as statements of policy of either USAID or the Government of Tuvalu.

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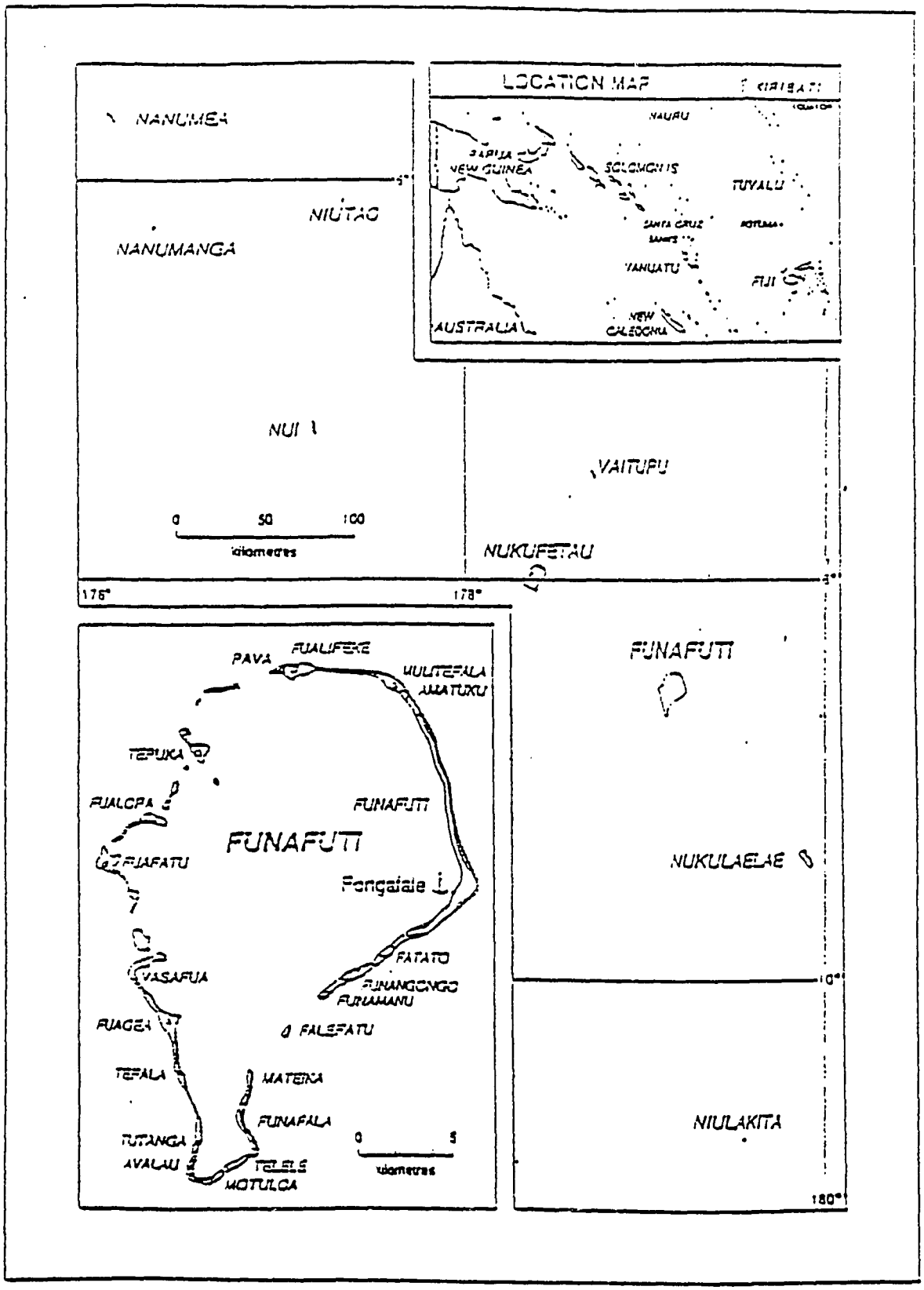
Figure 1. Map of Tuvalu.



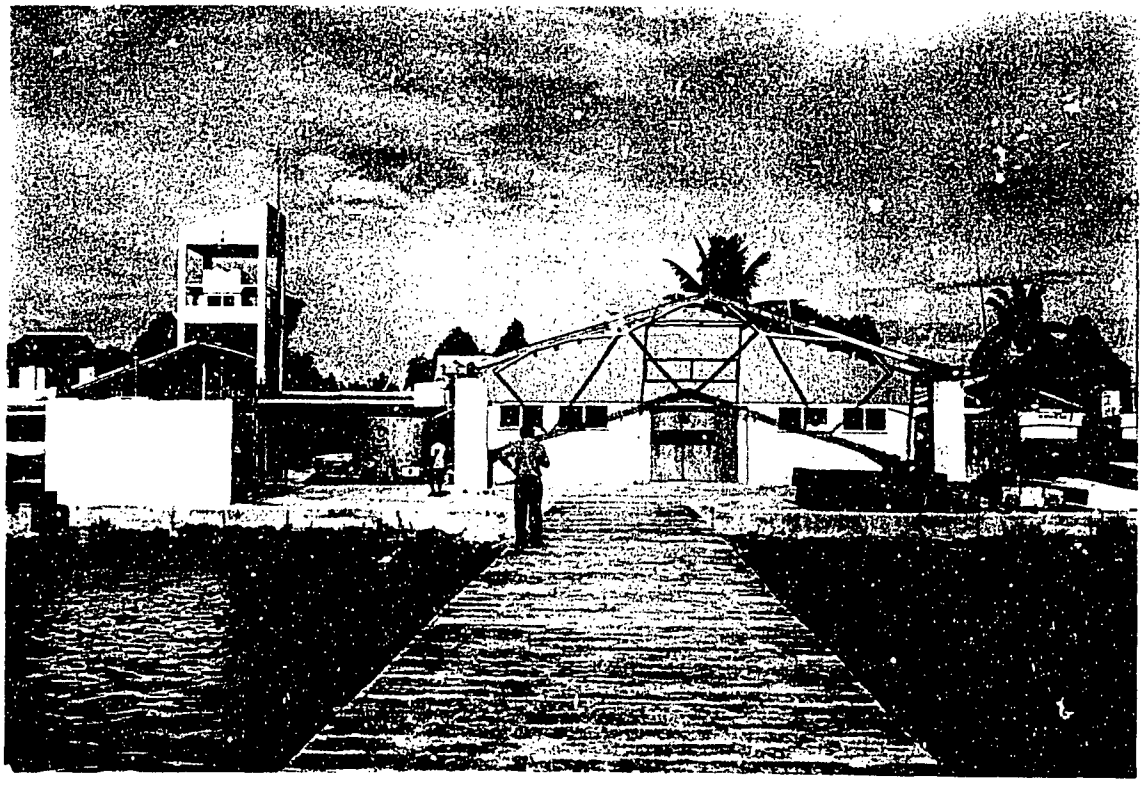


Figure 2. NAFICOT headquarters and landing site on Funafuti.

Figure 3. Funafuti lagoon.

ABBREVIATIONS

A$	Australian dollar
C	Centigrade
CPUE	Catch per unit effort
EEZ	Exclusive Economic Zone
FAD	Fish Aggregating Device
GOT	Government of Tuvalu
GPS	Geographical positioning system
IRR	Internal rate of return
kg	Kilogram
km	Kilometer
l	Liter
m	Meter
MRA	Marine Resources Adviser
MSY	Maximum sustainable yield
mt	Metric ton
NAFICOT	National Fishing Corporation of Tuvalu
nm	Nautical mile
°	Degree
PCC	Project Coordination Committee
PIMAR	Pacific Islands Marine Resource
RDA	RDA International, Inc.
RDO	Regional Development Office
SP	South Pacific
SPC	South Pacific Commission
US$	United States dollar
USAID	United States Agency for International Development

CURRENCY EQUIVALENTS

Tuvalu currency unit = A$ = Australian dollar

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

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FINAL REPORT:
TUVALU BOTTOMFISH PROJECT

1.0 EXECUTIVE SUMMARY

The Tuvalu Bottomfish Project, a cooperative venture between the Government of Tuvalu (GOT) and the United States Government, is a component of USAID's Pacific Islands Marine Resource (PIMAR) program. The project was situated in Funafuti, the capital of Tuvalu. The contractor, RDA International, Inc., signed the contract on 13 September 1991 and began field operations shortly thereafter. Field work was completed on 30 September 1994, and all project technical reports were completed by 30 January 1995. The project was completed on time and under budget, with excellent results. The Tuvalu Bottomfish Project successfully demonstrated that small-scale commercial exploitation of the bottomfish resource in Tuvalu is economically viable and sustainable on a modest scale if appropriately managed. As a direct result of this project, foreign exchange earnings are expected to increase by 75%, with private sector employment increasing by 10% or more. In the course of operations, the project also discovered and mapped two new and previously unknown seamounts, providing additional fishing grounds for Tuvalu.

The PIMAR program was originally designed by USAID as a five-year program of assistance for the development of small-scale marine resources activities in the South Pacific. The goal of this program, of which the Tuvalu Bottomfish Project is part, was to increase income generating opportunities for men and women within the Pacific Islands through means which enhance the conservation and management of natural resources. The project purpose was to develop, demonstrate and replicate innovative technologies and strategies which increase the benefits to Pacific Island communities from sustainable, small-scale, private sector uses of marine resources. Within the Tuvalu Bottomfish Project, both the goal and purpose of PIMAR were fully met.

The national purpose of the Tuvalu Bottomfish Project was to adapt and apply new fishing technologies and fisheries management strategies to expand small-scale commercial offshore fishing operations targeted initially on bottomfish along the seamounts to the north and south of Tuvalu. The regional purpose was to test and demonstrate a widely applicable strategy for small-scale commercial offshore bottomfishing. Both the national and regional purpose of the Tuvalu Bottomfish Project were met. In addition, the principal objective of the project was to demonstrate and establish the economic viability and commercial feasibility of a bottomfish fishery and export industry in Tuvalu. This objective was met.

The contractual outputs of the Tuvalu project were: 1) assessment of bottomfish resources of Tuvalu; 2) development of a management plan for bottomfish in Tuvalu; 3) bottomfish methods developed and tested through trial fishing; 4) tested methods introduced to private sector through training; and 5) bottomfish boat suitable for Tuvaluan needs is designed (if needed).

For convenience in reporting and administration, RDA divided the project into six components: bottomfish resource assessment, test fishing for bottomfish species, economic and marketing evaluation of bottomfish, bottomfish resource management plan, designing small-scale fishing boats for offshore bottomfishing, and specialized training for fisheries development in Tuvalu.

The results of the Tuvaluan seamount resource assessment and bottomfishing were promising. The maximum sustainable yield (MSY) 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 distant seamount bottomfish fishery were optimally fished and 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. 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.

In an attempt to determine the best method for producing the most economic catch rates for bottomfish and pelagic species, test fishing for these species was conducted. Test fishing trials focused on locating productive fishing grounds on seamounts, catch effectiveness in terms of species landed and total weight, necessary gear maintenance, availability of supplies, and economic aspects. Vertical longlining with Samoan-type handreels was the method being employed with various forms of setup. The number of branchlines and hooks, including variations between monofilament and dacron line, were the tested styles of setup. Depths of the lines

were also varied. Testing these variables assisted in the determination of the most appropriate methods for maximizing the most economic catch rates. One factor in maximizing catch rates and reducing operational cost is the determination of an appropriate and efficient fishing vessel.

The long distances required for fishing on these distant seamounts requires a fuel efficient vessel that can meet appropriate safety standards while having sufficient work, storage, and crew comfort space. It has been determined that a minimum Ovessel length of about 10 m and minimum engine size of about 20 hp will be required. A slightly larger and more highly powered vessel is recommended, but commercial consideration may require meeting only the minimum suggested dimensions and power requirements.

In order to facilitate the future expansion and success of the fishing industry in Tuvalu, beyond the specific life of the project, a variety of training programs were provided for Tuvaluan fishermen and fisheries personnel. The training activities were divided into four different categories of training. The first category of training activities included formal in-country workshops on topics such as data collection and data entry, bottomfishing operation and gear technology, FAD deployment, bottomfish export marketing, and bottomfish management. The second category of training activities included formal overseas workshops on topics such as fish marketing and processing, data analysis, export marketing, and vessel operation. Training activity also included a two-year diploma course at the University of South Pacific for two Tuvaluan trainees. However, the most important training activities involved the day to day training of Tuvaluan fishermen in every aspect of bottomfishing, fish handling, and fish exporting. The training programs worked to ensure the successful future expansion of the bottomfishing industry in Tuvalu.

Successful exploitation of the Tuvaluan bottomfish resource will require a high degree of cooperation between the GOT and the private bottomfishing operators. 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%. 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 sufficiently 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.

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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 ensure that catch rates remain sufficiently high to justify the commercial investments. However, if the small fleet of bottomfishing vessels is 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 employment in a like number of industry-support jobs, increasing Tuvalu's private sector employment by at least 10%. In addition, the industry could generate A$150,000 to A$170,000 annually in foreign exchange earnings for Tuvalu, increasing Tuvalu's export earnings by about 75% over their 1993 level.

The normal range of project administrative activities were carried out with a minimum of confusion and mistakes. Procurement and delivery of equipment and supplies, although sometimes delayed, did not adversely affect completion of tasks. All required reports were submitted, and all personnel and subcontractors fulfilled their contractual obligations.

As with most projects, there were particular problems encountered and lessons to be learned. Problem areas in the Tuvalu Bottomfish project revolved around the delays in obtaining a GOT-supplied, suitable ice-making machine, the delays in obtaining a commercial bottomfishing vessel for use in the commercial fishing trials, and the mechanical problems with the commercial vessel after it was chartered by the GOT.

By the end of field operations, all of the contracted outputs were accomplished: extensive evaluation of the bottomfish resource was conducted; bottomfish export marketing trails and training demonstrated the feasibility of exporting Tuvaluan bottomfish to Hawaii; the economic and commercial feasibility of Tuvaluan bottomfishing was demonstrated; management options and plans were presented for bottomfish resources; guidelines for an appropriate bottomfishing vessel were developed; training of local people in all aspects of the bottomfishing industry occurred; and finally, the possibility of a new cost efficient industry was introduced to the people of Tuvalu.

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Figure 1-1. Local fisherman holding fresh caught longtail red snapper.

Figure 1-2. RDA Tuvalu field office staff and associates (l-r; RDA Master Fisherman L. Pasefika; U.S. Peace Corps Volunteer B. Luprek; RDA Marine Resources Advisor/Team Leader S. Petaia; RDA Field Office Secretary T. Teii; and NAFICOT General Manager S. Taafaki).

2.0 INTRODUCTION

This is the Final Report of the Tuvalu Bottomfish Project. This report has been prepared by RDA International, Inc. (RDA), as part of the Tuvalu Component of the Pacific Islands Marine Resource (PIMAR) Program, Contract No. AID 879-0020-C-00-1231-00, funded by the United States Agency for International Development (USAID/RDO/South Pacific).

2.1 Background on Tuvalu

Tuvalu is an archipelago composed of nine distinct coral atolls in the South Pacific. The exposed land mass lies between 5° and 11° South Latitude and 176° and 180° East Longitude. The population of approximately 9,500 people occupy the 26 square kilometers of land available. Approximately 40% of the population live on the main island and capital, Funafuti. The remaining 60% of the population live on the outer islands. Funafuti has a population density of 1,376 persons per square kilometer, while Vaitapu, the largest island in Tuvalu, has a sixth of the population density of Funafuti. The limited vegetation on the islands is primarily coconut woodland. However, coastal strand, coastal marsh, mangrove swamp, and inland broadleaf woodland exist. Land for agricultural use is largely unavailable due to the infertile soils derived from the calcareous sands and gravels. Indigenous animal life is limited to several species of seabirds, lizards, insects, and crustaceans, although several introduced animal species (chickens, ducks, pigs, dogs, cats, and rats) predominate on the islands.

Tuvalu is characterized as having a marine tropical climate with prevailing tradewinds blowing from the southeast. Strong "westerlies" blow during the cyclone season of November through April. Temperatures vary slightly and range from 25 to 31 degrees Centigrade. The islands receive annual rainfall ranging from 260 to 340 centimeters per year. Groundwater is virtually non-existent. Therefore, collected and conserved rainwater is the primary source for freshwater on the islands. Subsistence agriculture and fishing are the predominant livelihoods. Bananas, taro, breadfruit and pandanus are grown for local consumption. Due to the lack of available land, the poor soil quality described above, and a constrained freshwater resource, agriculture, other than what is already in place, is not a viable economic resource to be further developed.

Tuvalu is among the least developed nations of the world with few opportunities for economic development. Tuvalu controls an Exclusive Economic Zone (EEZ) covering approximately 600,000 square kilometers, and has a higher ratio of sea to land area than any other nation. Of the 600,000 square kilometers of EEZ, only 26 square kilometers are land. (See Figure 2-1 on page 2-3.) In addition to their modest terrestrial area, the island's elevation usually does not extend over 3 m above sea

level. Although there may be extensive mineral resources, their vast and largely unexploited marine resource base offers essentially the only known option for development. Tuvalu's marine environment consists of fringing or patch reefs in the shallower waters surrounding atoll islets; patch reefs and relatively barren coralline sand flats within shallow lagoon waters; and a vast surrounding area of deep open ocean. Open ocean waters range to depths of approximately 5000 m. However, scattered throughout the EEZ are numerous submarine seamounts whose summits may rise to within less than 30 meters of the water's surface. These submarine seamounts provide an environment suitable for dense populations of bottomfish. Deep-water snappers, groupers, and emperors are typically caught around the perimeters of islands and offshore seamounts, and most of the fish species targeted for export are taken in depths of about 200-400 m. Figure 2-2 on page 2-5 presents a schematic representation of the deep-water habitats of bottomfish on the steep submarine slopes of the Tuvaluan seamounts. Because the thermocline in these waters is relatively deep, the highest-valued bottomfish species are found in abundance at depths of 250-400 m. As the seamount surfaces are relatively shallow, the main bottomfish habitat is on the perimeters of the seamounts, the submarine slopes of which are very steep. Fishing effort will be concentrated on these submarine slopes. Using the length of the 200 meter isobath as an index of fishable habitat, as is commonly done throughout the South Pacific, the combined lengths of these isobaths in Tuvalu is 248 nautical miles for all seamounts, and 128 nautical miles around islands, giving Tuvalu a total of 376 nautical miles of fishable habitat.

2.2 Project overview

The Tuvalu Bottomfish Project, a cooperative venture between the Government of Tuvalu and the United States Government, is a component of USAID's Pacific Islands Marine Resource (PIMAR) program. The Tuvalu Bottomfish Project was situated in Funafuti, the capital of Tuvalu. The contractor, RDA International, Inc. (RDA), signed the contract (No. AID 879-0020-C-00-1231-00) on 13 September 1991, and began field operations immediately thereafter. The original contract specified a Project Assistance Completion Date (PACD) of 30 September 1995, the same PACD as for the overall PIMAR project itself. Amendment 4 to the contract specified that all field activities would end by 30 September 1994 and changed the estimated completion date to 30 January 1995. Field work was completed and the field office was closed on 30 September 1994. The project was completed on 30 January 1995, when copies of all substantive project reports were sent to USAID and the GOT. This Final Report on the Tuvalu Bottomfish Project was drafted in January 1995 and subsequently submitted to USAID.

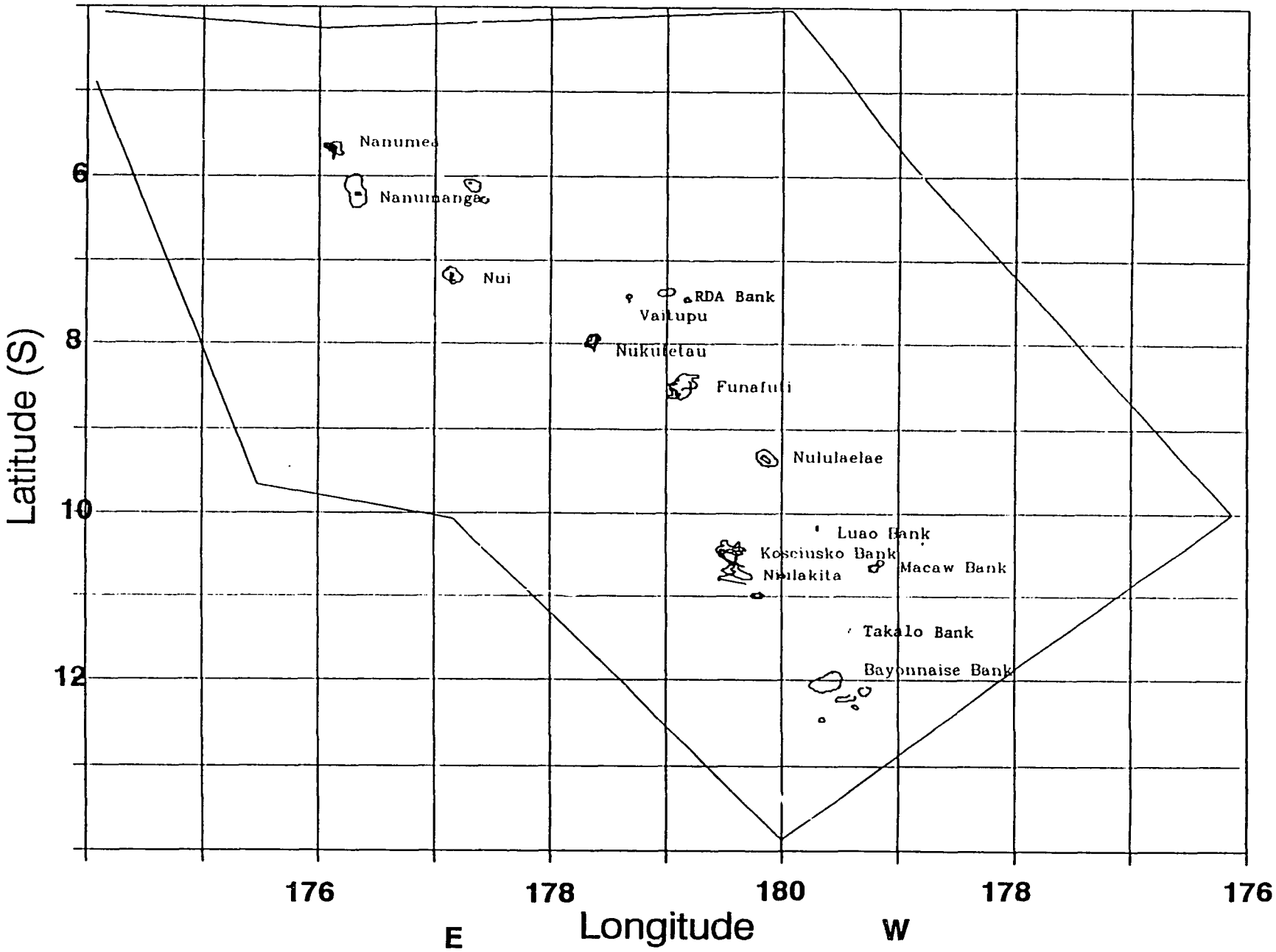
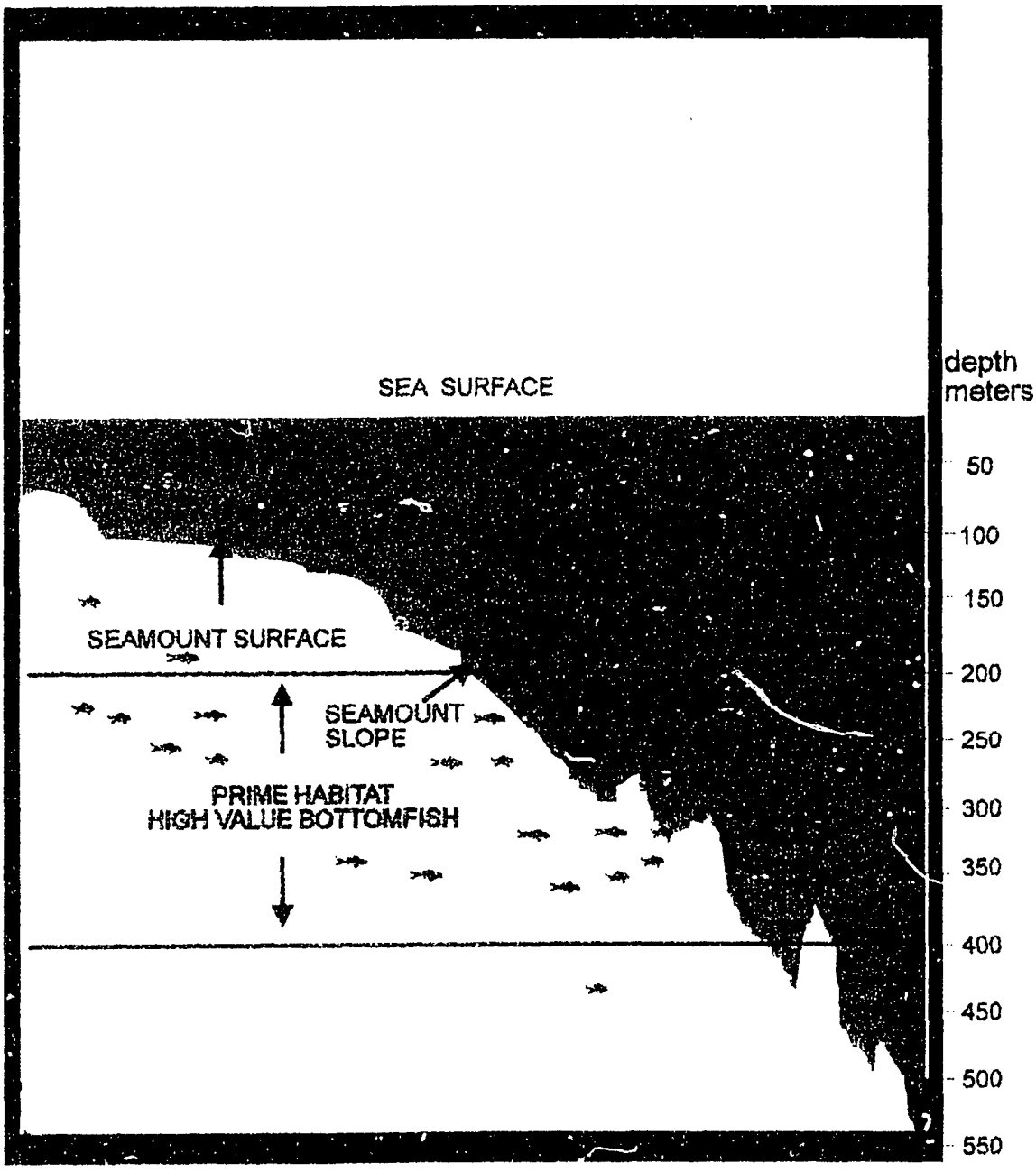


Figure 2-1. Republic of Tuvalu EEZ.

Figure 2-2. Typical bottomfish habitats on Tuvaluan seamounts



NOTE: FISH ARE NOT TO SCALE (FOR VISUAL PURPOSES ONLY)

2.2.1 Project description

The Tuvalu Bottomfish Project was one component of the PIMAR Project, a USAID program of assistance to the South Pacific island countries administered by the Regional Development Office/ South Pacific (RDO/SP) in Suva, Fiji.

The goal of the PIMAR Project was to increase income generating opportunities for men and women within the Pacific Islands through means which enhance the conservation and management of natural resources.

The purpose of the PIMAR Project was to develop, demonstrate and make available for replication innovative technologies and strategies which increase the benefits to Pacific Island communities from sustainable, small-scale, private sector uses of marine resources.

At the national level, the PIMAR Project planned to implement 5 project components in Tuvalu the Cook Islands, Papua New Guinea, Tonga, and Kiribati. These project components were individually targeted on generating sustainable measurable economic gains for the countries participating in the project.

At the regional level, to multiply project benefits, the PIMAR Project was designed to have a regional impact component to support activities at a regional level to promote these wider applications.

The Tuvalu Component of the PIMAR Project is the Tuvalu Bottomfish Project. The rationale of the Tuvalu Bottomfish Project was to explore the potential exploitation of Tuvalu's next potential resource base, the offshore bottomfish. An initial bottomfish resource assessment was to be followed by the development of a rational management plan. Since fishing for bottomfish has not been practiced by Tuvaluan fishermen, the project was to test the most appropriate deep-water bottomfish techniques and gear within the Tuvaluan physical and cultural environment. This was to be followed by training of Tuvalu Department of Fisheries and NAFICOT personnel and private fishermen in bottomfish fishing techniques. Encouraging the development of the private sector investment in commercial bottomfishing in Tuvalu was the final aspect of this component.

The national purpose of the Tuvalu Bottomfish Project was to adapt and apply new fishing technologies and fisheries management strategies to expand small-scale commercial offshore fishing operations targeted initially on bottomfish along the seamounts to the north and south of Tuvalu.

The regional purpose was to test and demonstrate a widely applicable strategy for small-scale commercial offshore bottomfishing.

2.2.2 Project outputs

The Contract's initially designated project outputs included the following: assessment of bottomfish resources of Tuvalu; development of a management plan for bottomfish in Tuvalu; bottomfish methods developed and tested through trial fishing; tested methods introduced to private sector through training; and designed (if required) a bottomfish boat suitable for Tuvaluan needs.

The bottomfish export marketing component of the project was substantially enlarged and the bottomfish vessel design component of the project was substantially reduced by Contract Amendment 4. The final configuration of project outputs, which provided a framework for project reporting, included the following: bottomfish resource assessment; test fishing for bottomfish and pelagic species; economic and marketing evaluation of bottomfish; bottomfish resource management plan; identifying key characteristics of an appropriate bottomfishing vessel for Tuvalu conditions; and specialized training for fisheries development in Tuvalu. These are the six categories of project outputs which will occupy much of the discussion throughout this report. Each of these categories of project outputs is described in more detail below.

2.2.2.1 Bottomfish resource assessment

In order to facilitate the development of small-scale bottomfish commercial fishery, it was essential at first to determine the potential of the bottomfish resource in Tuvaluan waters (southern and northern seamounts) through stock assessment surveys. The resource assessment was to provide appropriate information to guide the optimum exploitation of the bottomfish resource to generate foreign earnings, while ensuring the sustainability of the resource through proper management.

The Republic of Tuvalu EEZ includes nine emergent coral atolls and several submerged banks lying between 4° and 14° South Latitude and 172° East and 176° West Longitude. The EEZ of the Republic of Tuvalu covers approximately 600,000 square kilometers. The Government of Tuvalu considers marine resources their most important asset, and realize that while exploitation of deep-water bottomfish fishery resources could provide potential economic development, tropical deep-water bottomfish have a long life span, slow growth rate and variable larval recruitment, which make these species highly susceptible to over-fishing. Therefore, to scale a viable long-term commercial fishery, it is imperative that the sustainable yield of bottomfish stocks within the EEZ first be estimated. Several approaches can be used to determine maximum sustainable yield (MSY) for an exploited commercial fishery

depending on the type, quality and quantity of data available. Most of these approaches depended on an extensive time series of catch-per-unit-effort (CPUE) data, or a large sample of both CPUE and length (of fish) data. Unfortunately, time and budget constraints precluded these more complex types of research programs and analyses for the Tuvaluan bottomfish stock. However, relative abundance and hydrographic data collected in this program allowed the unexploited biomass within the EEZ to be estimated. The range of MSY values were then calculated for the unexploited stock.

2.2.2.2 Test fishing for bottomfish and pelagic species

The project needs to determine and assess the viability and effectiveness of appropriate fishing gear and boats, particularly for small-scale commercial bottomfish operations, through experimental fishing trials. Through commercial fishing trials local fishermen learn new fishing technologies and fishing grounds for exploiting deep bottomfish resources.

In attempting to determine the best method for producing the most economic catch rates for bottomfish and pelagic species, test fishing for these species was conducted. Test fishing trials focused on locating productive fishing grounds on seamounts, catch effectiveness in terms of species landed and total weight, necessary gear maintenance, availability of supplies, and economic aspects. Vertical longlining with Samoan-type handreels was the usual method employed with various forms of setup. The number of branchlines and hooks, including variations between monofilament and dacron line, were the tested styles of setup. Depths of the lines were also varied. Testing these variables assisted in the determination of the most appropriate methods for maximizing the most economic catch rates.

2.2.2.3 Economic and marketing evaluation of bottomfish

The increase in volume of production from this new fishery is expected to require the implementation of a viable export marketing system to realize the maximum potential economic benefit. This will require proper marketing and processing facilities, as well as an efficient air transport link. The establishment of an efficient export marketing system will be developed to assist in sustaining the long-term viability of an expanded small-scale bottomfishery in Tuvalu. A contract amendment expanded the export marketing component to assess and evaluate the viability of and alternative options and channels for exporting bottomfish from Tuvalu, and to conduct export marketing trials and training. A preliminary economic evaluation conducted early in the project determined the general feasibility of bottomfishing in Tuvalu, and a final economic evaluation conducted near the end of the project provided a final assessment of the commercial feasibility of initiating a bottomfishing industry in Tuvalu.

The Tuvalu Bottomfish Project conducted 7 export marketing trials, with associated training. These trials established that exporting bottomfish from Tuvalu to Hawaii via air is technically and financially feasible.

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. The final economic evaluation explored marketing potentials, revenues, and costs, and examined the commercial feasibility of bottomfishing in Tuvalu, with discussions on numerous development considerations and options.

2.2.2.4 Bottomfish resource management plan

If the long-term sustainability of a tropical bottomfish resource is to be ensured, then a detailed and effective resource management plan must be developed and implemented before the fishing industry expands to any considerable degree. Such a management plan should be flexible in order to accommodate the continually changing conditions of the fishery and resource.

Following completion of the resource assessment, the test fishing, and the commercial fishing trials, a Tuvalu bottomfish resource management plan was developed. Three bottomfish management plan workshops were conducted in Tuvalu to ensure the development of a plan which would be both acceptable to public and private sector participants and enforceable by the GOT.

The final bottomfish management plan recommended that fishing effort in the fledgling fishery be restricted to a maximum of 3 or 4 vessels in order to maximize economic yield. Although maximizing participation and employment may be an appropriate goal in an artisanal fishery which provides food and employment for a local community, this is not so in a commercial fishery in which most of the catch is exported. In the latter case, maximizing efficiency (and thereby net profits in the form of foreign exchange to the country as a whole) is a more appropriate and recommended objective. It was also recommended that a licensing system be introduced to restrict participation in the fishery . The license should in effect be an

export license which permits the owner-operator of a suitable vessel to catch and export deep-water bottomfish from Tuvalu subject to quality control procedures. A quality control inspection system was recommended to maximize the value of the catch, but this should not be such that it hinders the packing and transportation of fish. The success or otherwise of the Tuvaluan deep-water bottomfish fishery is strongly dependent on maintaining a high reputation and market price for its products. A permanent monitoring system is also recommended. It is proposed that the submission of fishing logbooks on which catch and fishing effort by area is entered by the fisher, be a legal requirement of participation in the fishery. The management plan also explored the option of allowing foreign fishing vessels access to stocks which are inaccessible to the Tuvaluan fleet in return for a negotiated fee. Lastly, some general concerns expressed by the public regarding the development of a bottomfish fishery in Tuvalu were addressed.

2.2.2.5 Identifying key characteristics of an appropriate bottomfishing vessel for Tuvalu conditions

The project contract originally called for the design of an appropriate and suitable prototype fishing vessel for a small-scale commercial bottomfishing operation in Tuvalu. Such a design would be based on the results of the commercial fishing trials and local conditions. The recommended design was to ensure optimal exploitation of the fishery resource and the expansion of the bottomfishing industry in Tuvalu. A contract amendment significantly reduced this component of the project, eliminating the vessel design component and substituting instead the task of identifying the key characteristics of an appropriate bottomfishing vessel for Tuvalu conditions.

As the project implementation proceeded, it was recognized that there are many alternative vessel designs and many alternative vessels available throughout the South Pacific which would be appropriate for bottomfishing in Tuvalu. Hence, the funds initially budgeted for a vessel design component of the project were redirected to conducting export marketing trials and further project training exercises. The vessel design component of the project was recast as a much smaller component involving the identification of the characteristics of an "ideal" or "model" bottomfishing vessel for use in a Tuvalu bottomfishing industry.

Apart from the six islands and two small seamounts to the north and northwest of Funafuti, all the potential fishing grounds for Tuvalu deep-water bottomfish are situated to the south and southeast of Funafuti. The distance from Funafuti to the furthermost seamount, Bayonnaise Bank, is about 225-250 miles to the southeast. Bayonnaise Bank, Tuvalu's largest seamount, also has almost 40% of Tuvalu's distant seamount bottomfish resources. Kosciusko Bank, which is only about 130-140 miles south of Funafuti, is Tuvalu's other major fishing ground. Roughly, about half of Tuvalu's bottomfish resources can be exploited by a vessel capable of traveling within about 140 miles of Funafuti. Exploiting the other half of Tuvalu's bottomfish resources will require a vessel capable of traveling about 250 miles from Funafuti. The identification and recommendation for a model vessel to fish at these distant

grounds was made with due consideration given to the costs, capability and safety of the vessel.

2.2.2.6 Specialized training for fisheries development in Tuvalu

The sixth major component of the Tuvalu Bottomfish Project was the provision of specialized training for fisheries development in Tuvalu. In order to facilitate the future expansion and success of the fishing industry in Tuvalu, beyond the specific life of the project, a variety of training programs were provided for Tuvaluan fishermen and fisheries personnel.

The training activities were split into four different categories of training. The first category of training activities included formal in-country workshops on topics such as data collection and data entry, bottomfishing operation and gear technology, FAD deployment, bottomfish export marketing, and bottomfish management. The second category of training activities included formal overseas workshops on topics such as fish marketing and processing, data analysis, export marketing, and vessel operation. Training activities also included a two-year diploma course at the University of South Pacific for two Tuvaluan trainees. However, the most important training activities involved the day to day training of Tuvaluan fishermen of every aspect of bottomfishing, fish handling, and fish exporting led by RDA Marine Resource Advisor/Team Leader S. Petaia and RDA Master Fisherman L. Pasefika.

2.2.3 Project inputs

2.2.3.1 USAID inputs

USAID provided inputs included the financing of the contractor's costs necessary to carry out the scope of work. The total obligated funds by USAID to the Tuvalu Bottomfish Project amounted to US$1,017,700. A preliminary assessment (conducted as this report was being drafted, but prior to the final billing of project expenses by the contractor) of actual spending of USAID funds on the Tuvalu Bottomfish Project suggests the project will be completed approximately US$50,000 under budget.

2.2.3.2 GOT inputs

The initial contract specified the GOT inputs to the Tuvalu Bottomfish Project as follows: two counterpart research staff; extension vessel and three fisheries training vessels; use of training facilities; and project support.

The GOT provided at least 2 counterpart research staff throughout the life of the project. These served principally as data collectors and data analysts for the project's resource assessment and trial fishing activities. A U.S. Peace Corps Volunteer was additionally assigned to serve as counterpart research staff for most of the project implementation period. In addition, the GOT generously made its facilities and those of NAFICOT available for project purposes. Facilities included, among other things, office facilities, furniture, meeting rooms, extra microcomputers for data entry and analysis, and vessel docking and slip facilities. The GOT also provided institutional support to the project. The GOT purchased an ice-making machine for project use with its Treaty funds in order that the commercial fishing trials and export marketing trials could be undertaken. The GOT cooperated with project management to make the extension vessel *Manaui* available for project resource assessment and fishing cruises. The GOT also especially chartered a commercial vessel, *TASU I*, with Treaty funds to facilitate the project's commercial fishing trials. (Unfortunately, the vessel suffered mechanical breakdowns repeatedly and was of little actual use; the *Manaui*, in the end, was used to conduct most project cruises.) GOT officials intervened numerous times to facilitate project activities. For example, GOT officials arranged negotiations with the Government of Fiji in order to obtain duty-free transhipment rights for the exported fish enroute to Hawaii markets during the project's export marketing trials.

2.3 Project management and administration

2.3.1 Project management

The project implementation was managed under the direction of a Project Manager, J. Rowntree, based in the RDA home office in California and a Marine Resources Advisor/Team Leader, S. Petaia, based in the RDA field office in Tuvalu. The Project Manager in the home office was assisted, as required, by a Project Support Officer (over the life of the project: M. A. Kane, K. A. Hemstreet, and M. Crowley). The Marine Resources Advisor/Team Leader in the field office was assisted by a Project Secretary (T. Teii) and a Master Fisherman (L. Pasefika). The three field office personnel were Tuvaluan local hires.

2.3.2 Project coordination

A Project Coordinating Committee (PCC), composed of representatives of RDA, USAID, and the GOT, provided continual oversight and advice to the project management team.

Following is the schedule of the PCC meetings held during the project:

1st PCC Meeting:	November 1991; Funafuti, Tuvalu
2nd PCC Meeting:	February 1992; Funafuti, Tuvalu
3rd PCC Meeting:	June 1992; Funafuti, Tuvalu
4th PCC Meeting:	September 1992; Suva, Fiji
5th PCC Meeting:	January 1993; Suva, Fiji
6th PCC Meeting:	May 1993; Funafuti, Tuvalu
7th PCC Meeting:	February 1994; Suva, Fiji
8th PCC Meeting:	August 1994; Funafuti, Tuvalu

3.0 BOTTOMFISH RESOURCE ASSESSMENT

3.1 Overview of bottomfish resource assessment

Twenty-nine research cruises were completed during the biological assessment phase of the project using the GOT vessel, the *R/V Manaui*. Thirteen different geographical areas were hydrographically surveyed and systematically fished. Included in the areas surveyed were 2 previously unknown and uncharted seamounts, RDA Bank and Takalo Bank. A total of 9,981 kg of fish of 44 different species were caught during research fishing operations. Of this total, 24 species were marketable, with a total weight of 7,661 kg. Three species, *Etelis carbunculus*, *Etelis coruscans* and *Caranx lugubris*, made up the majority of catch by weight. The average CPUE (catch per unit effort) of all species was 5.55 kg/line-hour, and 4.05 kg/line-hour for marketable species, values similar to other regions in the South Pacific. Based on hydrographic research survey results, the total length of the 200 m depth contour (for all seamounts, islands and banks) is estimated at 376 nautical miles (nm) within the Tuvalu EEZ. (The area defined by the 200 m depth contour [isobath] has become a standard measure of bottomfish habitat useful in calculating the estimated biomass and fish stock, and in comparing habitat size among various geographic areas throughout the South Pacific.) The associated unexploited biomass of deep-water bottomfish is estimated to be 639 mt. Estimated yield at MSY ranges from 64 to 192 mt. Based on these MSY estimates, it has been calculated that this fishery could potentially support about 4 vessels fishing on the distant seamounts and about 2 additional vessels fishing around Tuvalu's islands. However, to ensure that catch rates remain high so that bottomfishing operations can maintain profitability, the economic and management analyses, reported later on in this report, suggest that the actual number of bottomfishing vessels in the Tuvalu fishery should be limited to 3 or 4 vessels.

3.2 Project implementation

The GOT considers marine resources Tuvalu's most important natural resource. Tuvalu realizes that while exploitation of deep-water bottomfish fishery resources could provide potential economic development, tropical deep-water bottomfish have a long life span, slow growth rate and variable larval recruitment, which make these species highly susceptible to over-fishing. Therefore, to scale a viable long-term commercial fishery, it was imperative that the sustainable yield of bottomfish stocks within the EEZ first be estimated. Several approaches could be used to determine maximum sustainable yield (MSY) for an exploited commercial fishery depending on the type, quality and quantity of data available. Most of these approaches depend on an extensive time series of catch-per-unit-effort (CPUE) data, or a large sample of both CPUE and length data. Unfortunately time and budget constraints precluded this type of research program and analysis for the Tuvaluan bottomfish stock. However,

relative abundance and hydrographic data collected in this program allow the unexploited biomass within the EEZ to be estimated. Systematic surveys were conducted throughout the archipelago at locations identified in Figure 3-1. These surveys provided information on local bathymetry, species composition, length frequency, catch rates and depth distributions. The range of MSY values were then calculated for the unexploited stock.

The bottomfish resource assessment component of the Tuvalu Bottomfish Project was developed throughout the life of the project. There were several key aspects of the assessment, including a preliminary resource review, hydrographic and bathymetric surveys, and test fishing.

Data collection was conducted onboard the GOT vessel, the *Manaui*. A total of twenty-nine research cruises were completed in order to assess the bottomfish resource of Tuvalu. The data collected involved the location of site fished, hydrographic position, depth of seamount surface and of fishing depth, fishing effort, and species caught by length and weight. The data collection also incorporated the design of the fishing equipment used. The project used a deep bottom droplining rig with variations in the number of reels, the number of hooks per line, the type of line used, and the depth to which they fished. The reels generally used were Samoan-type handreels which varied in number between one and four. (The *Manaui* did, however, have 2 electric reels onboard which were used on some research and commercial fishing cruises.) The number of hooks per line varied between five and seven. The type of fishing line varied between dacron and monofilament line or combinations of the two. The fishing depths varied between about 80 m and 350 m. Recording and the subsequent analysis of this data provided the basis for the biological assessment of the bottomfish resource in Tuvalu.

One hundred one (101) data sets were compiled from the data collected during the biological assessment phase of the project. The data were entered into database software in Tuvalu. These data were subsequently sent to the RDA Marine Biologist for analysis. Statistical analyses were done using the SAS statistical package. Hydrographic data were analyzed and plotted using a commercial digitizing template and Quattro Pro and Surfer hydrographic plotting software.

Hydrographic measurements were taken using a GPS positioning unit and a color sounding chromoscope. From this data, hydrographic chartlets of areas of potential fishery habitat were produced and plotted. Approximately 95% of fishable seamount and submerged bank habitat in the Tuvaluan archipelago was surveyed by hydrographic measurements and research fishing. During the course of fishing and hydrographic operations, five small seamounts were located and charted. In addition, the poorly charted submerged bank areas in the south of the archipelago (Kosciusco Bank, Bayonnaise Bank, and Macaw Bank areas) were extensively surveyed. The

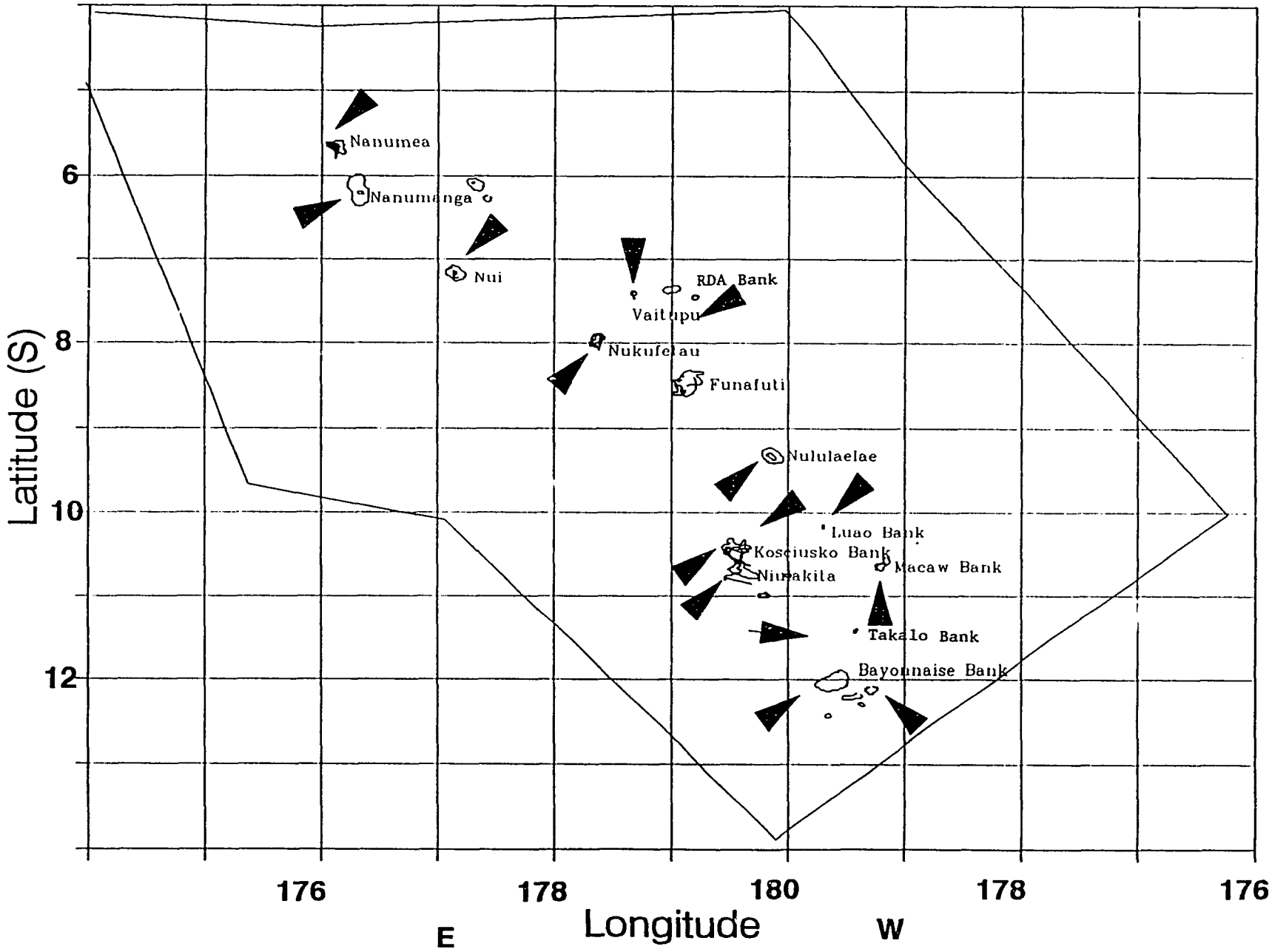


Figure 3-1. Survey areas of the islands, banks and seamounts of Tuvalu.*

*Arrows denote survey areas.

hydrographic data were digitized using the electronic template to calculate the length of the 200 m contour for each seamount or bank system. This 200 m depth contour is a measure of the potential bottomfish fishery habitat.

A brief summary of the schedule of events on an annual basis describes how the bottomfish resource assessment was conducted. At the end of 1991, during the first quarter of the project, the preliminary bottomfish resource review, based on existing information, was undertaken by the RDA Marine Biologist W. Haight with assistance from the MRA/Team Leader S. Petaia and Fisheries Department staff. The preliminary review was completed and submitted at the first PCC meeting during February 1992. In the year of 1992, the first full year of project activity, the GOT vessel, the *R/V Manaui* completed 17 bottomfish resource assessment cruises. In November 1992, 2 Tuvaluan data collectors participated in a data analysis workshop in Hawaii.

During a visit to Tuvalu in February 1993, RDA Marine Biologist W. Haight reviewed the results of the first year data collection efforts, updated the database program, and assisted the MRA/ Team Leader S. Petaia with the formulation of a sampling design for the 1993 bottomfishing season. W. Haight also provided training to the local data collection staff in all aspects of the data collection procedures. Later in the year, the resource assessment cruises were interrupted when the crew went to Suva to obtain the second vessel chartered by the GOT, the *TASU-1*. There was no one available to act as the skipper on the *Manaui* to continue the resource assessment cruises when the RDA Master Fisherman, L. Pasefika, went to Suva. A total of 8 resource assessment cruises were undertaken for the year of 1993.

During the first quarter of the 1994 year, both the *Manaui* and the *TASU*-1 were utilized to collect hydrographic and fish sampling data. Unfortunately, due to the mechanical problems with the *TASU-1* and *Manaui* running aground, only 4 research cruises were taken. During February 1994, the RDA Marine Biologist W. Haight worked with the project data collectors to compile all of the resource assessment and hydrographic data from the resource assessment cruises. Plans were then made for the data analysis workshop to be conducted in April 1994 in Honolulu. A preliminary analysis of the resource assessment data collected throughout the project was completed in Hawaii in April 1994, in conjunction with a data analysis workshop. Then a final 5 commercial fishing trial cruises were conducted during the third quarter of 1994.

In the month of December 1994, the Tuvalu bottomfish resource assessment was completed and the RDA Report "Tuvalu Bottomfish Project Final Biological Assessment" was submitted to the GOT and USAID in accordance with contract requirements.

3.3 Findings

3.3.1 Hydrographic surveys

Hydrographic measurements were taken using a GPS positioning unit and a color sounding chromoscope. From this data, hydrographic chartlets of areas of potential fishery habitat were produced and plotted. Approximately 95% of fishable seamount and submerged bank habitat in the Tuvaluan Archipelago was surveyed by hydrographic measurements and research fishing. The hydrographic data were digitized using the electronic template to calculate the length of the 200 m contour for each seamount or bank system. Potential fishery habitat, expressed as the length of the 200 m contour, is given in Table 3-1, reproduced here from the RDA Report "Tuvalu Bottomfish Project Final Biological Assessment".

Table 3-1. Length of 200 m isobath within the Tuvalu EEZ.

Bank	Isobath Length (nautical miles)
Luao	6.72
Kosciusko-Martha-Niulakita[a]	80.47
Macaw	24.79
RDA	1.75
Talie	3.23
Bayonnaise	95.62
Hera	9.65
Takalo	12.12
Rose[b]	13.31
Total (seamounts)	247.66
Total (islands)	128.2
Total (Tuvalu)	375.86

[a] The large seamount surface extending from Niulakita was included in the 200 m isobath measurement for Kosciusko. Martha Bank was also included with the Kosciusko Bank.

[b] The isobath length for Rose Bank is presented here separately, but it is sufficiently indistinguishable from Kosciusko Bank that it could as well have been included, along with Martha Bank, with the isobath length for Kosciusko Bank.

During the course of fishing and hydrographic operations, five small seamounts were located and charted. Figure 3-2 showing the depth contour map and Figure 3-3 showing the 3-dimensional profile of the newly discovered RDA Bank are examples of the graphic presentations developed from the hydrographic surveys of Tuvalu's distant seamounts. In addition, the depth contour maps of the two largest, but poorly charted, submerged bank areas in the south of the archipelago, Kosciusco Bank and Bayonnaise Bank, are presented in Figures 3-4 and 3-5, respectively.

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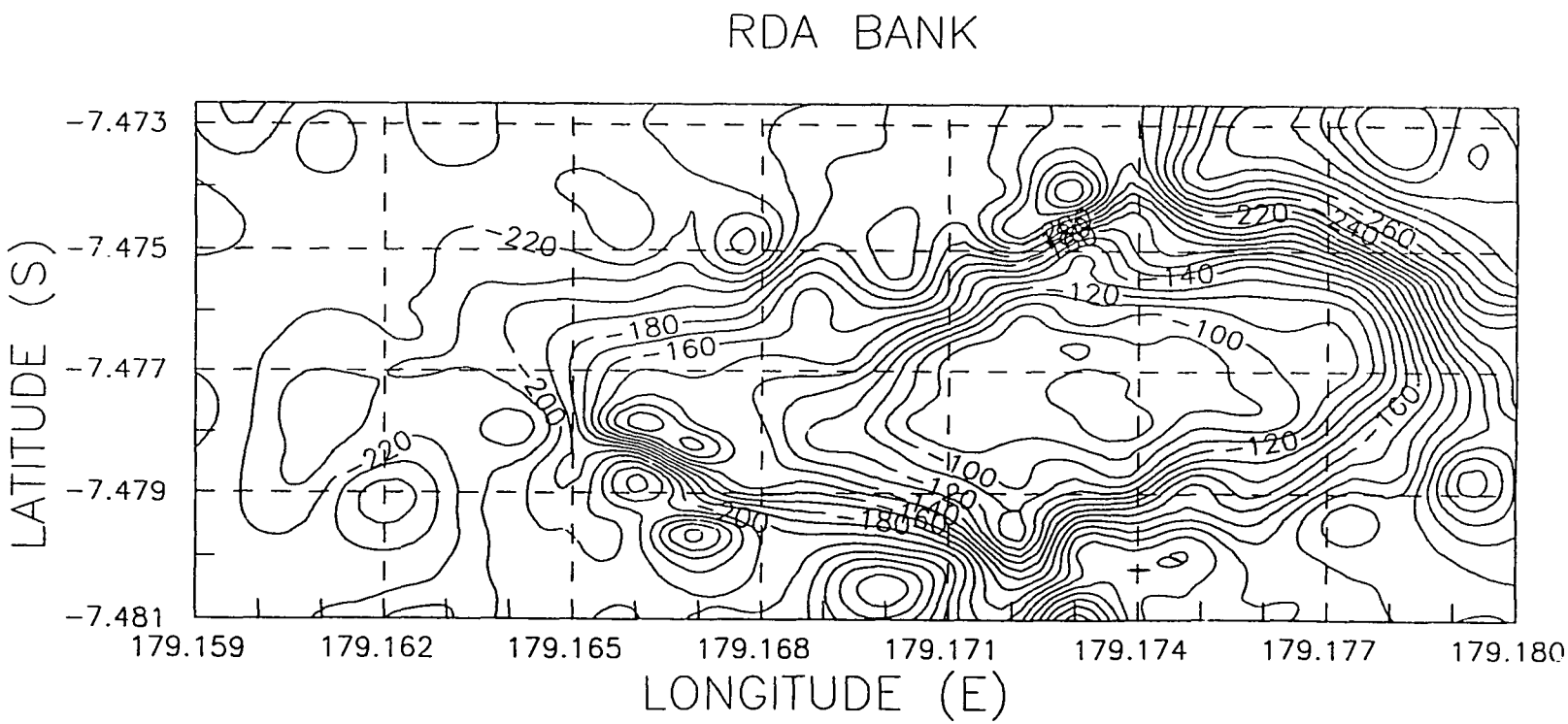


Figure 3-2. Depth contour map of RDA Bank.

Figure 3-3. 3-dimensional profile of RDA Bank.

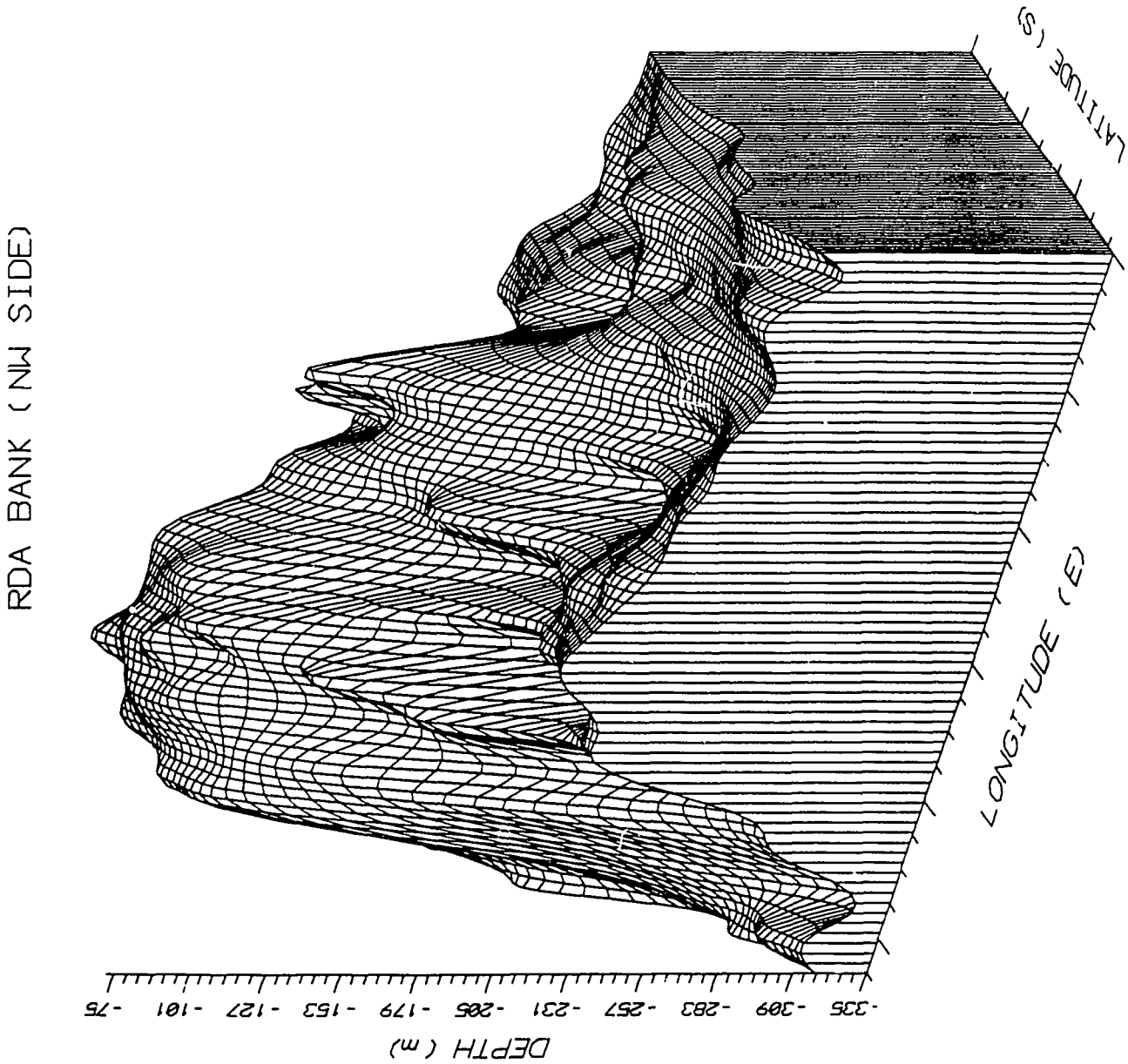


Figure 3-4. Depth contour map of Kosciusco Bank area.

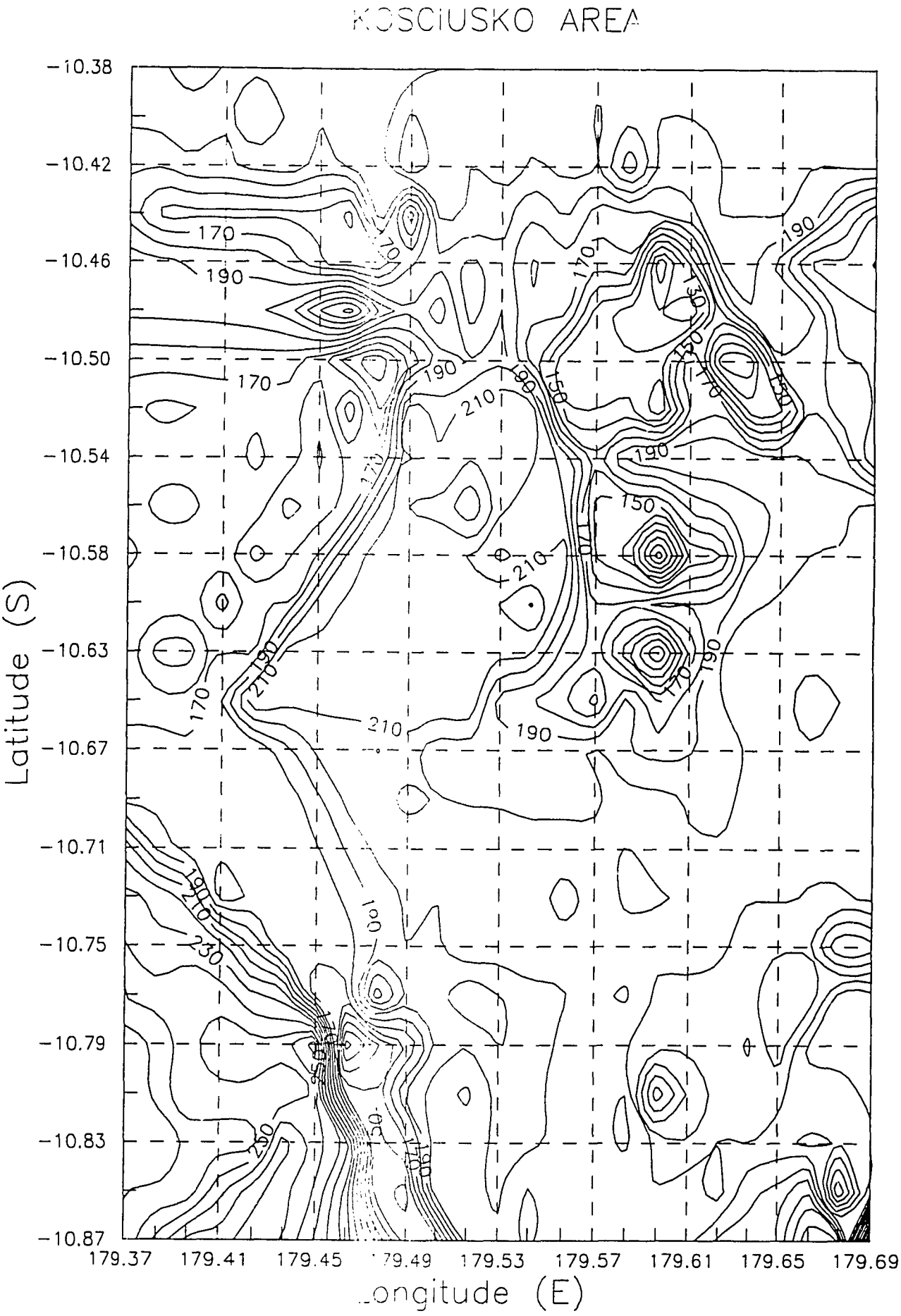
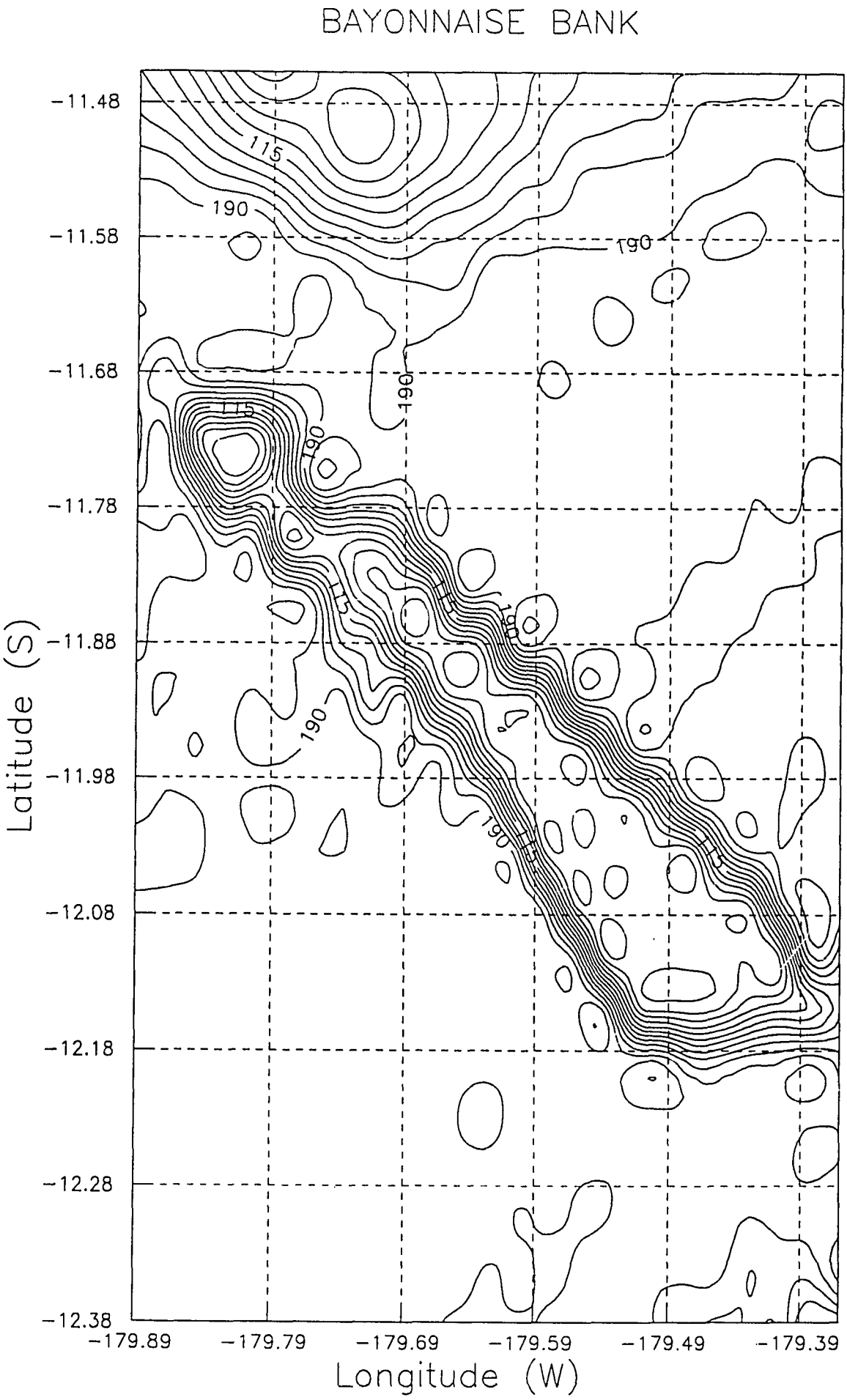


Figure 3-5. Depth contour map of Bayonnaise Bank.



3.3.2 Research fishing

A total of 9,981 kg of fish of 44 different species were caught. Of this total, 24 species were marketable, with a total weight of 7,661 kg (77%) (Table 3-2). Three species, *Etelis carbunculus, Etelis coruscans* and *Caranx lugubris* made up the majority of catch by weight. The average CPUE of all species was 5.55 kg/line-hour, and 4.05 kg/line-hour for marketable species. These CPUE values are average by regional standards and probably represent the lower bound of a commercial CPUE range. This is because research fishing is usually not as directed or intense as commercial fishing. (More information of project fishing activities is found in Section 4.0.)

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Table 3-2. Total catch by species and weight (marketable species only).

Species	Weight (kg)	Percent of Total Weight (%)
A. furcatus	12.1	0.16
A. rutilans	635.2	8.29
A. virescens	136.9	1.79
E. carbunculus	1682.7	21.96
E. coruscans	962.4	12.56
E. radiosus	62.7	0.82
P. lausakarii	133.6	1.74
P. auricilla	109.0	1.42
P. filamentousus	520.0	6.79
P. flavipinnus	369.8	4.83
P. multidens	68.5	0.89
P. zonatus	336.6	4.39
E. areolatus	16.0	0.21
E. chlorostigma	51.9	0.68
E. fasciatus	2.0	0.03
E. morrhua	329.2	4.30
E.septemfasciatus	538.9	7.03
V. louti	26.3	0.34
V. albomarginata	15.0	0.20
Other grouper	35.6	0.6
C. ignobilis	45.2	0.59
C. lugubris	1343.5	17.54
S. susmerili	54.0	0.70
S. rivoliana	164.0	2.14
TOTAL	7660.8	100.00

3.3.3 Biomass and MSY estimation

Unexploited biomass was calculated using a comparative approach based on data from 18 depletion surveys from similar regions in the South Pacific. The estimated unexploited biomass per unit area (mt/nm) for seamount and insular areas was calculated (Table 3-3), using habitat estimates from the hydrographic surveys (Table 3-1), relative abundance estimates from the research fishing, and the depletion survey information. The results of applying 3 different fishery models (Beverton-Holt, Gulland and Pauly) to data from the above regions in the South Pacific suggests the potential yield at MSY of stocks in the region is 10-30% of the unexploited biomass. Based on these calculations, the potential yield at MSY is 42-126 mt for seamounts in the Tuvaluan EEZ (Table 3-3). If atoll areas are included, the MSY is estimated to be 64 to 192 mt.

Table 3-3. Unexploited biomass and MSY range for Tuvalu.

Fishable Habitat	B_∞ (mt)	MSY Range (mt)
Seamounts	421	42 - 126
Islands	218	22 - 65
Total	639	64 - 192

If each fishing vessel in this fishery should catch 150 kg of bottomfish per fishing day for 90 fishing days per year, then the mid-range estimate of the MSY on the seamounts could be caught by about 6 vessels and the mid-range estimate of the MSY on both the seamounts and around the atolls could be caught with about 9 vessels. Care should be taken in applying an analysis of this type to the island contour as it assumes the bottomfish stocks are currently unexploited in those areas. Furthermore, the total allowable catch, and therefore the number of fishing vessels, will need to be restricted below the above estimates if, as they do, financial considerations require the maintenance of high CPUEs. It should be noted that the MSY estimates presented here are based on the results of research fishing trials, and represent a preliminary estimate of yield after the commercial fishery reaches an equilibrium exploitation level. As the commercial fishery develops, catch and effort data should be collected to create a time series database which can be used to refine the MSY estimates.

These resource assessment data were then incorporated into Table 3-4 and Figure 3-4, which show the islands and the seamounts of Tuvalu, their respective distances and steaming times from Funafuti, and the 200 m isobaths and MSY's of the seamounts. Table 3-4 and Figure 3-6 show that the 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 is expected to 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 MSYs; 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 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.

3.4 Conclusions

The hydrographic surveys on approximately 95% of Tuvalu's fishable seamount and submerged bank habitat taken by the project staff on research and test fishing cruises show that Tuvalu's distant seamounts have about 248 nautical miles of bottomfish habitat, as defined by the 200 m isobath or depth contour. Together with the fishable habitat near the islands, Tuvalu has a total 200 m depth contour of about

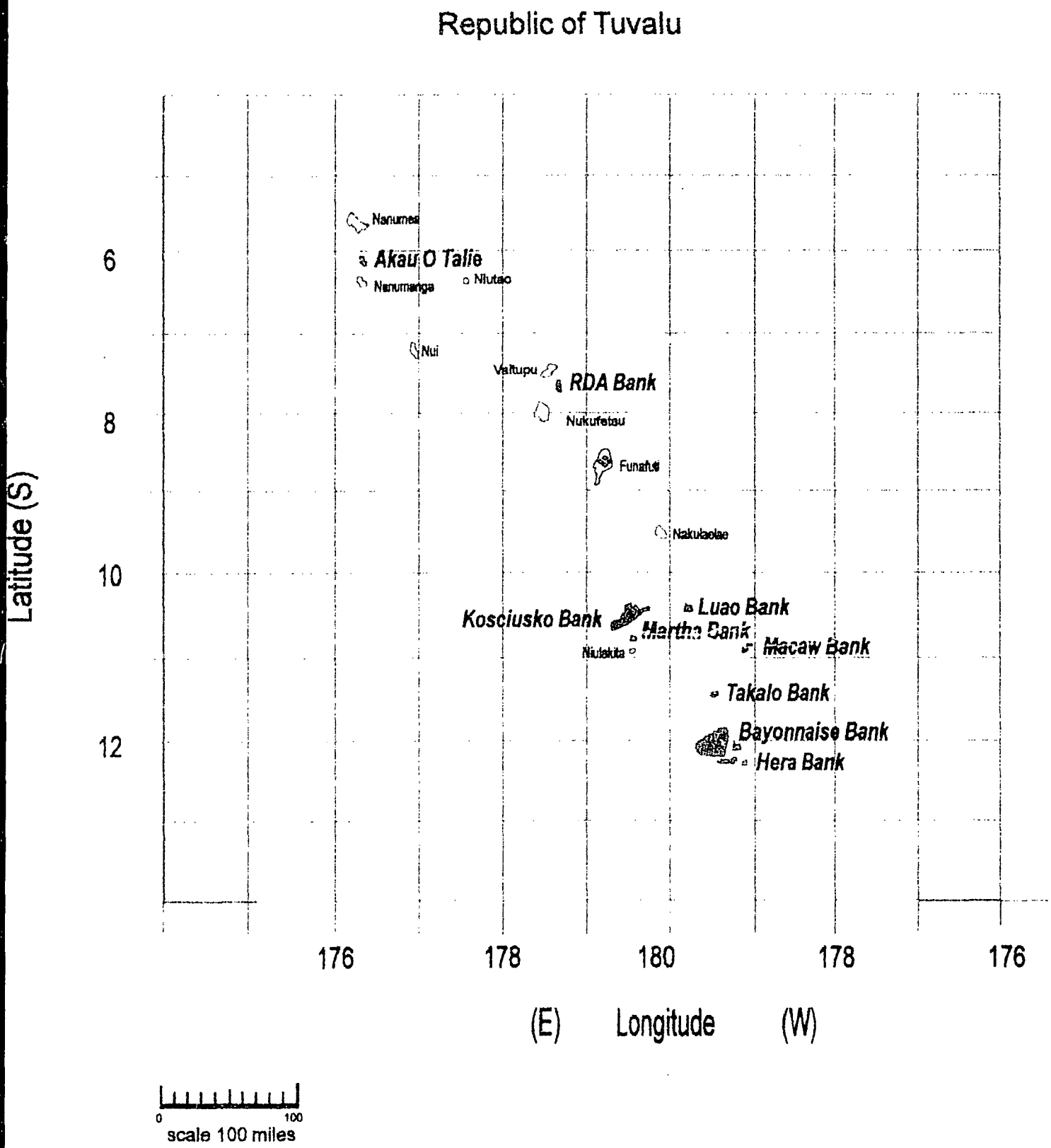
Table 3-4. The islands and seamounts of Tuvalu and their respective distances and steaming times from Funafuti, and the 200m isobaths and MSYs of the seamounts.

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		
	*AKAUL 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		
	*BDA 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
	*BALLONNAISE 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

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



376 nautical miles. The associated unexploited biomass of Tuvalu's deep-water bottomfish on the distant seamounts is estimated at 421 mt, while that for all of the Tuvalu EEZ is estimated at 639 mt. The estimated MSY range for Tuvalu's seamounts is 42-126 mt, and the estimated MSY range for the entire Tuvalu EEZ is 64-192 mt. Based on these MSY estimates, it has been calculated that this fishery could potentially support about 3 or 4 vessels without seriously reducing catch rates and profitability. Contour maps of all of Tuvalu's distant seamounts and 3-dimensional profiles of the smaller seamounts were prepared and should prove useful to the GOT and to new entrants to the fishery. The Final Biological Assessment by the Tuvalu Bottomfish Project concluded that Tuvalu does indeed have sufficient bottomfish habitat, stock biomass, and MSY to warrant the development of a modest commercial bottomfishing industry.

4.0 FISHING TRIALS

4.1 Overview of fishing trials

Twenty-nine research cruises were completed during the biological assessment phase of the project. A total of 9,981 kg of fish of 44 different species were caught during research fishing operations, 24 species of which were marketable with a total weight of 7,661 kg. The average CPUE of all species was 5.55 kg/line-hour, and 4.05 kg/line-hour for marketable species, values similar to other regions in the South Pacific. These CPUE values, average by regional standards, probably represent the lower bound of a commercial CPUE range because research fishing is usually not as directed or intense as commercial fishing. There were, in addition, 6 commercial fishing trial cruises, 1 of which was interrupted and discontinued due to an accidental grounding.

4.2 Project implementation

Test fishing for deep-water bottomfish species began in May 1992 in conjunction with the resource assessment activities. Twenty-nine test fishing cruises and 6 commercial fishing trial cruises were carried out onboard the GOT extension vessel, the *R/V Manaui*, or the GOT-chartered vessel, the *TASU-I*. Table 4-1 shows the schedule of the project cruises by quarter and by principal purpose, bottomfish resource assessments, commercial bottomfishing trials, and pelagic test fishing and FAD deployment. There were 26 cruises focused on bottomfish resource assessment, 6 cruises focused on commercial fishing trials, and 3 cruises focused on pelagic test fishing and FAD deployment. Virtually all successful fishing was done on the *Manaui*, as the *TASU-I* repeatedly had mechanical failures throughout the many attempts to utilize the vessel. The test fishing cruises focused on locating and charting productive fishing grounds on seamounts within the Tuvaluan EEZ. Several of the last test fishing cruises focused on catching exportable bottomfish species which were then exported in marketing trials.

The test fishing cruises monitored the catch effectiveness of fishing methods and equipment used noting what species were landed along with their lengths and weights. Other variables which were plotted included the fishing gear maintenance requirements, availability of supplies, and types of bait used. For bottomfishing test runs, the project used a deep-bottom droplining rig with variations in the number of reels, the number of hooks per line, the type of line used, and the depth to which they fished. The reels were Samoan-type handreels which varied in number between one and four. The number of hooks per line varied between five and seven. The type of fishing line varied between dacron and monofilament line or combinations of the two. The depths varied between 80 m and 350 m. For the pelagic test runs, the project used a longline technique employing seven branchlines with ten hooks per branchline. The types of line varied between monofilament and dacron, and the types of bait were varied.

Table 4-1 shows the schedule of the project cruises. There were 26 cruises principally focused on bottomfish resource assessment, 6 cruises principally focused on commercial fishing trials, and 3 cruises principally focused on pelagic test fishing and FAD deployment.

Table 4-1. Summary of project cruises.

Quarter	Resource Assessment Cruises	Commercial Fishing Trial Cruises	Pelagic Test Fishing and FAD Deployment Cruises	Comments
Oct-Dec 1991	0	0	0	
Jan-Mar 1992	0	0	0	
Apr-Jun 1992	6	0	0	
Jul-Sep 1992	6	0	0	
Oct-Dec 1992	5	0	0	
Jan-Mar 1993	0	0	1	Principally for FAD deployment and pelagic test fishing, but included some test fishing for bottomfish.
Apr-Jun 1993	0	0	2	Principally for FAD deployment, but included some test fishing for pelagics and bottomfish.
Jul-Sep 1993	1	0	0	
Oct-Dec 1993	4	0	0	Includes some *TASU I* cruises with mechanical breakdowns.
Jan-Mar 1994	4	0	0	Includes a *TASU I* cruise. Includes catch for 3 export marketing trials.
Apr-Jun 1994	0	1	0	*Manaui* grounded.
Jul-Sep 1994	0	5	0	Includes catch for 4 export marketing trials.
Totals	26	6	3	

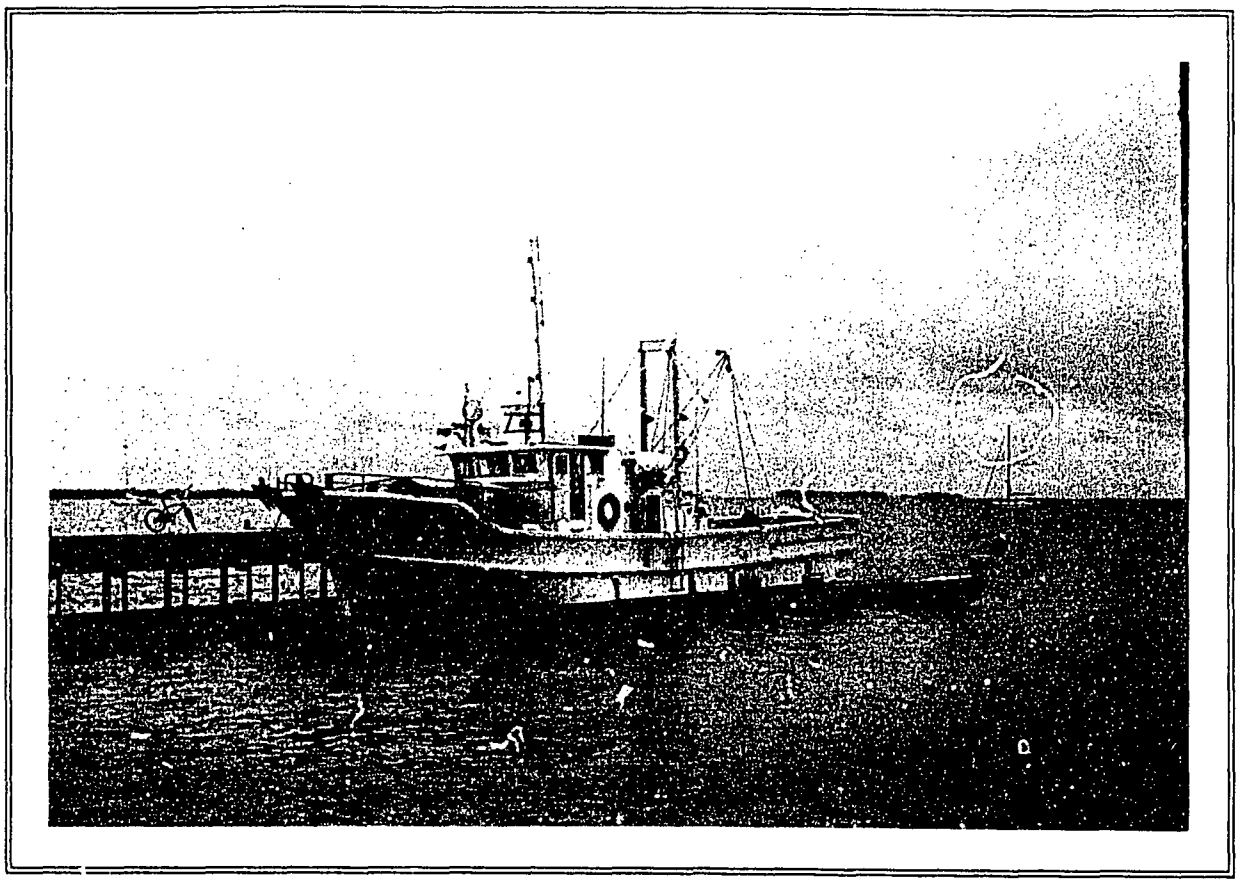


Figure 4-1. GOT extension vessel, the *R/V Manaui*.

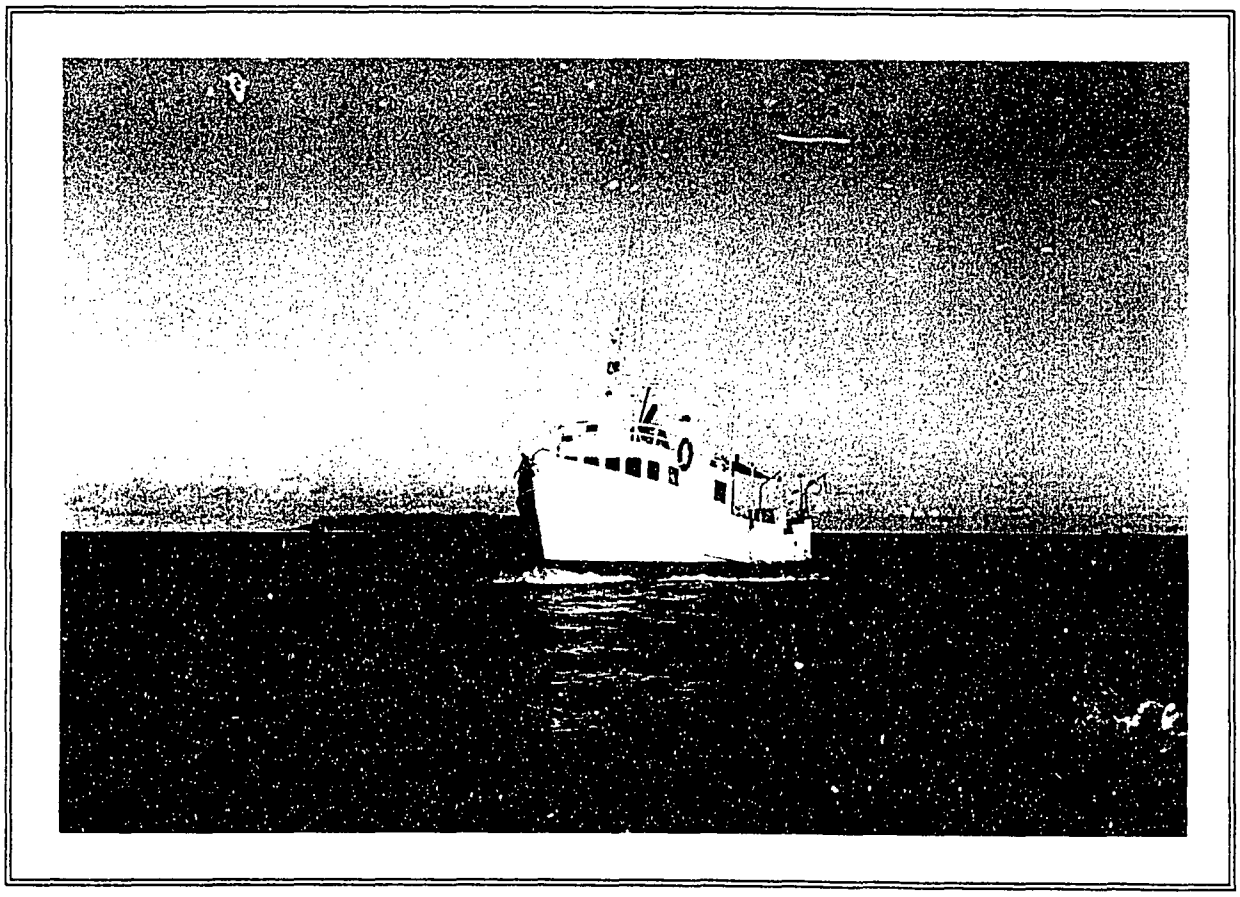


Figure 4-2. GOT charter commercial fishing vessel, *TASU-I*.

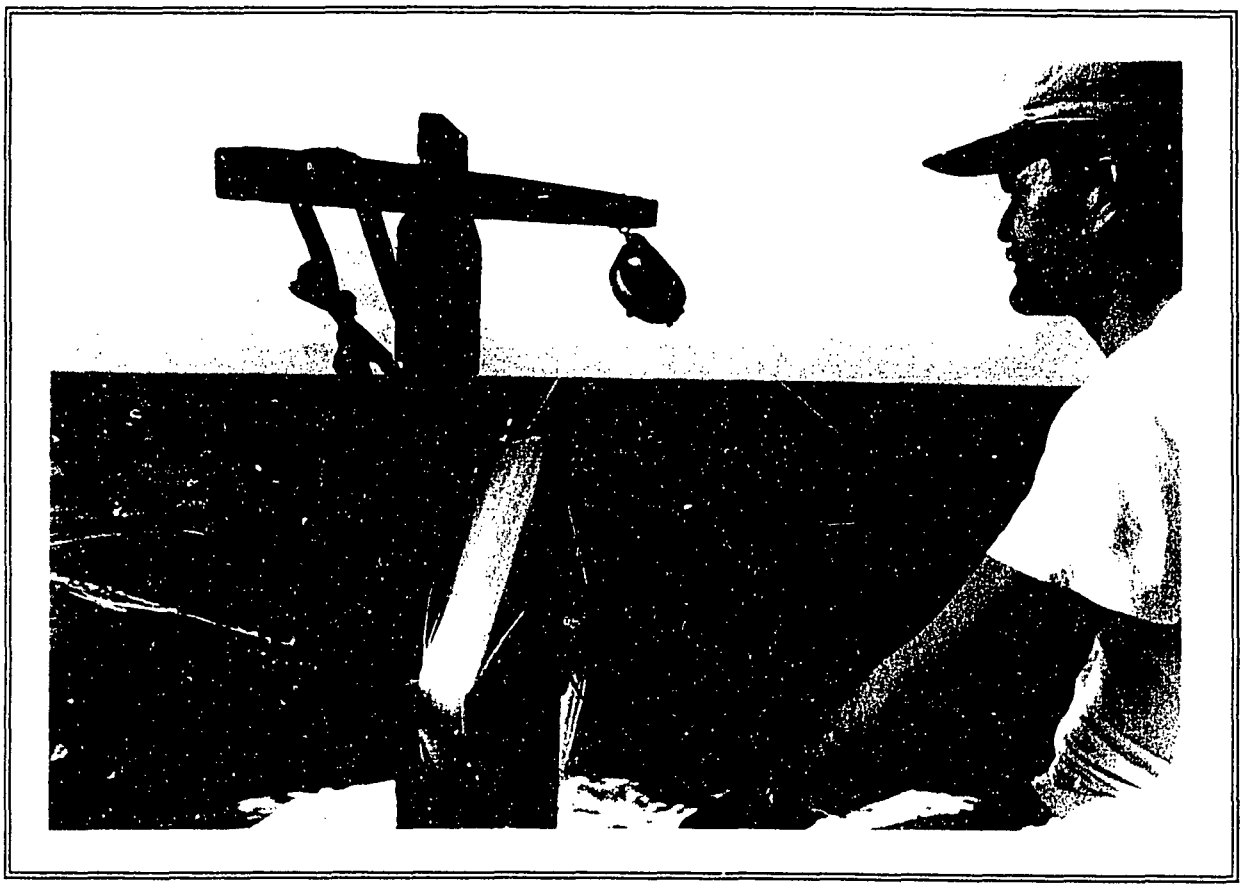


Figure 4-3. Samoan-type handreel.

In the first quarter of the Tuvalu Bottomfish Project, no activity was conducted with respect to the test fishing segment of the project due to the unavailability of a suitable vessel. The proposed Government of Tuvalu vessel, the *Te Kaleva*, was destroyed by a storm in December 1991, after which alternative vessels were explored. Test fishing activities for deep-water bottomfish species were undertaken in May of 1992 aboard the GOT extension vessel, the *R/V Manaui,* in conjunction with the resource assessment surveys. Test fishing trials focused on locating productive fishing grounds on seamounts, catch effectiveness in terms of species landed and total weight, necessary gear maintenance, availability of supplies, and economic aspects. A total of 17 test fishing trips were taken in conjunction with bottomfish resource assessment cruises during the year of 1992.

In the first half of the 1993 year, test fishing activities were primarily composed of three cruises focusing primarily on FAD deployment and partially on pelagic fishing trials. FADs were constructed and set for deployment. It was discovered at the end of the first quarter of 1993 that the Government of Tuvalu video camera was broken, so the videotaping of the FAD deployment was not carried out as planned. W. Haight, RDA Marine Biologist, joined the crew on the first pelagic fishing trial cruise. A longline rig with 7 branchlines and 10 hooks per branchline was the type of rig used. The problems experienced during the pelagic fishing trial were anticipated to continue due to lack of fresh bait for tuna longlining and lack of refrigeration storage capacity. Due to the unavailability of the *TASU-I*, the *Manaui* was used to conduct bottomfish resource assessment and bottomfish test fishing. The pelagic fishing evaluation was curtailed at this time due to the previously mentioned problems and lack of a second vessel. Five bottomfish test fishing trials were conducted in conjunction with the bottomfish resource assessment during the second half of the 1993 year.

During the first quarter of 1994, 4 bottomfish test fishing trials were conducted in conjunction with the bottomfish resource assessment. However, little test fishing for bottomfish was actually done because attention was focused on collecting sufficient hydrographic data. During the second and third quarters of 1994, the commercial fishing trial cruises were conducted. Six cruises were completed in this period, 5 of which were successful.

The information and experience gained in performing the test fishing trials led to development of a report on "Improving Commercial Feasibility of Tuvalu Bottomfishing" which focused on the need to target the high-valued longtail red snapper and the ruby snapper, and on the need to fish at greater depths that was commonly done during the test fishing associated with the resource assessment. This report was prepared and submitted to the Government of Tuvalu and USAID in January 1995.

The combination of the bottomfish resource assessment and the bottomfish fishing trials provided detailed information regarding the availability and suitability of catch for different sites within the Tuvaluan EEZ.

4.3 Findings

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 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 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 bottomfish ranged from 5 kg to 6 kg per line hour on several of the cruises and reached 6.88 kg per line hour on the final cruise.

The pelagic fishing trails were successful in demonstrating that tuna are indeed abundant and catchable in Tuvaluan waters. These trials were not a high priority for the project, and so few fishing trials were conducted that little information was found that would be useful in making policy recommendations. The initial findings are, however, suggestive of the need for the implementation of the regional component of the PIMAR Project, namely, to extend the results of the Tonga Small-Scale Tuna Longline Project to Tuvalu.

A total of 8 FADs were successfully deployed, one near each of the main Tuvalu islands.

4.4 Conclusions

The Tuvalu Bottomfish Project conducted a total of 35 cruises, principally for test fishing associated with the resource assessment and for commercial fishing trials. It was concluded on the basis of the project's fishing trials that commercial bottomfishing operators should be able to achieve CPUEs of 5-6 kg/line hour, sufficient to warrant a thorough economic and financial analysis of the commercial feasibility of bottomfishing in Tuvaluan waters.

The project also demonstrated the general catchability of tuna and set out 8 FADs near the 8 main islands of Tuvalu.

5.0 MARKETING AND ECONOMIC ANALYSES

5.1 Overview of marketing and economic analyses

The Tuvalu Bottomfish Project conducted 7 export marketing trials and established marketing linkages for the export of Tuvalu bottomfish to Hawaii. In addition, a preliminary economic evaluation established that continuing fishing and marketing trials was warranted, and a final economic evaluation established the commercial feasibility of developing a small but well-managed bottomfish fishery in Tuvalu.

5.2 Project implementation

The increase in volume of production from this new fishery, was expected to require the implementation of a viable export marketing system to realize the maximum potential economic benefit. This requires proper marketing and processing facilities, as well as an efficient air transport link. The establishment of an efficient export marketing system was to be developed to assist in sustaining the long-term viability of an expanded small-scale bottomfishery in Tuvalu. A contract amendment effective 1 July 1993, expanded the export marketing component to assess and evaluate the viability of and alternative options and channels for exporting bottomfish from Tuvalu, and to conduct export marketing trials and training.

At the beginning of the project, the potential development of a bottomfishing industry in Tuvalu was evaluated. The first stage of the economic and marketing evaluation of bottomfish involved a preliminary two-week field survey of the economic aspects of bottomfishing in Tuvalu in November 1991, conducted by Fisheries Socio-Economist, P.W. Philipson. The consultant held numerous discussions with GOT officials and with businesspeople in Fiji that have experience in export marketing of bottomfish. The results of this report were sufficiently promising that the resource assessment and fishing trials were instituted. An evaluation of the existing processing and marketing facilities for the export of bottomfish was determined to be inadequate and an upgrade of the facilities was discussed.

During the first quarter of 1992, the upgrade of the existing marketing and processing facilities was approved by the PCC and the capability of NAFICOT to handle export marketing activities with existing facilities at early stages of the project prior to the proposed upgrading was discussed. Later in the year the revised draft version of the preliminary economic evaluation was accepted during the third PCC meeting. The economic evaluation focused on the following: marketing constraints as a result of unavailability of basic marketing facilities and expertise; issues of subsidy to provide local fishermen with enough capital to purchase suitable boats; and the possibility of privatizing NAFICOT.

In accordance with the contract amendment dated 1 July 1993, export marketing trials were added to the project. Activity on the development of the detailed economic evaluation was delayed until sufficient data had been obtained from the commercial fishing trials and export marketing trials.

During 1994, there were a total of 6 commercial fishing trials conducted out of Funafuti for export to Hawaii. During these trials the RDA Marketing Advisor was able to provide the Tuvaluan fishermen with training in bottomfish care and handling techniques, established procedures to test for ciguatera poisoning, consulted with GOT officials responsible for a ciguatera monitoring program, and provided training for the fishing and export crews in the necessity of avoiding exporting any fish with possible ciguatera poisoning. Several fish were shipped to Hawaii explicitly for ciguatera testing. Project Manager and Senior Economist J. Rowntree visited Tuvalu in late October through early November to finalize details regarding the detailed economic evaluation.

Finally, the information provided by the resource assessment cruises and the fishing trials allowed RDA Senior Economist J. Rowntree to prepare a report on "The Commercial Feasibility of Bottomfishing in Tuvalu: A Final Economic Evaluation."

5.3 Findings

5.3.1 Marketing

5.3.1.1 Local marketing

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 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 few 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 was 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.

5.3.1.2 Export marketing

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. The 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 provided a firm basis on which to evaluate the current marketability and expected price situation.

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). (See Figures 5-1 and 5-2.) 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 condition of the fish as well as the current market conditions in Hawaii. This overview of bottomfish marketability in Hawaii is summarized in Table 5-1 below.

Table 5-1. 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

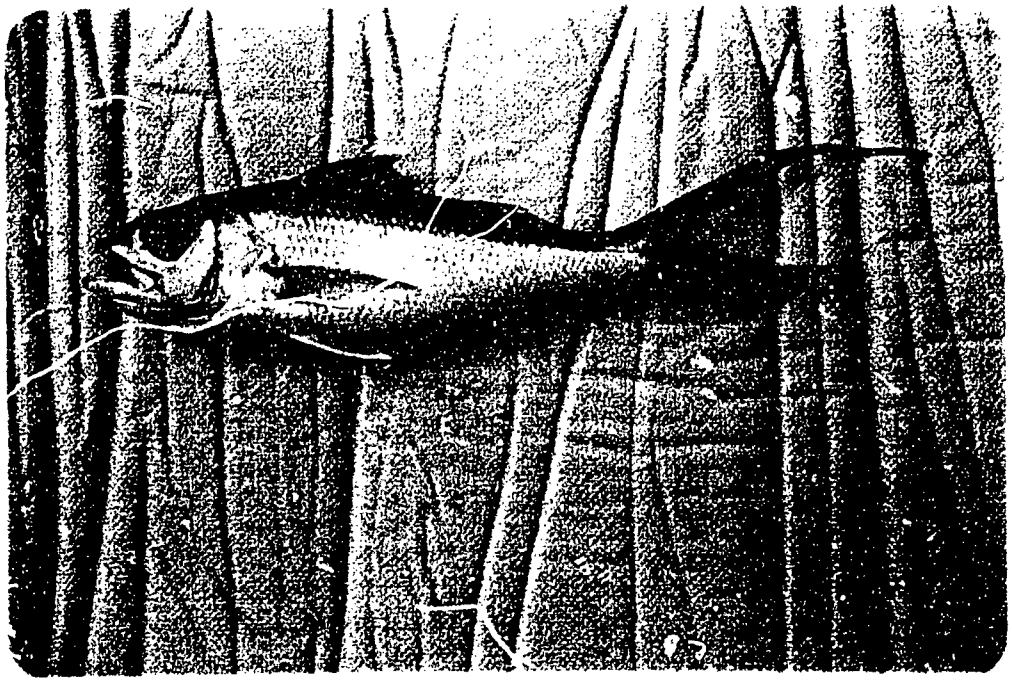


Figure 5-1. High-valued *Etelis coruscans* (longtail red snapper or onaga).

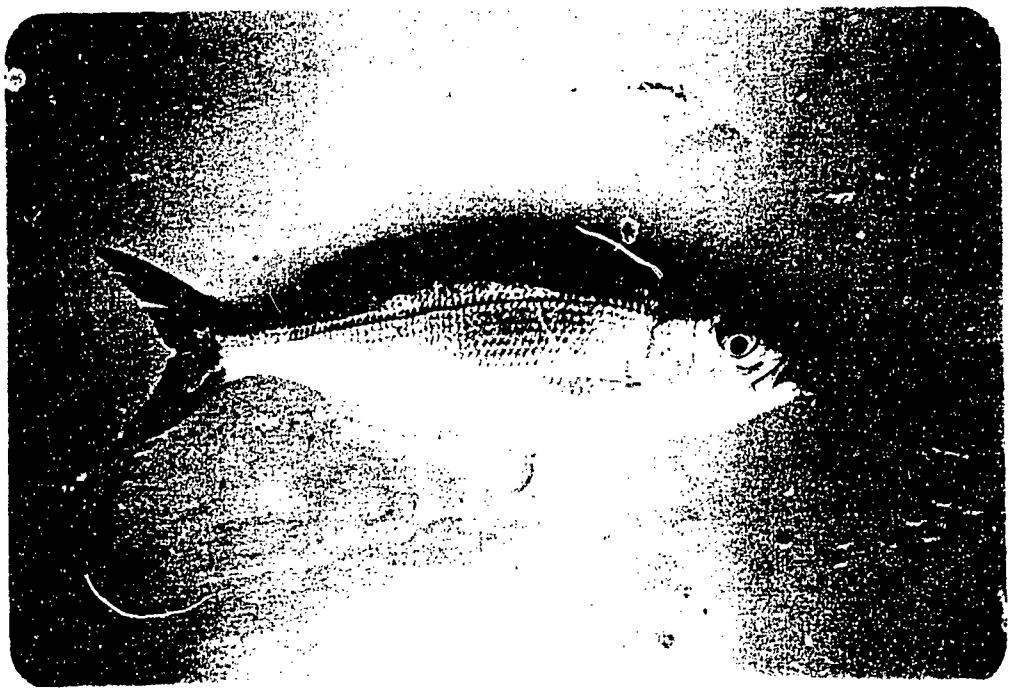


Figure 5-2. High-valued *Pristipomoides filamentosus* (ruby snapper or opakapaka).

While the project was 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, but project 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. 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 5-2 below.

Table 5-2. 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$10.25	50%	65%
Medium	A$ 8.61	30%	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 receive 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. This suggests that a commercial operation may be able to receive higher prices than those used here.

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.

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 before it is 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. (RDA Marketing Advisor P. Bartram trained Tuvaluans in these handling techniques and assisted in the export marketing trials.)

There is only one air carrier, Air Marshall Islands, serving the route from Funafuti, Tuvalu to Nadi, Fiji. Also, 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.

Figure 5-3. Packing of bottomfish for shipment to overseas market.

Figure 5-4. Cartons of iced bottomfish being put onboard Air Marshall Islands carrier enroute to Nadi, Fiji.

Air freight costs on Air Marshall Islands from Funafuti to Nadi currently amount to A$1.25/kg. Packing materials added about 30% to the weight of the fish over the 7 export marketing trials, with greater economy in packing material weight resulting as the trials proceeded. Air freight costs from Funafuti to Nadi per kg of fish were 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.

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.

Based on project experience, the total export marketing costs of Tuvaluan bottomfish sold in Honolulu was estimated to amount to A$5.80/kg of shipped fish. The detailed costs are summarized in Table 5-3 below.

Table 5-3. 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

5.3.1.3 Summary of marketing issues

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.

5.3.2 Fishing costs

5.3.2.1 Investment and fixed costs

There were several difficulties in estimating fishing costs in a developing Tuvaluan bottomfishing industry, principally due to the lack of prior Tuvaluan experience with this or any other commercial fisheries. Prior to the project's bottomfish export marketing trials, there were no official fish exports from 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. Up until only a few years ago, most vessels in Tuvalu's reef fishery were small canoes and skiffs. The only vessel now in Tuvalu which can travel to the distant seamounts is the *Manaui*, an 18.6 m fully equipped vessel, provided to Tuvalu by Japanese overseas aid in 1988, which is too expensive to function appropriately as a commercial bottomfishing vessel.

The general cost and revenue situation suggested that return projections required that the overall investment of a commercial fishing not exceed roughly A$50,000, 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. (See section 7.0.) The hull is presumed to be approximately 10 m in length and to cost approximately A$20,000, and the engine was assumed to be a 20 hp Yanmar diesel engine, costing less than A$10,000. 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 handreels. 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 handreels. 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 handreels. This discussion highlights some of the trade-offs which must be encountered in every beginning commercial bottomfishing operation in Tuvalu.

These initial investment costs are summarized in Table 5-4 below.

Table 5-4. 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

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 5.5 below.

Table 5-5. Annual fixed costs for a bottomfishing operation in Tuvalu.

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.

5.3.2.2 Running costs

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. A more suitable and more economically-powered vessel which can be supported by a commercial operation would use, for example, a 20 hp diesel engine consuming only about 3 l/hr at cruising speed. Fuel costs for a 5-day fishing cruise, with 3 actual fishing days, of an appropriate sized commercial

bottomfishing vessel for 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, were estimated at A$124. This compared with the fuel cost of a similar trip by the *Manaui* of A$1,087.

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 GOT purchased a 1 mt/day capacity fractured ice-making machine. The ice-making machine was placed on NAFICOT grounds 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. 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. 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.

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During the project, skipjack tuna was 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. In view of the high costs of imported bait, the limited refrigeration capacity in Tuvalu for storing frozen bait, and the high cost of electricity in Tuvalu, however, it was concluded that fishing for bait is likely to continue being the most economical source of bottomfish bait.

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. However, it was concluded that approximately A$3.00 per day per crew member for provisions would be considered satisfactory by crew members and potential boat owners. Provisions for a 3 person crew for a 5 day fishing trip would cost approximately A$45.

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 and 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 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. After balancing all of the financial considerations involved, it was concluded that 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.

In addition to the above discussed cost items, the financial calculations also assumed that an allowance of A$25 per fishing trip should be made for gear replacement. In addition, miscellaneous fishing costs were estimated at A$25 per fishing trip.

A summary of the running costs of a typical 5-day fishing trip for a suitable commercial bottomfishing vessel are shown below in Table 5-6 below. These were the running cost estimates used in calculating projected rates of return on investment in a fishing operation.

Table 5.6. Summary running costs for a typical 5-day fishing trip.

Cost Category	Commercial Vessel 3-person crew
Fuel	A$124
Ice	A$125
Bait	A$ 0
Crew Provisions	A$ 45
Crew Wages	A$347
Gear Replacement	A$ 25
Miscellaneous	A$ 25
Total Cost Per Trip	A$691

5.3.2.3 Commercial feasibility of bottomfishing on Tuvalu's distant seamounts

Based on the above discussed expected revenues and costs, the prospective rates of return on investment in bottomfishing in Tuvalu were estimated. Four basic scenarios were investigated. The 4 scenarios 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. Each fishing trip was assumed to involve 3 days of fishing and 60 line hours of fishing effort. In the following rate of return calculations, the vessel was assumed to last for 10 years and be sold for 15% of its initial value at the end of a 10 year period. Rates of return for the 4 basic fishing scenarios were calculated, after which, the sensitivity of these rates of return to 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 were examined. The results are presented in Table 5-7 below.

A brief review of the implications of the rates of return in Table 5-7 will clarify several key features of the commercial feasibility of bottomfishing on Tuvalu's distant seamounts.

Only 3 of the 4 base fishing scenarios yield 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 were also calculated for the base scenarios. 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.

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 6.0-7.5 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-

Table 5-7. The sensitivity of rates of return on investment in bottomfishing in Tuvalu.

	Base Scenarios (A$50,000 initial investment; 30 fishing trips per year)	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%

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.

The additional columns in Table 5-7 show the sensitivity of the rates of return to small changes in the assumptions.

First, 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% increase or decrease in the size of the initial investment decreases or increases the prospective rates of return by a factor of roughly 20%-40%, highlighting the importance of employing a relatively small and inexpensive vessel.

Second, the rates of return on investment are also quite sensitive to small changes in the number of fishing trips undertaken each year. Increasing the number of fishing trips from 30 to 35 per year increases the range of rates of return from 7.4%-26.1% to 13.1%-34.7%.

Third, the impact of a doubling of fuel costs is particularly strong. 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.

Fourth, since only a third of the fish catch is marketed locally and since the price received on local sales is so low, 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.

Fifth, 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. 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.

This overview demonstrates 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.

5.4 Conclusions

The project successfully completed 7 export marketing trials, trained numerous Tuvaluans in fish handling, packing, and shipping procedures, identified market contacts and linkages for ensuring the successful export of bottomfish from Tuvalu to Hawaii, and conducted a preliminary and a final marketing and economic evaluation of bottomfishing in Tuvalu. It has been determined that a small, well-managed bottomfish fishery targeting high quality export quality bottomfish can be a commercial success in Tuvalu.

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6.0 BOTTOMFISH RESOURCE MANAGEMENT PLAN

6.1 Bottomfish resource management plan overview

To ensure the long-term sustainability of the bottomfish resource, the project developed, in cooperation with GOT and private industry representatives, a bottomfish management plan. Several bottomfish management plan workshops were conducted in Tuvalu to elicit input and operation from all sectors of Tuvalu. The final bottomfish management plan recommended that fishing effort in the fishery be limited to 3 or 4 vessels in order to maximize economic yield. A licensing system was recommended to restrict participation in the fishery. A quality control inspection system and a permanent monitoring and reporting system were recommended to be established. Success and sustainability of an export-oriented bottomfish industry will require a high degree of cooperation between the GOT Department of fisheries and the private sector bottomfishing operators.

6.2 Project implementation

High-valued exportable deep-water bottomfish have been caught using lines and baited hooks in depths of over 200 meters in Tuvalu. Results from this project and elsewhere suggest that the resource is fragile, involving slow growing species with long life-spans and limited habitats. Typical results of developing such a fishery are that catch rates and fish sizes decrease with increasing exploitation. The mean length of fish decreases as initial catches of larger, older fish are replaced by those of younger fish, and the stocks are easily depleted by fishing. The development of a bottomfish resource management plan for Tuvalu is necessary to ensure the sustainability of the bottomfishing in Tuvalu.

Formulation of the bottomfish resource management plan began with the examination of current Tuvaluan fisheries legislation relating to the management of the bottomfish resource by the RDA Marine Resources Advisor with assistance from the RDA Marine Biologist. Conservation and management legislation for the Tuvaluan bottomfish resource was determined to be non-existent. Therefore, the management plan had to be created from discussions and interactions with the Department of Fisheries and other GOT officials and staff, fishers, and other private sector representatives, and from data gathered during test fishing and bottomfish resource assessment activities.

The development of a bottomfish resource management plan began with the compiling of data for the bottomfish resource assessment and test fishing conducted throughout the first two years of the project. These data provided the status of the stocks, with respect to size, location, and depth of bottomfish catches. The data provided by the bottomfish resource assessment and test fishing needed to be compiled and evaluated before the management plan could be developed.

To assist in the development of the management plan, several workshops were conducted by the RDA staff for interested parties, including GOT officials, representatives from the Tuvalu Development Bank, and private fishermen. At the workshops, project findings were presented and initial ideas regarding the development of the bottomfish management plan were explored. J. Rowntree and S. Petaia conducted a preliminary bottomfish management plan workshop for about 20 participants during early August 1994. RDA Marine Biologist M. King traveled to Tuvalu in late October-early November 1994 to begin drafting the bottomfish management plan. It was agreed at the PCC meeting held in August that the draft management plan would be circulated for Tuvaluan comment simultaneously with USAID review in order to speed the process of reaching consensus and soliciting local input to the design of the management plan. A second workshop conducted by RDA Senior Economist J. Rowntree and RDA Marine Biologist M. King in November 1994 discussed the requirements of a bottomfish management plan for Tuvalu. A final project workshop conducted by M. King in January 1995, reviewed the Draft Bottomfish Management Plan. The final version of the management plan, "Management Plan for the Deep-Water Bottomfish Fishery in Tuvalu," was completed in January 1995.

6.3 Findings

The development of the bottomfish resource management plan was based on the information and analysis prepared in the bottomfish resource assessment and test fishing component and in the economic evaluation component of the project. These latter analyses recommended that the fishing effort in the fledgling fishery be restricted to an initial maximum of 3 to 4 moderately-sized vessels which have low running cost, in order to maximize economic yield and thereby net profits in the form of foreign exchange to the country as a whole. The Management Plan then recommended that the number of vessels in the fishery be restricted by means of a licensing system. The license should in effect be an export license which permits the owner-operator of a suitable vessel to catch and export deep-water bottomfish from Tuvalu, subject to quality control procedures. A quality control inspection system was recommended to maximize the value of the catch, but this should not be such that it hinders the packing and transportation of fish. The success or failure of the Tuvaluan deep-water bottomfish fishery is highly dependent on maintaining a high reputation and market price for its products.

A permanent monitoring system was also recommended. It was proposed that the recording of catch and fishing effort by area in a fishing logbook should be a legal requirement of participation in the fishery. An additional option of allowing foreign fishing vessels access to stocks which are inaccessible to the Tuvaluan fleet in return for a negotiated fee was discussed. Some concerns expressed by the public regarding the development of a bottomfish fishery in Tuvalu were also addressed.

Factors which would put the development of the new fishery at risk include: 1) a reduction in catch rates, caused, for example, by too many vessels in the fishery; in general, the larger the number of vessels, the lower the catch rate of each; 2) a decrease in fish prices, caused, for example, by a failure of quality control or by a reduction in demand for the main species; and 3) an increase in costs, caused, for example, by larger vessels entering the fishery and causing over-capitalization, or by any increase in freight charges.

6.3.1 Tuvalu's bottomfish resources

Deep-water snappers and groupers are caught commercially using lines and baited hooks in depths of about 200 m in several countries of the South Pacific, including Western Samoa, Tonga, Vanuatu, Papua New Guinea and Fiji. Deep-water bottomfish are typically caught around the perimeters of islands and offshore seamounts. In Tuvalu it would appear that the highest-valued exportable species are taken at depths of 200 m - 400 m. Using the length of the 200 m isobath as an index of fishable habitat, the combined lengths of these isobaths in Tuvalu is 248 nautical miles for all seamounts, and 128 nautical miles around islands, giving a total of 376 nautical miles of fishable habitat. The length of the 200 m isobath around Funafuti itself is about 40 nautical miles. In comparison, the length of the 200 m isobath in Tonga is 294 nautical miles for all seamounts, and 930 nautical miles for all fishable habitats. The fishable area of Tuvalu is closest in size to that of Western Samoa, which has approximately 304 nautical miles of 200 m depth contour in which approximately 75 mt of deep-water snapper are caught per year.

In the Tuvalu project trials, the high-value export species, including *Etelis coruscans, Etelis carbunculus,* and *Pristipomoides filamentosus*, accounted for 64.7% of the catch. The composition of the most important export species differs in other countries. The following information is included for comparisons. In Western Samoa, the species, *Etelis coruscans, Aphareus rutilans, Paracaesio kusakarii,* and *Pristipomoides typus*, account for approximately 84% of the estimated 75.4 mt of deep-water snapper caught per year (King, 1989). In Tonga, *Etelis carbunculus, Epinephalus septemfaciatus, Epinephalus morrhua,* and *Pristipomoides filamentosus* are the most important export species.

It is expected that a commercial operation, with the benefit of project survey results and financial incentives, would improve on project trial catch rates, and make catch rates of between 4 kg and 5 kg per line hour of export marketable species. These initial catch rates can be maintained only if the number of vessels entering the fishery is kept low, and the stock weight (biomass) is allowed to remain relatively high.

Western Samoa, which has a similar total fishable habitat to that of Tuvalu, has an annual sustainable yield of 38 mt. In Tonga, the total annual catch of all bottomfish throughout the Kingdom is estimated to have reached a maximum of 514 mt in 1987, and subsequently to have declined to less than 200 mt. The most recent analysis of the data suggests that the maximum sustainable yield for the five main species caught in Tonga is approximately 350 mt per year, and for the two major export species (*Etelis coruscans* and *Pristipomoides filamentosus*) is 210 mt per year.

An initial estimate of sustainable yield for Tuvalu made by using the length of 200 m isobath as an index of fishable habitat concluded that the sustainable yield for around islands is 44 mt and for the seamounts is 84 mt. (See Section 3.0 above.)

6.3.2 Fishery management strategies

A likely fishing operation will be one in which a vessel completes 30 trips each year, 3 fishing days each trip, and 24 line hours of actual fishing time per day. Based on a catch rate of 4 kg per line-hour for the main target species, a fishing operation would land 288 kg per trip and 8.6 mt of exportable fish each year (Table 6-1). This assumes that catch rates can be maintained at the survey level. The expectation is that a commercial vessel will initially improve on the survey catch rates as higher densities of fish are targeted, but catch rates will slowly decrease as the stock biomass is markedly reduced by fishing.

Table 6-1. Fishing operational information and estimated catch per trip per year from 1 vessel.

Trips per year	Fishing days per trip	Line-hours per day	Catch (kg) per line-hour	Catch (kg) per trip	Catch (mt) per year
30	3	24	4	288	8.6

If fishing operations conform to the scenario suggested in Table 6-1, the sustainable yield of 76 mt from Tuvalu could be taken by approximately 9 vessels. A smaller number of vessels than this, would result in the maintenance of higher catch rates and greater profitability.

There are many alternative strategies for developing the deep-water snapper fishery in Tuvalu, but taking into account the high setting-up expenses, it is likely that only 1 or 2, or at least very few, purpose-built vessels will start fishing for deep-water snappers within the foreseeable future. Their fishing operations would ideally consist of fishing on seamounts within a 150 nautical mile radius of Funafuti when weather

permits, and fishing around Funafuti only in unsettled weather. As the annual sustainable yield for Funafuti itself is perhaps 8 mt, it is essential to ensure that this more accessible stock is not over-exploited. As has been suggested above, Tuvalu should limit the total number of vessels engaged in bottomfishing to 3 or 4 vessels.

Historically, the main objective of fisheries management has been the conservation of fish stocks. In modern fisheries management this limited aim has been extended to address additional economic, social and environmental objectives such as fishers' welfare, economic efficiency, the allocation of resources, and environmental protection. The broad objectives of fisheries management may, therefore, include the conservation of fisheries resources and their environment, the maximization of economic returns from the fishery, and payment of fees to the community from profits made by the exploitation of a public resource. Subsuming all these objectives is the need to ensure that fisheries are exploited on an ecologically sustainable basis. As the proposed fishery makes use of passive (non-towed) fishing gear in deeper water habitats which are ecologically divorced from traditionally exploited inshore ecosystems, there is likely to be little environmental and sociological impact in developing the fishery. Three broad and alternative objectives are maximizing participation, sustainable yield, or economic yield from the fishery, and these are discussed briefly below.

6.3.2.1 Maximizing participation

Maximizing the participation of local people in the developing fishery would involve encouraging and providing training for local fishers to fish for deep-water bottomfish off nearby reefs. As the vessels used would be those already in existence, their size and range suggests that this fishing effort would most likely be concentrated on the 40 nautical miles of reef surrounding Funafuti lagoon.

This strategy would result in a large number of fishers using relatively inefficient and discontinuous fishing operations to catch small numbers of fish per trip. In addition, it would be difficult to maintain the quality of the catch, and to coordinate its landing and export. Also, the collective catch of these fisheries would almost certainly exceed the sustainable yield of Funafuti Atoll which is estimated at approximately 8 mt.

As this management strategy would undoubtedly result in local over-exploitation, and a catch suitable only for local markets, it represents a waste of a resource which is potentially valuable to Tuvalu in terms of earning export income.

6.3.2.2 Maximizing sustainable yield

This strategy would involve maximizing the sustainable catches from the fishery by allowing the entry of a relatively large number of vessels. The maximum sustainable yield of 76 mt for all of Tuvaluan fishing areas may be taken by approximately 9 vessels (assuming that these vessels fish according to the operation summarized in Table 6-1).

However, the disadvantage with this strategy is that, at this level of exploitation, catch rates will be much lower than those obtained at lower rates of exploitation. Theoretically, catch rates in a fully exploited fishery are about half of those obtained initially. Such low catch rates are unlikely to cover the high costs of fishing, and at the point of maximum sustainable yield, financial returns (net profits) from the fishery are likely to be low or negative.

6.3.2.3 Maximizing economic yield: The recommended option

Maximizing the net financial returns from the fishery and profit to the country, in general, requires a fleet which is small but efficient. A strategy of maximizing profits will exclude the use of larger vessels with high operating costs, and require the use of smaller more efficient vessels. These could be used safely within a 150 nautical mile radius of Funafuti, but may not be capable of reaching the more distant grounds surveyed except in extended periods of good weather. An additional advantage of this strategy is that the level of fishing required is biologically conserving, and is unlikely to over-exploit the fish stocks.

A disadvantage is that, in the longer term, the profits made by a few boats are likely to attract others into the fishery. However, the economic benefits from the fishery will only be maximized if the number of vessels in the fishery is restricted. At higher levels of exploitation, the average catch rates of all vessels will be reduced below that necessary to cover costs. In other words, the fishery will only be profitable if entry into it is restricted to a few efficient vessels.

In summary, management strategies which maximize participation in the fishery and sustainable yield may be appropriate in the case of artisanal inshore Pacific Island fisheries, where the resource provides employment or food for a large number of fishers; in this context employment and food gathering may be chosen in favor of efficiency. The deep-water bottomfish fishery, however, is a commercial export-based operation, and there is a strong case for maximizing foreign earnings to the country from the fishery.

It is therefore recommended that fishing effort is restricted in order to maximize economic yield. The most direct method of restricting access to the fishery is by means of a licensing system which is discussed in the following section. The number of vessels in the fledgling fishery should be restricted to a maximum of 3 or 4 moderately-sized vessels which have low running costs, and could be used safely within the area of Tuvalu's distant seamount fishery. This number of vessels should ensure that high catch rates are maintained, and that the fishery has a good chance of being profitable.

6.3.2.4 An additional option: Limited foreign access

The recommended fishery management strategy is to maximize the net financial returns from the fishery and to maximize profit to the country. This requires the use of smaller, low cost (<A$40,000) vessels which have the capacity to exploit grounds, first within a 150 nautical mile radius and later within a 250 nautical mile radius of Funafuti. The use of smaller vessels may in effect leave the more distant but productive grounds unexploited.

One option available to the government is to allow foreign vessels to have access to stocks which are inaccessible, for cost reasons, to the Tuvaluan fleet in return for a negotiated fee. For example, Fiji-based fishers may be allowed to take fish up to a maximum allowable limit from seamounts located from 150 to 250 nautical miles south of Funafuti. Access fees paid by the fishers would ensure that excess profits accrue to the government and people of Tuvalu.

The disadvantages include the burden of placing observers on board the foreign vessels to ensure that the total allowable catch is not exceeded. In addition, if foreign vessels landed their catches in Funafuti, they may compete with local fishers for limited ice and air-cargo space.

6.3.2.5 An additional management measure: Quality control

In any management strategy which relies on maximizing returns from exported fish, the maintenance of quality is essential. The poor sale value of fish exported from some Pacific Islands has been mentioned previously. The success or otherwise of the Tuvaluan deep-water bottomfish fishery is highly dependent on maintaining a good reputation and market price for its products. As a single shipment of poor-quality fish is likely to undermine the efforts of those who have been striving to maintain a good reputation for Tuvaluan fish exports, a quality control system is recommended.

A full quality control system would involve the government inspection of fish intended for export, and approval to export would be given only for fish reaching a defined minimum standard of quality. However, the requirement for inspection before

exportation should not be such that it delays the air-shipment of a highly perishable product. An alternative to inspection of all exports would be the random inspection of fish being landed and packed.

6.3.3 Fisheries regulations

Fisheries regulations are imposed on a fishery to support a strategy designed to achieve predefined objectives. Regulations are used either to reduce or contain effective fishing effort (*input controls*), or to restrict the total catch (*output controls*) to predefined limits. However, most regulatory measures traditionally applied to fish stock are inappropriate in the case of deep-water snapper stocks.

Legal minimum lengths, making it illegal to retain individuals smaller than a prescribed minimum size, is not suitable for deep-water species, as the survival of fish returned to the sea after being hauled to the surface from deep-water is low. This regulation is not recommended.

Closed seasons are sometimes applied to fisheries at the time of recruitment (when young fish are added to the stock), or during the spawning period to allow fish to breed without interference. However, there is no evidence that seasonal closures would be of any benefit to the bottomfish fishery, as the recruitment periods and spawning seasons of the species are not known. In addition, small fish (larvae) may be recruited to seamounts from other distant areas. This regulation is not recommended.

Rotational closures, in which different fishing grounds (seamounts) are periodically closed and opened to fishing on a rotational basis have been recommended for the bottomfish fishery in Tonga. Potentially this allows fishing areas time to recover from intense fishing, and may result in an increased reproductive output. However, the efficacy of this depends on the time required for local seamount stocks to recover from heavy fishing. Because of the slow growth rates of the species, the recovery time is likely to be long, and individual areas would have to be closed for many years to be of benefit. Rotational closures are also expensive to enforce, and require the use of a sea-going patrol vessel. This regulation is not recommended.

Gear restrictions are common in many fisheries. In the case of deep-water bottomfish fisheries, regulations have been suggested which ban the use of more than four reels, and ban the use of electric or hydraulic reels. However, from an economic point of view, gear regulations lead to inefficiency, since they raise the cost of catching fish. These regulations may be appropriate in the case of artisanal inshore fisheries, where the resource provides employment or food for a large number of fishers. But as most deep-water bottomfish fisheries are export-oriented, there is

a good economic case for allowing fishers to become as efficient as possible, in order to compete with the marketing of similar species from other Pacific Island countries. This regulation is not recommended.

Catch quotas are used to restrict the catch from a resource to a predetermined total allowable catch (TAC). Catch quotas have been recommended for deep-water bottomfisheries in other Pacific Islands, including the deep-water snapper fishery in Fiji. The main problem with such a measure is the difficulty in ensuring that quotas are not exceeded. If quotas are based on catches recorded in logbooks, there is a strong motivation for fishers to under-report catches. This regulation is not recommended.

License limitation has been introduced in fisheries in many parts of the world. Under this regulation, a limited number of vessels, or vessel owners, are given licenses to fish. The number of licenses issued is set at a level at which it is believed capable of imposing the fishing effort required to take some predetermined level of catch. **This regulation is recommended.**

Enforcement would involve periodic checks that vessels landing bottomfish export species held valid licenses. Enforcement would be simplified, and made more workable, if it were made illegal to export (rather than catch) deep-water bottomfish without a license. However, unlicensed fishers may attempt to circumvent the regulations by selling their catch through licensed fishers. A suitable deterrent would be that license holders engaging in this activity risk the possibility of losing their licenses.

The view may be held that the community, which has had to forgo its right to fish in favor of a few license holders, is entitled to share in the profits made from the fishery. In this case, excess profits from the exploitation of a public resource may be collected in the form of fishing license fees. This ensures that profits from the exploitation of a nationally-owned resource, are shared by the country as a whole, rather than remaining with a selected few licensed individuals. However, the profitability of deep-water bottomfish fishing in Tuvalu is not likely to be high, and a small license fee may be appropriate to amortize fishery management and monitoring costs.

In summary, it is recommended that participation in the fishery be restricted to a maximum of 3 or 4 moderately-sized vessels by means of a licensing system. This would be the only regulation applied to the fishery.

The license should in effect be an export license which permits the owner-operator of a suitable vessel to catch and export deep-water bottomfish from Tuvalu, subject to quality control procedures. A small annual license fee should be imposed to

amortize the costs of fishery monitoring and quality control; this license fee could be waived during the early years of development. Licenses should be issued with the conditions that the license holder must fill in and return fishing logsheets (recording catch, fishing effort and fishing area), and agree to allow a Fisheries Department observer on board during any fishing trip.

Regular enforcement would involve periodic checks (perhaps along with quality control checks) that bottomfish export species have been landed by those holding valid licenses.

6.3.4 Monitoring the developing fishery

Whichever options and management measures are selected, a permanent, even if low level, system of data collection should be established to monitor the "health" of the fishery, and to determine the effectiveness or otherwise of management strategies. Catch and fishing effort information are the basic data requirements, and these may be supplemented by the regular collection of length-frequency data. The completion and submission of fishing logs with catch and fishing effort by area should be a legal requirement of participation in the fishery. To monitor fishing effort, inventories of boats and fishing gear used in the fishery must be maintained and continually updated. A trend of falling catch rates may indicate that a fishery is being exploited above the sustainable rate, and a decrease in the mean length of fish in the catch (estimated from length frequency data) may indicate the same thing.

From a financial viewpoint, fishing costs and catch value should also be monitored. The early detection of trends, such as increasing fishing costs, or decreasing market values of the catch, for example, may suggest that a change in the fisheries management strategy is required in order to maintain profitability.

6.3.5 Public concerns regarding the proposed fishery

Concern has been expressed that the development of a deep-water bottomfish fishery will have a negative impact on the fish stocks of local reefs. However, the deep-water and coral reef habitats are quite distinct, and the ecological links between the two are tenuous. For these reasons, fishing in deep-water will have little or no effect on shallow coral reef fish stocks, and the concern appears unfounded.

Another concern is in regard to the export of fish which could be consumed locally. However, the costs of catching deep-water fish are high, and above the price for which such fish could be profitably sold on local markets. Indeed, the development

of a deep-water fishery is only possible if costs can be covered by the export of the high-value species. It should be noted that during the project surveys and trials, 35.3% of the landed catch consisted of less valuable but desirable species which were marketable locally.

There may also be public concern and jealousy regarding the profits made by the small number of boats permitted to operate in the fishery. Fisheries and government officials may be under considerable pressure to allow more vessels into the fishery. This pressure must be resisted in order to ensure the profitability of the fishery. A larger number of vessels will reduce average catch rates and profitability.

It is recommended that any increase in the number of vessels in the fishery be considered only after the GOT Fisheries Department has reviewed catch-rates and profitability of the fishery after two years of operation and data collection.

6.3.6 Views of stake-holders

Discussions at a Bottomfish Management Plan Workshop conducted in Funafuti in January 1995, focused on a range of issues relating to the development of a new deep-water bottomfish fishery and a review of the draft version of the management plan, raised several issues.

6.3.6.1 Licensing issues

Workshop participants generally agreed that licensing a small number of boats to fish for bottomfish was necessary. However, some participants were concerned regarding the license fee, and whether licensing would restrict people from fishing in traditional areas close to islands. Workshop participants were assured that the main purpose of licensing was to restrict the number of fishermen in the new deep-water bottomfish fishery in order to keep catch rates high and to maximize net profits to Tuvalu. Government representatives claimed that license fees could be nominal; a fee of A$20 was suggested. It was also stated that licensing was not directed at those catching fish for local consumption or sale, but at those catching and exporting deep-water bottomfish.

6.3.6.2 The role of middlemen in the new industry

Participants suggested that middlemen can play an important role in the fishery, by taking responsibility for packing, marketing and shipment. However, it was also suggested that the likely profits are too modest to support an extra link in the commercial chain. Another point made was that the packing of fish for export could be done most effectively during the journey back from the fishing grounds.

6.3.6.3 The role of government

Participants suggested that government could play an important role by:

- regulating the fishery (e.g., by licensing),
- aiding in marketing negotiations,
- negotiating cheaper air transport fees (Funafuti to Nadi), and
- training those involved in the new industry.

There was also perceived to be a requirement for enhanced:

- port and docking facilities,
- maintenance and repair facilities,
- ice making capabilities, and
- training for skippers and engineers.

6.3.6.4 Role of foreign investors

The participants were in agreement that the deep-water bottomfish resources should be harvested by Tuvaluan nationals. Licenses should not be issued to foreigners, and joint ventures between nationals and foreigners should not be encouraged.

A bank representative stated that the investment and skills required are within local capabilities and that the Tuvalu Development Bank may consider partnerships between itself and local fishermen in order to reduce the loan required by an individual.

It was suggested in the workshop that the development of the deep-water bottomfish fishery is a totally different undertaking from that of the tuna fishery. In the bottomfish fishery, locally-owned ventures are not only possible but desirable, but in the tuna fishery, foreign investment and partnerships may be required because of the finance and expertise required. The two different fisheries should be disassociated from each other in future discussions.

However, it was suggested that some of the facilities required for developing a tuna fishery (docks, refuelling facilities, etc.) could also be used by fishermen in the deep-water bottomfish fishery.

In addition, it was suggested that some foreign assistance may be required to provide additional training programs related to the development of the bottomfish fishery.

6.3.7 Risk assessment

Factors which would put the development of the new fishery at risk include:

- a reduction in catch rates, caused, for example by too many vessels in the fishery; in general, the larger the number of vessels, the lower the catch rate of each;

- a decrease in fish prices, caused, for example, by a failure of quality control or by a reduction in demand for the main species; and

- an increase in cost, caused, for example, by larger vessels entering the fishery and causing over-capitalization, or by any increases in freight charges.

Many of these risk factors, including the number of participating vessels and fish quality issues, are within the direct control of the management authority in Tuvalu. However, other factors, such as airline freight charges, are beyond the direct control of Tuvalu, although the government may still be able to exert some pressure to control these.

6.4 Conclusions

The Tuvalu Bottomfish Project developed a bottomfish resource management plan which has general support of GOT Department of Fisheries staff, other GOT officials, and private fisherman in Tuvalu. The management plan calls for limiting the number of fishing vessels to 3 or 4 vessels via a licensing system. In addition, the establishment of a quality control inspection system and a permanent monitoring and reporting system were recommended. Public and private sector cooperation will be required to ensure success, profitability, and sustainability of an emerging Tuvalu bottomfishing industry.

7.0 BOTTOMFISH VESSEL DESIGN

7.1 Bottomfish vessel design overview

The project contract originally called for the design of an appropriate and suitable prototype fishing vessel for a small-scale commercial bottomfishing operation. Such a design would be based on the results of the commercial fishing trials and local conditions. The recommended design was to ensure optimal exploitation of the fishery resource and the expansion of the bottomfishing industry in Tuvalu. As the project implementation proceeded, however, it was recognized that there are many alternative vessel designs and many alternative vessels available throughout the South Pacific which would be appropriate for bottomfishing in Tuvalu. Hence, the vessel design component of the project was recast as a much smaller component involving the RDA Master Fisherman preparing a brief report identifying the characteristics of an "ideal" or "model" bottomfishing vessel for use in a Tuvalu bottomfishing industry. The change in this component was finalized in a Contract Amendment effective 1 July 1993, and the funds initially budgeted for a vessel design component of the project were redirected to conducting export marketing trials and further project training exercises. Replacing the vessel design component of the project was a task of identifying the key characteristics of an appropriate bottomfishing vessel for Tuvalu conditions.

7.2 Project implementation

RDA Master Fisherman L. Pasefika developed his report on the ideal characteristics of a Tuvalu bottomfishing vessel after acting as skipper on almost all of the project's resource assessment, test fishing, and commercial fishing trial cruises on the *Manaui*. The issues were discussed with RDA Master Fisherman J. Marks during his visit to Tuvalu in August 1994. In May 1994, L. Pasefika, while in Fiji conducting other activities for the project, looked at some of the alternative available vessels which might be used in a Tuvaluan bottomfishery. Then in October 1994, RDA Master Fisherman L. Pasefika and Skipper T. Tupao traveled to Hawaii where they joined RDA Master Fisherman J. Marks in a survey of alternative vessels and vessel designs available in Hawaii. A vessel characteristics report was then prepared on the basis of the project's bottomfishing experiences and a careful survey of alternative vessels and vessel designs currently available in Hawaii.

7.3 Findings

RDA Master Fisherman L. Pasefika prepared a report entitled "Desired Characteristics of a Tuvalu Bottomfishing Vessel," which identifies the characteristics of the ideal or model vessel for bottomfishing on Tuvalu's distant seamounts.

The *Manaui*, the GOT extension vessel, was used during most of the project resource assessment and fishing cruises. While it was an excellent training vessel with the capacity to carry a large crew along with training personnel for extended distant trips at sea, the *Manaui*, at 18.6 m with a 163 hp Yanmar engine, is far too large a vessel to be a commercially feasible bottomfishing vessel in the Tuvalu bottomfish fishery. Accordingly, the bottomfishing vessel characterized in this report is much smaller and more economical to operate than the *Manaui*.

The long distances required for fishing on these distant seamounts requires a fuel efficient vessel that can meet appropriate safety standards while having sufficient work, storage, and crew comfort space. It has been determined that a 10-11 m vessel powered by a 20-30 hp diesel engine and capable of cruising at 6-7 kn/hr will be required. A slightly larger and more highly powered vessel is recommended, but commercial consideration may require meeting only the minimum suggested dimensions and power requirements. An array of characteristics were reviewed in this report in the effort to provide guidance to potential commercial operators who might desire to enter this distant seamount bottomfishery.

Depending on the final choice of dimensions, the hull and superstructure for the model vessel could be built in Tuvalu at an estimated cost of A$20,000 - A$25,000. This does not include engine, fishing and navigational equipment, sails and other gear that are needed onboard. The construction of the model vessel in Tuvalu would be time consuming due to the unavailability in Tuvalu of suitable materials and equipment. It would perhaps be more advantageous if a similar type of vessel now available in other Pacific countries could be brought in to start the bottomfishery in Tuvalu.

The traditional 9 m "Alia" type vessel is available in the South Pacific, but it is viewed as too small to be appropriate for bottomfishing on Tuvalu's distant seamounts. The Alia design has a limited fishing range and would have a relatively high delivery cost. A slightly enlarged Alia type vessel, with an inboard diesel engine and enclosed cabin might be designed to be appropriate for this fishery, but it would require special design and construction. The 10 m steel hull vessels readily available in New Zealand are somewhat too expensive to purchase, maintain, and operate. Furthermore, they would have high delivery costs.

After examining various vessel options, it was concluded that the most appropriate type of already-designed vessel is the 10 m diesel-powered VAN-1, built in Vanuatu. Unfortunately, these vessels have not been mass produced. The VAN-1 is considered to be at about the minimum size for bottomfishing on Tuvalu's distant seamounts, and a slightly enlarged VAN-1 model would be ideal. Once the minimum safety requirements are met, the choice of vessel will depend on a balancing of economy, efficiency, and comfort considerations.

Some of the features of the model bottomfishing vessel are briefly discussed below.

A displacement type hull with a V-bottom, fiberglassed over good quality marine plywood is recommended. The vessel superstructure and general layout should be similar to the 10 m diesel VAN-1. Whether a 20 hp or 30 hp diesel engine is used, a set of heavy duty batteries chargeable from the main engine should be used to operate navigational and fishing equipment and to supply lights. Two 600-750 kg insulated ice boxes should be provided and stowed on deck. Up to 500 l of diesel fuel is recommended and could be carried in one or two tanks, but a minimum fuel capacity of 400 l is recommended.

An array of navigational and fishing equipment will be required, including the following: 1 radar, 24 miles range; 1 GPS; 1 fish finder, color sounder; 1 autopilot and compass; 1 SSB radio; 1 weather fax (optional); and a sextant and tables for navigational purposes. A small tool box with all the required tools should be provided to maintain the engine and/or make necessary engine repairs at sea. All other tools for deck and sail repairs should also be provided.

Based on past experience in the Tuvaluan fishery, 3 or 4 FAO Samoan-type removable handreels are recommended. Given the long hours of fishing that will be required, more effective fishing may be possible if 2 or more hydraulic reels were used, supplemented by an extra Samoan-type handreel for use by the skipper when fishing is very good. Tuvaluan fishermen enjoy fighting the fish as they use the Samoan reels. However, these reels are very labor intensive. Hydraulic reels have become much less expensive in recent years. A commercial operator may choose to use hydraulic reels because fishing can be conducted for longer periods and they appear to justify their extra cost. All related fishing line, hooks, and gear for deep-water bottomfishing and trolling should be supplied.

The following boxes are recommended: 1 box to stow the fishing anchor and line, 1 box to stow the main anchor and chain, and 1 box to stow the spare anchor, chains and lines. For safety backup in case of engine failure and for fuel economy when the trade winds can be appropriately used to supplement the engine power, a backup sail is recommended. An emergency 15 m sail will also be required. A manual bilge pump to drain out bilge and ice boxes, will be required.

Three or 4 wooden bunks should be provided, the number depending on the crew size. A fourth crew member will make for crowded quarters and work space on a small vessel. A small 2 burner gas stove and a gas cylinder should be provided, along with pots, plates, and related cooking and kitchen equipment. It is essential that adequate amounts of water are carried to ensure maximum utilization of time on fishing activities. The return of a vessel to port due to a shortage of fresh water should not occur. The total amount of fresh water should be at least 500 l.

Lastly, the vessel should meet all safety standards, by carrying the required fire extinguishers, life vests, rafts, emergency lights, and so forth.

7.4 Conclusions

It is a common belief that no single design is appropriate to all fisherman or even to different fisherman in the same fishery. The recommendations in the vessel characteristics report for the model or ideal Tuvalu bottomfishing vessel were therefore made with utmost care to minimize costs and at the same time maintain a high standard of performance and safety. The report suggested the desired vessel characteristics and associated gear and equipment that are most appropriate for a commercial bottomfishing venture in Tuvalu. While a variety of vessels could be successfully employed in this fishery, a vessel similar to a slightly enlarged VAN-1 appears to meet most of the requirements for a Tuvaluan bottomfishing vessel identified during the course of the test fishing and commercial fishing trial cruises.

8.0 TRAINING

8.1 Training overview

The sixth major component of the Tuvalu Bottomfish Project was the provision of specialized training for fisheries development in Tuvalu. In order to facilitate the future expansion and success of the fishing industry in Tuvalu, beyond the specific life of the project, a variety of training programs were provided for Tuvaluan fishermen and fisheries personnel.

8.2 Project implementation

The revised draft of the first year training plan was completed in January 1992, at the end of the first quarter of project implementation. The plan was reviewed and accepted by the PCC at its second meeting held in February 1992. Subsequent annual training plans were included in the annual Project Implementation Plans which were reviewed and approved by the PCC at its formal meetings.

A variety of training activities were conducted throughout the life of the project. Highlighted and summarized below are the 12 formal in-country workshops and training programs, the 10 formal overseas study tours, and the 2 long-term university participant training programs conducted by the project. However, some of the most important training activities were those conducted on a day by day basis. The RDA Marine Resource Advisor/Team Leader S. Petaia and RDA Master Fisherman L. Pasefika continually provided hands-on training in every aspect of bottomfishing, fish handling, and fish exporting. These were among the most effective training activities conducted by the project.

8.2.1 In-country training

The following in-country training programs were conducted in Tuvalu over the course of the project:

Data Collection and Data Entry Training 1 (December 1991, Tuvalu): GOT staff were trained in the data collection and data entry procedures in conjunction with the set up of the data collection procedures by the RDA Marine Biologist.

Data Collection and Data Entry Training 2 (April 1992, Tuvalu): GOT data collectors were trained on shore and onboard the *Manaui* in data collection and data entry procedures.

Bottomfishing Operation and Gear Technology Training (June-December 1992, Tuvalu): Over the course of the first 17 cruises involving test fishing associated with

the resource assessment activity, a total of 23 Tuvaluan fishermen were provided hands-on training in bottomfishing operation and gear technology onboard the Department of Fisheries extension vessel, the *Manaui.* These training activities focused mainly on fishing gear rigging, coastal navigation, fish handling, and other relevant aspects of bottomfishing operations.

Data Collection and Data Entry Training 3 (February 1993, Tuvalu): GOT Fisheries Department staff, RDA field staff, and two new data collectors undertook training in data collection procedures, data entry, and data analysis. The training included classroom training as well as hands-on field training onboard the *Manaui.* The participants also reviewed the first year data collection procedures.

FAD Deployment Training (February-April 1993, Tuvalu): RDA Marine Resource Advisor/Team Leader provided practical hands-on training for GOT Fisheries Department staff and project crews in the construction and deployment of FADs as part of a FAD deployment activity during February-April 1993 in Tuvalu.

Business Training Workshop (January 1994, Tuvalu): Several Tuvaluan fishermen and GOT Fisheries Department and NAFICOT staff participated in a Business Training Workshop conducted by RDA Marketing Advisor P. Bartram in Tuvalu in January 1994. The program focused on small business training and the need for proper handling of fish from the moment it is brought onboard. The importance of keeping accurate records of their expenditures and revenues received from their fishing activities was stressed. Some aspects of export marketing were also included in the training program.

Bottomfish Export Marketing Workshop and Training (January 1994, Tuvalu): Several GOT Fisheries Department staff, local fishermen, and project crews were trained on aspects of export marketing of chilled fish by RDA Marketing Advisor P. Bartram in Tuvalu in January 1994. The training emphasized proper fish handling, icing, gutting, packaging and documentation. This training was conducted on fishing boats in order to provide actual hands-on experience. Participants were able to receive training in spiking, mixing ice slurries, and the handling and gutting of fish for the export market. They were also shown how to stack and store fish on ice in the fish holds. They were also trained to avoid the export of fish carrying ciguatera and in the use of ciguatera test kits. Cleanliness and hygiene of the whole operation as related to export marketing were also emphasized during the training. After the fishing trip all participants were trained in the packing of the fish in boxes for export and in preparing the necessary documents for the shipments.

Data Analysis Training (February 1994, Tuvalu): GOT Fisheries Department staff and the project's data collectors participated in a 1 week data analysis training program conducted in Tuvalu in February 1994 by RDA Marine Biologist W. Haight.

Bottomfish Management Plan Workshop 1 (August 1994, Tuvalu): Approximately 20 Tuvaluans, including GOT Department of Fisheries staff, fishermen, and representatives from the Tuvalu Development Bank and several GOT ministries, participated in a 1 day workshop focusing on the findings of the project to date and the necessity of developing a bottomfish resource management plan in order to assure the sustainable development of a Tuvalu bottomfishing industry.

Bottomfishing and Export Marketing Training (August 1994, Tuvalu): An extensive training program on shore and onboard the *Manaui* was provided to fishermen and project crews in August 1994 in Tuvalu by RDA Master Fisherman J. Marks and RDA Marketing Advisor P. Bartram. The onboard training focused on the use of the sounder, vessel positioning and the use of the anchor, use of chum bags, fishing depths, and a variety of techniques for ensuring that the higher-valued export species are targeted by the fishing operation. Onboard and on shore, emphasis was put on fish handling, chilling, packing, and shipping procedures to ensure high quality export shipments.

Bottomfish Management Plan Workshop 2 (November 1994, Tuvalu): A second workshop discussing the requirements of a bottomfish management plan for Tuvalu was conducted by RDA Senior Economist J. Rowntree and RDA Marine Biologist M. King in November 1994 in Tuvalu. Government officials, the head of the Tuvalu Development Bank, Department of Fisheries staff, and fishermen participated in the discussions.

Bottomfish Management Plan Workshop 3 (January 1995, Tuvalu): A final project workshop reviewing the Draft Bottomfish Management Plan was conducted by RDA Marine Biologist M. King in January 1995 in Tuvalu.

8.2.2 Overseas training and study tours

The project conducted several international training and study tours over the life of the project, including the following:

Fish Marketing and Processing Study Tour, Phase 1 (October 1992, Tonga): Four Tuvaluans spent 2 weeks in Tonga during September 1992, on a Study Tour coordinated by B. Holden, a private fisherman Tonga, and the Tongan Fisheries Division. The participants included one participant each from NAFICOT and the GOT Fisheries Department and two participants from the Tuvalu Fishermen Association. The participants spent several days fishing and were introduced to every aspect of the fishing, fish handling, packing for export, and shipping of bottomfish from Tonga. The Tuvalu Fishermen Association representatives visited with the Fishermen Associations in Tonga to learn how they are organized and what services they provide to fishermen.

Fish Marketing and Processing Study Tour, Phase 2 (October-November 1992, Fiji): Three Tuvaluans spent 3 weeks in Fiji during October 1992, on a Study Tour coordinated by J. Russo, a private fisherman in Fiji. The participants included one each from NAFICOT, the GOT Fisheries Department, and the Tuvalu Fishermen Association. Training focused on fishing, fish handling, packing for air shipment, marketing, and record keeping aspects of a bottomfishing operation.

Data Analysis Workshop 1 (November 1992, Hawaii): Two GOT staff members serving as data collectors for the project's resource assessment cruises undertook a 2 week training program during November 1992, in data analysis in Honolulu, Hawaii. The workshop was a training exercise jointly sponsored by the Tuvalu Bottomfish Project and the Tonga Small-Scale Tuna Longline Project. The Tuvaluan trainees worked with RDA Marine Biologists W. Haight and M. King, among others.

Vessel Operation Certification (April-May 1993, Fiji): The *Manaui* mate traveled to Suva, Fiji to train and be examined for certification as a Class-5 skipper in order that he would be able to serve as the skipper on the GOT chartered vessel.

FADs Workshop (May 1993, Fiji): RDA Master Fisherman L. Pasefika attended a USAID-funded 2-day workshop organized by the University of Rhode Island on "FADS: Pitfalls and Potentials," in May 1993 in Suva, Fiji.

Bottomfish Vessel Operation (May and August 1993, Fiji): The RDA Master Fisherman and the *Manaui* engineer traveled to Suva in May 1993 to inspect, test, and familiarize themselves with the bottomfishing vessel chartered by the GOT for use in the commercial fishing trials. Then in August 1993, 4 Tuvaluan crew members were sent to Suva to be introduced to and be certified to operate the charter vessel prior to sailing it back to Tuvalu.

Export Marketing Study Tour 1 (January-February 1994, Fiji and Hawaii): Three Tuvaluans, including a fisherman, a Department of Fisheries staff member, and a NAFICOT representative, accompanied the first bottomfish export trial shipment to Hawaii. This allowed these participants to experience the necessary steps and procedures regarding the exportation of chilled fish to overseas markets. The participants attended lectures by fish buyers and visited various fish marketing outlets, fish processing factories, and auction markets.

Data Analysis Workshop 2 (April 1994, Hawaii): Three Tuvaluans participated in a 1 week training program for data analysis during April 1994, in Honolulu, Hawaii. The workshop prepared the trainees for continuing their data analysis activities for the GOT Fisheries Department after the conclusion of the project.

Export Marketing Study Tour 2 (August 1994, Hawaii): One Fisheries Department staff member and one NAFICOT staff member participated in a 1 week export marketing study tour to Hawaii in August 1994. The tour was coordinated by RDA Marketing Advisor P. Bartram and allowed the participants to familiarize themselves with bottomfish marketing channels, outlets and procedures. The participants also had an opportunity to observe fish processing factories in Hawaii.

Vessel Characteristics and Export Marketing Study Tour 3 (September-October 1994, Hawaii): The skipper and mate of the *Manaui* spent 2 weeks in Hawaii in September-October 1994, working on two separate tasks. First, they worked with RDA Master Fisherman J. Marks on discussing bottomfishing vessel characteristics, surveying vessel options in Hawaii, and receiving further training in the use of the sounder for finding high-valued bottomfish at depths of 300 m - 400 m. Secondly, they worked with RDA Marketing Advisor P. Bartram on surveying the export marketing channels in Honolulu, including visiting fish buyers, the fish auction, and related activities.

8.2.3 Long-term training

In addition to the in-country and overseas training activities, the project also coordinated the training activities of two Tuvaluan long-term participant trainees in a two-year diploma course at the University of the South Pacific, a training program the funding for which was separately handled by USAID/RDO/South Pacific.

8.3 Conclusions

The Tuvalu Bottomfish Project sponsored and conducted a variety of in-country and overseas workshops, training programs, and study tours which provided a wide range of theoretical and practical hands-on training for many Tuvaluan fishermen, GOT Department of Fisheries staff, and NAFICOT staff. Training covered every aspect of the bottomfishing industry, from vessel operation and anchoring to drift fishing methods and using chum; from fish handling onboard to fish packing for export shipment; and from data collection, entry, and analysis to business methods. This training has provided Tuvalu with a large number of GOT staff and private fishermen with essential knowledge for successful development of a bottomfishing industry in Tuvalu.

9.0 CONCLUSIONS

This section first presents a number of development considerations regarding bottomfishing in Tuvalu. This is followed by a section on particular problems and lessons learned, including discussions on the provision of project vessels, the relationship with the GOT, external project evaluations, regional impact, and public-private relationships. Then a brief overview of project accomplishments is presented before some final observations.

9.1 Development considerations

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

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 248 miles, while the total 200 m isobath length of Tuvalu's islands is estimated at 128 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. These 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 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 over-fish 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 the 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.

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. Subsistence agriculture and fishing provide employment for about 75% of adult Tuvaluans, and the government is the dominant employer. Private sector employment opportunities are very limited, with the number of paid employees in private enterprises not exceeding 200. Accordingly, a small bottomfishing industry generating 20-25 well-paid jobs would make a substantial contribution to private sector wage employment.

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 Tuvalu exported some copra up through the mid-1980s, in 1993, Tuvalu's total exports of A$216,000 were made up of stamps produced by the government Philatelic Bureau. Thus, a modest sized export-oriented bottomfishing industry could increase Tuvalu's export earnings by about 75% over their 1993 level. 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

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 over-fishing. 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 longtail red snapper (or *Etilis coruscans*), 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 deep-water 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 on 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.

Despite these concerns, however, it is clear that Tuvalu has the potential to develop a modest sized export-oriented bottomfishing industry.

9.2 Particular problems and lessons learned

9.2.1 Provision of project vessels

One of the contractually specified GOT contributions to the Tuvalu bottomfish project was the fishing vessel, the *Te Kaleva*. This vessel was not fully appropriate for bottomfishing on the distant seamounts and was scheduled for some re-outfitting before it was destroyed by a storm in December 1991. The only other vessel available in Tuvalu which could travel the distances required for fishing on the seamounts was the GOT extension vessel, the *Manaui*. The GOT agreed to make the *Manaui* available for project resource assessment cruises on an intermittent basis, as the vessel is used locally for a variety of purposes.

Unfortunately, the *Manaui* was much too large a vessel to test commercial style fishing feasibility. The GOT began efforts to locate a second vessel, i.e., an appropriate sized commercial bottomfishing vessel, to charter for project test fishing activities. There were repeated delays in locating and ultimately chartering a vessel.

Despite these delays, the GOT did finally charter the *TASU-I* from a commercial operator in Fiji. As the vessel was due to be delivered, however the GOT was notified that the operator would need to be paid some of the charter fee in advance in order to finance necessary repairs. One delay let to another, and, finally, the GOT advanced the entire charter fee to the operator. USAID representatives encouraged the GOT to finalize the charter arrangement, but when the vessel was delivered, months late so that the 1993 fishing season was lost, it was not in a useable condition.

The *TASU-I* required continual maintenance and repair work. Without stabilizers, the vessel was unsafe to take on distant trips. A malfunctioning steering system made steering difficult. Repeated mechanical breakdowns interrupted attempts to conduct fishing trials. As *TASU-I* caused delays jeopardized the conduct of the fishing trials in the 1994 fishing season, the GOT again made the *Manaui* available to the project to conduct fishing activities.

While there was no way to anticipate the destruction of the *Te Kaleva* or the malfunctioning of the *TASU-I*, it is now apparent that the original design of the project was over ambitious in requiring the GOT to supply an appropriate commercial bottomfishing vessel for the project. Chartering the *TASU-I* was very costly for the GOT, yet, as experience proved, the affordable vessel alternative turned out to be an unacceptable vessel. With hindsight, it is now clear that after the *Te Kaleva* was destroyed, many project delays and expenses could have been avoided had USAID funds been allocated to providing a fishing vessel and had the GOT contribution to the project been renegotiated.

9.2.2 Relationship with the GOT

Throughout the life of the project, GOT representatives were extremely concerned and supportive, both financially and programmatically, of the project and its success. The Tuvalu Ministry of Natural Resources Development, Department of Fisheries, and NAFICOT were extremely cooperative with project management and staff in resolving issues and in encouraging speedy and successful project implementation. The Department of Fisheries, the principal Tuvalu institution with which the project worked, was particularly supportive.

The cooperation and support of the GOT is demonstrated by the fact that the GOT, for example, provided helpful counterpart staff; made an office, training, and related facilities available for project use: purchased an ice machine with Treaty funds in order that the project's fishing trials would have appropriate and sufficient ice; interceded on behalf of the project in international negotiations with the Government of Fiji to obtain fish landing and transhipment rights; assisted in identifying GOT and Tuvaluan fishermen to participate in project implementation and training programs; arranged several times for meetings with, briefings of, and workshops for GOT

secretaries, ministers, and other officials; made its extension vessel, the *Manaui*, available to the project more than was initially expected and, in view of competing demands for use of the *Manaui*, to a most generous extent; chartered, with Treaty funds, a commercial fishing vessel for use by the project, and when it became apparent that the chartered vessel was inadequate for project purposes due to mechanical failures, made the *Manaui* again available to the project; secured the cooperation of NAFICOT in allowing the project to use NAFICOT fish landing and packing facilities; repeatedly made its computer, photocopy, library, and other facilities available to project staff when required; and so on and so forth. The cooperation by the GOT officials and institutions was indeed exemplary among overseas technical assistance projects.

9.2.3 External project evaluations

The RDA contract with USAID for conducting the Tuvalu Bottomfish Project stipulates that "The project shall be subject to two formal evaluations to be undertaken by an independent party under AID contract." Unfortunately, however, there were no formal USAID-sponsored evaluations of the project. Aside from periodic review of project work plans and implementation schedules by the PCC, there was only one evaluation of the project that was conducted. RDA conducted its own internal informal review of the project in the spring of 1993. There were repeated discussions of conducting a contractually required external USAID-sponsored evaluation, but none was held. USAID plans to conduct an external evaluation of the project in late 1993 or early 1994 were set aside in late 1993 when it was learned that the USAID/RDO/SP/Suva office would be closed in September, 1994.

Despite the fact that the project faced many specific obstacles to the successful implementation of the project (such as the difficulties and delays in the GOT providing a suitable ice-making machine, the delays in obtaining a commercial bottomfishing vessel to use in the commercial fishing trials, and the mechanical problems with the commercial vessel after it was chartered by the GOT), RDA in cooperation with the GOT overcame these obstacles to successfully complete the scope of work on-time and within budget. Based on the project's hydrographic surveys of Tuvalu's distant seamounts, test fishing, biological assessment of the bottomfish stocks and expected MSY, commercial fishing and export marketing trials, development of a bottomfish resource management plan, and extensive training of Tuvaluan GOT representatives and fishers, a final economic evaluation demonstrated that Tuvalu is indeed in the position to develop a modest sized export-oriented bottomfishing industry. Furthermore, a sufficiently large number of Tuvaluans have been trained in fishing for and marketing of bottomfish that the feasibility of developing a bottomfishing industry is about to become a reality. In fact, several potential entrants to the industry as well as representatives of the Tuvalu Development Bank have expressed an interest in pursuing investment options in bottomfishing in Tuvalu. This project would appear, then, to be an almost model overseas assistance project with outstanding results

which are about to initiate a new era in Tuvalu marine resources development. Unfortunately, this project success is likely to go less well-recorded than appears warranted.

The single most important tool for critiqueing a project is the external evaluation process by objective, knowledgeable and unbiased experts. The project was designed to include two formal USAID evaluations. Unfortunately, both project evaluations were eliminated by USAID due to overall USAID budget considerations. Regrettably, both the contractor, RDA, and the host country, Tuvalu, must now accept less recognition for the successful implementation and completion of a major foreign assistance project in fisheries development than they deserve.

9.2.4 Regional impact

The Tuvalu Bottomfish Project, as a component of the USAID PIMAR Project, was designed with an explicit charge to "multiply project benefits" via "a regional impact component to support activities at a regional level to promote these wider applications." The Tuvalu Bottomfish Project sponsored a joint baitfish-bottomfish data analysis training workshop in Hawaii in cooperation with the USAID PIMAR Tonga Small-Scale Tuna Longline Project. The Tuvalu project also sent a Tuvaluan representative to a USAID-sponsored FAD workshop in Fiji. Interim project reports were distributed to SPC, the agency which received USAID regional impact funding for PIMAR activities, but there appears to have been little regional dissemination of PIMAR results and findings to date. This is the extent of regional impact activities actually implemented.

Tuvalu is a late-comer to the South Pacific bottomfishing industry. In fact, in Tonga, Western Samoa, and numerous other South Pacific countries an export-oriented bottomfishing industry has already endured a cycle of rapid (over) expansion with many fishers and vessels entering their fisheries and subsequent decline in yields, returns, and, ultimately, fleet sizes. These experiences are somewhat sobering to bottomfish industry expansion plans in Tuvalu, and project reports and workshops have made abundantly clear the dangers of over capitalizing Tuvalu's bottomfishing industry. Tuvalu's guarded approach to developing a bottomfishing industry should prove instructive to other South Pacific island countries which have not yet exploited their bottomfish resources.

The failure to strengthen the regional impact of the USAID PIMAR country projects is particularly distressing in Tuvalu's situation. The USAID PIMAR Tonga Small-Scale Tuna Longline Project demonstrated the success and profitability of introducing the small-scale tuna longlining techniques in Tonga. In fact, the project's results were so striking, that even before the end of the project, several vessels had entered Tonga's small-scale tuna longline industry. Tuvalu has enormous marine resources and is know have abundant migratory tuna in its EEZ. Replicating the results of the

Tonga Small-Scale Tuna Longline Project in Tuvalu is a development opportunity which should be explored if the PIMAR Program is to succeed in achieving its regional impact targets.

9.2.5 Public-private relationships

Included in the purpose statement of the Tuvalu Component of the USAID PIMAR Project is the charge to "...adapt and apply new fishing technologies and fisheries management strategies to expand small-scale commercial offshore fishing operations...." Among the indicators for progress for achieving the project purpose is that "Tuvaluan fishermen are making investments in boats and gear for bottomfishing and are regularly carrying out bottomfishing operations." Project viability depends on the demonstration of commercial viability of bottomfishing in Tuvalu and the adoption of the technologies by local entrepreneurs. The contract notes that "The key strategy for the long-term success of this project is the adoption of technology by private fishermen. Private sector development is critical to achieving project objectives."

This emphasis on private sector development is quite appropriate but may become a source of misunderstanding in the case of Tuvalu. The entire country has a population of only about 11,000 people, and the main island, Funafuti, has a population of just over 4,000. There is little commercialized activity in Tuvalu. Subsistence fishing is the main economic activity, and there were no fish exports prior to the Tuvalu Bottomfish Project export marketing trials. One of the principal problems facing commercial development is the lack of private investment capital. The scale of economic activities in Tuvalu is generally quite small, and, as noted above, the largest fisheries related loan previously made by the Tuvalu Development Bank was for only A$30,000. While there have been an increasing number of micro-enterprises spring up in Tuvalu in recent years, what is frequently called the entrepreneurial spirit has as yet only modestly developed in Tuvalu. In the socio-economic context of Tuvalu, it is a promising development if only a few individuals take the necessary initiative to investigate possible participation in the bottomfishing opportunity.

On numerous occasions, the project fostered discussions of the potential for Tuvalu bottomfishing industry development among Department of Fisheries and other GOT staff, private fishers, representatives from the Tuvalu Development Bank, and others. During these meetings, workshops, and discussions, there were several fishers who expressed strong interest in exploring the possibility of entering the bottomfishing industry. Two fishers, in particular, said that they intended to enter the bottomfishing industry, and are presently investigating vessel and financing options. There were also private individuals who expressed an interest in becoming a marketing agent for bottomfish operators. And the Tuvalu Development Bank representative, at the final project workshop on the management of Tuvalu's bottomfish resources, suggested

that the bank may consider partnerships between itself and local fishermen in order to reduce the loan required by an individual. These initiatives confirm that the project was successful in demonstrating to private sector individuals that bottomfishing for the export market promises a profitable opportunity to some Tuvaluans.

However, the separation between the private and the public is not so sharp in Tuvalu as it is in more developed settings. NAFICOT (the National Fishing Corporation of Tuvalu), the main fish market (for the small proportion of the local fish catch that is actually sold) in Tuvalu is a parastatal enterprise, The only fractured ice-making machine was purchased by the GOT and put under the responsibility of NAFICOT. The GOT will necessarily be involved in continuing arrangements with the Government of Fiji to ensure that Tuvaluan fish can be landed and transhipped duty free through Fiji enroute to Hawaii. There are yet further ways that the GOT can be expected to be involved in the development of a bottomfishing industry. Given the modest size and fragility of Tuvalu's bottomfish stocks, proper bottomfish resource management will require close cooperation between the Department of Fisheries and the commercial fishers. The fishers will be required to hold a valid bottomfish export license and to keep accurate log books on bottomfishing locations; catch by length, weight, and species; and fishing effort (e.g., number of reels and hours fished). They will be required to accept Department of Fisheries observers onboard at the request of the Department of Fisheries. These and other management measures will require utmost cooperation between the private and public sectors in the development of the bottomfishing industry in Tuvalu.

9.3 Project accomplishments

RDA has successfully completed all of its contractual obligations on time and within budget. All of the necessary inputs have been provided and documented. The outputs produced by the project include:

- Completion of all bottomfish resource assessments, including hydrographic surveys of and test fishing for bottomfish on Tuvalu's distant seamounts;
- Completion of a final economic evaluation of the potential development of a bottomfishing industry in Tuvalu;
- Completion of 29 resource assessment and test fishing cruises and 6 commercial fishing trials·
- Completion of 7 bottomfish export marketing trials;
- Completion of a bottomfish resource management plan for Tuvalu;
- Deployment of 8 FADS, one near each of Tuvalu's main islands;

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- Conduct of hands-on training of 23 Tuvaluan fishers in bottomfishing operation and gear technology;

- Conduct of 3 bottomfish management plan workshops for Tuvalu public and private institutions and individuals;

- Conduct of 12 short-term in-country training programs, 11 short-term overseas training and study tours, and 2 long-term Tuvaluan participant training programs with the University of the South Pacific;

- Completion and distribution of 11 technical reports, 12 quarterly reports, 3 annual project implementation and training plans, several workshop summaries and other informal reports, and regular monthly status reports prior to the preparation of this final report.

The achievement of contractual end-of-project targets is mixed. The contractually specified indicators of progress for achieving the project purpose along with a brief assessment of project accomplishment are listed below:

- "Tuvaluan fishermen are making investments in boats and gear for bottom fishing and are regularly carrying out bottomfishing operations."

  While no commercial fisher or vessel has yet actually entered Tuvalu's bottomfish fishery, as this project is being completed, several Tuvaluan fishers are seriously investigating the option, surveying available vessels, and discussing vessel loan possibilities with the Tuvaluan Development Bank which is itself investigating the possibility of creating a partnership between itself and fishers to reduce the initial loan requirements of a Tuvaluan bottomfishing entrepreneur.

- "Catch levels (volume of yield of bottomfish in metric tons) are sustainable as defined by stock assessment results (estimated MSY in metric tons) and profitability (gross sales value minus model of costs) to private Tuvaluan fishing operators."

  The project studies have confirmed that Tuvalu has a bottomfish MSY of about 84 mt on its distant seamounts and a bottomfish MSY of about 44 mt on the deep slopes around its atolls. Further, the project studies have confirmed that an export-oriented bottomfishing industry limited to 3 or 4 vessels should be able to yield annual profit rates of 20% to 25% on invested capital for private sector fishing operators.

- "Conclusions on the replicability of bottomfisheries strategy are disseminated through the regional component."

  The project has distributed all of its technical reports to the SPC for further dissemination through the regional component of PIMAR. The contractor is unaware of the current status of the regional impact component of PIMAR.

9.4 Final observations

Several constraints on the development of a distant seamount bottomfishing industry have been explored. These constraints include the lack of any Tuvalu commercial fishing or exporting experience to date, the lack of the current availability in Tuvalu of any suitable bottomfishing vessel, the limited capacity in Tuvalu for vessel and engine maintenance and repair, the limited availability of private capital or bank financing to initiate commercial bottomfishing operations, the limited number of trained skippers in Tuvalu capable of conducting distant seamount bottomfishing, the high running costs of bottomfishing vessels operating on Tuvalu's distant seamounts, the limited and irregular ice making capacity currently in Tuvalu, the high cost of air freighting exportable bottomfish to the Hawaii fish market, the limited number of air flights per week with good connections through Fiji to the Hawaii fish markets, the limited experience of the GOT in monitoring and managing its marine resources, and the existence of unresolved political issues regarding ownership of and fishing rights to Tuvalu's island and distant seamount bottomfish resources.

Despite these various constraints on the development of bottomfishing industry in Tuvalu, the project has demonstrated the feasibility of developing a small commercial export-oriented distant seamount bottomfishing industry.

The Tuvalu Bottomfish Project has demonstrated that 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 factors 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. 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 careful monitoring and management of Tuvalu's bottomfish fishery will be required.

10.0 LIST OF PROJECT REPORTS

The following is a complete list of all formal project reports submitted to USAID and the GOT by RDA. The reports are ordered by year and report number (e.g., 92-01 is the first report produced in 1992).

92-01 Preliminary Economic Assessment, P.W. Philipson, January, 1992.

92-02 Revised Draft Work Plan, RDA International, Inc., February, 1992.

92-03 Quarterly Progress Report, October-December 1991, RDA International, Inc., January, 1992.

92-04 Implementation Plan, RDA International, Inc., March, 1992.

92-05 Training Plan, RDA International, Inc., March, 1992.

92-06 Quarterly Progress Report, January-March 1992, RDA International, Inc., April, 1992.

92-07 Field Program Outline, W. Haight, May, 1992.

92-08 Data Entry Program User's Guide, R. McClure, June, 1992.

92-09 Quarterly Progress Report, April-June 1992, RDA International, Inc., July, 1992.

92-10 Quarterly Progress Report, July-September 1992, RDA International, Inc., October, 1992.

93-01 Implementation Plan 1993, RDA International, Inc., March, 1993.

93-02 Biological Assessment Summary, Year One, W. Haight, March, 1993.

93-03 Quarterly Progress Report, October-December 1992, RDA International, Inc., March, 1993.

93-04 Quarterly Progress Report, January-March 1993, RDA International, Inc., April, 1993.

93-05 Quarterly Progress Report, April-June 1993, RDA International, Inc., July, 1993.

93-07 Quarterly Progress Report, July-September 1993, RDA International, Inc., October, 1993.

93-08 Quarterly Progress Report, October-December 1993, RDA International, Inc., January, 1994.

94-01 Implementation Plan 1994, RDA International, Inc., March, 1994.

94-02 Quarterly Progress Report, January-March 1994, RDA International, Inc., May, 1994.

94-03 Report on the First Export Marketing Trial, P. Bartram, March, 1994.

94-04 Quarterly Progress Report, April-June 1994, RDA International, Inc., July, 1994.

94-05 Quarterly Progress Report, July-September 1994, RDA International, Inc., October, 1994.

94-06 Desired Characteristics of a Tuvalu Bottomfishing Vessel, L. Pasefika, November, 1994.

94-07 Tuvalu Bottomfish Project Final Biological Assessment, W. Haight, December, 1994.

94-08 The Commercial Feasibility of Bottomfishing in Tuvalu: Final Economic Evaluation, J. Rowntree, December, 1994.

94-09 Improving Commercial Feasibility of Tuvalu Bottomfishing, P. Bartram and J. Marks, Jr., December, 1994.

94-10 Supplies and Procedures for Exporting Bottomfish from Tuvalu, P. Bartram, December, 1994.

95-01 Management Plan for the Deep-Water Bottomfish Fishery for Tuvalu, M. King, January, 1995.

95-02 Final Report: Tuvalu Bottomfish Project, RDA International, Inc., January, 1995.